

2012 Annual Merit Review Results Report

October 2012

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Introduction

The 2012 U. S. Department of Energy (DOE) Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting (AMR) was held May 14-18, 2012 in Crystal City, VA. The review encompassed all of the work done by the Hydrogen Program and the Vehicle Technologies Program: a total of 309 individual activities were reviewed for Vehicle Technologies, by a total of 189 reviewers. A total of 1,473 individual review responses were received for the technical reviews.

The objective of the meeting was to review the accomplishments and plans for the Vehicle Technologies Program (VTP) over the previous 12 months, and provide an opportunity for industry, government, and academia to give inputs to DOE on the Program with a structured and formal methodology. The meeting also provided attendees with a forum for interaction and technology information transfer.

It should be noted that select DOE-funded projects, both oral and poster presentations, were not reviewed during the 2012 AMR. Generally, this was a result of subprogram preferences, including a rotation of projects that are formally reviewed one year, not reviewed the following year, reviewed the year after that, etc. Further, it was determined that all subprogram overview presentations would not be reviewed during the 2012 AMR. Another example is scheduling formal reviews based on project activity. For example, regulatory program activities tend to be ongoing, highly structured, and specifically directed by Congress. Thus, such VTP activities are typically evaluated on a less frequent basis. For those projects that were designated for review, the intention was to have a minimum of three reviewers. In a few specific cases, some projects had less than three reviewers due to medical emergencies, late cancellations, or other unforeseeable circumstances that impacted reviewer availability and subsequently, project reviews.

The reviewers for the technical sessions were drawn from a wide variety of backgrounds, including current and former vehicle industry members, academia, government, and other expertise areas. In the technical sessions, these reviewers were asked to respond to a series of specific questions regarding the breadth, depth, and appropriateness of the DOE Vehicle Technologies Program activities. The technical questions are listed below, along with the scoring metrics (if appropriate). These questions were used for all Vehicle Technologies Program reviews, including any American Recovery and Reinvestment Act (ARRA) reviews.

Question 1: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Question 2: Approach to performing the work: the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts. (Scoring weight for overall average = 20%)

Scoring: 4=outstanding (sharply focused on technical barriers; difficult to improve approach significantly); 3=good (generally effective but could be improved; contributes to overcoming some barriers); 2=fair (has significant weaknesses; may have some impact on overcoming barriers); 1=poor (not responsive to project objectives; unlikely to contribute to overcoming the barriers).

Question 3: Technical accomplishments and progress toward overall project and DOE goals: the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals. (Scoring weight for overall average = 40%)

Scoring: 4=outstanding [excellent progress toward objectives, suggests that barrier(s) will be overcome]; 3=good (significant progress toward objectives and overcoming one or more barriers); 2=fair (modest progress in overcoming barriers, rate of progress has been slow); 1=poor (little or no demonstrated progress toward objectives or any barriers).

Question 4: Collaboration and coordination with other institutions. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (close, appropriate collaboration with other institutions; partners are full participants and well coordinated); 3=good (some collaboration exists; partners are fairly well coordinated); 2=fair (a little collaboration exists;

coordination between partners could be improved); 1=poor (most work is done at the sponsoring organization with little outside collaboration; little or no apparent coordination between partners).

Question 5: Proposed future research: the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (plans clearly build on past progress and are sharply focused on barriers); 3=good (plans build on past progress and generally address overcoming barriers); 2=fair (plans may lead to improvements, but need better focus on overcoming barriers); 1=poor (plans have little relevance toward eliminating barriers or advancing the program).

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Responses: excessive, sufficient, insufficient.

Responses to the questions were submitted electronically through a web-based software application, PeerNet, operated by the Oak Ridge Institute for Science and Education (ORISE). Database outputs from this software application were analyzed and summarized to collate the multiple-choice, text comment, and numeric scoring responses and produce the summary report.

The report is organized by technical area. Responses to the questions are summarized in the pages that follow, with summaries of numeric scores for each technical session, as well as text and graphical summaries of the responses for each individual technical activity. A list of the activities (and page numbers) for each section appears at the start of each section.

1. Hybrid and Vehicle Systems Technologies

Hybrid and vehicle systems research provides an overarching vehicle systems perspective to the technology research and development (R&D) activities of the U.S. Department of Energy's (DOE's) vehicle research programs, and identifies major opportunities for improving vehicle efficiencies. The effort evaluates and validates the integration of technologies, provides component and vehicle benchmarking, develops and validates heavy hybrid propulsion technologies, and develops technologies to reduce the parasitic losses from heavy vehicle systems. Analytic and empirical tools are used to model and simulate potential vehicle systems, validate component performance in a systems context, benchmark emerging technology, and validate computer models. Extensive collaboration with the technology development activities is required for success. The results of hybrid and vehicle systems activities are used to estimate the national benefits and impacts of DOE-sponsored technology development, and successfully transfer developed technology to industry.

In August 2009, the Department announced the selection of ten projects totaling \$425 million for development, deployment, and validation of hybrid vehicles, and deployment of charging stations across the nation. American Reinvestment and Recovery Act (ARRA)-funded transportation electrification activities will aid in the deployment of technologies that help to reduce petroleum consumption. Activities include deployment of 18,000 public and private charging stations in major metropolitan areas across the country, and deployment of truck stop electrification infrastructure at 50 sites across interstate corridors. Additional deployment activities include development, validation, and deployment of light- and medium-duty electric drive vehicles.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
‡ Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation	Don Karner (Electric Transportation Engineering Corp.)	1-5	3.40	3.60	3.60	3.60	3.55
‡ Advancing Transportation Through Vehicle Electrification - PHEV	Abdullah Bazzi (Chrysler LLC)	1-8	3.25	3.50	3.50	2.75	3.34
‡ Advanced Vehicle Electrification	Darren Gosbee (Navistar, Inc.)	1-10	2.50	2.67	2.67	2.67	2.63
‡ Interstate Grid Electrification Improvement Project	Jon Gustafson (Cascade Sierra Solutions)	1-13	3.14	2.86	2.86	2.29	2.86
‡ Advanced Vehicle Electrification and Transportation Sector Electrification	Greg Cesiel (General Motors)	1-17	4.00	3.33	3.33	3.33	3.50
‡ Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification	Robin Mackie (Smith Electric Vehicles)	1-20	3.25	3.00	3.00	3.25	3.09
‡ Electric Drive Vehicle Infrastructure Deployment	Kumar Gogineni (Coulomb)	1-22	3.50	3.50	3.50	3.00	3.44
‡ Class 8 Truck Freight Efficiency Improvement Project	Derek Rotz (Daimler Trucks North America LLC)	1-23	3.71	3.71	3.71	3.29	3.66
‡ Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	Scott Newhouse (Peterbilt)	1-26	3.00	3.43	3.43	3.43	3.32

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Medium- and Heavy-Duty Vehicle Field Evaluations	Kevin Walkowicz (National Renewable Energy Laboratory)	1-30	3.67	3.33	3.33	3.33	3.42
DOE/DOD Parasitic Energy Loss Collaboration	George Fenske (Argonne National Laboratory)	1-32	3.50	3.25	3.25	2.75	3.25
DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations	Kambiz Salari (Lawrence Livermore National Laboratory)	1-35	4.00	3.75	3.75	3.50	3.78
† PHEV Engine Control and Energy Management Strategy	Paul Chambon (Oak Ridge National Laboratory)	1-38	2.75	3.00	3.00	2.25	2.84
Plug-In Hybrid (PHEV) Vehicle Technology Advancement and Demonstration	Greg Cesiak (General Motors)	1-40	2.50	2.00	2.00	2.25	2.16
Ford Plug-In Project: Bringing PHEVs to Market	Julie D'Annunzio (Ford Motor Company)	1-42	3.75	3.75	3.75	3.25	3.69
Idaho National Laboratory Testing of Advanced Technology Vehicles	Jim Francfort (Idaho National Laboratory)	1-44	3.33	3.33	3.33	2.67	3.25
Advanced Vehicle Testing Activity & Evaluation	Don Karner (ECOTALITY North America)	1-46	3.67	3.33	3.33	3.33	3.42
Advanced Technology Vehicle Lab Benchmarking - Level 1	Henning Lohse-Busch (Argonne National Laboratory)	1-48	3.75	4.00	4.00	3.50	3.88
Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth)	Erik Rask (Argonne National Laboratory)	1-50	4.00	3.50	3.50	3.50	3.63
Electric Drive and Advanced Battery and Components Testbed (EDAB)	Barney Carlson (Idaho National Laboratory)	1-52	3.20	3.00	3.00	2.80	3.03
Advanced LD Engine Systems and Emissions Control Modeling and Analysis	Stuart Daw (Oak Ridge National Laboratory)	1-54	3.25	3.25	3.25	3.25	3.25
Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis	Jeffrey Gonder (National Renewable Energy Laboratory)	1-56	3.50	3.50	3.50	3.00	3.44
LDV HVAC Model Development and Validation	Jason Lustbader (National Renewable Energy Laboratory)	1-58	3.00	3.00	3.00	3.00	3.00
Integrated Vehicle Thermal Management - Combining Fluid Loops in Electric Drive Vehicles	John Rugh (National Renewable Energy Laboratory)	1-60	3.33	3.00	3.00	3.17	3.10
Codes and Standards to Support Vehicle Electrification	Ted Bohn (Argonne National Laboratory)	1-63	3.60	3.80	3.80	3.20	3.68
† Testing and Validation of Vehicle to Grid Communication Standards	Krishnan Gowri (Pacific Northwest National Laboratory)	1-66	3.33	3.00	3.00	3.00	3.08
Development of High Power Density Driveline for Vehicles	Oyelajo Ajayi (Argonne National Laboratory)	1-68	2.40	2.20	2.20	2.60	2.30
Wireless Plug-in Electric Vehicle (PEV) Charging	John Miller (Oak Ridge National Laboratory)	1-72	3.33	3.17	3.17	3.60	3.26
Advancing Plug In Hybrid Technology and Flex Fuel Application on a Chrysler Mini-Van PHEV DOE Funded Project	Abdullah Bazzi (Chrysler LLC)	1-74	3.75	3.75	3.75	3.25	3.69
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Dennis Jadin (Navistar International Corp.)	1-76	3.83	3.67	3.67	3.67	3.71
Evaluation and Adaptation of 5-Cycle Fuel Economy Testing and Calculations for HEVs and PHEVs	Henning Lohse-Busch (Argonne National Laboratory)	1-79	2.75	3.25	3.25	2.50	3.03

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Grid Interaction Tech Team, and International Smart Grid Collaboration	Keith Hardy (Argonne National Laboratory)	1-82	3.80	3.80	3.80	3.20	3.73
Optimal Energy Management of a PHEV Using Trip Information	Dominic Karbowski (Argonne National Laboratory)	1-85	2.86	2.86	2.86	2.71	2.84
Impact of Battery Management on Fuel Efficiency Validity	Eric Rask (Argonne National Laboratory)	1-89	3.20	3.40	3.40	3.00	3.30
Electric Drive Vehicle Level Control Development Under Various Thermal Conditions	Namdo Kim (Argonne National Laboratory)	1-91	2.67	2.83	2.83	2.67	2.77
Hydraulic HEV Fuel Consumption Potential	Aymeric Rousseau (Argonne National Laboratory)	1-94	3.33	2.67	2.67	2.67	2.83
The Meritor Dual Mode Hybrid Powertrain CRADA	Andreas Malikopoulos (Oak Ridge National Laboratory)	1-96	3.00	2.67	2.67	3.33	2.83
New York City Taxi Electric Vehicle Project	PT Jones (Oak Ridge National Laboratory)	1-98	3.20	3.80	3.80	3.20	3.58
Vehicle Mass and Fuel Efficiency Impact Testing	Jim Francfort (Idaho National Laboratory)	1-101	2.75	2.75	2.75	3.00	2.78
CoolCab Test and Evaluation and CoolCalc HVAC Tool Development	Jason Lustbader (National Renewable Energy Laboratory)	1-103	3.50	3.25	3.25	3.25	3.31
Mitigation of Vehicle Fast Charge Grid Impacts with Renewables and Energy Storage	Tony Markel (National Renewable Energy Laboratory)	1-105	2.67	3.00	3.00	2.67	2.88
Fuel Consumption and Cost Benefits of DOE Vehicle Technologies Program	Neeraj Shidore (Argonne National Laboratory)	1-107	3.00	3.20	3.20	3.00	3.13
Fuel Displacement & Cost Potential of CNG, LNG, and LPG Vehicles	Jason Kwon (Argonne National Laboratory)	1-109	2.33	2.50	2.50	2.67	2.48
PACCAR CRADA: Experimental Investigation in Coolant Boiling in a Half-Heated Circular Tube	Wen Yu (Argonne National Laboratory)	1-112	3.75	3.25	3.25	3.75	3.44
Integrated External Aerodynamic and Underhood Thermal Analysis for Heavy Vehicles	Tanju Sofu (Argonne National Laboratory)	1-115	3.00	2.00	2.00	3.00	2.38
A Complete Vehicle Approach to the SuperTruck Challenge	Pascal Amar (Volvo Trucks)	1-117	3.17	3.50	3.50	3.17	3.38
Improving Vehicle Fuel Efficiency Through Tire Design, Materials, and Reduced Weight	Jay Kim (Cooper Tire)	1-119	3.20	3.00	3.00	3.20	3.08
Materials Approach to Fuel Efficient Tires	Timothy Okel (PPG)	1-121	3.20	2.60	2.60	2.80	2.78
System for Automatically Maintaining Pressure in a Commercial Truck Tire	Robert Benedict (Goodyear)	1-123	3.40	2.80	2.80	3.00	2.98
Next Generation Environmentally Friendly Driving Feedback Systems Research and Development	Matthew Barth (University of California at Riverside)	1-125	3.50	3.33	3.33	3.17	3.35
Look-ahead Driver Feedback and Powertrain Management	Zwick Tang (Eaton)	1-127	3.17	3.33	3.33	2.83	3.23
† Improved Cold Temperature Thermal Modeling and Strategy Development	Forest Jehlik (Argonne National Laboratory)	1-129	3.33	2.67	2.67	3.00	2.88
† Advanced HD Engine Systems and Emissions Control Modeling and Analysis	Stuart Daw (Oak Ridge National Laboratory)	1-131	2.50	2.75	2.75	2.75	2.69

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† Electric Drive Vehicle Climate Control Load Reduction	John Rugh (National Renewable Energy Laboratory)	1-133	3.00	3.33	3.33	3.00	3.21
† Defining Real World Drive Cycles to Support APRF Technology Evaluations	Erik Rask (Argonne National Laboratory)	1-135	2.67	3.00	3.00	2.67	2.88
† Autonomous Intelligent Electric Vehicles	Andreas Malikopoulos (Oak Ridge National Laboratory)	1-137	3.33	3.00	3.00	3.00	3.08
ANSI Electric Vehicle Standards Roadmap	Jim McCabe (American National Standards Institute (ANSI))	1-139	3.67	3.33	3.33	3.00	3.38
Overall Average			3.25	3.16	3.16	3.03	3.17

† denotes poster presentations

‡ denotes ARRA funded projects

Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation: Don Karner (Electric Transportation Engineering Corp.) – arravt066

Reviewer Sample Size

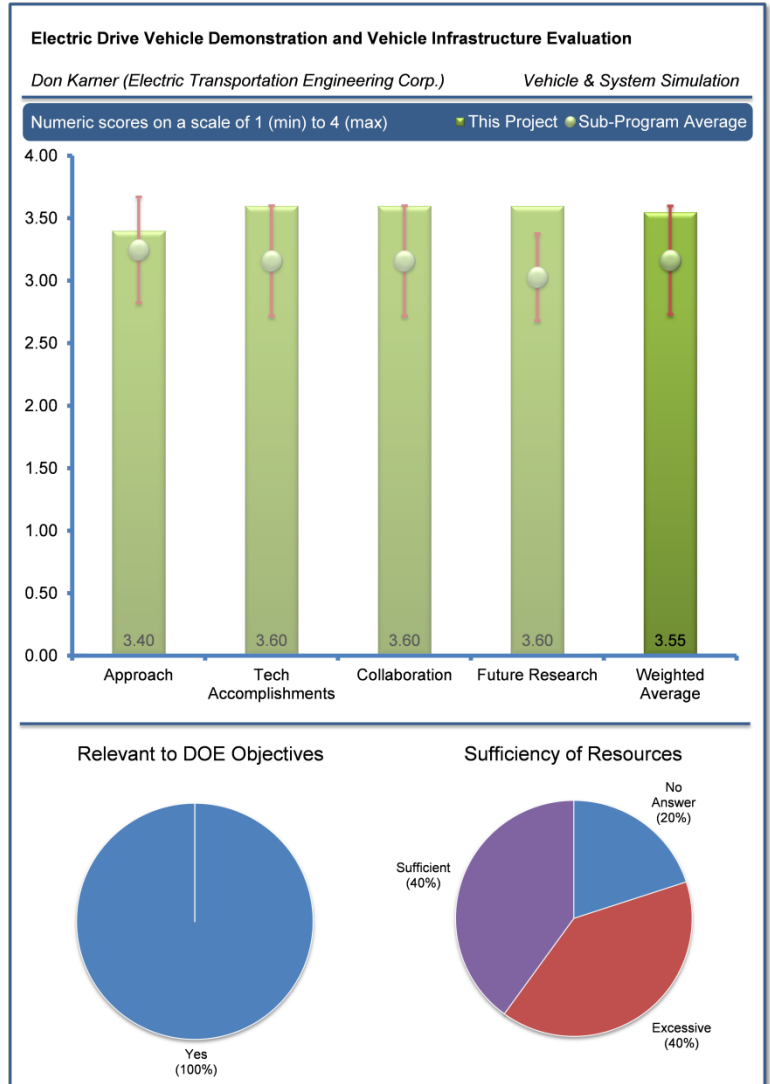
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All five panelists emphatically agreed that the project supports the Department of Energy (DOE) objectives. One panelist asserted installation and evaluation of electric vehicle (EV) charging stations is a key first step to increasing the rollout of EVs. A second panelist wrote that charging infrastructure is certainly relevant to electric vehicles and the petroleum displacement benefit they can deliver. The third panelist indicated the large rollout of electric vehicle supply equipment (EVSE) and data collection to optimize future utilization is highly relevant. A fourth panelist simply stated the installation of electric vehicle charging infrastructure supports the deployment of electric vehicles which directly replace petroleum usage with electricity for transportation. The last panelist reiterated that this project has major relevance to DOE's petroleum displacement objectives. Furthermore, the development and deployment of cost-effective electric and hybrid-electric vehicles is a critical strategic initiative that supports the overarching goal of reduced petroleum usage in the United States. The panelist asserted that while design and production of such vehicles is obviously one critical aspect, an equally important one is providing the infrastructure that will improve the viability and customer acceptance of electric vehicles. A sound support infrastructure is pivotal to promoting a significant increase in electric vehicle sales going forward. This panelist identified that the project seeks to understand and quantify the charging infrastructure requirements for electric vehicles, and includes several key activities to achieve that objective, namely development of an electric charging grid in selected areas of the country that will be the basis of the study; support of electric vehicle deployments in these areas; data collection to understand significant patterns for vehicle charging; use of collected data to refine vision for infrastructure requirements; identification and resolution of barriers to larger scale deployment, including utility and legal requirements that will govern future infrastructure development; and recommendations for larger scale infrastructure deployment.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall the panelists assured that the approach was good. One panelist complimented the efforts, noting the project team seemed to understand well the tasks, barriers, and objectives and has good focus on documenting and improving the deployment of charging stations, learning to understand critical areas. Another panelist stressed the benefits of the project scale. While the overall scale of the project being so wide seems to be a challenge in and of itself, having data from such diverse locations will be of significant value as the market develops and having the different project partners in order to get local stakeholders involved and supportive



was also a good approach stated this panelist. For this reviewer, given that one of the objectives of this project was to identify barriers, this approach is effective because many of the barriers are being identified and solutions are being defined. A third panelist called the technical approach logical and effective. This panelist shared key steps of the approach. First, facilitate deployment of 8,000+ vehicles in selected sectors. Second, deploy infrastructure in sectors, including evaluation of options for charging stations. To accomplish this, extensive work was required to select charging equipment, work through barriers including local regulations, American Disability Act (ADA) requirements, signage requirements, and energy costs. Third, collect data to establish charging patterns, driving habits, etc. This information will be subsequently utilized to develop specific recommendations for infrastructure deployment on a large scale. Idaho National Laboratory (INL) is receiving the data and preparing monthly report outs. Finally, explore smart grid integration to develop potential complete systems solutions for vehicle charging that will minimize energy cost. Another panelist remarked the lack of EVs available to market reduced the amount of data and penetration of systems indicating that it was most likely a result of optimistic market penetration assumptions. The last panelist confirmed the overall approach and integration with other stakeholders (local regulators, installers, utilities, vehicle manufacturers/dealers, etc.) was good and that gleaning information about non-network charging events from the INL data was also good. This panelist suggested additional data (such as the second-by-second speed traces between charging events) from willing participants could have been accomplished by offering one equipment discount to participants only willing to provide charging data and a higher discount to those willing to provide additional data. Another suggestion this panelist listed was that greater attention be paid to the demographics of participants and comparison of their travel patterns with the population at large to interpret the results and understanding how far they can be extrapolated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most panelists expressed that while progress was good, it was slow for various reasons. The first reviewer observed that the project team appeared to be aggressive in its approach to making progress, while the second reviewer acknowledged that progress was slow due to rollout of EVs to market. A third reviewer asserted much progress has been made to identify barriers, a stated objective, and some solutions were noted. This reviewer also commented that the overall size and scale of the project appeared to have hampered early progress which provides a valuable lesson learned on just how difficult it is to deploy infrastructure on a mass scale. The panelist asserted the lessons learned are in-themselves of value and should be considered a technical accomplishment. The evaluator noted the overall electricity usage was given and could have been correlated to a petroleum savings. Another respondent opined good progress was made on EVSE installation, data collection and dealing with regulatory issues. Additionally the project has set up a solid back bone system for collecting data from the chargers. This respondent stated the mapping application looked helpful for participants to locate a charger, but could be improved by including the location of other public chargers and specifying which chargers will give free or discounted electricity for participation in the study. The reviewer also considered progress toward the ARRA goal of job creation, noting the presentation mentioned greater than 100 new personnel and 38 certified installation contractors, but the total number of jobs created from DOE's investment in the project was not clear. The last panelist stressed the program generally followed the carefully thought out plan with the most significant issue that has delayed the program to date being the slower rate of vehicle deployment. The panelist declared this issue to be beyond the ability of this team to resolve, but stated it has somewhat affected the overall progress, and limited the amount of data collected to date. This reviewer further indicated that nevertheless, good progress has been made in terms of vehicle deployment, planning and installation of EVSE equipment, evaluation and resolution of technical and regulatory issues governing EVSE installations, and development of a network to capture vehicle data. The panelist commented that much of the vehicle and infrastructure deployment is complete and that the program will now focus on data collection and analysis. The respondent reiterated that a key deliverable from the project is development of specific detailed recommendations (based on data collected) for future infrastructure deployments.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers agreed that a good mix of stakeholders and extensive collaboration and coordination were evident in this project. One reviewer asserted it was no small task to coordinate and achieve buy-in from all key stakeholders and without this multi-point coordination; the project could not have succeeded. This panelist remarked that success on this project was highly dependent on successful collaboration with a variety of entities, including original equipment manufacturers (OEM) [General Motors

Corporation (GM)] and Nissan, whose electric vehicles made up the test fleet), utilities (approval of rates and insight into most economical charging times), state and local authorities (for approval of installations and also confirmation of ADA requirements being met), Underwriters Laboratories (UL) (for independent testing of the chargers), and finally vehicle users (data collection and home charger installations). Another reviewer acknowledged that the mix of stakeholders would provide good project data in the large scale deployment of infrastructure that will be good for lessons learned from region to region going forward. This reviewer expressed having UL on the team is a definite benefit. A third reviewer commented that collaborations included working with local regulators, private companies, utilities, trained installers (to install chargers), working with dealers and individual consumers (to involve participants), working with INL (to collect/analyze data), but did not recall the roles of Oak Ridge National Laboratory (ORNL) and two universities that were also listed. One reviewer indicated that there appears to be some common objectives and perhaps even some redundant activities between this project and another presentation (arravt071) and a lack of coordination/communication between the projects. The panelist expressed this as a potential opportunity for both projects to compare notes on approach, results achieved to date, and possible synergy that could be exploited between the two programs. The reviewer also indicated, per discussion at the 2012 Annual Merit Review, that results and conclusions from both programs will be compared and analyzed by DOE, who will look for common themes, conclusions, recommendations, etc.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The majority of the reviewers agreed future research as proposed would be beneficial. One reviewer indicated that the project's focus on documenting and understanding issues associated with charging installations gave the team a good understanding of future work requirements. The second reviewer recognized that the articulated plans for future data analysis and identification of lessons learned should be of significant value and the energy usage and lessons learned data from the diverse locations will be of value in its aggregate to support future market transformation efforts. This reviewer further suggested that close attention be paid to how driver energy usage changes in regions where significant fast chargers are installed. The third reviewer said it appeared that the results of this project can provide many answers that will accelerate acceptance of electric and hybrid vehicles although the project is reported to be approximately at the halfway point. This person noted a key output of the data is to evaluate electricity demand for vehicle charging vs. available capacity at utilities. The respondent indicated that guidelines for when to charge, or development of strategies for automatically charging only when overall grid demand is low, are some of the concepts being explored. This reviewer commented that with the vehicle and infrastructure deployments reaching completion, emphasis now shifts to data collection and analysis. The respondent remarked that results will be used to generate a detailed set of recommendations for future infrastructure deployments, vehicle charging strategies, and development of business models for the EVSE charging infrastructure. A fourth reviewer stated that little detail was given on how the future work would help to overcome the challenge of making the business case for non-home charger installation. This reviewer also articulated planned future activities include observing user response to introduction of EVSE access fees, partnering with utilities to evaluate demand response, and summarizing lessons learned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reaction to this question was mixed. The first two reviewers said that the resources were sufficient. One stated that it appears that human resources and funding were adequate. This reviewer noted that over 100 new personnel had been hired to manage and implement the program. The respondent indicated that at \$219 million, the project budget would seem to be well suited to support key program objectives. This individual also re-stated that one of the most significant impediments was the slower than anticipated deployment of electric vehicles, which has limited the amount of data collected so far. Because the program runs until September 2013, this reviewer asserted that there should be sufficient time and vehicle miles to gather data that will yield meaningful conclusions. Two other reviewers concluded that the resources were excessive. One person acknowledged that this is difficult to judge from a 20-minute presentation, however the scope of this activity seems greater than the Coulomb ARRA project, but perhaps not nearly 10 times greater as the budget would suggest. Another reviewer suggested that infrastructure could easily outpace the market for EVs.

Advancing Transportation Through Vehicle Electrification – PHEV: Abdullah Bazzi (Chrysler LLC) – arravt067

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three panelists agreed the project has the potential to reduce petroleum use. One panelist asserted that the effort significantly improves fuel economy during road operation and the supplemental energy when vehicle is stopped eliminates the need for idle. The second panelist remarked the project develops an advanced electric vehicle that uses grid power to provide 20 miles of driving range. The same reviewer noted that the project’s capability goal to provide auxiliary power from battery storage (energy stored from the grid) has the potential to reduce petroleum use by portable generators. Another panelist commented that utilization of grid power for pickup trucks certainly would displace a considerable quantity of petroleum, but the researchers did not provide a baseline fuel economy for the vehicle so that this could be demonstrated.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewers’ comments on the approach were mixed.

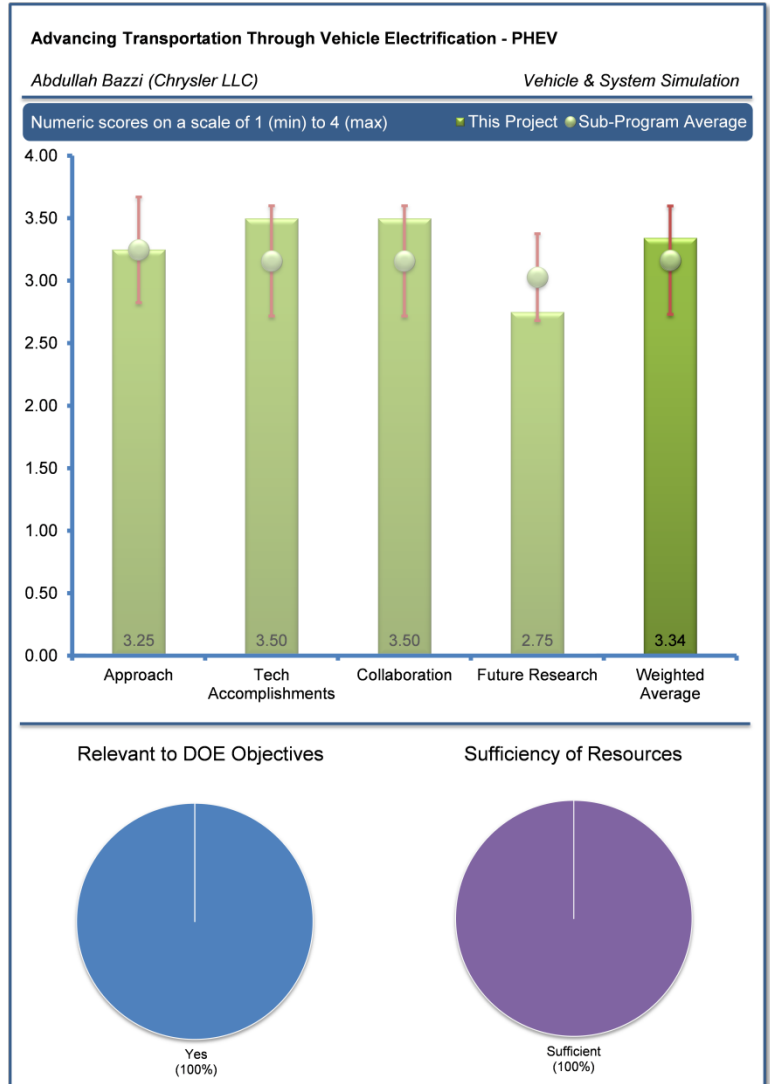
One reviewer stated the technical aspects of vehicle design and testing were all fine and praised the data collection and analysis part of the project that will enable accurate assessment of the types of uses and locations that make the most sense for plug-in hybrid-electric vehicles (PHEV) pickup trucks. Another reviewer recounted that the summary indicated that only 20 fleet vehicles were deployed in 2011 but the work plan indicated that more than 200 should have been deployed, thus their plan and results diverge significantly. The reviewer however noted that the reality of their approach seems superior to their earlier plans.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall the experts concluded that the work was on track. One expert affirmed the project has demonstrated an over-achievement in reaching fuel economy improvement for the vehicle. Another expert acknowledged less difficult barriers here than for less futuristic projects.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The evaluators have differing opinions on the level of collaboration. One evaluator recognized the project has involved a number of partners for evaluation and different use cases. Another evaluator stated that a large preponderance of the demonstration partners seem to be utilities. This person noted it would be interesting to add other types of users – lumber yards, general contractors, and individuals who use pickup trucks.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panelist commented that the project looks like it will continue to proceed as planned and that the original plan must have been acceptable to give the project that much money. Another panelist commented that the progression of the research steps makes sense and the reality of limited deployment numbers seems to make more sense than the large numbers shown in the plan. This panelist suggested that the future research plan should focus on validating and evolving advances on a small number of vehicles followed by a stair step increase in deployed vehicles that demonstrate the evolving technology improvements. The panelist stated this will help the project to conserve resources and focus on making technology improvements that will improve the chances of success for the operation of the larger numbers of fleet deployments. A third panelist expressed that a technology demonstration will end up influencing product decisions and investments in company's capabilities in these technological areas. The last panelist articulated that the presentation did not speak to the application of lessons learnt and how these may or may not be applied. This panelist suggested smart grid may be a worthwhile initiative.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers expressed that resources were sufficient for the project. One reviewer asserted that reasonable levels were established for resource needs. Another reviewer commented the project seems to have more than any other and it looks like it is at least enough.

Advanced Vehicle Electrification: Darren Gosbee (Navistar, Inc.) – arravt069

Reviewer Sample Size

This project was reviewed by six reviewers.

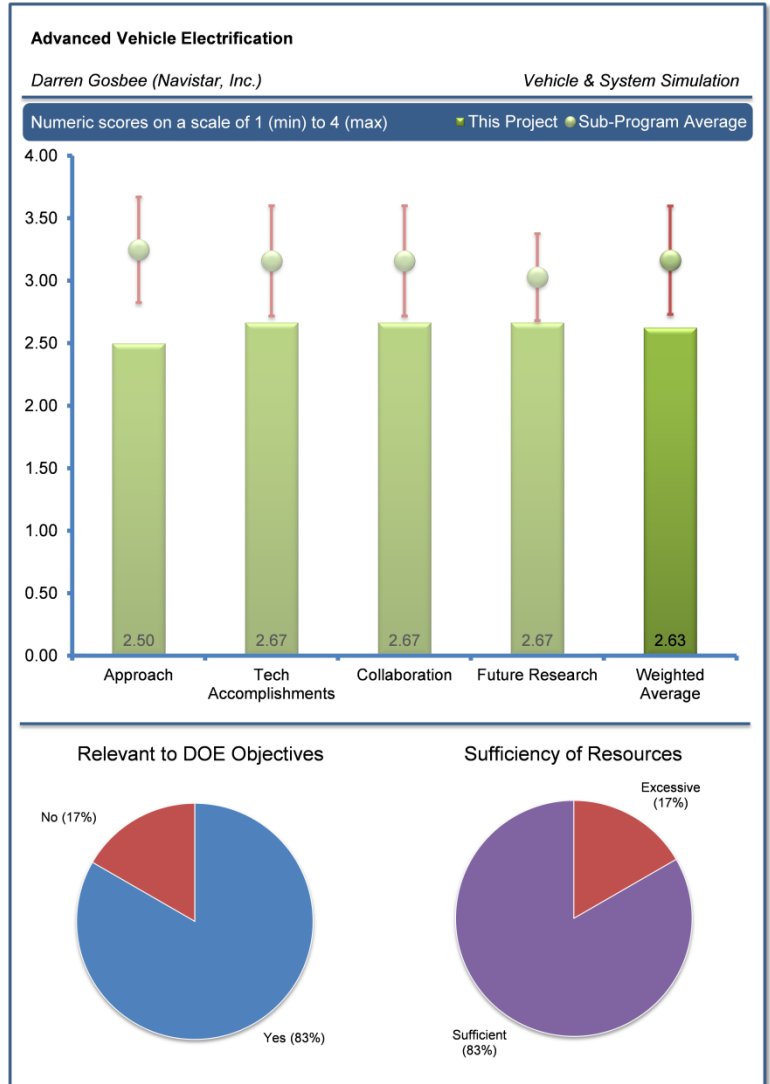
Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers concurred that the project had the ability to displace some petroleum use. One panelist stated the project has the potential to allow grid power to displace energy from petroleum for medium-duty (MD) vehicles. Another panelist asserted that it reduces fuel (oil) consumption through use of battery-electric propulsion power exclusively. A third panelist opined that electrification of medium-duty commercial trucks will certainly help displace petroleum use, though the displacement potential of limited-range all-electric vehicles (AEVs) will be limited by the relatively low driving miles of the conventionally-powered trucks that they replace. For this reason, the panelist continues, the ability to avoid pollutant emissions in dense urban areas may need to be an additional rationale considered. Another panelist commented that obviously replacing petroleum-fueled vehicles with EVs saves petroleum. But whether the amount is significant or not depends on what type vehicles and how they are used; however, the only clue is the purported saving of 1,250 gallons per year, the panelist indicated. This person considered that MD trucks are a low volume/ miles application with limited savings potential. Further, the panelist mentioned

if it is light-duty (LD) vehicles, it could be much better but the slides were confusing on that score. The final panelist articulated that the original premise of the project appears to have altered. This panelist stated that originally the project was focused on the deployment of the Modec/eStar vehicle, however the focus now appears to have been transferred to the development of a Generation 2 (GEN2) platform based on an existing stripped chassis format. The panelist noted that although not expressly stated it appears the production of the eStar is being halted.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers agreed that the approach was addressed at a high level. One expert stated that the project demonstrated excellent learning on utilizing an existing platform and developing for markets as markets mature. Another expert asserted that this was a high level presentation and not much detail was shared. A third expert recounted that the approach included efforts to transfer/adapt technology from a foreign platform to the U.S. market, and to subsequently develop a next generation vehicle. The expert continues that the apparent limitations of the foreign platform suggest that GEN2 development activities should have been moved earlier in the five-year project plan. This expert states that little also appears in the approach on data collection/utilization, which seems like a missed opportunity. Another expert shared a similar sentiment, expressing that the approach does not reflect sufficient risk mitigation strategies at decision points. This expert commented that the presentation of the work plan is low resolution and the high level results presented indicate a significant need for risk mitigation strategies. The fifth expert articulated



that the project goals appear to have altered. The final expert found it very difficult to evaluate this project because so little technical detail and so few numbers are included. This expert explained that their ratings will be lower because information is missing and the reviewer cannot rate non-information as high as information. The work may all be excellent, but the reviewer could not tell that from the presentation. This person would have liked to see a lot more detail on what the project team expects to learn from the data collection, which it is the most valuable part of the project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first evaluator stated the project seems to have accomplished what it set out to do in a reasonably competent manner. The second evaluator remarked the project demonstrated adaptability to market forces, ensuring progress toward greater acceptance. A third evaluator commented that the lack of market acceptance indicates that overcoming barriers has been slow. Another evaluator articulated that the listed accomplishments include platform, battery and charger improvements to the Generation 1 vehicle and progress on assembling the development team and designing the GEN2 vehicle. This evaluator however noted that a number of the accomplishments seem to be carried over from the 2011 presentation, so it is unclear how much has been achieved since then. The evaluator asserted little technical detail was provided in the presentation. The last evaluator remarked that technically the production of eStar has been established and significant technical barriers overcome; however a comprehensive misunderstanding of customer requirements has led to a wholesale change in the project trajectory. This evaluator expressed concern about how the voice of the customer was managed in context of the technical development and what has been learnt that will prevent the same mistakes happening again with the GEN2 development.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One panelist acknowledged that the project team has developed industry relationships at all levels through being a founding member of electric vehicle organization. Another panelist mentioned the project listed collaborators including National Renewable Energy Laboratory (NREL) for data collection, supplier partners and customers. This panelist however also stated that few details are provided and these collaborations have no doubt been limited by the limited number of vehicles delivered to date. A third panelist would expect any truck project to have on board somebody who worried about tires, etc. The panelist stated this collaboration seemed a bit thin however considered that maybe there is more than this rather generic presentation mentioned. The final panelist asserted that no collaboration has been established with universities or other skills-based learning organizations, and no collaborations have been established with other DOE funded projects.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter expressed that future tasks follow plan as set out originally. Another affirmed that focus was on future products and key technical barriers in gearbox development. A third commenter said the main focus of future work was to be development and continued cost improvement of the GEN2 product. This reviewer asserted this seems prudent given the limited success of the Generation 1 vehicle thus far. Additionally the reviewer commented that the proposal to pursue General Services Administration (GSA) certification seems like a good approach to boost sales. This reviewer also alerted that little was said about how and if the 950 vehicle deployment target would still be met before the end of the project. The fourth reviewer informed that there is a scarcity of evidence and detail that the planned work will overcome the barriers. The final reviewer expressed concern about how the future research would lead to improved adoption of the product or overcome the barriers that exist for the adoption of the eStar or other platforms that will be developed from the core technology.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Five reviewers stated the funds were sufficient. One reviewer asserted there is large number of vehicles to be deployed, justifying the high cost. Another reviewer admitted it was a little difficult to judge. The reviewer noted the project was listed as 44% complete, but less than 20% of the planned DOE funds have been used. The reviewer pondered that perhaps the total budget is being reduced from the original plan of \$39 million from DOE plus \$39 million from Navistar. If that was the case the reviewer expressed this might be reasonable given the relatively slow pace of vehicle deliveries thus far. One reviewer expressed the funds

were excessive. The reviewer articulated that the lack of evidence of a structured plan to overcome the barriers and the stated progress of goal achievement suggest that the resource allocation timeline may need to be restructured significantly.

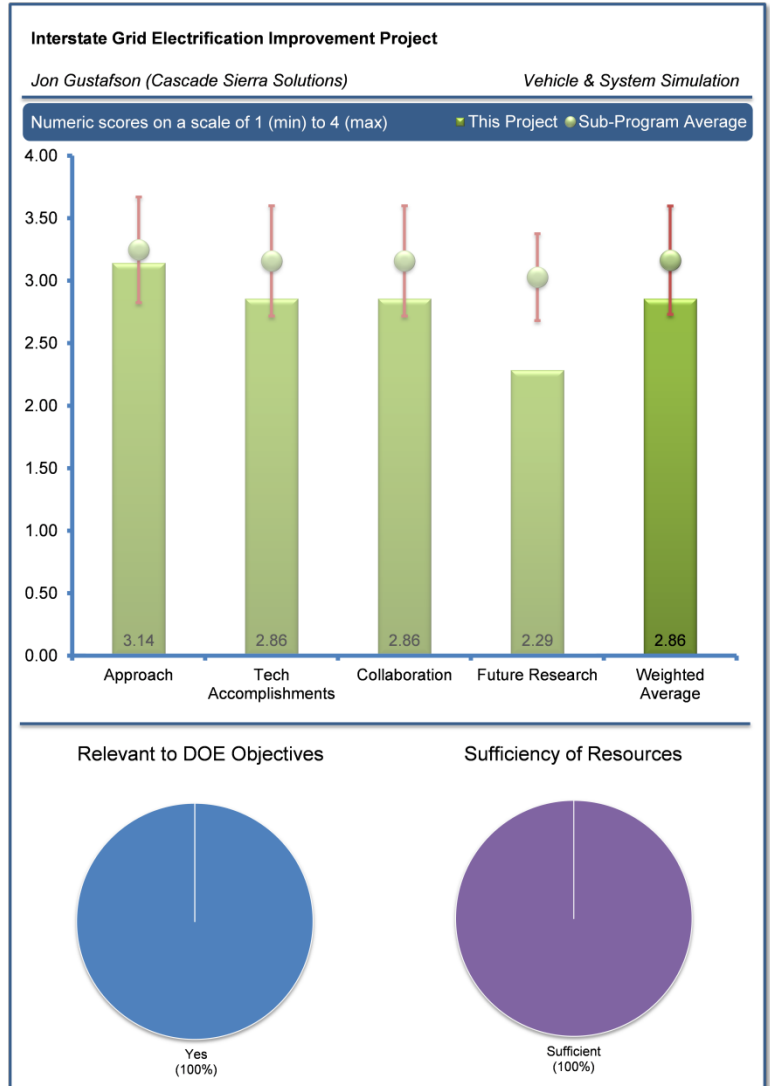
Interstate Grid Electrification Improvement Project: Jon Gustafson (Cascade Sierra Solutions) – arravt070

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most experts agreed that the project would reduce petroleum use. The first expert said the goal was to save eight million gallons of petroleum per year. The second expert expressed that fuel consumption during idle is one of the key problems and that the program can help reduce the fuel consumption if the goal can be achieved. Another expert recognized that successful implementation of this project will enable thousands of truckers to remain comfortable when they sleep in their cabs, without burning any petroleum. A fourth expert asserted truck idle reduction through electrification is a direct replacement of petroleum with electricity in maintaining cab conditioning and refrigeration on trailer refrigeration units (TRUs). Another expert acknowledged that through truck stop electrification, over the road truck idle fuel usage can be substantially reduced. This expert remarked the target of eight million gallons annually by 2014 sounded aggressive, but to truly assess, there is a need to understand the percentage uptake of available operators to this technology to know if this is an acceptable target. The final expert commented that even though this project on truck stop electrification (via shore power) will reduce idling and thus displace petroleum, it should have been incumbent upon the author to show in the presentation how much petroleum would be displaced and how much emissions avoided on a per truck basis, and second, how much of the ARRA and DOE Vehicle Technologies Program (VTP) goals that this particular project hopes to achieve. This expert had an additional comment about the title of the presentation being somewhat misleading in that the expert thought it was about the transmission of electricity through the power grid across state lines and for clarification. The same reviewer further stated that the author should have clarified by using interstate highway.



even though this project on truck stop electrification (via shore power) will reduce idling and thus displace petroleum, it should have been incumbent upon the author to show in the presentation how much petroleum would be displaced and how much emissions avoided on a per truck basis, and second, how much of the ARRA and DOE Vehicle Technologies Program (VTP) goals that this particular project hopes to achieve. This expert had an additional comment about the title of the presentation being somewhat misleading in that the expert thought it was about the transmission of electricity through the power grid across state lines and for clarification. The same reviewer further stated that the author should have clarified by using interstate highway.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked that it was a good approach to work on developing infrastructure and rebates for onboard idle reduction equipment, as well as good objective to deploy by end of 2012 and then initiate monitoring, with a final year of analysis. Additionally this person expressed it was a good approach to use seven different onboard idle reduction technologies. A second reviewer stated working on electrification with both the trucks and the truck stops is a good approach, as the presenter identified it as working on both the supply and demand sides. The reviewer affirmed this effectively tries to address the chicken or the egg barrier that exists in most transportation electrification endeavors. Further, this reviewer articulated that likewise concentrating on dedicated champions to use and support the technologies is a good approach since these individuals have a vested interest in making the technology and market transformation a success. In this reviewer’s opinion, past experience at siting electrification

projects where property owners do not support the technology has shown how it can become quickly abandoned and used as a justification to label a project a failure. The reviewer emphatically agreed that concentrating on champions that will support the technology provides the best value to transform the market and provide a better return on public funding. Another reviewer commented that one reason why electrified parking spaces have enjoyed limited success has been the lack of adequate coverage along major trucking routes. Therefore, this reviewer asserts, drivers needed to have on-board equipment to ensure they could stay comfortable overnight. The reviewer then concludes that one reason why simple plug-in technology was underutilized is that only trucks with electrical equipment on-board could use them and thus by creating a network of coverage on truck routes and also creating a user base, this project aims to provide both the chicken and the egg simultaneously. The reviewer also remarked that data collected will allow us to determine what works and what does not, and why. The fourth reviewer expressed that the truck stop electrification and rebates/incentives assists the availability aspect, however getting the trucks to have the enabling technologies may be the more important barrier. This reviewer questions what opportunity is there to identify high idle operators and provide needed information to them, and gather from them to properly build out network to meet their needs – thus having largest idle reduction impact. Additionally, the reviewer stated that site location is critical and truckers with investment in idle reduction technologies need to utilize this equipment at every stop.

The final reviewer questioned the motivation and strategy to idle reduction, and felt that it appeared the author was more interested in an approach that flaunts numbers. The reviewer added that if DOE wants idle reduction to work, it needs to nudge this author into putting the resources (truck stop electrification by providing shore power) at the most effective locations. Based on the reviewer's expertise, the reviewer stated that the most effective locations for reducing idling, and thus, displacing petroleum use, is at truck stops where the truckers have to make a rest stop because their hours of service have run out. The reviewer noted that the author did not seem to understand that the U.S. Department of Transportation (DOT) has rules for how long a truck driver can be on the road. For reference the reviewer stated that rest stops usually require a long period of rest – eight hours, thus, eight hours of idling can be avoided. Instead of maximizing the total amount of idle reduction, the author sought to maximize the number of truck stops to be electrified even if the trucker is at the truck stop for only five minutes. The reviewer suggested that the author should have been required to submit a plan of what truck stops should be electrified for review and approval before being allowed to proceed. Another point this reviewer made is that there is nothing in the project that touches on the issue of standardizing shore power and accommodating different levels of shore power. The reviewer acknowledged that the question had to be asked before the issue was recognized. Additionally, the reviewer remarked that without some standardization or knowledge of the frequency of the different types of shore power connections and power for hotel loads on a truck, this project will not succeed. Another point made by this reviewer is that there is nothing in the project about collecting financial data from the truckers or the truck stops. Based on truck safety projects associated with on-board collision avoidance systems, the reviewer strongly emphasized that truckers will not buy such a system (e.g., lane departure warning system) no matter how much data you have on how effective the system is in preventing a crash unless you can demonstrate a short-term return on investment with real-world data from other truckers. The similar situation applies to truck stop owner/operators. If the author does not collect and analyze such data, this reviewer asserted that there is no chance of this project succeeding on a self-sustaining basis – no one can ever be convinced that truck stop electrification via shore power is a worthwhile investment. The final point this reviewer makes is that there is nothing in the project about collecting data on the actual amount of idle reduction. This reviewer would like to know without collecting such data, how one measures this particular project's success. The reviewer inquired whether the measure of success is the number of truck stops electrified with shorepower, or is it the total amount of idle reduction, and hence, the total amount of petroleum displaced.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer asserted that the accomplishments seem reasonable for the amount of time spent to-date. This reviewer expressed that the trucking industry has seen several competing concepts go by the wayside so recruiting participants in this program would be tough, thus, getting the participant identified and getting 3,500 trucks identified is good progress. Another reviewer remarked that the project appears to be progressing at a sufficient pace, all 50 sites are either completed or under construction, and 3,500 of 5,000 trucks are selected. The third reviewer expressed sites are up and running, and equipment is on trucks, however now the reviewer wants to see the data. A fourth reviewer indicated that this is a good program to provide the grid

connection, however not significantly technically advanced. This reviewer suggested that as the project tracks the usage and estimates fuel use in future years the project team should investigate ways to improve use of facilities. The next reviewer articulated it was not clear how the trucks with the equipment that can utilize the grid were coordinated with this program. The reviewer expressed that it is all about the installation of the grid stations. The sixth reviewer asserted not much progress (5%) to date and there was much to do to meet deadlines. The last reviewer noted there are only two objectives given for this project: electrification (via shore power) at 50 truck stops along interstate highways, and processing of 20% rebates on battery-operated and/or shore power idle reduction equipment on 5,000 trucks. The project commenced May 2011 and will end in May 2014. By this reviewer's estimation the project should be one-third of the way through the three-year project period, while Slide 2 noted that the project is 60% complete and the slide titled Project Status notes that only nine sites are complete with 31 under construction. This reviewer also recalled there is no mention of any rebates having been processed. In this reviewer's opinion, there is no way that the project can be 60% completed and for there to have been 60% completion, 31 sites would have had to be completed (instead of being under construction). The reviewer asserts that the information provided is misleading (or contradictory) about progress and the author should have provided a schedule of milestones.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first evaluator affirmed the industrial partners are especially strong on the equipment manufacturer side and the quad chart suggests truck stop and truck manufacturer partners as well, but these do not show on the partner logo slide. The second evaluator proclaimed that the partnering chart showing all the different entities building hardware and getting the industry associations to support this project was outstanding. Furthermore, the evaluator articulated the industry has come a long in a short period of time and it was good to see a majority of the supply side companies there. This evaluator noticed there was not a list of some of the specific trucking companies that are participating in the program. In this evaluator's estimation to see some major carriers such as Swift, Schneider involved in the program would have brought this project up to outstanding. The third evaluator confirmed there was good collaboration with industry and universities per the slide that lists prospective alliances; however, it is not clear how many of these alliances came to fruition. Another evaluator stated tracking usage of the project partners is important, but the progress in build the improvements and gathering use partners appears to be on track. One evaluator indicated this area requires more information, and specifically, how the collaboration works with other partners. The evaluator expressed that listing all partners without some details would not help too much. The last evaluator declared no attempt was made to partner with any state DOTs or State highway agencies and no explanation was given as to why state DOTs or State highway agencies were excluded. The evaluator noted that on the other hand, there was a plethora of private partners, but it is difficult to tell which ones are truck stop owner/operators.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first panelist strongly articulated the project is right on track with the excellent plan that won them the award. Another panelist stated the objective of monitoring and collecting data for one year and analyzing and acting on the results for a second year is good; however, the panelist noted the details are not known. A third panelist expressed the aspect with regards to truck stop electrification is critical since past use of improved sites had infrequent use. This panelist remarked that going forward learning how to increase use through both through truck side and site side improvements will be critical to success. The next panelist did not recall seeing a chart on future research. This panelist indicated that the presenter articulated a future analysis of the usage data but this would have been good to see in a chart, and could have answered a question another panelist brought up regarding peak energy usage. This panelist expressed that having an analysis plan to guide this project would have been beneficial and showing some additional market transformation planning would have also been welcome. The fifth panelist also articulated no future research was mentioned. This panelist postulated that it seems that the project just needs to install the station and ask the trucks to use the facilities. The last panelist asserted that without changing the approach as noted in Section 2, Approach, it is not possible to see how this project can advance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All seven panelists agreed that resources for the project are sufficient. One panelist said the project seemed to be on track schedule wise and the presenter did not indicate that there were any funding or scope issues, which tends to show good scoping of the project versus having to adjust scope as the project goes along. Another panelist articulated that it appears funding level is appropriate, but there are no details for funding breakdowns. The last panelist commented this is a pretty tight budget given that the researchers are trying to achieve a successful demonstration with \$22 million from DOE for economical deployment of a system similar to one that failed commercially and lost well over \$300 million. The panelist affirmed that this was a pretty neat trick that might work because the project was thought through intelligently.

Advanced Vehicle Electrification and Transportation Sector Electrification: Greg Cesiel (General Motors) – arravt071

Reviewer Sample Size

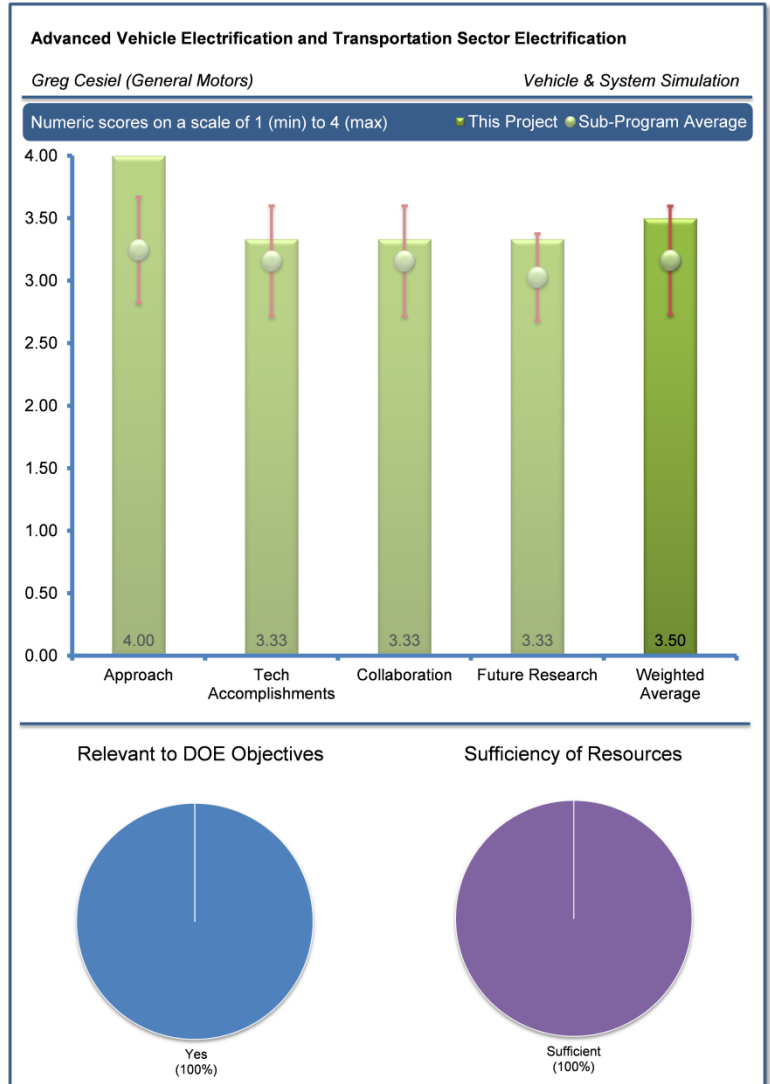
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first expert asserted that this project is highly significant to national efforts to reduce dependency on petroleum. Further the development and deployment of cost-effective electric- and hybrid-electric vehicles is a critical strategic initiative that supports the overarching goal of reduced petroleum usage in the United States. The expert continued that this initiative has two critical but equally important work streams: design, development, and production of electric and hybrid vehicles; and establishing a charging infrastructure that will make usage of such vehicles easier while improving the overall viability of vehicle electrification. The expert shared that the development of the Chevrolet Volt was conducted largely at private expense, and is not within the scope of this program but rather this project is focused on deployment of these vehicles in several geographical locations, creation of a charging infrastructure/microcosm (both privately owned and public access), and data acquisition of the vehicle to better understand usage patterns, duty cycles, and charging schedules. The expert indicated the resulting data analysis will help the OEM refine/improve the vehicle, better define the specific needs of a charging infrastructure, and provide insight as to how these vehicles can be operated most efficiently. Another expert stated it was a large-scale demonstration of a series-electric hybrid vehicle and that it was too bad it could not have been even bigger.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer expressed the project appears well organized and focused on the primary objective. The next reviewer similarly stated the approach was fundamentally sound. Additionally the reviewer indicated the basic elements of the project were: launching the Chevrolet Volt and subsequent deployment to several key markets that will serve as the basis for the study; utilizing the capabilities of GM's OnStar system to gather data and send to INL for consolidation, analysis, and report out; working with utilities and vehicle owners to facilitate installation of charging stations, which addresses one of the two main barriers identified; and a final report, including analysis of all data collected and specific recommendations for vehicle re-design opportunities, future battery requirements/ enhancements, and infrastructure requirements once electric vehicle penetration increases. The reviewer added that since this project involved only one vehicle type (Chevrolet Volt), it must be understood that conclusions drawn regarding driving habits and charging needs are specific to this type of "range extender" electric vehicle. Further the reviewer suggested that if other vehicles had been included in the program (Nissan Leaf), there may be some different conclusions drawn.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The project evaluator expressed that in general, good progress has been made, and project seems to be on track to achieve most objectives by the completion of the program in 2013. This person identified the following technical accomplishments: key vehicle components and subcomponents validated (assuming this was completed as part of the original vehicle launch, and not as part of this program); all Federal Motor Vehicle Safety Standards (FMVSS) and compliance testing completed (again, assuming this was accomplished prior to production launch of the vehicle); connectivity with smartphones developed, allowing 24/7 access; and efficiency gages and green leaf screens developed to provide driver with feedback concerning operating efficiency. The evaluator also noted completions not specifically listed under technical accomplishments but achieved so far are: electric charging stations being installed by utilities (for public charging venues) and by vehicle owners; and data collection beginning in the Fall of 2010, being sent to INL for summary and analysis, and issuing of monthly reports.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that GM's partners/collaborators for this program are: DOE and the Electric Power Research Institute (EPRI), which is seeking involvement of other utilities and also providing information that will be helpful in setting up other technology demonstrations (fast charging, smart charging and battery to grid); nine utilities in various parts of the country, primarily dealing with installation of charging stations; INL, which is receiving data and creating monthly summaries of vehicle usage and charging; and North Carolina State University that is evaluating charging infrastructure requirements and issues for a parking lot/parking garage. The reviewer indicated that there appears to be some common objectives and perhaps even some redundant activities between this project and another presentation (ARRAVT066) and a lack of coordination/communication between the projects. The panelist expressed this as a potential opportunity for both projects would be to compare notes on approach, results achieved to date, and possible synergy that could be exploited between the two programs. The reviewer also indicated, per discussion at the 2012 Annual Merit Review, that results and conclusions from both programs will be compared and analyzed by DOE, who will look for common themes, conclusions, recommendations, etc. Another reviewer commented that it would have been interesting to learn more of how GM is coordinating with the other projects developing charging infrastructure, two of which list GM as a partner.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first expert stated the future plans include: continuation of data collection through the third quarter of 2013; additional charging station installations; continued investigation of fast charging, smart charging, and secondary use of batteries (grid storage, etc.); and assumed, but not specifically stated, is a final report that will draw conclusions on vehicle duty cycles, driving habits, charging schedules, and findings on special projects (fast and smart charging, secondary battery use). The expert commented that there is not as much substance in this report out as desired. To support this opinion the expert shared questions that were not addressed. Specifically, the reviewer would like to know how many more charging stations will be installed. The reviewer would like to know whether other areas will be selected for participation and data collection. Finally, the reviewer inquired about how many total Chevrolet Volts will ultimately be included in the data collection program. While this last question may be dependent upon future Chevrolet Volt sales, the expert expressed it would seem that there should be some type of target quantity. The expert found the special projects particularly interesting, but it is a little unclear whether or not this project team has the lead in the activities. The reviewer asserted that the use of OnStar to communicate with grid and determine the best time for charging should result in smoothing out power demand requirements and also help the vehicle owner save money. This person assumed that GM is taking the lead on this. Additionally the expert indicated that fast charging development initiatives seem to be ongoing independent of this project, but GM and the rest of the team are providing input on vehicle integration and standardization. Another reviewer did not catch whether the fast-charging piece was a part of this project or something presented as incidental, nice-to-know. Further, given that the Chevrolet Volt is a series hybrid with an internal combustion engine, this person was not clear on how the fast charging station fits prominently into this work, unless GM will be introducing a battery electric-vehicle (BEV), but noted that was not mentioned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All panelists agreed resources were sufficient for this project. One panelist noted that there is no indication of projected shortfalls in either category and assumed that both funding and human resources are adequate for completion of project, although the spending to date was not provided. This panelist expressed the only question mark may be whether enough vehicles will be deployed to obtain the desired sample size for the data collection and analysis as this was not specifically addressed in the presentation.

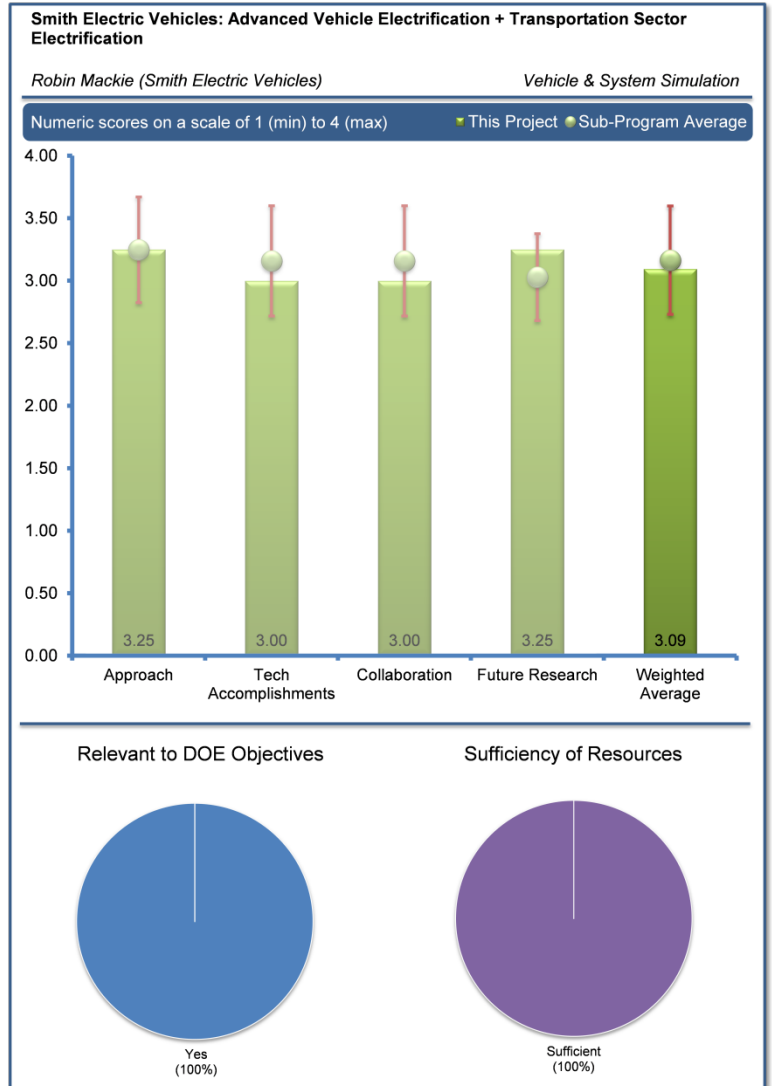
Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification: Robin Mackie (Smith Electric Vehicles) – arravt072

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first evaluator indicated that medium-duty vehicle development is directly applicable to displacing petroleum fueled vehicles. The next evaluator agreed electrification of medium-duty commercial trucks will certainly help displace petroleum use, though the displacement potential of limited-range all-electric vehicles (AEV) will be limited by the relatively low driving miles of the conventionally-powered trucks that they replace. For this reason, the evaluator stated the ability to avoid pollutant emissions in dense urban areas may need to be an additional rationale considered. The last reviewer expressed some reservations that the total distance driven by each of these trucks is only 30 miles per day, so the savings are at least an order of magnitude smaller per truck than for the Class 8 projects. While there is some petroleum displacement, this reviewer stated the real justification for MD electrification is air pollution and noise in cities which are not addressed. Additionally, the reviewer had an issue with the carbon calculation, which looks like it has a factor of ten lost (or else something was not well labeled).



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the small company was demonstrating very effective use of its limited resources to support this deployment program. Another panelist stated the project approach included leveraging United Kingdom (UK) development experience, which is a good strategy to quickly start U.S. customer deliveries. The panelist recounted that AEV buyers are slated to receive 92% of the ARRA grant funds in exchange for providing data on the vehicles' operation. This person noted the payment amounts to about one-third the cost of the vehicle, which seems like an effective way to increase sales. Additionally, the panelist commented that corresponding benefits include greater opportunity for learning from the product delivery and customer use experience, and the creation of associated jobs. This panelist asserted that the balance of the ARRA funds appear allocated to vehicle modification/certifications required by U.S. customers and regulators, as well as to development of the next generation components/systems. The panelist indicated it was good to see Smith's approach includes providing about three-fourth of the support for these activities out of its own cost-share funds. The third panelist articulated that the two main parts of this project are vehicle deployment and development of a very cool system for collecting and analyzing data and that this data will be particularly useful for identifying the most productive types of uses for such vehicles. This panelist further stated, the biggest barrier that Smith faces is battery cost, which is not in their arena thus the researchers must either wait and hope that battery prices will drop, or

possibly consider using cheaper batteries, like nickel metal hydride (NiMH), for applications where additional mass is not a major drawback. The last panelist commented the system itself seems well-designed and sound. However that mileage of the vehicles is low and therefore it does not make much economic sense for the market with regards to electrification.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers expressed satisfaction with the technical accomplishments. The first reviewer articulated it was good to see that the project is well on its way to not only meeting but exceeding its vehicle deployment target. This reviewer expressed that the large amount of data collected, over 1.8 million miles of driving, will benefit customers as well as other DOE projects. Further, this person remarked positive progress seems to have been made in development of the next generation drive and battery pack, as well as in improved understanding of how to better meet customer needs (such as by offering multiple battery sizes). The reviewer stated that one opportunity for improvement would be to more clearly chart out the eventual business case for customers as grant funds and other purchase incentives start phasing out. Another reviewer asserted that Smith is doing a fine job of getting the vehicles on the road and collecting data to assess performance. While performance improvements are not discussed in detail, this reviewer commented performance improvements also seem to be going well. The last reviewer affirmed there was good progress to deploy and study vehicles but significant challenges still exist with cost and range.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first panelist stated major collaboration is with vehicle customers. The panelist shared that some issues exist and that potential improvement is possible in vehicle turnover to operators to achieve optimal vehicle performance. The second panelist remarked that collaboration seems good with NREL, and several university collaborators that were listed in the presentation, though time constraints limited the amount of details that could be provided on those efforts. The last panelist expressed that little information was provided, but the collaborations seemed adequate.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first evaluator stated that continued deployment and study of operation is planned. Additionally this evaluator expressed a focus should be placed on lessons learned from data. The next evaluator indicated that very little detail is provided although the project seems to be following the proposed path nicely and the researchers will keep doing as planned. The last commenter articulated that the future work plans include data transfer improvements for the monitored vehicles, implementation of prognostic problem detection from the data, and further development/launch of the improved battery and drive systems. Given the vehicle deployment success thus far, this reviewer shared that perhaps the ARRA funding could be stretched further by reducing the per-vehicle payment for data collection. The reviewer indicated that improvements to the Generation II vehicle design may start reducing the amount needed for this payment (which effectively serves as a buy-down incentive) and could in turn increase the total number of vehicles deployed through the project (by spreading the funds over an even greater number of trucks).

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All panelists agreed that resources for this project were sufficient. The first panelist expressed that while a small organization, Smith USA has done a good job of resourcing the project and covering all aspects of a vehicle rollout. The next panelist asserted that Smith's significant cost-sharing seems like it is helping the funds go farther than they would otherwise. This panelist remarked that it is also good that cost savings has enabled expansion of the vehicle deployment target. Perhaps reducing or beginning to phase out the data collection/purchase incentive payment could help expand the deployment even further. The last panelist noted that the fact that vehicle buyers need such large incentives verifies the small savings potential due to low miles driven and that the basic economic case for electrifying such trucks is weak.

Electric Drive Vehicle Infrastructure Deployment: Kumar Gogineni (Coulomb) – arravt073

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One panelist articulated that understanding the installation of EV charging stations and their acceptance has enormous potential impacts for how EVs can be introduced.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One panelist stated that the overall approach and the project appear sound and on track although this person found the presenter difficult to understand because the presenter spoke very quickly. With only a PowerPoint and the presenter’s voice to go by, the panelist indicated it made assessing the project more difficult.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panelist affirmed that installations are almost complete and the project appears to be well on schedule.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

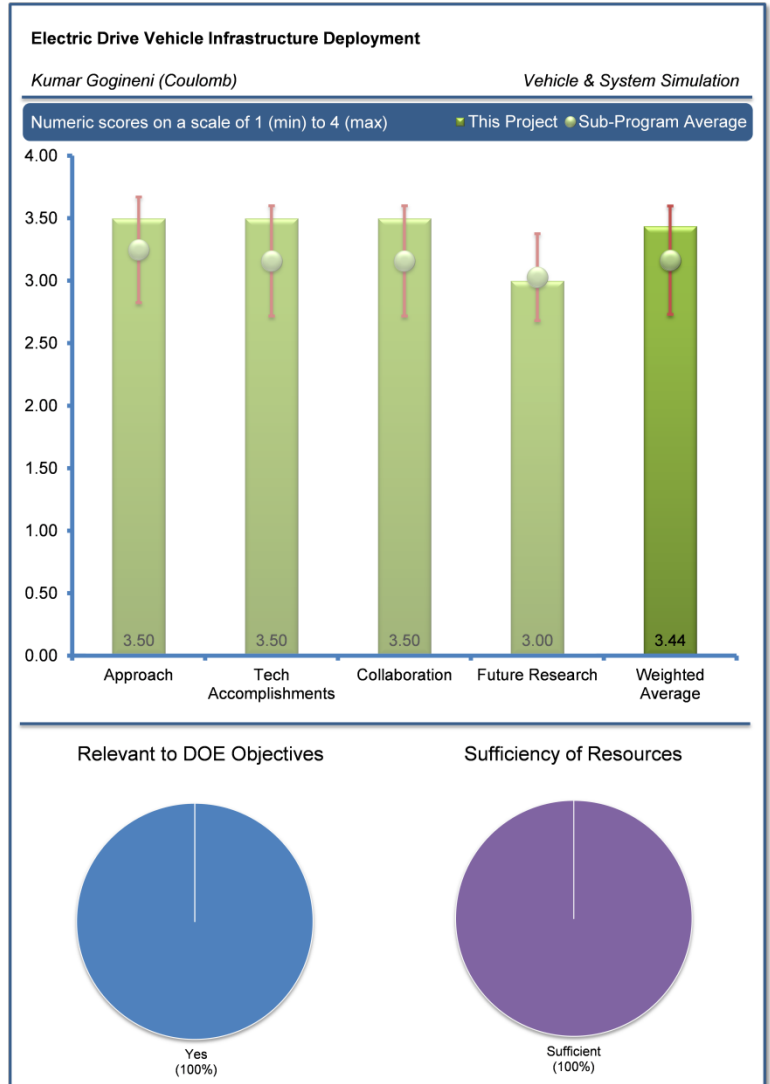
One panelist asserted the coordination appears extensive, especially within the private sector.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers agreed the resources for this project were sufficient.



Class 8 Truck Freight Efficiency Improvement Project: Derek Rotz (Daimler Trucks North America LLC) – arravt080

Reviewer Sample Size

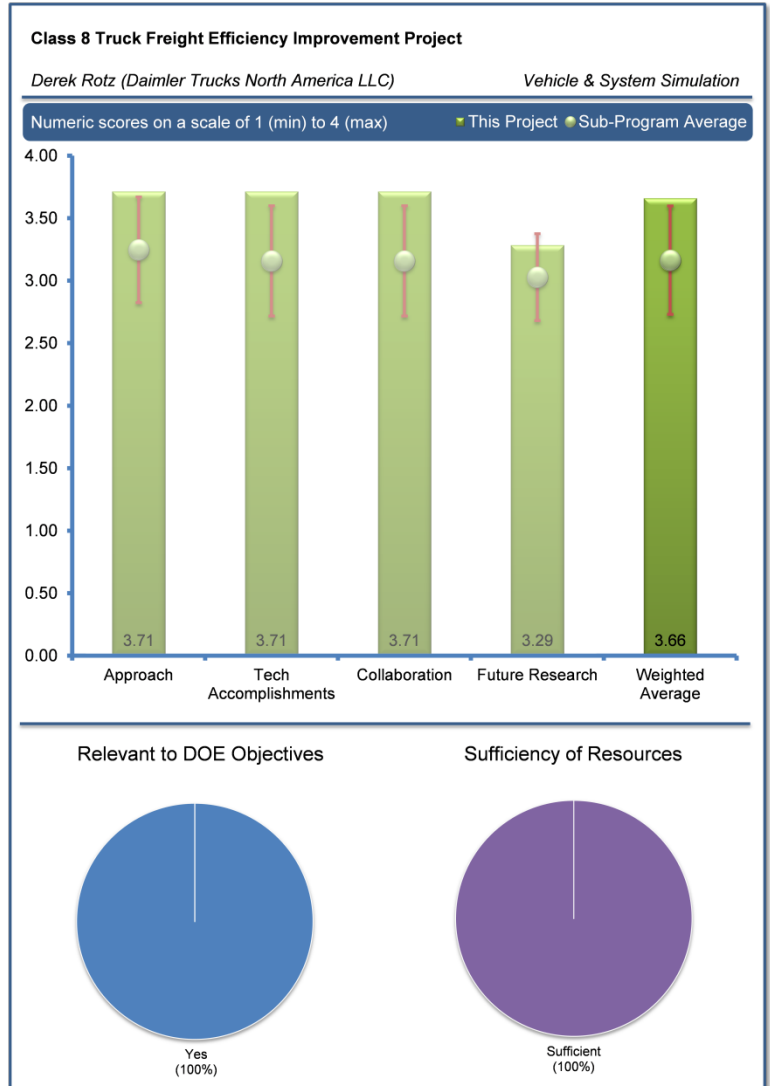
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Many reviewers believe that the SuperTruck project is very important due to its main objective of petroleum displacement in Class 8 trucks. One person stated that the project objectives are key enablers to energy efficient highway transportation. Another mentioned that SuperTruck is very relevant due to the large amount of fuel consumed by over-the-road (OTR) trucks and Daimler is the market share leader in this segment. Another evaluator pointed out that this project is relevant as it will develop technology options for the largest commercial fleet segment in the United States and that the project analyzes many options for reducing fuel consumption in this fleet. This person added that as with all of the SuperTruck projects, the project goal is a 50% reduction in fuel use for on-road heavy-duty (HD) trucks. Another reviewer believed this would make a big dent in petroleum use. This person added that the SuperTruck program is a bold initiative to accelerate the development of new technologies that can have a major impact on fuel consumption. The next reviewer added that the program calls for development of a Class 8 vehicle that delivers a 50% improvement in freight efficiency (expressed in terms of ton-miles per gallon). It is further stipulated that the engine must deliver a 20% improvement, and equal or exceed 50% brake thermal efficiency. The next evaluator said that this project, one of four being conducted under the SuperTruck program, very clearly aligns with and supports the DOE initiative for reduced petroleum dependence. The last reviewer felt that in order to achieve such dramatic improvements, revolutionary, rather than evolutionary changes will be required. This person added that this program provides significant funding for OEMs to explore, down-select, and develop the technologies that can deliver such dramatic improvements.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One evaluator stated that Daimler is taking a complete system approach to this challenge and are using the available funding and resources to investigate some significant, challenging areas of big truck design. The best example that this expert found was Daimler's investigation into distributed cooling systems for aerodynamic opportunity. Another commentator thought it was interesting that the focus is on frame rails, sandwich structures, transmission shifting, and oil formulations/control. Many of the reviewers liked several elements of this project because they address significant problems in a low-cost way. For instance, one reviewer stated that one such element is the eco-driving feedback and that another is the analysis of time-of-day differences. This reviewer also added that the level of hybridization seems to be appropriately low for long-haul, so that a large battery is not required, avoiding significant mass and cost penalties; and that having a small battery means that something else is needed for



hotel load at night, hence the solid oxide fuel cell auxiliary power unit (SOFC APU). This reviewer continued that it remains to be seen whether it is better than a diesel and that they would like to see integration of the APU to avoid component duplication. This person also added that the plug-in capability for the APU would be desirable. The next expert to respond stated that the technology roadmap and analysis conducted to identify the pathways for vehicle and engine efficiency gains. Aerodynamic improvement, power-train and drive-train efficiency improvement, light-weighting, energy management, parasitic loss reduction and hybridization were all identified as technical approach. This person continued that the experimental tests were conducted on tinker trucks to quantify the gain from each of the proposed technologies and that this was overall a good approach. The reviewer also felt that the issue of total vehicle gain when all the technologies are integrated should be addressed. One commentator stated that Daimler Trucks North America (DTNA) has taken a very logical, methodical approach to creating a SuperTruck. This person observed that Phase 1 of their program explored a wide variety of technologies that could contribute substantially to improved efficiency. This reviewer believed that most of this activity was analytical in nature, with some limited confirmation testing to evaluate and eventually down-select the most promising technologies and that the objective was to trim down the list of technologies to be further evaluated. The same commentator observed that in Phase 2, a shortened list of technologies is subjected to testing to validate the Phase 1 analysis. This person added that to facilitate this effort, two mule vehicles were built and dedicated testing on specific components and systems were conducted. The reviewer added that significant aerodynamic testing has been done with scale models to zero in on the optimum tractor trailer shape and configuration. The reviewer also noted that the strength of Phase 2 testing and analysis, final designs will be generated for the SuperTruck in Phase 3, accompanied by more extensive analysis to fine tune the designs. Continuing to the next phase the reviewer noted Phase 4 is the procurement and build phase for the final SuperTruck. The individual components and systems will be tested to reconfirm anticipated improvements, affirmed the expert. In Phase 5, the completed SuperTruck will be subjected to extensive testing to confirm the freight efficiency improvement. Separately the engine will be dynamometer tested to confirm the improvement in brake thermal efficiency. According to another commentator, a freight efficiency budget has been generated to document how much freight efficiency improvement is anticipated for each component or subsystem (aerodynamics, powertrain, light-weighting, energy management, parasitic loss reduction, and hybridization). The team has wisely built in more total savings than required, so that any shortfalls in projected performance in one component or subsystem are potentially compensated for in other areas. Most reviewers felt that it does cover all necessary technologies to achieve the goal. However, one reviewer pointed out the barriers addressed so far are the tradeoff between aerodynamic efficiency and cooling requirements; the design, development of safe and efficient high voltage distribution; and the balance between cost, weight, and efficiency. One expert remarked that there was good analysis of light-weighting costs versus stiffness issues; however, this person stated that the sizing components was good but could add more detail on how battery sizing was completed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All of the reviewers felt that the project seems on track and is progressing. One reviewer noticed that all of the preliminary concept development and design are well underway, and modeling and analysis supports these efforts. Another reviewer stated that the initial tests of individual components on tinker trucks are in progress in which significant improvements have already been identified. The Phase 1 analysis and modeling portion has largely been completed, continued the reviewer. Two mule vehicles have been built for testing and evaluation of individual components and systems. The next reviewer observed that extensive analysis and testing has been conducted on aerodynamic shape; thermal management of the engine and hybrid system; light-weighting analysis of major structural components; integration and optimization of the powertrain/drivetrain; reduction of parasitic losses (power steering, air compressor); energy management, including predictive torque and anti-idling; and hybridization. The same reviewer believed that these efforts will help to quantify what each major design change can deliver in terms of efficiency improvement, so there should be few surprises during the latter stages of the program. The reviewer concluded with the feeling that the project appears to be right on schedule. The next commentator observed that, in terms of meeting freight efficiency targets, the DTNA set a goal of 25% improvement for Phase 2 activity. This reviewer said that DTNA appears to have achieved approximately 37% based on testing and analysis conducted to date, significantly exceeding their intermediate goal. The next reviewer felt that Daimler is progressing with major concept decisions using analytical tools and tinker trucks. They are engaging suppliers and their resources in Germany in a very efficient and strong way. The next commentator to respond agreed that the tests are underway or planned as scheduled and that the overall project is on schedule. The person added that the analysis completed for

some of the individual technologies tested and the gains quantified. The last reviewer liked that this project was incorporating driver behavior. This person added that the accomplishment at this stage was only in the component level, which makes it hard to make judgments.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first commenter expressed that the DTNA SuperTruck program has a full complement of partners and collaborators from the following areas: energy management, hybridization, aerodynamics and cooling, light-weighting, powertrain and parasitic losses, and fleet advisors and test fleets. This reviewer pointed out that there are no fewer than 25 partners/collaborators engaged in this program, a few internal to Daimler, but mostly external resources (suppliers, fleet customers, DOE, National Labs). There appears to be strong expertise in each of the key areas noted. The next commenter felt that it seemed like the project actively worked with all of their partners. Another reviewer stated that the extensive collaboration and partnership with the key technology players in each of the approaches being pursued is needed and is present. Involvement of fleet owners is excellent idea, added the same reviewer. The reviewer added that all of the major areas of truck design, construction, and testing seem to be covered. Another reviewer suggested doing measurements of heat load during idling at night, when most idling actually occurs, in order to get a more realistic idea of performance. The last reviewer believed that the project should elaborate on requirements versus project goals (i.e., how did requirements drive activities). Overall, most of the reviewers felt this project showed very good decision making. For instance, their discussion of integrating electric turbo compounding if the bench tests prove that it offers a good payback, stated one reviewer. Only one reviewer showed concern in that their team is so internally-focused that they may miss a few opportunities outside of the Daimler family.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to respond felt that the project was on schedule, and that more system level testing is ongoing and/or planned. However, the plan did not address system integration and optimization testing. Another reviewer said the researchers have a strong plan for future work. The next reviewer stated that future activity will proceed consistent with the detailed multi-phase plan described. The reviewer described next steps: continuation of system level testing; completion of full scale cab model for aerodynamic evaluation; build up preliminary SuperTruck chassis for System integration (complex controls for hybrid, powertrain, waste heat recovery, and predictive torque management); and the completion of integrated tractor/trailer configuration for light-weighting and aerodynamic optimization. One reviewer felt that the project will continue down their current productive path, but the details in the presentation are a bit sketchy. This reviewer would have like to have seen more about the integration, since so many elements are being tested one at a time. A different reviewer expressed concern when the presenter did not mention how hybrid work is integrated with the future work, and how it can help to improve the vehicle efficiency in typical vehicle cycle. The final reviewer remarked this is another one of the SuperTruck projects that this reviewer is non-plussed with.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Seven reviewers felt that the project resources were sufficient. The first reviewer said the project is well funded at \$79 million. Another reviewer stated that the team seems to have done a good job on planning the tasks to match the funding available. The next person to comment believed that the resources seemed capable and were sufficient to complete goals. A different reviewer stated that the project is well positioned to finish on time, and to achieve the performance objectives identified. Another reviewer said that, based on the broad-based design and testing activities on multiple fronts, it is obvious that there is a substantial human resource commitment to this program. The contribution of 25 partners ensures that technical assistance is readily available to deal with a broad range of new component and system designs. The final reviewer really expected to see some solid results.

Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: Scott Newhouse (Peterbilt) – arravt081

Reviewer Sample Size

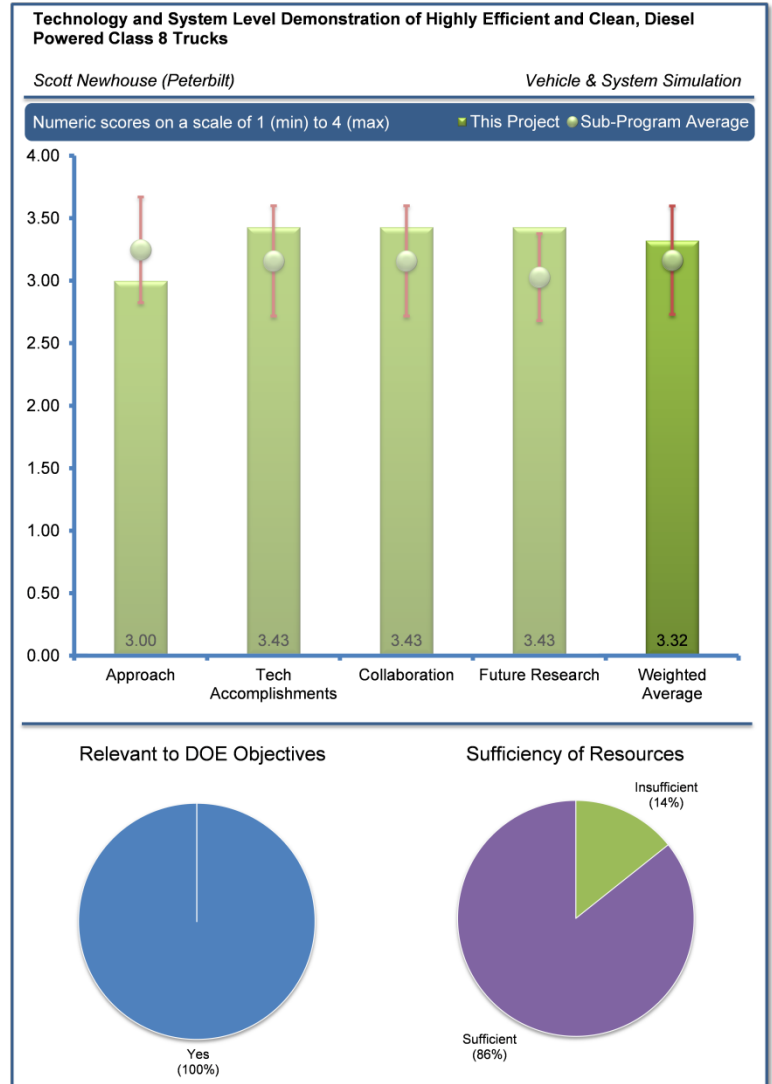
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first commentator stated that project objectives set by the SuperTruck program are consistent with DOE objectives. The project also addressed the issue of job creation, which was the main objective of the ARRA program. Another reviewer believed that this project, one of four being conducted under the SuperTruck program, very clearly aligns with and supports the DOE initiative for reduced petroleum dependence. A different reviewer liked that this included the emissions portion as well. The reviewer stated that this has typically been overlooked in past DOE Vehicle Technology Reviews. Another reviewer stated that as for all of the SuperTruck projects, the overall goal of 50% reduction in fuel use supports the objective of petroleum displacement perfectly. The next reviewer stated that in order to achieve such dramatic improvements, revolutionary, rather than evolutionary changes will be required. This program provides significant funding for OEMs to explore, down-select, and develop the technologies that can deliver such dramatic improvements. Another commentator believed that the project objectives are key enablers to energy efficient highway transportation. The following commenter observed that per requirements set forth in the Funding Opportunity Announcement (FOA), the engine must deliver a 20% improvement and equal or exceed 50% brake thermal efficiency. The SuperTruck program is a bold initiative to accelerate the development of new technologies that can have a major impact on fuel consumption. The reviewer said the program calls for development of a Class 8 vehicle that delivers a 50% improvement in freight efficiency (expressed in terms of ton-miles per gallon) and that the Cummins-Peterbilt team will also target a 68% improvement in freight efficiency over a 24-hour duty cycle (overnight hoteling included). The last reviewer expressed that Peterbilt and its sister PACCAR OEM, Kenworth, has significant market share in this sector of the HD Truck industry.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer expressed that the project seems well-designed and is on schedule to meeting its milestones. This person noted that the team did the logical thing and validated individual components on a mule truck before putting everything together. The reviewer was unclear as to what modeling was done first beyond the aerodynamics computational fluid dynamics (CFD) calculations. This reviewer also wondered why a fuel cell APU, and whether duplicate components for hotel load could have been avoided. The same reviewer further indicated a desire to hear about features like the route management that reduce fuel use without significant cost or weight. Another reviewer stated that the project considered many technology enhancements and



approaches to achieve the technical goals of aerodynamics, engine, transmission, axles, tire, route management, weight reduction, and idle management. This person observed that the project uses current truck configurations as engineering mules for testing. This, the reviewer opined, will certainly ease final product acceptance by fleet owners and customers. The next reviewer observed that the team is using the following multi-phase approach to develop the SuperTruck: Objective 1 (Phase 1), which involves engine demonstration of 50% brake thermal efficiency; Objective 2a (Phase 2), which involves vehicle drive cycle demonstration of 50% improvement in freight efficiency; Objective 2b (Phase 3), which involves vehicle drive cycle demonstration of 68% improvement in freight efficiency over a 24-hour duty cycle; and Objective 3 (Phase 4), which involves engine demonstration of 55% brake thermal efficiency. The specifics of the approaches for each objective were not shared in great detail for the program, noted this reviewer, but it appeared that a combination of analysis and component/subsystem level testing was conducted. This reviewer said that it would have been helpful to the reviewers to better understand the list of technologies or products that were originally considered. The same reviewer pointed out that it is commendable that the freight efficiency targets are believed to have been achieved or exceeded at this point, based on analysis and component/subsystem testing. This reviewer continued that, to date, two of the five identified program barriers have been addressed (i.e., under-hood cooling with waste heat recovery and required vehicle and engine weight reduction). This person added that there is good detail presented showing where the weight reduction is being achieved. A different reviewer explained that with the technology settling down in emissions, this is getting easier; however, the project team will need to keep up-to-speed on the development of catalysts for emissions. Another reviewer was concerned about the due diligence of the project team's work. This person questioned the robustness of the project team's work in aerodynamics, anti-idling, and tires/wheels because very few details were shared. The same reviewer stated that the project team's partner, Cummins, seemed well situated on the project; however, from a vehicle standpoint, the reviewer did not see evidence of a good, deep, quality approach to the 50% challenge. This person added that although it was possible that the details were available, just not provided, this reviewer could not make a determination without seeing similar information to the other three SuperTruck companies. The next reviewer stated that the presentation could have elaborated more on the technical integration issues and other areas besides aerodynamics. This person added that the presentation did not discuss plans for weight reduction, transmission/axle, or tire effects on the project goals. The same reviewer further noted that the project should address integration concerns or challenges that will affect new technology success (i.e., potential compromises with the aerodynamics approach caused by cooling). The last commenter described the freight efficiency improvement over a 24-hour duty cycle as overly optimistic.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked to keep going. Another reviewer stated that the project is on track and had achieved and/or exceeded their goal in tests with the technologies successfully packaged into 587 trucks. This person added that the project demonstrated efficiency gains through weight reduction, aerodynamic drag reduction, with some room for improvements. The analysis showed normal shaped vehicles as good as futuristic looking vehicles, added the reviewer. Another reviewer wondered whether the skirts and boat-tails will be durable and also acceptable to customers. For production models, it may be appropriate to back up on the last few increments of the coefficient of drag (C_d), stated the reviewer. This person stated that these things cause a severe weight penalty and advised not to forget that a lighter truck can haul more tons. The next respondent to comment listed the major accomplishments that were identified in the presentation: defined path to achieving required efficiencies for both the engine and the vehicle (52% improvement projected against a target of 50%. This could result in a shortfall if one or more of the candidate technologies do not deliver as anticipated); an approach for aerodynamic improvement was identified through CFD modeling and components were fabricated for initial testing; Cummins performed initial evaluations of waste heat recovery system (other engine related developments are being reported out in a separate session); performed initial testing of advanced transmission; and performed assessment of auxiliary power unit. The reviewer observed that more progress noted in the presentation included: completed packaging of technologies without significant tear up to the vehicle or wheelbase extension; identified attractive weight savings for both the tractor and trailer that is expected to provide a 3% improvement in freight efficiency (specific data was provided showing the projected weight savings for major components and subsystems); and numerous CFD analyses were conducted on Demo 1 and Demo 2, with Demo 1 configurations exceeding the 14% target, however the Demo 2 fell slightly short of the 24% goal. This reviewer felt that the conclusions drawn from this evaluation were a little surprising. The reviewer added that, unlike the other three SuperTruck programs, this team has opted to stay with what is essentially a production cab design. The

conclusions from the CFD analysis indicate that only very minor improvements would be achieved by a more radical redesign, which runs counter to conclusions reached in the other SuperTruck projects. The next reviewer stated that the project was meeting the goals with minor supporting documentation; tradeoffs such as cost and weight were not shared. The reviewer added that the goals and details versus obtained results (or plans to get results) could be discussed in more detail. It is unclear if major milestones had been obtained and if efficiency goals are on track, expressed the reviewer. The last reviewer mentioned that Slide 16 requires clarification on why the advanced concept vehicles only show very little improvement on C_d , even with different trailers (side skirt and tail). Use of this sample is misleading, added the commentator.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said this team covers all the bases, from engine and drivetrain experts to trailer manufacturers to APU suppliers and end users and that the team appears to be getting the job done together. The second reviewer said that the list of participants and collaborators on the project are the industry leaders in their area. A third reviewer stated that with Cummins serving as the contract lead, there are a total of 14 partners and collaborators active on the project (including Peterbilt). The second reviewer continued saying that expertise in the following components/systems/and technologies is readily available: cooling, transmissions, brakes and suspension, axles, tires, wheels, APUs, heating, ventilation and air-conditioning (HVAC), global positioning system and dash display, CFD, trailer design and manufacture. Cummins has the lead on engine improvements and related systems (waste heat recovery) while Peterbilt has the lead on vehicle design and integrations added another commenter. It is unknown whether Cummins or Peterbilt are engaging any of the national labs for technology development or testing. Another reviewer said that the researchers appear to have much less engagement by suppliers and DOE labs; however, they seem to have reasonable fleet input. The final reviewer thought the project seems to involve many partners, but this reviewer is not sure in what level it is.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that it seemed like all the future work was focused toward the program objectives. The second reviewer commented that the project plans to test optimized engine and advanced transmission systems to increase the gain further. There is plan to build and test a demonstration vehicle in which the various technologies are incorporated. The reviewer found that the technology implementation and marketing after the program is over is commendable. Another commentator observed that the future work as defined in the presentation for the next 12 months is as follows: engine calibration and optimization, vehicle testing of advanced transmission, testing of tractor/trailer aerodynamic solution, build and test SuperTruck Vehicle 1, design freeze of Vehicle 2, and the initial calibration of the GEN2 auxiliary power unit. This commentator continued saying that three program barriers are considered open issues, and will be evaluated on the demonstrator truck: effects of reduced engine speed on drivetrain components and potential vibration issues, trailer aerodynamic devices that meet operational requirements, and vehicle and powertrain communication speed. This commentator said it is unclear whether or not contingency plans are in place to address these open issues should the lead approaches prove ineffective. The next reviewer stated that the proof of a successful program will be the truck's performance once completely integrated and tested in year four. As with the other teams, a coherent work plan was formulated up front, and the team appears to be following it on schedule, which means that the future work is appropriately formulated, to the extent that one can tell from such an abbreviated presentation. Another reviewer added that better elaboration on Slides 19 and 23 would be helpful for reviewers to understand details on what will exactly happen and when it will happen. The last reviewer to comment thought this project needs to continue being explored, especially as catalyst technology improves. The reviewer continued saying this would be helpful to extend to other fuels, while bring mindful of how alternative fuels affect emission. This reviewer also noted that they would like to see emissions explored as it relates to compressed natural gas (CNG)/liquefied natural gas (LNG)-fueled vehicles.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One expert felt that there were insufficient resources and that given the lack of detail presented, this reviewer questioned whether there are sufficient resources working on this project. Six of the seven reviewers felt that the project resources were sufficient. One reviewer stated that the program appears to be adequately funded, at approximately \$79 million. The 14 partners suggest that the project has access to technical expertise in a number of critical areas. The pace of this project has been

swift, and there are no indications that the project will not be completed on time, added the reviewer. This reviewer felt that there was no clear indication that contingency plans or parallel paths exist in case the lead approaches for technologies do not deliver anticipated savings. This person continued stating that such plans may exist, but were not shared as part of the presentation. If these plans do not exist there could be an unusually high demand for resources late in the program as the team works to overcome potential shortfalls in performance. Another commenter said that the project team has figured out what they wanted to do, and are doing it on schedule and on budget. The final reviewer stated that this project took on a hard piece of modeling work.

Medium and Heavy-Duty Vehicle Field Evaluations: Kevin Walkowicz (National Renewable Energy Laboratory) – vss001

Reviewer Sample Size

This project was reviewed by three reviewers.

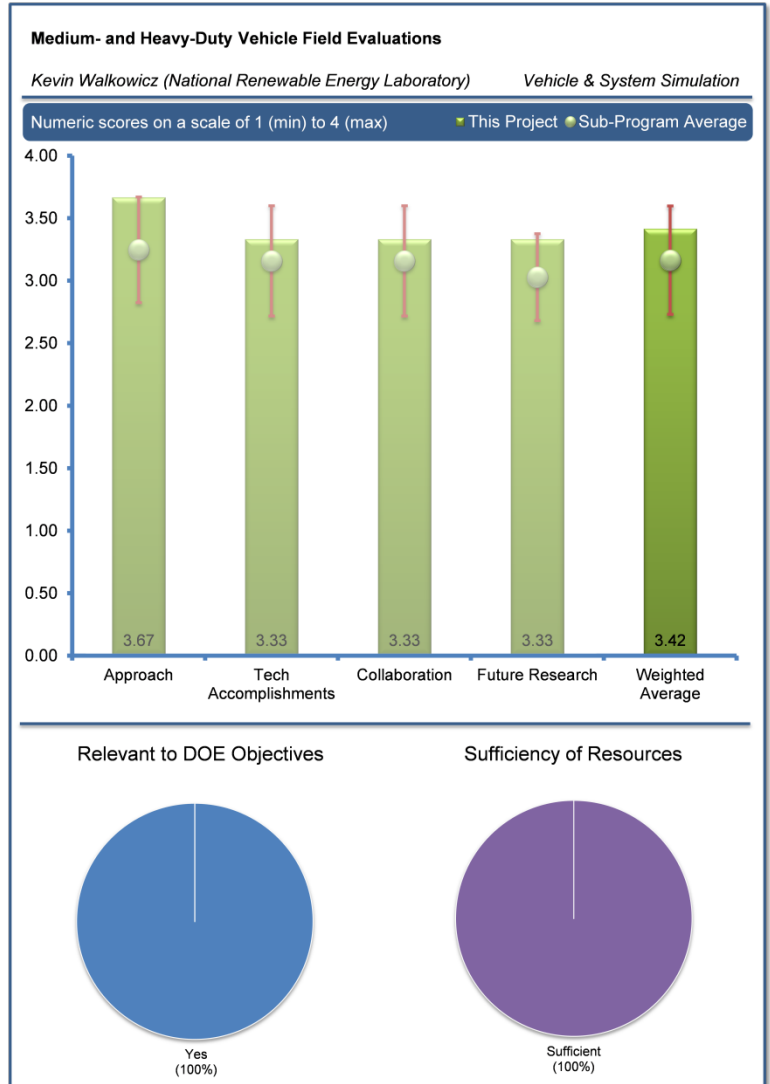
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer believed that this project is the single most comprehensive investigation of the performance characteristics of plug-in electric MD/HD trucks. The potential relevance to public and private fleets is tremendous, added the commenter. Another reviewer stated that this project seems to be doing a good job of collecting real-world data on how new technology hybrid-electric vehicles (HEV) are performing in the field. This person added that the data will be useful to the industry and to government in understanding if the technology is really worth investing in. The last reviewer felt that there is a need for understanding whether the hybrid technologies reduce fuel consumption and are user friendly.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that there is an appropriate selection of partners and a good parcel of data from each truck.

The reviewer added that publication of the data is helpful for the general market, and expressed hope that other projects capture some of the other non-production technologies and the possible fuel economy impacts. Another commenter observed a very good approach and noted that the data was collected and analyzed well. This person especially liked the comparison to the conventional that is made here in the MD/HD project. The same reviewer remarked that utilizing the chassis test to help provide more insight seemed good. This reviewer highlighted that the example of forcing a route switch between the HEVs and conventional shows that the project is staying on top of the data and trying to get representative data. The same reviewer expressed uncertainty as to whether there is a clear end in sight for this project, and questioned when it would be known that a new technology is close enough to another that you already logged that it does not need to be logged. This reviewer remarked that this was not clear in the material. The next commentator stated that the project is well-formulated from a technical standpoint. One critique indicated by this commenter is that there is fairly limited emphasis on addressing significant deviations from vehicle performance specifications. This person commented that the team reports an efficiency of 1.6 kWh/mile for the Smith EV, though according to specifications, that vehicle is supposed to achieve 0.8 kWh/mile. Without any effort to investigate the causes or potential remedies for this deviation, explained this reviewer, the results would likely eliminate this vehicle as a viable option for most applications. This project will find itself quickly irrelevant if nobody will use the vehicles it is testing, opined the reviewer. It was understood by this reviewer that these are preliminary results, but stressed that a more proactive approach to interpreting results and identifying problems and remediations is crucial.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer to respond felt that the project appeared to be moving along well and was eager to see more data. Another reviewer believed that the project achieved good results for the comparison between the conventional and hybrid trucks. This person agreed that the uptime, fuel economy, and maintenance cost were all factors that would help fleets decide on whether to implement hybrid technology. The next reviewer to respond felt that the progress was hard to judge; however, the project seems to be progressing well with a lot of good data collected, added the commenter. The reviewer suggested that it would be nice to have clear targets to look back on during the next year to see how well the targets were set. One example that the reviewer stated would help was the specific number of miles logged per month. Data on logged miles per dollar spent would help compare this project to others that might be doing the same thing in the future. This reviewer believed that it would be helpful to publish an understanding of why the dynamometer results differed from field results for fuel efficiency. This would help the fleets pick the right routes for their vehicles. This person also felt that it would be helpful to understand and publish why the actual range of the Smith is different from the predicted range.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the project had a good list of fleet and system provider partners. Another believed that there was a good collaboration between the partners in order to get access to different vehicles. The last reviewer to respond stated that the complexity of negotiating multiple stakeholders to deliver and gather data from multiple vehicles is tremendous. This person also believed that the team had done an admirable job simply getting vehicles into fleets for use. This reviewer mentioned the awareness of this project and its results in the federal fleet was poor and was even worse among private fleets. This activity has the potential to make an immediate real-world impact, added the reviewer. The reviewer continued saying that the lack of performance data prevents fleet managers from adopting these vehicles and believes that the results from this study fill this critical gap. The reviewer mentioned the federal fleet in particular because the DOE can help by directly informing and influencing federal fleet procurement decisions by raising awareness of this project. The outreach efforts for this program look like any other research project, but a more aggressive effort is called for. The reviewer concluded that this project needs a more ambitious and better-constructed outreach plan.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer believed that the Parker hydraulic hybrid drivetrain (HHD) system was a good system. And that it is necessary in order to understand if the fuel savings will pay off the cost of system. The next commenter stated that the development of the fleet database seems especially worthwhile. Although general route creation has been done before, it would be nice to have drive cycle routes readily available that are independent of the vehicle size, added the reviewer. The commenter suggested that speed targets and stop times should be included; instead of just the measured speed profiles that end up being dependent on the vehicle, driver, and controls used in the tests. The last reviewer stated that on the top two bullet points on the future work slide are more continuations of existing work than anything new. The reviewer added that a better outreach plan is necessary since the FleetDNA database is insufficient in maximizing the impact of this program. The reviewer also believed that it would be good to see a distinction between the other ongoing and similar battery efforts.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers to respond felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. The first commentator felt that the project had sufficient resources in order to meet its technical objectives. The next reviewer suggested that a measure of data per dollars spent should be available.

DOE/DOD Parasitic Energy Loss
Collaboration: George Fenske (Argonne National Laboratory) – vss005

Reviewer Sample Size

This project was reviewed by four reviewers.

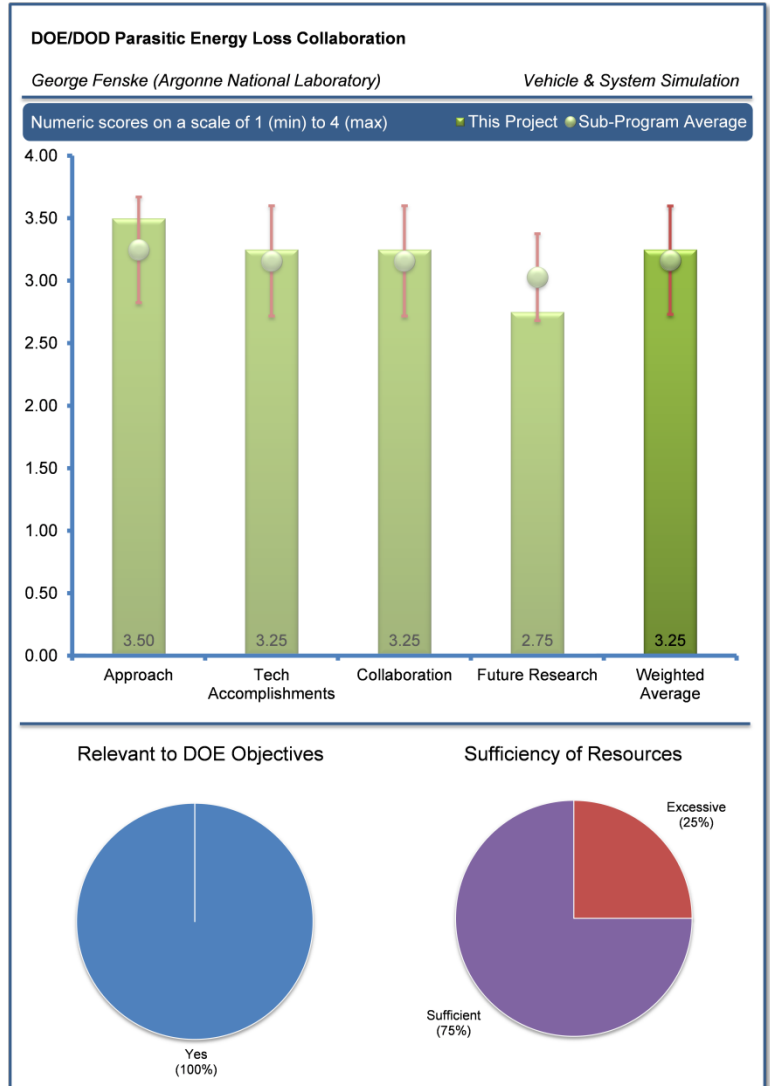
Question 1: Does this project support the overall DOE objectives? Why or why not?

One observer reported the stated objective of the program is to reduce fuel consumption. Another observer noted that it was important to be able to measure the impact on fuel economy of advanced tribological concepts, and that this work allows designers and operators to know the cost benefit of using advanced lubricants. The next panel member saw a clear link of friction reduction to fuel savings, and indicated that linkage with the Department of Defense (DOD) is a promising approach to save tax payer dollars and achieve similar fuel savings objectives. The final reviewer stated that powertrain parasitic friction is well understood to have a significant negative impact on fuel consumption in ground vehicles, and pointed out that the results of a quick spin down test performed recently on a heavy-duty diesel engine underscore this (i.e., the drag torque was calculated as approximately 10% of the rated engine torque at normal operating speeds). This reviewer expressed that development and extension of a comprehensive, unbiased, and relatively accurate database should offer a high degree of utility. The reviewer also noted that the title of the project should have been revised to eliminate ambiguity. This reviewer explained that the parasitic losses addressed here are focused on the engine, which should have been explicitly included in the title. The reviewer conceded, however, that engine friction is the largest parasitic friction component in a typical powertrain, so the broad title is technically applicable. The same reviewer concluded that this research is relevant to DOE objectives across a broad range of the mature ground vehicle industry, being focused on internal combustion engines.

This reviewer explained that the parasitic losses addressed here are focused on the engine, which should have been explicitly included in the title. The reviewer conceded, however, that engine friction is the largest parasitic friction component in a typical powertrain, so the broad title is technically applicable. The same reviewer concluded that this research is relevant to DOE objectives across a broad range of the mature ground vehicle industry, being focused on internal combustion engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer considered friction to be a sensitive and nonlinear physical phenomenon that will require the strong blend of empirical analysis planned here. This reviewer agreed that mapping results across a full matrix of normalized load and speed will insure a broad range of applicability. The same reviewer further commented that this seems like a good compromise because additional combinations can be tested efficiently with the given test setup, and it is just a matter of obtaining extra material samples and some extra time on a dedicated test rig. The reviewer concluded by stating that the coupling of tribology-related durability and reliability characteristics should further improve the utility of the data, and the inclusion of sophisticated crank-throw dynamics analysis to determine impact on the friction mean effective pressure should improve the availability of the data to engine practitioners. Another observer reported that the Principal Investigators (PI) understand the barriers, that the U.S. Military will benefit from this work, and that the new lookup table and model will be a valuable tool for engine designers. The next panel



member liked that the approach will combine with DOD goals, and liked that the testing of available commercial solutions and experimental solutions proposed by industrial partners. This panel member suggested that the researchers work on newer experimental approaches, such as laser engraving and micro embossing in evaluating engineered surfaces. The panel member questioned if there was too much reliance on only testing things that the industrial partners are pulling. This panelist acknowledged that this is a tricky balance, as some of the experimental techniques may never become commercially feasible. However, acknowledged this reviewer, someone needs to do the basic research. The final reviewer indicated that this project adds very little to the current state of the art of engine tribology, and that this effort duplicates research and development that have been well covered over the last several decades. This reviewer pointed out that Ricardo codes being acquired and utilized have been used by the engine community for decades, and these users include GM, Ford, Caterpillar, Cummins, Detroit Diesel, and more. Many of these codes have been validated, continued this reviewer, who further found the work barely complements to the current Massachusetts Institute of Technology (MIT) consortium work and prior work by many. Examples identified by this reviewer include work documented by the following: MIT (i.e., Professors Nam Suh, Ernest Rabinowicz, Victor Wong, Dave Dawson, etc., from the 1970s to date); Japan (i.e., Professor Shoichi Furuhashi); University of Michigan (i.e., Professor Dom Patterson); Penn State University (i.e., Elmer Klaus, Larry Duda, Joe Perez, etc.); Wayne State University (i.e., Professor Naeim Henein); Georgia Tech (i.e., Ward Winer, et. al); Midwest Research Institute (i.e., Paul Sutor); National Institute of Standards and Technology (NIST) (i.e., Steve Suh); ORNL (i.e., Charlie Yust); and Argonne National Laboratory (ANL) (Drs. F. Jones and M. Kaminiski in the 1980s and 1990s). The same reviewer remarked that these examples make the point that a literature search would produce the majority of the expected results and outcomes of this project, and revealed that many of these results have used the same tools (simulation and experimental) or similar tools to arrive at validated, high fidelity results. This reviewer concluded that this project is reinventing the wheel.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer evaluated this project to be on target and on schedule. Another reviewer offered that it was progressing nicely toward goals and that the work is of the highest, world-class quality and well recognized as valuable by the industry. The next observer saw that good progress seems to have been made, overall. This observer indicated that it seemed the Cooperative Research and Development Agreement (CRADA) was added after the fact, and wished that the presenter had explained better the specific benefits the CRADA brings in this case. The observer further wondered if the objective related to a common DOE/DOD strategy was to generate common solutions or to apply a common methodology to generate such solutions. The observer stated that if the first was meant, there was little mention of successful common solutions or the potential of such. If the second was meant, continued this reviewer, good progress has been made. In any case, this reviewer recommended that this ambiguity be clarified. The final panelist reported that TACOM and DOE (ECUT and later on vehicle programs) have sponsored similar programs, and recommended that the researchers check these databases to discover what accomplishments and progress may be claimed here.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated the project exhibited an excellent level of collaboration. This reviewer found it difficult to fully judge as some of the OEM names are confidential. The reviewer further hoped that the CRADA with Ricardo would be signed quickly and would not lead to delays. This reviewer noted that collaboration with universities or small companies would be a plus, but that they may fit better in other DOE programs or projects. The reviewer further saw that collaboration with DOD brought new technical challenges and operating requirements, and indicated this work would likely shed new insight and further advance work on commercial vehicles as new challenges often lead to new innovations. The reviewer liked this approach, and concluded that, if successful here, it might be extended (e.g., by looking at friction problems in solutions in jet engines and applying back to heavy trucks). Another observer indicated that overall collaboration was good, but most collaborators were not full participants. This observer pointed out that the collaborator associated with the CRADA poses a potential concern in that information from this research that would otherwise be directly available may be controlled and metered to industry only at a relatively high expense. The observer found this especially concerning in light of other interested government agencies like the DOD, and recommended careful consideration of this potential conflict. The next panelist saw good collaboration, but suggested that Air Force Research Laboratory (AFRL) be added because they are also working in this area. This panelist recognized that ANL has the expertise in this area, suggested that the PI should publish the work at the Society of Automotive Engineers (SAE), and suggested including

life cycle cost analysis. The final reviewer did not understand the absence of automotive and engine companies, and speculated that the rationale is that the automotive and engine companies are ahead in this research area, some of whom are ahead by a wide margin. The final reviewer conceded that these companies may consider some of the company know-how as a competitive advantage and questioned the role for DOE.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panel member found that this research builds nicely on previous work at both ANL and elsewhere. This panel member would have liked to see future work connected to universities and higher risk, higher reward solutions, but accepted that this should be after the current work is well advanced. The panel member indicated that it would be interesting to see what comes out of the relationship beginning with the MIT consortium. Another reviewer observed that most of the planned activity had not been executed yet, and therefore found that this section was not especially relevant. This reviewer pointed out that the engine validation in Phase 3 does not seem to be firmed up yet. The same reviewer suggested that it may be of value to include different types of internal combustion engines of interest for this phase, such as natural gas, gasoline, and diesel. The next observer stated that ANL is the leader in this area, and that while Dr. Choi, who is no longer with ANL, is the founder of nanofluids, ANL still has the experts in this field. This observer emphasized that this is important work. The final reviewer commented that there was no need to duplicate prior work by others.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers rated resources as sufficient, and another reviewer opined that resources were excessive. One indicated that the resources appeared to be relatively lean but sufficient, and observed a good example of cost-effective research. This reviewer added that the friction testing appeared to be relatively low overhead and specimen material cost is likely covered substantially by the collaborators. Another reviewer agreed that this is a good use of funds, and that the project is certainly not overfunded.

DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations: Kambiz Salari (Lawrence Livermore National Laboratory) – vss006

Reviewer Sample Size

This project was reviewed by four reviewers.

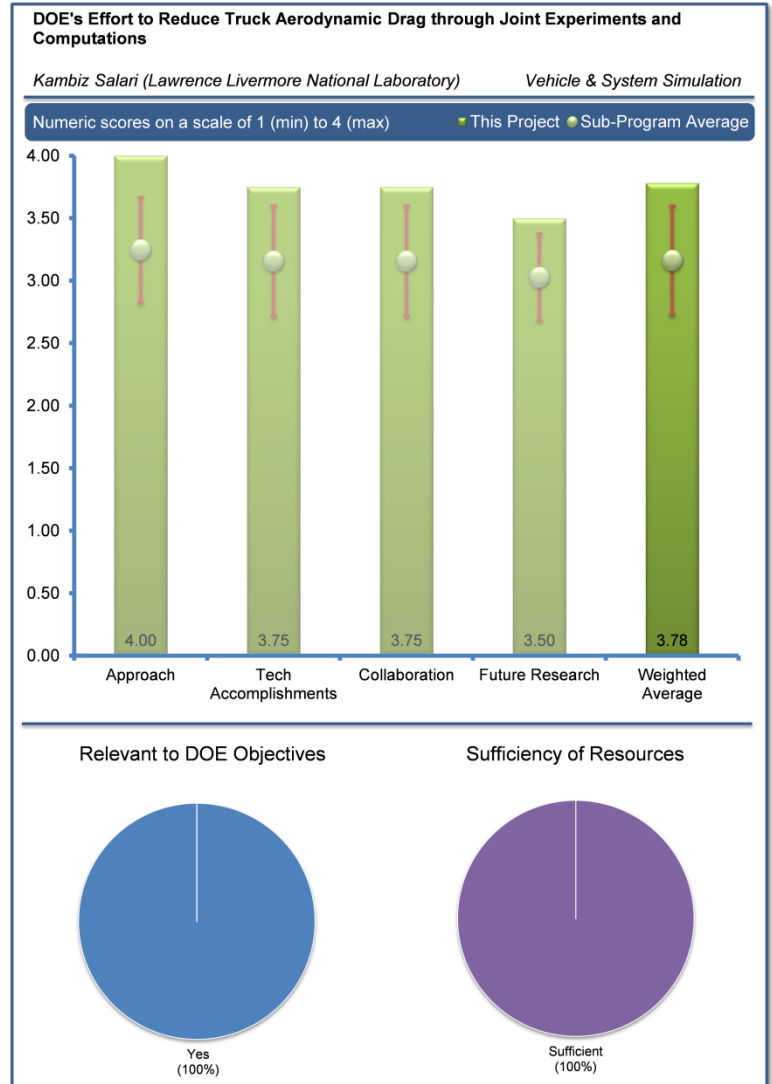
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented clear link to fuel savings. This program over many years has been a larger contributor to fuel savings delivered to commercial vehicles on the road. According to another reviewer, this project is demonstrating potential to significantly impact the DOE objectives quickly and cost-effectively. Using the figures provided, aerodynamic treatments may result in a 12% reduction in fuel consumption equating to 3.2 billion gallons or \$13 billion of diesel fuel across the entire fleet. If 3% of the fleet adopts these treatments as is estimated in 2012 alone, it is equivalent to nearly 100 million gallons or \$400 million of diesel fuel right off the bat. This reviewer noted that trailer skirts are being sighted on the interstates in increasing numbers. Wide-based single tires are also penetrating the market already. This research will help spur adoption rates by providing unbiased high fidelity data to prospective fleets. The third reviewer noted that trailers are an area of low hanging fruit for fuel reducing technologies. Adoption rates of the various technologies

are very low primarily driven by a low business case return if the fleets have very high trailer to tractor ratios, causing low average miles per trailer. According to this reviewer, this kind of project has significant relevance because it will get good information out there. For the fourth reviewer, aerodynamics represents one of the largest energy losses on the vehicle. It is also one of the lowest-cost means of improving efficiencies and stands the best chance for commercialization and widespread deployment. Focusing research to reduce aerodynamic drag losses is one of the most effective means towards the goal of displacing petroleum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to respond stated that this project is very balanced and well managed. This person observed that the testing began in wind tunnels, moved to tracks, and eventually developed two real fleets. This person also thought that choosing Navistar as the main program manager brought solid aerodynamic and project management expertise to the project. This project is very well done, added the reviewer. The next reviewer mentioned that with the combination of modeling, wind tunnel testing, and controlled field tests, the fleet tests provided really powerful results. The project's willingness to keep pushing the work to new areas such as the tanker and regional vehicle market to promote more fuel saving opportunities is impressive to keep bring more and more fuel savings opportunities to markets. Another reviewer noted that the review presentation was excellent overall. This person believes that the presentation's summary and visuals will help with information dissemination. The reviewer also felt that the cost and payback estimates were lacking and should have been included in the presentation. This reviewer stated that the approach taken to



pre-filter solutions based on commercial feasibility would insure quick adoption in the marketplace. This person added that it will help address the issue of added operation and maintenance costs from aerodynamic treatments and will enable the existing supply base to provide innovative and effective solutions. The use of the full scale wind tunnel on large trucks, though expensive, is a nice use of the facility for the commercial arena. This person mentioned that track testing is also expensive but is vital to provide the unbiased, high fidelity data needed to spur adoption of the technologies by pragmatic fleet owners running on thin margins. This reviewer also felt that the inclusion of wide-based single tires in this research seemed strange since aerodynamics and rolling resistance are largely independent. The reviewer mentioned that it seemed like the present emphasis on the project was only on aerodynamic optimization. The final reviewer observed that the focus on trailer aerodynamics addresses the technical barriers of aerodynamic drag. This person felt that the trailer aerodynamics is only part of the equation and that the research should also focus on the tractor aerodynamics. This person believed that there is an opportunity that still remains to be addressed to treat the tractor and trailer as a single aerodynamic system. The CFD simulation on gap seals did not appear on to be a workable solution that addresses matters such as trailer swing/articulation and back-of-cab access, added the reviewer. This person stated that they would also like to see physical mockup work on gap seals on the vehicle in the future.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter was impressed years ago when they saw large truck OEMs adopting this technology. This reviewer was even more impressed to see that the fleets were now purchasing aftermarket devices from smaller companies to add to their vehicles. This reviewer concluded that while it is hard to make a one-to-one link, it is clear this program has had a large impact in delivering solutions to everyday commercial use. The second commentator stated that they had seen this project presented at a number of truck forums over the past few years and had been impressed with their approach and technical accomplishments. This person remembers seeing the project at American Trucking Association Technology Maintenance Council in February, where videos portrayed truck drivers at two different fleets who were sharing their perspectives on how the various trailer technologies affected their operations. This reviewer complimented that the project has had impressive accomplishments in an area that has big opportunities. Another reviewer observed progress being made during the previous year where the buildup and testing of a trailer aerodynamic system collected real-world experience in order to validate the expected savings. This person continued, stating that the collected dataset on Slide 16 indicated the conducted test did not appear to be rigorous. The reviewer observed that vehicle speeds and driving distance varied and that there was no record of ambient conditions. Due to the lack of information, the reviewer believed that the fuel economy values made it difficult to draw meaningful conclusions. The final reviewer felt that it was unclear how much of the plan was currently completed (as a percentage) and what the planned project completion date was. All of the technical accomplishments are self-evident by the fact that an increasing number of trailer skirts and wide-based single tires are being sighted on the interstates. There is ample evidence of actionable data to date.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first viewer to respond stated that this project was technically excellent and showed strong collaboration and the ability to work with companies of all types and sizes. Another commenter said that there was a good use of resources such as Lawrence Livermore National Laboratory, fleets, and technology suppliers. The next responder to comment felt that the program seemed to have a good composition of partners relevant to the program including trailer, trailer aero, truck OEMs and fleets. Michelin's involvement in an aerodynamics program, however, seemed confusing, added the reviewer. The last commentator stated that this research is a good example of strong, broad-based industry collaboration. This person added that the level and quality of communication regarding this research is outstanding and the effects are self-evident by the relatively quick rate of adoption in a value conscious industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had positive feedback on proposed future research. The first reviewer is looking forward to seeing what this team will attack next since they seem to consistently come up with new projects to complete. A different reviewer stated that transitioning to tankers seemed like a reasonable next step, given the significant opportunities to reduce aerodynamic drag. This person added that

they would also like to see work done on the tractor, since it is also a significant contributor to aerodynamic drag. The third reviewer stated that dry van trailers had the highest tractor to trailer ratios since they are used as stationary inventory storage. This person felt that lowering the miles driven will show a potential for fuel savings. Future work can be in tankers and flatbeds, where the tractor and trailer tend to stay connected giving the trailer more miles, added the reviewer. This reviewer stated that this project should be extended if funding is available. This person believed that the work completed could also help support the Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) with future greenhouse gas (GHG) regulations that will include trailers. The final reviewer felt that focusing on tankers seemed like a good next step, especially since the tractor/trailer ratio of tankers is nearly 1:1. The reviewer stated that this means the equivalent cost of the added aerodynamic treatments to the trailer will only be a third of that of a typical on-highway application with a tractor/trailer ratio of 1:3. Special consideration should be given to refrigerated trailers which also have a tractor/trailer ratio closer to unity, added the commenter.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers to respond felt that the project resources were sufficient. The first reviewer to respond stated that a lot of work had been accomplished for a budget of \$500,000. This person felt that the outcomes delivered appeared to be proportionate to the resources provided. Another commenter mentioned that this project seemed to be balanced and appropriate. A third reviewer said the resources appeared to be sufficient given the broad range of collaborative support and facilities. This person added that this is not an inexpensive program but the payback has been well demonstrated. Foreseeably, this research could extend for some time and continue to add value (although oddly a planned end date was not provided). This person felt that this project will experience diminishing returns and future resource levels should be commensurate with this. The final reviewer said that the funds are adequate but not excessive. This person added that this group delivers results and should be kept funded even if other opportunities must be cut by shrinking budgets.

PHEV Engine Control and Energy Management Strategy: Paul Chambon (Oak Ridge National Laboratory) – vss013

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

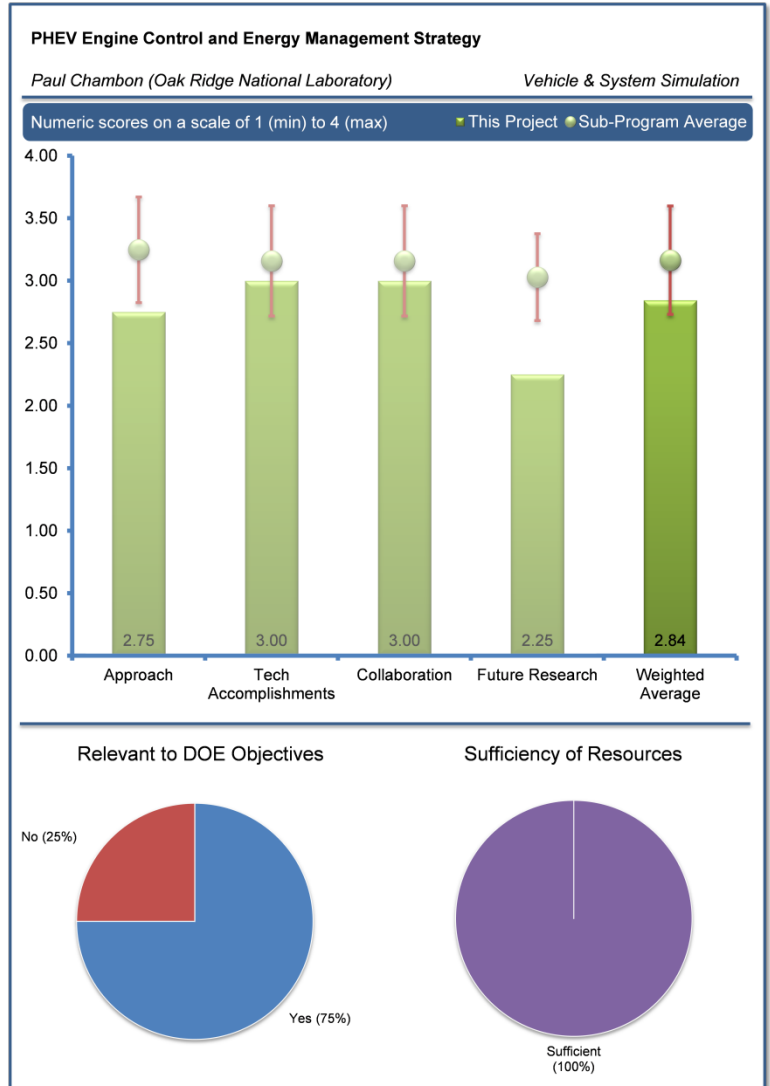
One commenter observed that this project is investigating initial strategies to mitigate criteria pollutants associated with cold starts, which are expected to be more frequent with plug-in hybrid-electric vehicles. Another investigator believes that by addressing this issue this project supports the proliferation of PHEVs which support petroleum displacement. The next commentator stated that HEV cold start issues had been addressed by OEMs, and that they would be taken care of adequately in PHEV by these same OEMs. By all forecasts, the penetration of PHEV in the future or near future would be small; therefore, the potential of using them for petroleum displacement would be minimal. The last reviewer stated that the cold start emissions are the leading challenge facing a successful commercialization of PHEVs. This person believes that the task of working to coordinate engine and hybrid vehicle control strategies in tandem will minimize cold start emissions and optimize fuel economy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that the approach taken is quite robust, given the limitations of one vehicle and one powertrain being tested. Another reviewer stated that the approach is reasonable utilizing engine-in-the-loop coupled with a simulated vehicle environment. The basic engine is characterized and control strategies are implemented through an open source prototype engine controller. The reviewer continued, stating that the existing modeling capabilities through Autonomie are leveraged and hybrid vehicle and engine control strategies as a system are assessed by utilizing results from the ANL-ORNL simulation study. This person believed that the focus is to coordinate both engine and vehicle control strategies as a system to minimize PHEV cold start emissions while optimizing fuel economy. Another commenter stated that the project did not have the equipment fast enough to study transient hydrocarbon emissions. This person questioned if the equipment could be rented or borrowed from someone. The last reviewer to respond stated that this small project addresses a specific issue and will provide insight into specific strategies to solve cold start emissions as well as improve vehicle modeling in Autonomie.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that good progress had been made once an industrial partner stepped up. The next reviewer to respond stated that the technical accomplishments and quantification of results for the project had limited. This person felt that this was due primarily



to the difficulty in acquiring a production controller from the industry. Most technical accomplishments have been related to set up and commissioning of the system (both hardware and simulation), though initial testing results are starting to filter in, continued the reviewer. A good example, given by this person, was the implementation of a stratified crank and how it has shown demonstrable improvements in cold start hydrocarbon emissions. This reviewer continued stating that simulation work had been completed to determine optimal vehicle control strategies and that the vehicle system control and engine control strategies still need to be coordinated. Overall, this person believed that it is difficult to determine the success of current technical accomplishments given the paucity of data since there appears to be a fair amount work still to be done to achieve completion by the end of Fiscal Year (FY) 2012. Another reviewer expected more progress to date for the overall budget and duration that this project described. This person observed that the project team had rallied late, by installing the engine on a better dynamometer system that could support hardware in loop testing of the complete hybrid powertrain, especially with the technical support from their new partner, Bosch, for the engine controls access. The last commentator to respond felt that this project was finished sluggishly.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that as of FY 2012, it looked like the external partners were fully engaged in the project. Another reviewer felt that the level of collaboration seemed appropriate given the scope of the project. This person, as well as the next reviewer, believed that it would be beneficial to see more coordination with the OEMs as to direction of the task and possible post FY 2012 activities. The last reviewer felt that the project is purely a learning exercise if the project does not get better support from OEMs.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to respond felt that the proposed future work was appropriate as this task is scheduled to conclude at the end of FY 2012. This reviewer mentioned that the proposed post FY 2012 activities should be carefully vetted with the industry. Another commenter felt that the future plans should build on the results achieved. This person expressed that the impact on overall fuel consumption of the new cold start strategy should be examined, as well as the integration with control system strategies. The next commentator stated that this project had ended and that no significant insight was offered. The last reviewer to respond noticed that the project ends in FY 2012. This person said that it was not clear whether hydrocarbon traps are the most fruitful area of study given the progress made on expediting warm up and maintaining catalyst temperatures.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers to respond felt that the project resources were sufficient. One commenter stated that the resources appeared adequate to accomplish the milestones. Another believed that the current project team and resources seemed sufficient to complete the task. The last reviewer felt that the resources were sufficient, but not well spent.

Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity: Greg Cesiel (General Motors) – vss018

Reviewer Sample Size

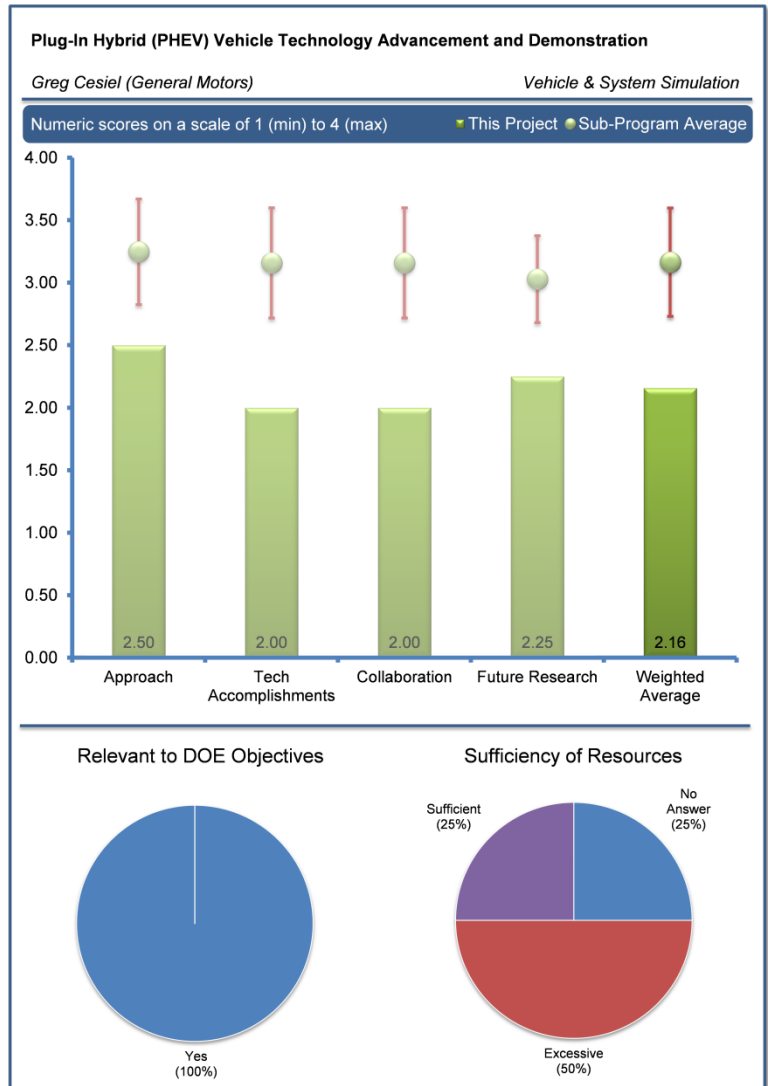
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that because hybrid vehicles will no doubt use less petroleum-based fuel, the project will reduce use of petroleum-based fuel. Another panelist noted that PHEV development clearly supports DOE objectives for petroleum reduction. The last panel member remarked that PHEVs are one of the best ways of reducing fuel consumption, which should fit the overall DOE program goal.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person indicated that the whole approach in general was good, and the key possible technical barriers were identified. Another observer noted that testing and development plan appears to be sound, although very little detail and results were presented to substantiate this. The next reviewer stated that no data or figures support the approaches, and observed only vague wordings or statements. The final panelist noted that the presented objectives of the program appear to be a moving target. This panelist suggested the reader compare Slide 3 of the 2011 presentation to that of the 2012 presentation.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the GM presentation was a weather report, with no substantive technical material presentation. Because there was nothing to show, this reviewer could not evaluate the project, and declined to provide any further scoring. Another panelist concluded that because little or no actual data and results were presented, it was impossible to truly assess progress on the project. This panelist reported that the presenter said the project is on track and has achieved its goals, but offered no proof. The next observer did not find it clear in the presentation that technical targets have been met. This observer agreed that no substantive results or data were presented to support technical accomplishments. The observer pointed out that charge infrastructure was presented as a barrier, but no action was present in this project to address that barrier. This observer concluded that either the barrier should be removed, or technical scope should be added to the project to address such barrier. The final reviewer could not quantify the program progress without any numbers and figures. This reviewer was surprised at the lack of detail presented and was disappointed that the PI was unable to make the presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One panelist reported that two project partners were identified in the presentation, but that details of the role and the extent of the collaborations were missing. Another person said that little collaboration was apparent, and that no results were presented for peer review. The last reviewer noted the project sounded like it had all partners involved, but had no results with data and figures to support it.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person noted the program to be well conceived and future work well planned, and expressed hope that detailed results will be forthcoming. Another person relayed that although the program is winding down, no details were provided on what is next. The last panelist said that too little information was available from the presentation to make any comments.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer observed sufficient resources, while two other reviewers found resources to be excessive. The first reviewer noted that GM resources for vehicle development and testing were excellent and appeared to have been applied to the program appropriately. The second reviewer agreed that given what was presented, it was impossible to judge resources. The final reviewer stated that without reporting tangible progress, the resources can be viewed as excessive.

Ford Plug-In Project: Bringing PHEVs to Market: Julie D'Annunzio (Ford Motor Company) – vss019

Reviewer Sample Size

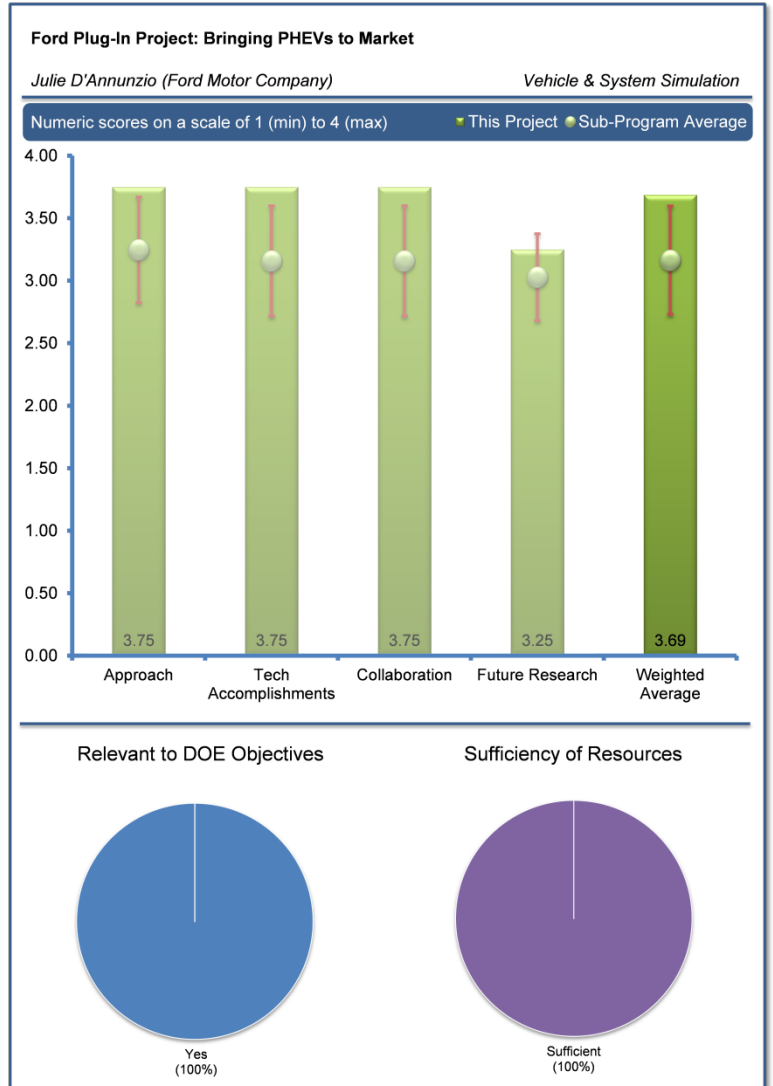
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the displacement of gasoline miles with electric miles clearly supports the reduction of petroleum use since passenger vehicles are considered a big market. Another commentator stated that grid connected electric vehicles have potential to displace a significant amount of petroleum usage in U.S. transportation sector, especially in the light-duty sport utility vehicle market.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commentator affirmed that customer focused development is key to long-term success of commercializing these advanced technologies. Another commenter stated that this project seemed to have been a relatively early, low-budget (pre-ARRA) project with the “let’s just try it” mentality. The person added that, as early experience came in, the designs and expectations were modified to make the vehicles work better.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that, in addition to vehicle performance accomplishments, the team discovered something key to the actual utility of the plug-in hybrid vehicle in the real-world: people just do not bother to plug in. This is interesting and important, but may be correlated with the vehicles not being for personal (or family business) use. According to this reviewer, different types of users might behave very differently, so this needs to be examined. The last reviewer that responded noted that the technical progress is evidenced by planned introduction of a production vehicle that uses the technology advancements from this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that there is evidence of strong collaboration with potential customers and validation partners. Another commentator responded by saying that the collection of utility partners is quite impressive, but additional types of users would give a much more balanced view of PHEV (and user) performance in the real-world.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that the future work indicates focus on harvesting potential for customer realization of fielded technology benefits as well as documentation of fleet performance; these are enablers for future sales of this technology in the market place. Another reviewer stated that future work would include a continuation and completion of tasks already underway. Not thrilling or innovative, just solid, added the reviewer.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the project resources were sufficient. One reviewer stated that this project looked cheap after seeing many of the ARRA projects.

Idaho National Laboratory Testing of Advanced Technology Vehicles: Jim Francfort (Idaho National Laboratory) – vss021

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One commentator stated that this project covers a broad range of technologies with real-world miles. Another investigator stated that this project clearly supports DOE's objectives by providing a well-constructed testing regimen for plug-in electric vehicles and EVSE that is not occurring elsewhere. The last commenter to respond stated that this project performs real-world assessments of high fuel economy (energy efficient) vehicles and determines which vehicle powertrain arrangements/features use the least energy in real-world driving conditions. The results are honest assessments of each technology and completely independent of the OEMs selling the vehicle, added the reviewer.

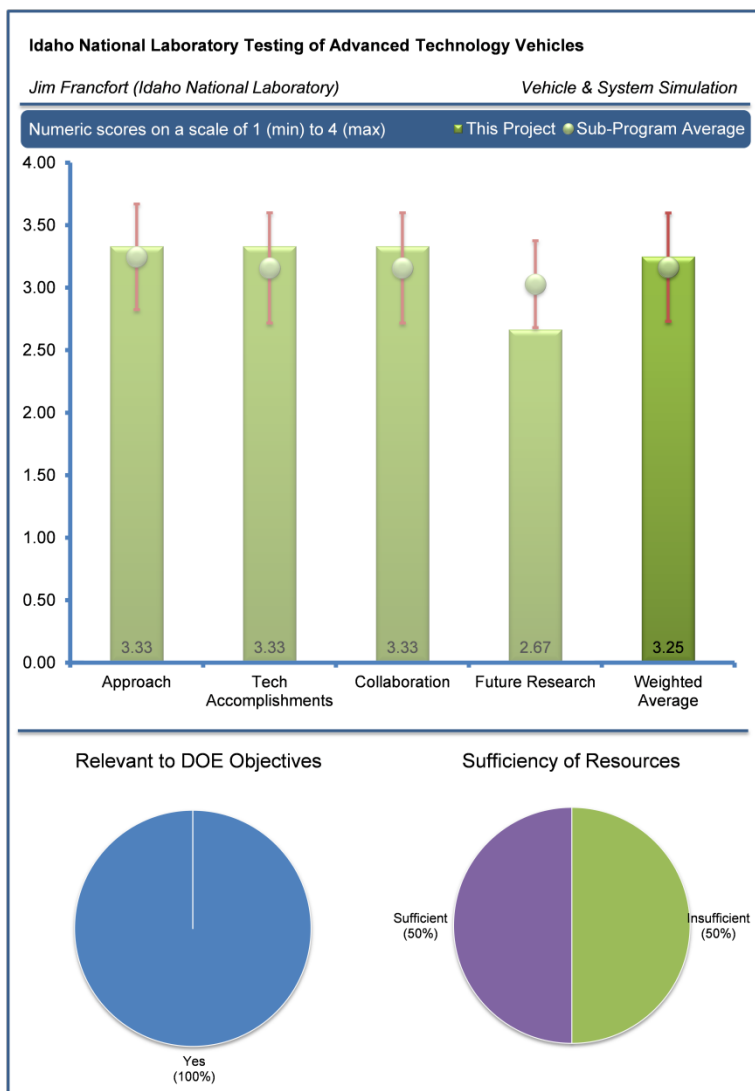
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One responder stated that this project appears to be well-designed to gather copious amounts of useful data.

Another reviewer said that although the broad range was good so far, both best and most likely to succeed technologies need to be identified. The last reviewer to respond stated that the efforts to address the cost barrier are not clearly explained or identified. This person stated that the main barrier is likely vehicle cost to the consumer despite the project's low-cost vehicle testing product. The reviewer continued by saying that it should be more clearly described how the assessment of vehicles reduces their overall cost, especially if a production vehicle is being tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that the progress in overcoming the cost barrier was not clearly identified in the presentation. According to the second reviewer, a significant amount of testing has been performed in many different areas. It was unclear in the presentation how each of the accomplishments relates back to the objectives/barriers. According to this reviewer, the presenters should do a better job of clarifying this. It seems like there are a lot of different projects occurring, but nothing is tying them together (back of the objectives). This reviewer recommends that accomplishments should quantify how much of each objective was satisfied; total progress toward goals is not clear currently. The last reviewer to respond stated that it was unclear how the end state of vehicle testing is defined in this project. Based on the information provided, there are 30+ million miles of data collected with thousands more vehicles on the road providing data; potentially generating 100+ million miles of data. This person was unsure on how many millions of miles worth of data it would take before a conclusion that electric drive vehicles worked or did not work. This reviewer



added that the volume of data produced by this project seems to contradict the public perception that electric vehicles are a new and unproven technology, yet EVs continue to be treated as a mystery. The reviewer concluded by stating that something is missing in this project that is preventing the scores of data collected to be translated into concrete, actionable analyses.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One evaluator stated that there is excellent work coordinating with manufacturers, councils and public groups occurring in this project. Another reviewer felt that it seemed like the partners are working together well, and that data is being communicated between them through the reports being generated. This person stated that it was not clear what and how much vehicle manufacturers are learning from the testing at INL that can help them improve their products. While testing for the DOE to verify OEM claims is important, this may limit the impact of INL testing on removing barriers related to improving the next generation of vehicles, stated the reviewer. The last reviewer stated that while the team's success in leveraging matching resources and forging industry partnerships is admirable, the communication within the federal government's fleet management community is lacking. This reviewer believed that a stronger outreach program is called for. DOE has the ability to influence the federal fleet more directly than private entities or individual consumers, yet, most fleet managers appear oblivious to the presence of these data, remarked the reviewer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer observed that the project was emphasizing conductive EVSE and wireless charging. Another reviewer stated that work will continue in many areas, but was not clear whether the proposed work would help meet the objectives stated. The future work was very general sounding and more specific information should be provided, added the reviewer. The last commentator to respond felt that, with the exception of wireless charging, the proposed future work does not suggest any new lines of activity that might advance new technologies or better inform consumers regarding current technologies. This person added that the data produced by this project are tremendously valuable, but the project risks stagnation if there is not a more cohesive and, frankly, ambitious vision for the future. Simply testing new models of vehicles does little to address the underlying problem that consumers are generally hesitant to adopt electric vehicles. This reviewer noted that producing summary reports is great, but the reviewer would like to know who is using those data to solve problems. This team reports that the Dodge Ram PHEVs are averaging about 19 mpg. Chrysler has indicated that the vehicles are supposed to get roughly 35 miles per gallon. This reviewer believes, unless there is a misunderstanding in interpreting the data, there is a pretty huge discrepancy between these results. Yet, according to this reviewer, rather than dig deeper into why that discrepancy exists, the team proposes to test additional vehicle models. The reviewer concluded by stating that if 30+ million miles of data are insufficient to address these issues, it is unclear what another 100+ million miles will provide.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found that funding is insufficient. One reviewer said that this project could use additional resources to perform a deeper analysis of the data it has already collected and expand its outreach efforts. Two reviewers found that funding is sufficient. A reviewer stated that project funding could increase if specific goals are expanded. Another reviewer felt that the resources appeared to be sufficient for vehicle/component testing. The equipment and testing procedures for advanced powertrains is evolving rapidly, so INL should work to meet or exceed the capabilities of OEMs.

Advanced Vehicle Testing & Evaluation: Don Karner (ECOTality North America) – vss029

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

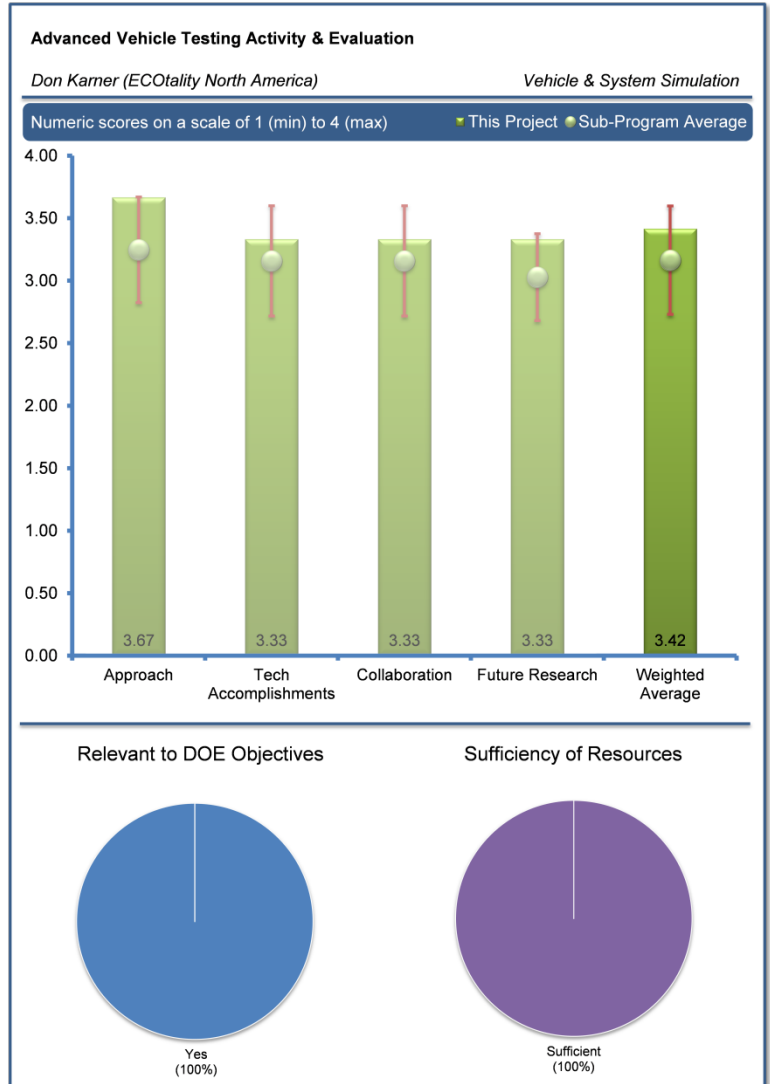
One reviewer stated that Antelope Valley Transit Authority is very important in order to speed the development of EVs for personal transportation. A second commenter felt that data collection and open publication on real-world performance of electrified vehicles will help researchers and infrastructure providers understand the societal impact. The independent evaluations of the various architectures and makers will help consumers make informed choices, thereby strengthening the market. The last reviewer stated that this is a key infrastructure contract for DOE to evaluate the actual field performance of multiple vehicle technologies.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
One reviewer stated that the project and operations appear to be well organized and tracked. The reviewer continued saying that the approach appears successful in conducting the required testing on behalf of DOE.

Another commenter stated that the team has long experience in this field and is committed to staying current in this rapidly changing space and that the technical barriers seem surmountable by the research team. The next respondent stated that this program is mature and has been refined over the years to be sharply focused on providing consistent unbiased data to DOE and the industry. Now that several EVs are in the mainstream market, this program could serve additional duty as a consumer information program. The reported results would need to be repackaged and presented in a more consumer like fashion, added the reviewer. The expert continued to mention that one of the public's concerns is the life of the battery pack. By using this program as outreach, perhaps more consumers would be persuaded to purchase EVs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the data collection is conducted on plan and on schedule with on-going quality checks. Another respondent felt that the program appeared to maintain the balance of testing production vehicles and enough new pre-production technology to keep it at the leading edge. This reviewer continued saying that this is a large program that stays in front of the technology helping to pull it into the mainstream while weeding out the lesser solutions. The final reviewer stated that the project appears on track for all relevant measures. This reviewer added that this project is service-oriented rather than development of new technology.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One respondent felt that the collaboration with INL was effective and essential. It is thus beneficial to maintain a long-term relationship, expressed this reviewer. Another reviewer stated that the collaboration with technology developers, vehicle manufacturers, and fleets is strong and seemingly productive. The next reviewer stated that it was not obvious if there was an additional opportunity to look for best practices in vehicle testing from the private sector (reaching beyond basic contract terms). This reviewer would encourage the project to collaborate on efficient test methods with OEMs that have done this kind of field testing for years. If this collaboration happens with the private sector (i.e., outside the National Lab partners), it is not obvious from the presentation, added the reviewer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One responder stated that based on previous performance they do not anticipate any difficulty with future projects of a similar nature. Another reviewer said that continuous upkeep of test procedures is evident. The commentator continued, stating that future research is guided by DOE technology selections. The last reviewer stated that despite being early into the new contract, there are no known disconnects related to resources versus performance expectations of the project.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers to respond felt that the project resources were sufficient. The first reviewer commented that the resources necessary to conduct this testing appear sufficient. Given the nature of the work and the history of the program the cost estimating process should be mostly academic. Another reviewer felt that the resources appeared to match the need to execute as vehicles are available to test. The use of private fleets for mileage accumulation seems appropriate and well-executed. The last commenter to respond agreed in saying that the projects are executed on schedule.

Advanced Technology Vehicle Lab Benchmarking - Level 1: Henning Lohse- Busch (Argonne National Laboratory) – vss030

Reviewer Sample Size

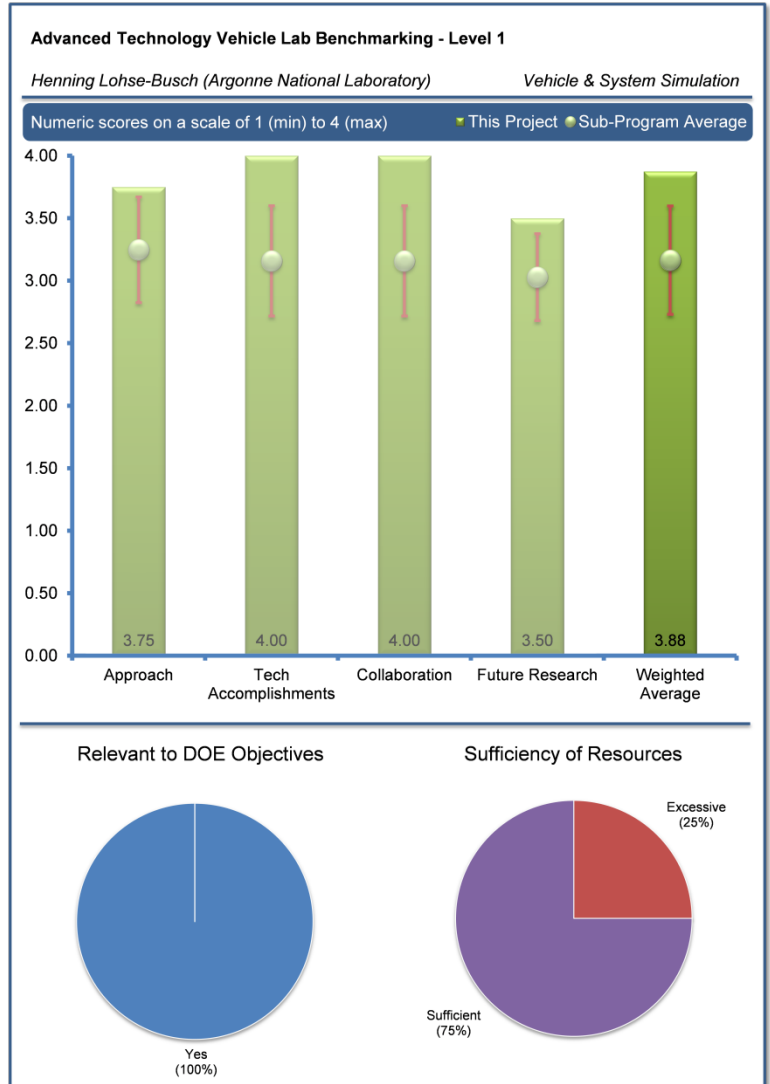
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first commenter felt that advanced technology vehicle testing is important to benchmark the state-of-the-art for powertrain systems and components. This independent evaluation of technology facilitates confidence in the technology and provides a basis in which to establish technical targets for the next generation of advanced vehicles. The reviewer continued by saying that testing acts as an enabler to accelerate technology development (feeding results back to industry) and commercial implementation. The next reviewer believed that benchmarking is critical in order to give DOE a reference for future project decisions and evaluations on technology performance and relevance. The final reviewer agreed and said that by benchmarking the leading EV technology, petroleum displacement is supported by speeding the development of effective and practical EVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that the project’s approach has been perfected over the years and the ideas for improvement are revealed along the way as new testing challenges emerge. The second reviewer remarked solid approach refined over years of experience. According to the third reviewer, this task is well-established and mature having been in existence since 1998. The reviewer added that most of the earlier challenges have long since been worked out and resolved. A proficient testing approach customizable to specific vehicles has been established. The commentator continued to state that a continuous improvement in testing procedures has been achieved and standards test plans including instrumentation and drive cycles. Test facilities and instrumentation have been steadily built up over the years and largely completed with the recent commission of five-cycle testing and hot (solar) and cold testing capability. A well-defined sequential process has been established between ANL, other DOE labs, and U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability (U.S. DRIVE) to identify, select, and evaluate advanced technology vehicles. It is not likely there are any significant glitches in the approach or process at this stage; however, there may be smaller opportunities to further enhance overall operating efficiency which should be continuously explored and implemented. The last commenter felt that there was an excessive amount of detail on few vehicles that were likely to miss incremental improvements in technology.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter stated that benchmarking of lower cost HEV technology was completed and provided characterization of other leading EV topologies. The second reviewer stated that given the level of funding for this task in FY 2011 (\$850,000) and FY 2012 (\$600,000), technical accomplishments and progress appear adequate. The Hyundai Sonata P2 (parallel) HEV has been benchmark tested, the Nissan Leaf efficiency (including systems)/range at hot/cold temperatures has been established, and J1711 concepts validated on the Chevrolet Volt, added the same reviewer. A significant number of publications and presentations have been generated. The third reviewer said that this Level 1 benchmarking has had a refined process over many years of experience. The person added that it accomplishes its mission and that the challenge now is to adapt to new capabilities of lab facility (e.g., hot/cold conditions). The final reviewer felt that the goals were too narrow, despite the good progress being made against them.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that collaboration and coordination is well established for this task with SAE (domestically and internationally), U.S. DRIVE and OEMs, other DOE labs, as well as internally with ANL modeling and simulation. The level of collaboration and coordination is good for this effort; nonetheless efforts should always be active to consider broadening collaboration as necessary. The second reviewer believed that ANL collaboration and coordination is critical due to the position they occupy in the process. They are in the center of the activity coordinating with every direct EV stakeholder. Another reviewer said that it appeared that the project communicated well about the collaboration that is ongoing in the industry related to this benchmarking activity. The reviewer continued to add that this project particularly emphasizes the involvement of public/private interests. The final reviewer pointed out that the data was open to wide range of industry as well as academic and government entities.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that future research is right on target with the current hurdles EVs face, i.e., operating at extreme temperatures without a significant loss of range and efficiency. The reviewer agreed that overcoming this barrier is necessary for widespread EV proliferation. The next reviewer stated that as a data collection/dissemination service project, ongoing work is tied to selection of vehicles for test and timely performance of same. This person described that the future work is more of the same and seems appropriate. The final commenter mentioned that proposed future testing activities are based on outcomes of DOE/INL/ANL/ECOTality summit meeting. This person continued saying that only vehicles that have unique technical features or upgrades are considered for testing. The reviewer described that many OEMs are now adding novel warm-up hardware and controls and the new PHEVs/ battery electric-vehicles are coming out from OEMs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers to respond felt that the project resources were sufficient. One of the reviewers said the modest budget appears to be sufficient for the level of work planned for execution. Another reviewer stated that current throughput was probably matched with funding level. This reviewer acknowledged that with more OEM offerings arriving on the market globally (with unique architectures/component sets) DOE should consider biasing more funding to this activity. The final reviewer stated that this task is adequately funded. This reviewer noted that steady efforts should be made to further improve efficiencies and lower testing/evaluation costs if at all possible. Per this reviewer, this is a good time to do this as facility upgrades are now completed, in operation, and utilization processes under way. The final expert to comment observed that a lot of money was used to test eight vehicles, most of which already have publicly available data.

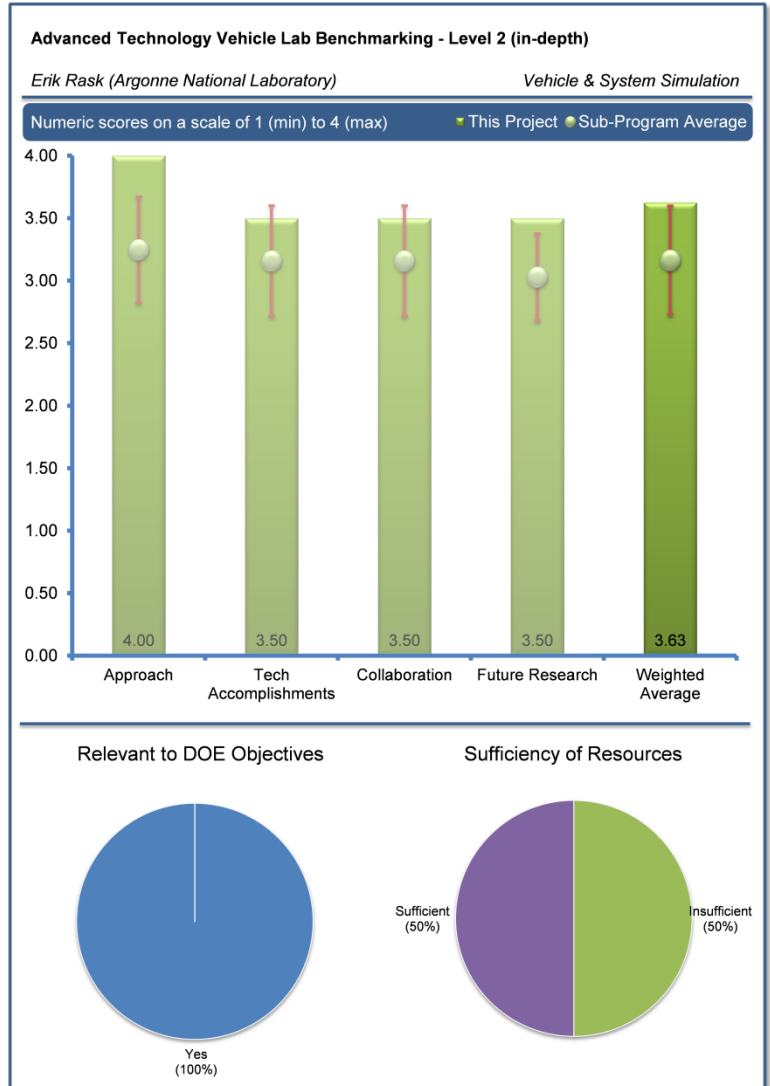
Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth): Eric Risk (Argonne National Laboratory) – vss031

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that this project had a good objective. One of the commentators agreed that benchmarking is critical in order to give DOE a reference for future project decisions and evaluations on technology performance and relevance. Another reviewer stated that ANL Level 2 benchmarking is at the leading edge of EV technology and showcases what is possible for today through detailed data, speeding the adoption of new EV ideas and advanced non-EV vehicles. The final reviewer stated that advanced technology vehicle testing is important to benchmark the state-of-the-art for powertrain systems and components. This reviewer continued saying that this independent evaluation of technology facilitates confidence in the technology and provides a basis in which to establish technical targets for the next generation of advanced vehicles. This reviewer also believed that this testing/evaluation acts as an enabler to accelerate technology development (feeding results back to industry) and commercial implementation.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that this project is excellent work and appears to be well organized to accomplish the intended detailed (component and systems levels) performance data. The reviewer concluded that this is a good natural extension from Level 1 benchmarking effort. According to the second reviewer, the Level 2 benchmarking and the vehicle selections keep the focus on practical petroleum displacement. By selecting non-U.S. market vehicles new ideas can be introduced into the U.S. product development process. Propulsion design and control remains both art and science. Concluded this reviewer, this is excellent work. Another reviewer found that the Advanced Technology Vehicle Lab Benchmarking – Level 2 is the in-depth invasive instrumentation/testing used for detailed analysis of power flows, components, duty cycles etc. for a small subset of vehicles of particular interest to DOE and OEMs. Only vehicles with specific uniqueness of their technologies and thought to be on the cutting edge of advancements are selected for Level 2 testing. According to this reviewer, this task is well established and mature with most of the testing/instrumentation challenges having been previously worked out and resolved. A proficient testing approach has been established with a continuous improvement in testing procedures, and test plans including instrumentation and drive cycles. Test facilities and instrumentation have been steadily built up over the years and largely completed with the recent commission of five-cycle testing and hot (solar) and cold testing capability. This reviewer concluded by stating that it is not likely there are any significant glitches in the approach or process at this stage given its maturity; however, there may be opportunities

to enhance overall operating efficiency which should be continuously explored and implemented. The final reviewer observed that the project provides data not available from other sources and that can be used to guide future work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewers generally felt that the information provided was comprehensive and showed useful data and formatting. One commenter stated that the project appeared to be on track. This person continued to say that given the level of funding for this task in FY 2011 (\$850,000) and FY 2012 (\$200,000), technical accomplishments and progress are good. Another reviewer continued saying that this task has conducted detailed analysis of the Hyundai Sonata including electric machine evaluation and cold start strategies. Another reviewer acknowledged that the Chevrolet Volt's unique charge sustaining operation and overall operating strategy have been examined while the Volkswagen TSI has been extensively benchmarked including its use of a reduced engine size, boosting, and a low-loss transmission. The last reviewer mentioned that with the temperature control of the dynamometer test chamber, Level 2 testing can achieve a new level of significance for DOE and the industry.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One commenter stated that there is a broad range of industry and other groups involved in this project. Another reviewer felt that collaboration and coordination is well established for this task with SAE for standards activities (domestically and internationally), U.S. DRIVE and OEMs, other DOE labs, as well as internally with ANL modeling and simulation. The same reviewer felt that the level of collaboration and coordination is good for this effort; nonetheless efforts should always be active to consider broadening collaboration as necessary. The third commenter mentioned that the network of other institutions is obvious and extensive. This person said that, similar to a 2011 comment, the presentation could include a block (process) diagram for how the collaborative community chooses the vehicles for tests (not just why they were ultimately chosen). This person felt that the block diagrams emphasize on how the voices of the collaborators are integrated for selection. The final commentator suggested that due to their position in the test process, ANL must collaborate and coordinate with the main industry and government stakeholders.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer mentioned that the Peugeot 3008 HYbrid4 will be evaluated given its unique vehicle configuration as a diesel hybrid with a stop-start system. This person noticed that this system allows for many different and unique operating modes. Given limited resources in FY 2012, this reviewer feels that the Peugeot seems like a good choice. The second reviewer believed that the testing of the Peugeot will likely reveal new concepts for propulsion design and control that yet to be employed in the U.S. industry. This reviewer believed that this will help the U.S. industry remain relevant and perhaps spawn new ideas yet to be tried anywhere. Another commentator stated that as a data collection/dissemination service project, ongoing work is tied to a selection of vehicles for testing. Future work is more of the same and seems appropriate, added the commentator. The final reviewer remarked that only one vehicle limits the scope.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two of the reviewers to respond felt that the project resources were sufficient. Two experts thought the project's resources were insufficient. According to one reviewer, this task will probably need to be more sufficiently funded in the future given the range of new vehicle entrants both across electric drive and advanced conventional technologies. Steady efforts should be made to further improve operating efficiencies and lower testing/evaluation costs if at all possible. According to this reviewer, this is a good time to do this as facility upgrades are now completed, in operation, and utilization processes under way. Unfortunately, the cost of Level 2 benchmarking can severely limit the number of evaluations in any given year. A second reviewer remarked well worth the cost to provide meaningful evaluation of competing technologies. A third reviewer remarked that resources appear to be sufficient to test most of the leading designs at a rate at which they emerge in the marketplace, and the final reviewer agrees the rate of vehicles (currently a pace of three per year) is probably matched to funding/resource level. According to this reviewer, with more OEM offerings arriving on the market globally (with unique architectures/component sets), DOE should consider biasing more funding to this activity.

Electric Drive and Advanced Battery and Components Testbed (EDAB): Barney Carlson (Idaho National Laboratory) – vss033

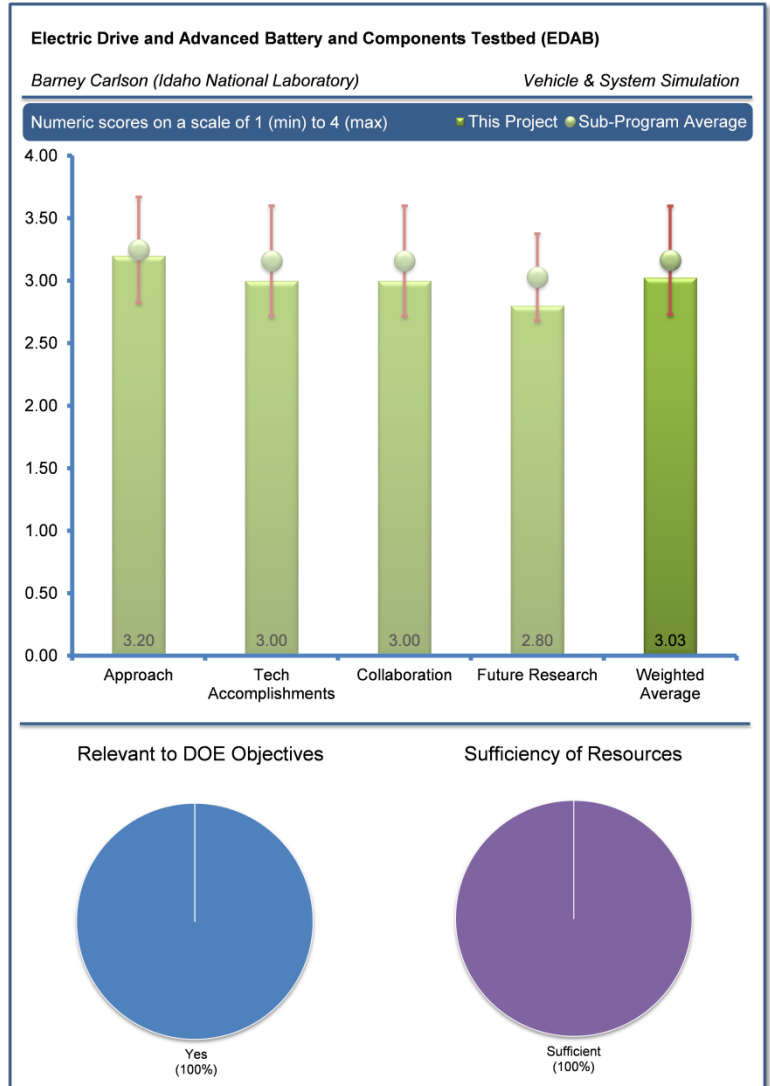
Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One respondent stated that this project provides a consistent controlled method for evaluating different energy storage systems for plug-in electric vehicles. Another respondent stated that the test bed allows for pre-production vehicle battery testing in a vehicle environment. The next reviewer said that battery technology is the single most important barrier to widespread EV adoption. Another commentator mentioned that evaluating new batteries for HEVs will hopefully reduce petroleum use.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? According to the first reviewer, the ability to evaluate battery packs in a real-world environment without building a car could save a great deal of time and expense. The second reviewer found that this project has a clear technical objective and appears to have executed a sound strategy to meet its technical objectives. The third reviewer concluded that the project is well-designed and well-executed. The team has made great progress towards building a functional system that can emulate various vehicle conditions through the series driveline. This reviewer's main concern with the proposed approach was that it is unclear what the benefit is of on-vehicle testing compared to lab testing. The presenters noted that there may be some interactions between the battery and other components of the vehicle that may be difficult to identify when emulating the road conditions in the lab. This is a valid point; however, to this reviewer it was difficult to see how this hurdle is overcome by emulating the known behaviors of the vehicle on a moving platform. The interactions between the components will only be visible when the actual components are used. This reviewer suggested that an interesting approach may be to refocus the project to better understand the interactions between the components and include these interactions in lab testing or even in testing standards development rather than building additional mule vehicles. The final reviewer was just not sure there is a great argument for doing this work in a vehicle. The reviewer understood that being out on the road allows ambient condition variability and real shock loads, but also that the shock loads are those for a pickup truck not the target vehicle and not production mounting. It seemed to this reviewer that if project implementers are going to make a pickup truck act like a Nissan Leaf then implementers can make a test cell act like a Nissan Leaf and run it 24 hours a day with test cell quality instrumentation and data logging and introduce the driving variation that implementers would like to understand in a controlled test environment.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer believed that the team has made significant progress toward meeting the project objectives. The second investigator stated that progress seemed to be good towards the plan and milestones. The investigator said that the calibration of controls to match baseline vehicle looked quite good. The third commentator felt that it is unfortunate that the initial battery to be tested comes from a company that just went bankrupt. The reviewer added, that aside, it would be helpful to have a clearly articulated strategy for selecting different energy storage systems for testing. The reviewer believed that this would help clarify the research objectives and better define the relevance of the results. The final reviewer expressed that the project needs a little more proof of correlation to in-vehicle use.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A respondent noted that the project team appears to have formed the core collaborations necessary to execute this project. Another reviewer stated that collaboration with ORNL, AVL and ECotality is sufficient, and has led to the fast progress of the project. The next commenter stated that it seems like appropriate collaboration is happening. The reviewer added that Oak Ridge came through on the controls and AVL with the vehicle dynamometer system. The last commentator mentioned that the role of collaborators seemed limited to the stage of project they are involved in and not enough industry/trade involvement was occurring.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One of the reviewers observed that the goal seemed very limited but is commensurate with funding. The next reviewer noticed that the plan was built on past progress and generally addressed overcoming barriers. Another respondent pointed out that the team states that they will test different energy storage systems, but it does not describe how or why each system will be selected for testing. One of the reviewers mentioned it seems like a lot of work to test a component without its accompanying production intent system around it, so new components are getting tested with current knowledge controls and other system components. The same reviewer inquired whether these could be included in a retrofit of the production vehicle. The reviewer believed that a new battery could be integrated with the current Nissan Leaf.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers to respond felt that the project resources were sufficient. A reviewer agreed that the team has effectively executed the project to this point, so it appears that existing resources are sufficient. A second reviewer said resources are sufficient to achieve the stated milestones in a timely fashion. Another reviewer would recommend more funding and broader goal (multiple units and involvement of industry). The final investigator said that it is hard to judge, but with all of the hardware in place and the controls and dynamometer work, it seems like the FY 2012 budget can go down from FY 2011.

**Advanced LD Engine Systems and Emissions Control Modeling and Analysis:
Stuart Daw (Oak Ridge National Laboratory)
- vss041**

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

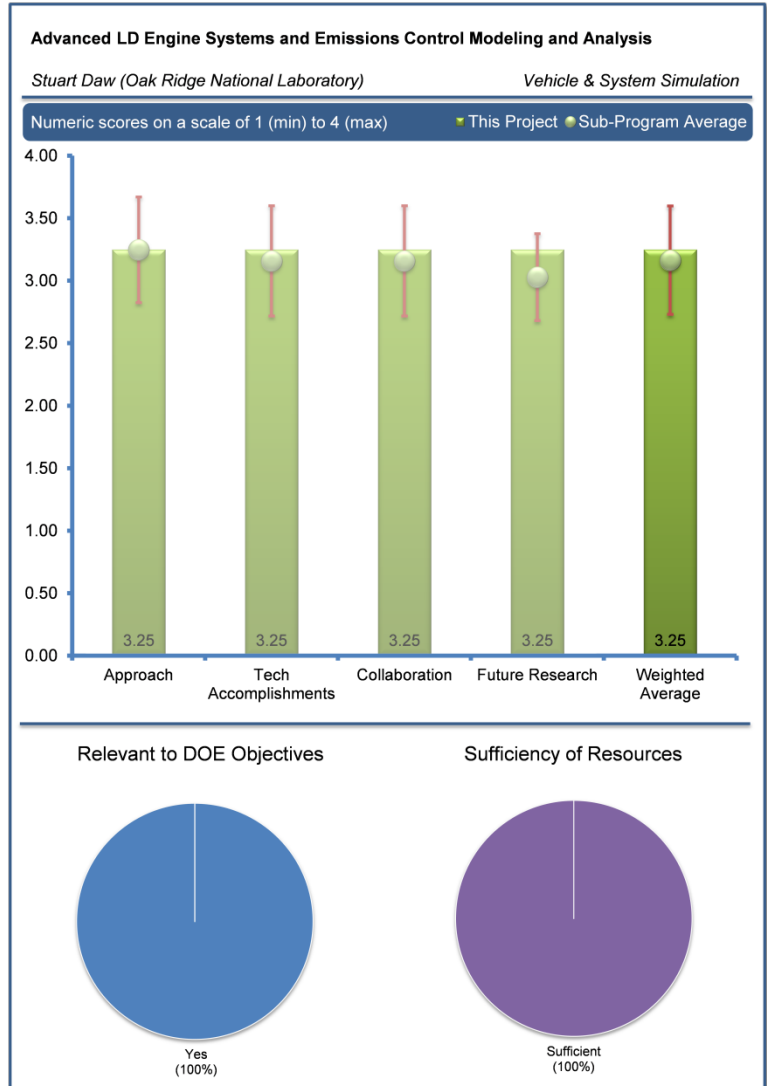
One reviewer pointed out that improving the fuel economy on Class 8 Trucks would reduce overall petroleum usage in the U.S. This reviewer also exclaimed that SuperTruck is a key program. Another panelist reported that the project is set up well to increase the efficiency of the internal combustion engine component of hybrid powertrains. The next person indicated that these advanced technology engines would have a good chance to get into HEVs in the near future, and that their fuel savings would be significant especially if non-petroleum fuel is used. The final reviewer considered this project to be relevant to the development of system optimization tools for efficient development of future powertrain systems. This reviewer, however, questioned how all of the many disparate elements shown in the presentation will eventually come together to meaningfully simulate systems in the real-world.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One observer indicated that this approach was a breath of fresh air, as it brings new eyes to look at this issue. However, this observer was disappointed that the conclusions arrived at were not new, and wondered if this project could keep pace with the industry. Another reviewer relayed that the approach is coordinated to a number of other projects, and is addressing some of the model gaps in new, emerging technologies. This reviewer opined that as presented, the project seemed to be a bit random in how these gaps were being chosen for study. The same reviewer recommended that future project presentations be introduced with a definition of the objectives and the paths to achieve the objectives, as this is a broad area of potential study that can get very random in nature if not executed around a planned set of outcomes. The final panelist asked how the researchers obtained the engine maps.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panel member stated that the project is only six months old and needs to progress further to assess long-term progress, but that short-term looks quite good. Another reviewer agreed that the progress is reasonable so far. The next observer remarked that this was good, but needed to be better. The last panelist observed that test conditions justified the work on the conventional Ford Fusion that was mentioned, even though this detracted from a project whose focus is hybrids. This reviewer stated that the



presentation raised the question of whether the project had too much conventional engine work, although it could have been the presentation more than the work itself, which was harder to assess.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that most of the collaborations are within DOE groups, and suggested that improvement could be made with more industry input and collaborations, whose input for ultimate application of the work would be useful. Another reviewer pointed out that real engine maps from OEMs or the best engines would not become available in the near future. This reviewer further recommended that the reviewers consider using some less-than-perfect engine maps and other data to construct the project team's model, improve it after iterations, and let OEMs run the model to obtain some results. The same reviewer pointed out that this may yield surprising results.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panelist opined that this program needs to be pushed further; to start pushing the envelope like Navistar. This panelist stated there was not much new in terms of conclusions. The next reviewer would have liked to see industry needs investigated and defined, as well as a plan on how these may be addressed to assure use of this work. Another reviewer noted the proposed future research was acceptable.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All respondents found the resources to be sufficient.

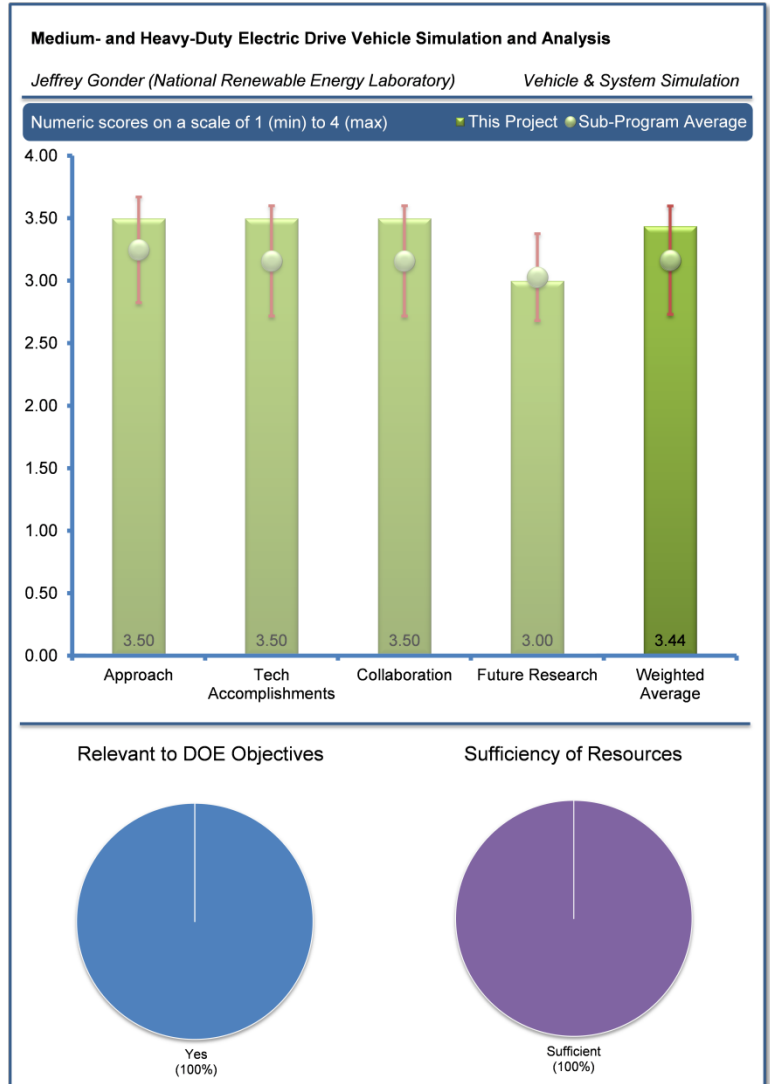
Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis: Jeffrey Gonder (National Renewable Energy Laboratory) – vss043

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One expert stated that this project studies circumstances where PHEVs or HEVs are best for users and the consequences on petroleum displacement. A second reviewer added that well-to-wheel efficiency of medium-duty delivery trucks and heavy-duty trucks can, of course, be significantly improved with the addition of electric drive. The same reviewer was unsure if this could allow us to reduce the total cost of ownership. This person added that if the battery costs dropped significantly, and petroleum prices rose sharply, there would probably be no need to justify investing in electric drive vehicles, but until then, this study provides valuable information. According to the third reviewer, the outcome of the project will be to help determine the optimal sizing on a PHEV drivetrain for fastest payback time. This, in turn, could help the adoption of PHEVs for MD applications. The final commentator noted that any data that can be supplied to potential customers on the applicability and costs associated with the products and their payback on particular applications and routes is a good thing. Picking the battery pack for potential replacement as a variable as well was a good thought. Battery cost replacement will be a worry and of concern to many potential buyers. Common urban drive cycles will need to be combined with range requirements, by the customer, to determine best battery pack sizing.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the project was well-designed and well-executed. A second expert stated that the team is sharply focused on addressing the technical barriers. The problem is multi-dimensional but the team was able to consider all of the major parameters in enough detail to give confidence in the results. The reviewer added that through various partnerships, the team will validate the modeling approach on actual production vehicles. Another reviewer noticed that the project provides plenty of evidence (in terms of total cost of ownership and in terms of validity of the simulation methodologies that were used to arrive at these conclusions) to support the adoption of electric vehicles for MD and (to a lesser extent) HD fleets. One of the technical barriers that was listed was risk aversion. One person suggested that perhaps more could be done to bring in results of other DOE funded projects that show the low levels of risk involved in the adoption of these technologies. This reviewer suggested perhaps the battery testing at INL, showing the battery state after 160,000 + miles of use. The last commenter simply stated that the study seems to have picked relevant drive cycles for the potential of the EVs versus the baseline diesel vehicle.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The team has made excellent progress towards the objectives stated one expert. The reviewer stated that the researchers have identified cost-effectiveness crossover criteria as a key metric/outcome of the study – a metric that will be of great interest to the community. Another commentator remarked that the technical accomplishments were good, and added that the project seemed to have selected the appropriate variables to try and model and analyze; that is, battery size, drive cycle, and then verifying and correlating data with that already existing. Another expert expressed that the adoption of PHEV is still dependent on government incentives. The final evaluator observed that the direction of the project appears to have taken a slightly different turn from the previous year, perhaps because of the change in the PI for the project, but otherwise significant progress has been made.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One expert believed that there was a good mix of commercial and government partners, and a second reviewer also observed a good combination of partners' results/resources and the team's own work. Another person stated that the collaboration with other institutions is outstanding. The team has partnered with component and vehicle manufacturers in order to validate their cost and parametric models. The team has also brought in the substantial work already done at the labs, for example, on battery degradation. The final reviewer referenced comments made in question two concerning how the direction of the project has changed since the previous year.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the future plan is very good. Making the models available to the public would encourage more interest in the technology, both from the industry perspective so that they can run their own models, and from the educational perspective. Another expert suggested that it is good that the project is considering adding grade to drive cycles for future work. However, all the analyses are restricted to just three drive cycles (the Heavy Duty Urban Dynamometer Driving Schedule, Hybrid Truck Users Forum Class 4 Parcel Delivery Driving Schedule, and the Orange County Bus Cycle) and wondered if it makes more sense to use many more drive cycles - several hundred if possible, to get a better idea of the spread that one would expect to see in the results. The reviewer felt that as long as this is done using simulation with a validated model, it should not be very expensive. Another reviewer suggested that the researchers consider limiting the scope of the research and this project to just MD vocations. The reviewer added that HD drive cycles are different enough from MD to potentially have significantly different results and paybacks. The last commentator stated that future research addresses problems identified in the current research and includes more plausible and important alternatives. The reviewer concluded by stating that the proposed future research lacks focus and the presenter seems uncommitted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers who responded felt that the project resources were sufficient. One expert commented the well-defined study matches resource with necessary efforts. Another stated that there is not a lot of time left for the completion of the project, and a significant change in resources at this point is not warranted. The final evaluator noticed that there was no slide addressing the resources consumed or required to complete the project.

LDV HVAC Model Development and Validation: Jason Lustbader (National Renewable Energy Laboratory) – vss045

Reviewer Sample Size

This project was reviewed by four reviewers.

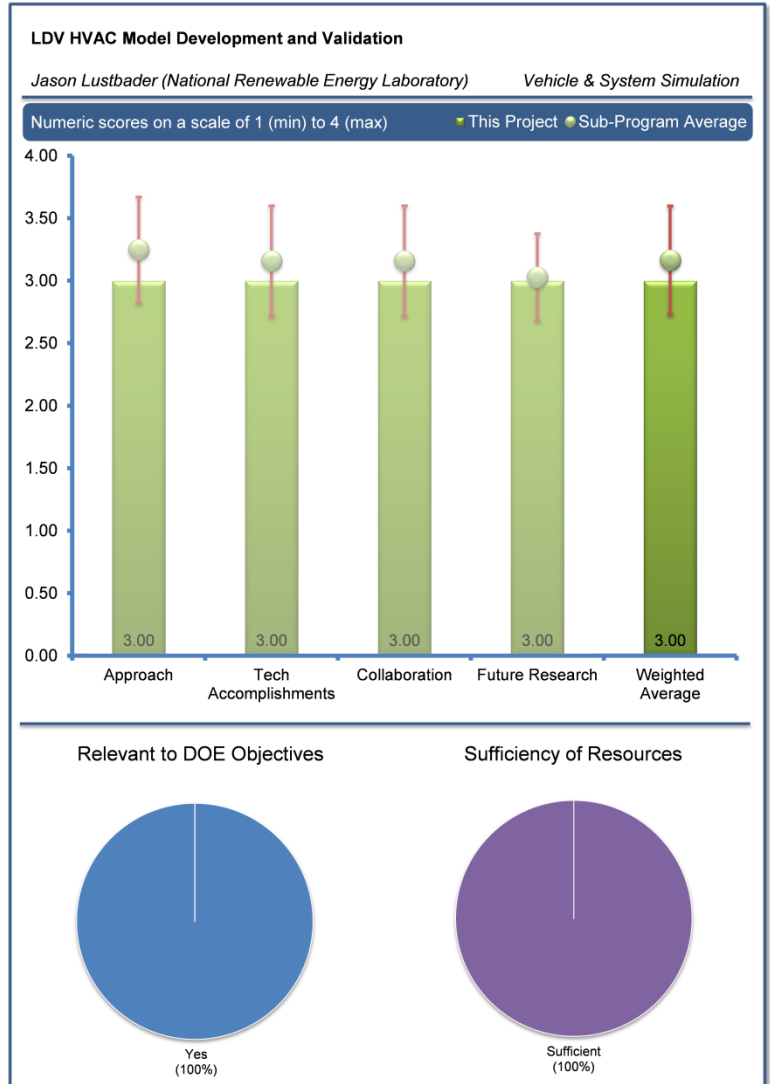
Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer expressed how this is important work with a highly qualified team that has been working in this area for some time. The reviewer added that air-conditioning (A/C) loads account for more than 5% of the fuel used annually for light-duty vehicles. A second expert stated that the A/C has large impact on fuel economy of vehicles and by modeling A/C the effects of proposed improvements can be calculated before they are implemented. The final commentator found that in general, yes the project supports DOE objectives, and remarked that having good models will help engineers do better system design and optimization for the complex vehicle systems that will help reduce petroleum use.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer concluded that it is a good approach overall to model the components in the system. It is also good that the model has been correlated to physical

results. The reviewer understands that other software packages will not plug into Simulink but the Simulink model results could be compared with other accepted software for A/C that do not plug into Simulink. The second reviewer found that having an open source thermal model that is validated is very useful to designers and users of the technology. Other people have thermal models but their models cannot link fuel consumption to HVAC loads. With EVs this work is even more important. Another reviewer remarked this is good, but that it is not rocket science either. For this reviewer, what would be interesting is whether our expectations in the United States much greater for A/C than that, say in Europe. This reviewer wondered whether our comfort expectations are making us spend more fuel. The final reviewer thinks that the project is not clearly stating why a new tool is needed to be created from scratch. Commercial tools can do this modeling. Per this reviewer, when asked about benchmarking commercial tools, the presenter gave an answer that sounded like commercial tools could not do the things this model does. This reviewer's understanding is that tools like GTSuite can do A/C system modeling with physics-based heat exchangers and transients. This reviewer acknowledges that a commercial tool is not freely available in terms of zero licensing cost. This reviewer commented that when DOE spends money to develop a tool that might already exist commercially, it needs to be clear on the objective. If another tool already exists that does something similar, it would be a good effort to compare the new tool to the benchmark to ensure accuracy. However, the reviewer found that for the model desired, the technical approach seems good. Lumping pipes to one per pass sounds like a good tradeoff of detail for execution speed. This reviewer noted that keeping it



fully transient capable sounds like the right thing in order to be useful for drive cycles and transient controls evaluation and development.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter stated that this was a realistic research plan with timeline and goals. Another reviewer thought there was good progress towards goals made. This reviewer added that it looks like the electric A/C model is slightly behind schedule. Model validation was done for condenser and evaporator and evaporator heat transfer coefficient was corrected. It seemed to this reviewer that some key pieces, like mapping of the components, have yet to be decided on for funding. This reviewer was not sure why this scope was not part of the original two years of funding for the project; or, if the scope was included and the timeline has slipped. The final reviewer said that if it can be assumed that a model needed to be developed from scratch, then it looks like good progress on creating the model. This person felt that the condenser heat transfer looks to match well. In this reviewer's experience with two-phase flow system, a 6% evaporator heat transfer match seems a little high. The reviewer concluded by acknowledging that some plans to improve this match were discussed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One expert stated that collaboration seemed appropriate and that test data results from Visteon seemed appropriate. Another person mentioned that the project team is publishing their work in SAE and suggests the team expands their publications to American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) papers as well. This reviewer pointed out that the ASHRAE Handbook covers HVAC design for vehicles. The next commentator noticed that it was not mentioned in the slide for latest work if collaboration is still being done with Volvo. The reviewer stated that if it was not, the reviewer would be very interested in the results.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert suggested including ASHRAE Standard 55 (which includes indoor air quality) in model. Another person suggested referencing prior comments on expectations for A/C in the United States versus, for instance, Europe. The reviewer inquired if our self-cooling expectations and need for creature comfort is costing the United States more money in petroleum dollars. A third reviewer believed that some the goals will not be realized if funding is not obtained for 2013. The final reviewer would like to know why it looks like the model will be released in FY 2012, but the user's guide will not be available until FY 2013. This person added that it seems like the user's guide would be needed when the model is released.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers to respond felt that the project resources were sufficient. One expert stated that funding is sufficient but additional projects should be considered. The reviewer noted that the present goal is a thermal model that is linked to fuel consumption. The reviewer suggested expanding this goal to include actual truck routes with global positioning system, traffic and road conditions (incline) in this model in future years. A user needs to know how much money they will save. This reviewer noted that life cycle cost should also be included. However, this reviewer emphasizes that these suggestions do NOT take away the opinion that this is excellent work.

Integrated Vehicle Thermal Management - Combining Fluid Loops in Electric Drive Vehicles: John Rugh (National Renewable Energy Laboratory) – vss046

Reviewer Sample Size

This project was reviewed by six reviewers.

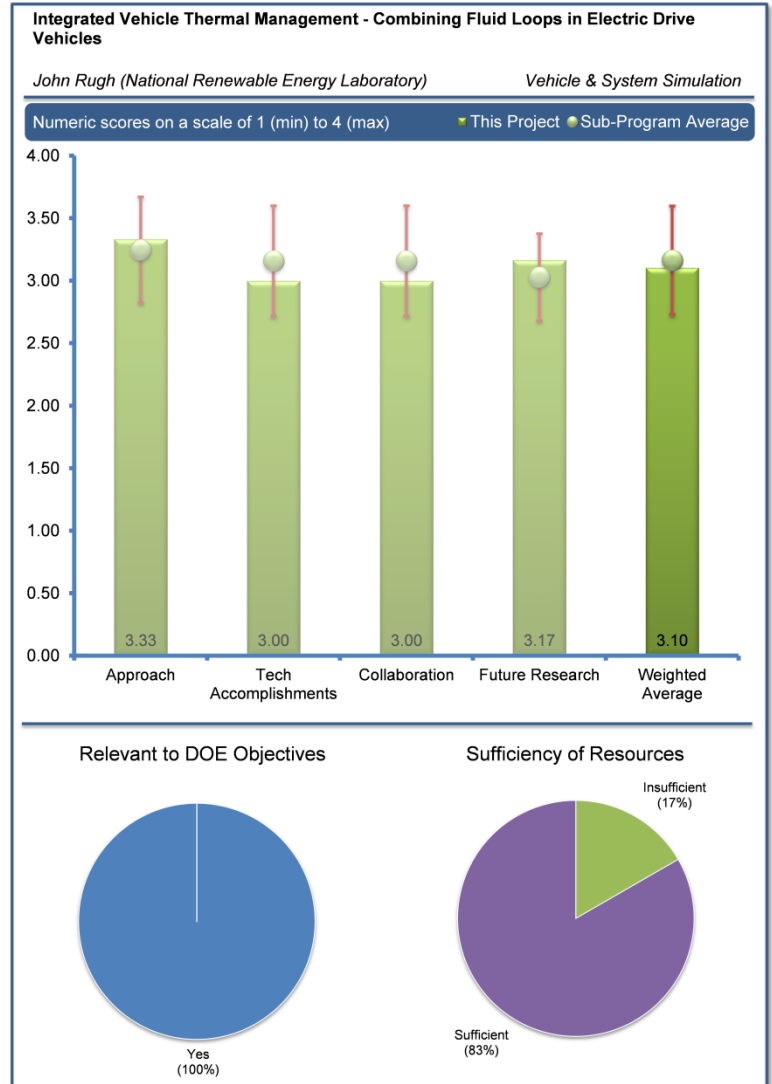
Question 1: Does this project support the overall DOE objectives? Why or why not?

One of the reviewers indicated that thermal management is key to increasing electric vehicle usage. The reviewer observed that the project is a collaboration between Energy Storage Systems (ESS) and Advanced Power Electronics and Electric Motors (APEEM) with a goal to reduce the number of components, and thereby reducing the cost of the vehicles. The reviewer said that improved thermal management will increase a vehicle's reliability and is an excellent example of different divisions working together to solve an important common problem. The same reviewer also mentioned that the success of EVs depend on the reliability of electronic components. The reviewer pointed out that high temperatures reduce an electronic component's service life. Therefore, as the reviewer explained, the tools from the project will make EVs more reliable and accepted into the marketplace. These comments were partially reiterated by two other reviewers. One reviewer indicated that combining cooling systems in electric drive vehicles may reduce costs, lower weight, and improve performance, which can facilitate consumer acceptance and increase use thereby reducing petroleum consumption. The other reviewer highlighted the need to integrate and reduce the number of systems on a vehicle to cool the various components as this reduces vehicle weight and cost. However, the reviewer indicated that only vehicle-level OEMs are typically concerned with this. The reviewer suggested that this information can assist them in scoping targets for component suppliers and industry standards. Another reviewer said that a part of the responsibility is to develop a vehicle-level energy management software, and in that context, the reviewer was aware of the extent to which OEMs are willing to go in order to achieve relatively small efficiency gains. The same reviewer, representative of OEMs, expects measurable benefits in fuel consumption by managing waste thermal energy intelligently, and indicated this project addresses that aspect, at least in part. A different reviewer commented that it is important to look at a system approach to EV efficiency rather than looking at each component or vehicle performance after the design is complete.

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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most of the reviewers had positive comments. One reviewer noted that performing the system level models is a good first step. The reviewer said that continuing to refine and incorporate more data as you go forward is a must. The reviewer continued to say that the bench test and finally vehicle level OEM involvement seems like the correct approach going forward. Another reviewer explained that the project is working with OEM partners and has the potential to introduce new thermal management systems that



are more efficient and cost less. The same reviewer also observed that the team is experienced and well qualified. These comments were also supported by a third reviewer who remarked it was a good approach to validate model, bench test and then expand to vehicle design. A different reviewer detailed that this task starts with thermal one-dimensional (1-D) modeling of APEEM, energy storage, engine, transmission, and passenger compartment thermal management systems. The reviewer noted that modeling is used to identify, select, and analyze promising combined thermal management concepts. The same reviewer continued to say that a number of existing models are leveraged and enhanced. The reviewer then indicated that subsequently, bench top testing will be used to verify modeling results. The reviewer pointed out that the goal is to enable the use of combined cooling loops with electric vehicles to drive down costs and weight. Overall, the reviewer asserted that the project seems to have a reasonable approach, but that it would be good to know whether it has been vetted and received positively by industry. The remaining reviewer suggested that risk aversion as a barrier to implementation of combined cooling loops should be considered. This reviewer noted that while the items listed under Barriers may all be barriers to acceptance of electric drive vehicles (EDVs), they are not barriers to acceptance of combined cooling systems in EDVs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed reviews were received from several reviewers. One reviewer indicated that this is a four year project, that the design tools are on schedule, and that the plan includes testing in actual vehicles. The reviewer also said that the team has a new CRADA with Ford. Overall, this reviewer noted that the project had an excellent research plan with realistic goals, tasks and timeline. Another reviewer summarized that a number of modeling simulations have been conducted for the energy storage system, cabin, electric motor, inverter, and overall heating / cooling system, and further explained that various drive cycles including aggressive hot and cold have been analyzed including cold and hot soaks. The reviewer noted that the results seem to indicate the possible feasibility of the approach, although temperatures approach design guidelines for power electric machines, which could potentially lead to uncomfortable cabin temperatures while the battery cells are being cooled to desired temperatures. A different reviewer indicated that baselining each of the systems is done on a similar thermal range so that results can be measured comparatively. However, the reviewer noted that no system will remain static, so there will continue to be variables going forward as improvements are made on any one system, which in turn will have vehicle-level ramifications. Similarly, if there are constraints made on a particular system, say regulations to restrict motor output, this will have vehicle level implications as well. Another reviewer indicated that the model seems okay but so far seems to be looking at limits and tradeoffs one at a time. The reviewer further highlighted the need for more ability to provide guidance for what needs to improve to provide optimum. More specific comments were provided by another reviewer indicating that one of the benefits of effective thermal management is being able to raise the operating temperature of the engine quickly, especially during the cold FTP cycle. The reviewer noted that this is expected to provide significant fuel economy benefits and suggested that it would be worthwhile to include this aspect in the project benefits. The same reviewer also said that the drive cycles that are listed in the presentation include US06, Davis Dam, and Bemidji, to cover a range of applications. From the reviewer's perspective, Death Valley and Las Vegas in summer are far more severe hot cycles. While the presentation provides a reference for a thermal model of a permanent magnet motor, the reviewer did not have a chance to read it, and said that it was not clear what level of detail is included in the electric motor model. According to the reviewer, it is critical to limit the peak temperature of the motor, and using a lumped model representation may not provide adequate resolution to capture the peak temperature. Lastly, the reviewer acknowledged taking a brief look at FASTSim, but had not had the chance to see it more extensively. Therefore, the reviewer questioned whether it is sufficiently accurate for purposes of this project, i.e., whether its accuracy of prediction of waste heat generation over some cycle suffices for the calculations that have been made.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers provided positive comments. One reviewer indicated that it is good that OEMs are being included. The reviewer observed some overlap between this project and VSS070 (Electric Drive Vehicle Level Control Development Under Various Thermal Conditions) and suggested that perhaps some of the thermal model development methodologies could be shared to achieve synergy. The other reviewer noted that collaborations for this task are very good including a vehicular HVAC manufacturer, OEMs, vendor for Kuli software and engineering support, and three VTP program offices (i.e., Systems, Energy Storage, and APEEM) all providing task cost-share. The reviewer also noted that a CRADA is the approval process with a Detroit OEM. Another reviewer acknowledged that the team is working with a software company and OEMs. A different reviewer pointed

out the project needs more direct contributions and involvement from major subsystem suppliers and an OEM. The reviewer explained that system component suppliers are motivated to optimize their own system from a weight and cost perspective, while the OEM is motivated to optimize all systems across the vehicles. The reviewer then explained that there are tradeoffs involved there that only the OEM can evaluate from an overall vehicle perspective. As such, the reviewer notes that experiences with sub system suppliers will give better insight into the process involved in setting subsystem specifications and targets.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

There were mixed comments from reviewers regarding this topic. One reviewer observed that new refrigerants and coolants are being proposed, and further recognized that this proposal includes a test platform that will be an excellent test bed for evaluating these new fluids. This same reviewer indicated that the U.S. AFRL is trying to do a better job on thermal management for satellites and that both agencies could benefit from an exchange of ideas. Another reviewer described that proposed future efforts are to further model analyze concepts for combining cooling loops to assess benefits, add new components, and refine the model. The reviewer additionally observed the selection, building, and evaluation of prototype systems via bench test, based on results. Further, the reviewer suggested that implementing at the vehicle level to test and validate combined cooling loop strategies, if ultimately promising. The reviewer noted that this approach is valid, but recommended the active involvement of OEMs sooner rather than later to identify and develop mitigation strategies for any potential showstoppers be they technical or business in nature. Another reviewer liked the idea of involving the OEM for vehicle-level integration, but cautioned it cannot be done too soon. The reviewer asserted that they will bring vehicle-level requirements, from their perspective, of which the researcher may not be currently aware. The reviewer concluded, the sooner the better. The final reviewer to comment expressed that the path from model to vehicle is not outlined very well.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer indicated that financial resources were insufficient. Five reviewers indicated that financial resources were sufficient. A reviewer commented that the resources for the task are sufficient. Another reviewer explained that this is an important problem and the budget appears to be adequate. Another reviewer said that based on the proposed future work, it appears that the funding level may be sufficient for bench testing of components and systems, but was unsure that it will be sufficient for a vehicle-level project. This person acknowledged that reviewers have the luxury of suggesting all manner of additions to the project scope, but the PI will have to work with the reality of limited funding and circumscribe the scope of the project appropriately.

Codes and Standards to Support Vehicle Electrification: Ted Bohn (Argonne National Laboratory) – vss053

Reviewer Sample Size

This project was reviewed by five reviewers.

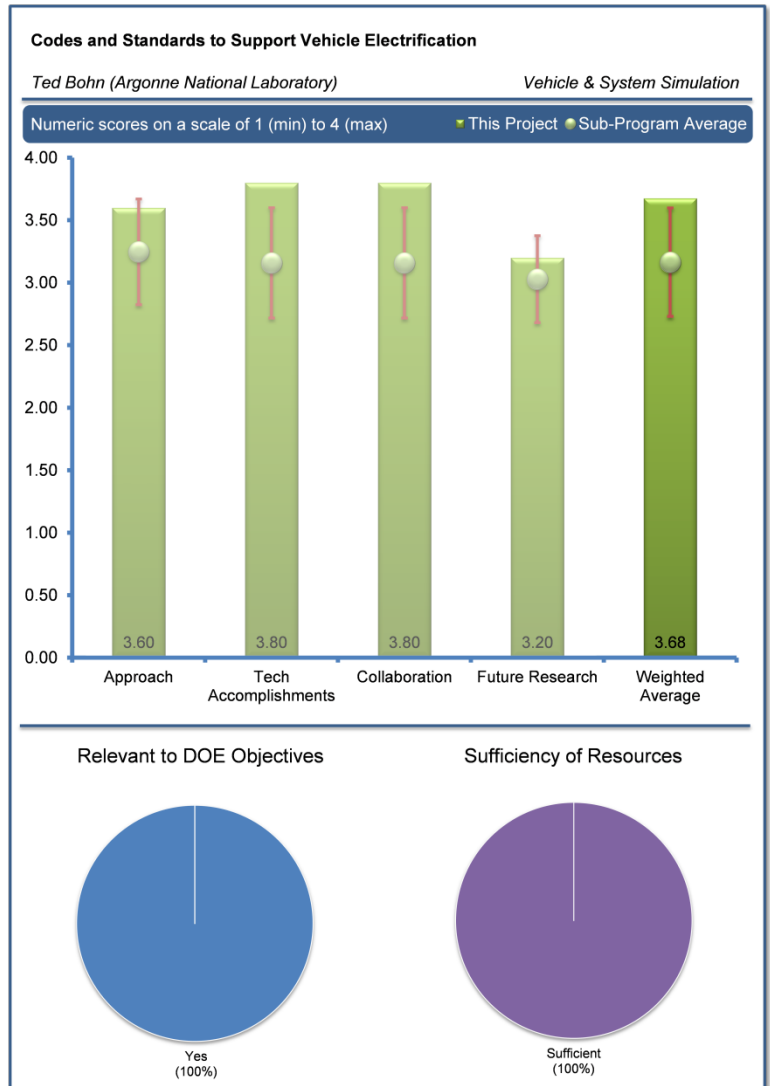
Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers agreed on project’s relevance and provided a range of comments. One reviewer indicated that this project supports the wider adoption of EVs through development (and hopefully adoption) of new standards which directly contribute to displacing petroleum use. The reviewer noted that the government plays a key role in bringing together industry to ensure compatibility of vehicles and charging points with each other and utilities, and developing these standards is a necessary function for government. As such, the reviewer said, this project is successfully advancing the necessary interconnectivity of vehicles to grid for wider EV adoption. A similar comment was reiterated by another reviewer in that the development of appropriate codes and standards is essential to the introduction of new products and technologies; without them, sustainable large-scale market penetration is much less likely. This was further supported by another reviewer who indicated the standards developed from this program will lower the risk for OEMs to put electrified vehicles into the market, as well as give end-consumers confidence that these new systems (charger connectors, etc.) will not be made obsolete in the vehicle lifetime, reducing consumer risk.

A different reviewer discussed in detail that the standardization of hardware- and software-based-interfaces between vehicle and grid is essential to lower the component costs both in the vehicle and at the EVSE level. In addition, the reviewer noted that as electrical vehicles need to be cost competitive to conventional gasoline-powered vehicles, this project contributes substantially to create unified component reference design platforms that allow mass-production. Another reviewer said that standards are of critical importance for electrified vehicle market acceptance and growth and noted that the impact is global and crosses industry boundaries; multiple standards bodies are involved.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers had positive comments on the approach, with some additional substantive comments. As one reviewer indicated, considering the complexity of the stakeholder network and the time limitations to reach technical consensus the achievements of this project are very significant. The reviewer noted in particular that the interdependencies between the different standards were monitored during the codes and standards development process. Another reviewer said that the project clearly seems to be addressing its technical barriers, and seems to be effective. A different reviewer stated that it seems the ANL have a world-wide knowledge of standards roadmaps for electrification and accept responsibility for their timely evolution. The reviewer pointed out that current emphasis is placed on connections, communications and wireless charging. Another reviewer pointed out that the hardware development, which this project indirectly supports, is beneficial and the schedule for completion seems in line with the



auto OEM manufacturing requirements, which is a very positive aspect of this project. A different reviewer noted that the approach seemed to be sound, however the presenter talked so fast it was challenging to follow the presentation, and on many areas gave excessive detail. Another reviewer indicated that the key approach to overcoming technical barriers by this project is to involve as many players as possible. The reviewer said that several big suppliers are being properly engaged in working groups, forums, etc. but that it was unclear from this presentation whether the international community will be involved to any great extent (they are not currently), and whether there are sufficient resources to do so. As such, the reviewer suggested that this project could benefit from increased vendor participation, and particularly international vendors which are not evident in the presented material. Another concern from the reviewer was that one of the key barriers noted is establishing consensus between competing approaches (at low cost), and it is not evident that the current approach evaluates the costs and benefits of each approach to reach consensus.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most of the reviewers had positive commentary regarding the technical accomplishments and progress of the project. In particular, one reviewer indicated that the key technical accomplishment is the completion of protocols and standards which allow the design and building of hardware that is ready to test—a significant step that was accomplished by this project. The reviewer also noted that progress will be further shown and be more evident when pilot projects are launched using technology that adheres to the protocols developed. The same reviewer indicated that although as noted above, the project would benefit from wider international cooperation, the work completed thus far, and the schedule adherence thus far, suggests that the technical barriers will be overcome in the coming year. Another reviewer specifically noted that considering the barriers, the following technical accomplishments are outstanding: SAE J1772 coupler standard implemented (AC [alternating current], DC [direct current]); SAE J2931-based vendor technologies evaluated; significant progress on SAE J2954 development; and SAE J2990 development initiated. Other commenters indicated that this project appears to be on-track regarding technical accomplishments. In addition, another reviewer stated that clear roadmaps, schedules, and evidence of driving to timely completion were presented. The final commenter said the project impacted development and/or revision of numerous (24 are shown on Slide 7) relevant standards for electric-drive vehicles and related systems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

This project received mostly positive commentary regarding collaboration and coordination with other institutions. One reviewer indicated that the very nature of this work is collaboration. As indicated by the reviewer, it appears ANL is taking a leading role in coordinating multiple activities across multiple world-wide standards making bodies. This is reiterated by two other reviewers. One said that the main theme of this project is collaboration between multiple parties to generate standards and that this project seems to be effective in this area. The other reviewer noted that all relevant stakeholders are involved in the standardization developments; the speed of development and the technical results reflect that the process is very well coordinated. One reviewer had mixed comments and indicated that this project has involved academia, industry, and government partners. The reviewer said that collaboration to develop and use these new codes are crucial for their adoption and that this project is successfully bringing together the necessary partners to make this happen. The reviewer noted that it is important to keep all manufacturers on the table, and collaborating through SAE should be sufficient, but the partners listed show only two foreign car brands. As such, the reviewer suggested that this process could benefit from wider participation of other car manufacturers. Another reviewer said that the list of partners on Slide 2 is good, except Argonne should also be collaborating with standards development organizations [definitely SAE, Institute of Electrical and Electronics Engineers (IEEE), American National Standards Institute (ANSI), UL, and International Organization for Standardization (ISO); possibly National Fire Protection Association (NFPA), American Society for Testing and Materials (ASTM), etc.]. This reviewer noted that later slides and remarks suggested that the project team is working with such organizations, but these should have been listed among the collaborations/partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments received regarding proposed future research were mainly positive with concerns regarding the timeline of the project. Several reviewers noted that the future research is addressing the right areas and is very well planned out but to be considered is

that this project is in its final year. This is reiterated by another reviewer who said that the future plans look good, but it is not clear if they are feasible within FY 2012. The reviewer suggested that a timeline for future projects and a tie in to technical barriers would help this discussion. Similar comments were provided by another reviewer who indicated that ongoing and future research is focused on completing the work that has been started. The reviewer noted that it is unclear from the presentation materials that there are defined deadlines for individual components. As such, the reviewer suggested that this project would benefit from showing and discussing more specific milestones to be completed. Similar to the comments received above, one reviewer supported that ongoing work is still needed and notes that the proposed validation (and if needed, adjustment) of standards is important. This was repeated by another reviewer who said that systems validation studies are of critical importance and that it seems additional resource will be needed for these activities. That same reviewer added that continued international harmonization will speed market growth due to efficiencies on the producer side and improve regulatory oversight.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated that sufficient funds were available for the project. While most comments received supported agreed that sufficient funds were available, some concerns were noted. Two reviewers said that the resources seem to be sufficient or adequate for the work packages to be accomplished. One reviewer indicated that effective project execution indicates sufficient resource and funding. However, the same reviewer saw that the budget has been reduced for 2012—yet the project is moving into system validation trials which would seem to require more resource. Thus, the reviewer noted that particular care should be taken to ensure the project is designed accordingly. Another reviewer discussed that resources are limited for international cooperation work, but are sufficient for U.S.-based work. Nonetheless, the reviewer noted that the project has been meeting schedule and that appropriate resources seem to be in place to complete future work. One comment from a reviewer indicated that the project leverages resources from other programs.

Testing and Validation of Vehicle to Grid Communication Standards: Krishnan Gowri (Pacific Northwest National Laboratory) – vss055

Reviewer Sample Size

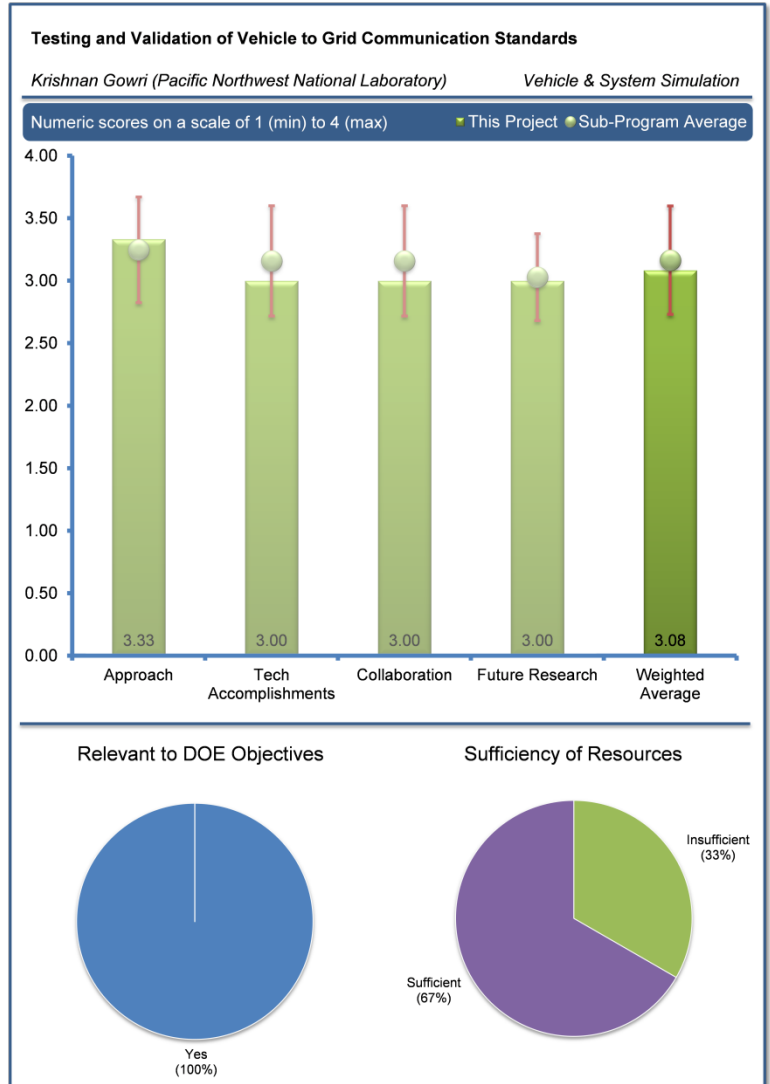
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments on this project were mixed. One reviewer indicated that the establishment of appropriate standards and protocols for vehicle to grid communications is essential to acceptance and maximizing the value added of electric vehicles to the consumer. The reviewer noted that electric vehicles potentially offer many additional utilities to the consumer including the ability for reverse energy flow and emergency power. Therefore, the reviewer adds that, to unlock this potential, appropriate standards needs to be in place to ensure safety and interoperability for all vehicles and home/ grid scenarios. Another reviewer indicated that consumers and utility providers alike need EVs to communicate with the grid for the successful deployment of this technology on a large scale. A different reviewer noted that the program provides an unbiased evaluation of hardware configurations relevant to implementation of standards developed by the SAE and supported by other DOE activities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two reviewers noted that this project provides technical support to SAE standards committees or to the SAE EV standards development process—an approach which is driven by SAE leadership, performing laboratory testing of communication technologies in support of standards activities, and validating end-to-end communications. Of those two reviewers, one discussed that the activities in support of this task are relatively discrete depending upon which standard and slash sheet is being supported and the particular technical support requirement. As such, the reviewer said that it is relatively easy to shake them out. Overall, the reviewer noted that the approach appears to be well organized and reasonable in addressing the particular acute needs of the SAE standards committees for vehicle to grid communications. The second reviewer parallels these comments and indicated that the project appears to be performing the necessary work to inform the standards process. A different reviewer noted that the work conducted has been well planned and effectively conducted. However, the reviewer indicated that other DOE supported organizations (ANL and Grid Integration Tech Team [GITT]) are conducting similar activities which may overlap or conflict with this activity. As such, the reviewer suggested that test work should be coordinated to assure DOE funds are most efficiently used.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most of the reviewers had positive comments on the technical accomplishments and progress of the project. One reviewer indicated that the progress towards objectives appears to be solid. This is further specified by another reviewer who indicates that a considerable amount of technical progress appears to have been achieved in support to SAE J2847/2, J2836/3, J2836/5, and the ANSI Electric Vehicles Standards Panel (EVSP) Roadmap. The reviewer added that this includes updated isolation monitoring requirements, state and sequence diagrams; harmonization; use case development; home area network (HAN) interaction scenarios; interface requirements for telematics and mobile devices; and a transactive controls concept; as well as participation in various working group meetings. The reviewer also said several presentations have been made as well as a report on Vehicle to Grid Communication Standards Development. In addition, the reviewer noted that a laboratory test bed and field testing of programmable logic controllers (PLC) on mains has been completed for testing SAE J2847/1 messages. The reviewer further mentioned that participation in a number of working group meetings for the ANSI EVSP has been completed. Concerns from one reviewer included that none of the technologies currently under test fully comply with specifications. This reviewer asserted that while much good work has been conducted to evaluate these technologies, a fully compliant technology has not been found. Thus, the reviewer noted that additional coordination with the standards committee will be necessary to find an acceptable solution.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most of the reviewers had positive comments on the project's collaboration and coordination with other institutions. One reviewer noted that the level of collaboration appears to be appropriate given the nature and scope of the support to vehicle to grid communications standards activities. The reviewer highlighted that Pacific Northwest National Laboratory (PNNL) is working with SAE, EPRI, and several industrial technology developers. The reviewer also added that as ANL is actively involved in SAE standards development for EVs, it is appropriate to remain well coordinated with them as well. Another reviewer indicated that collaboration and coordination with SAE and EPRI is vital for this type of work. The reviewer commented that it appears that the roles and responsibilities of each organization are established and working well. A third reviewer observed that collaboration with hardware suppliers, EPRI and SAE has been outstanding. However, the reviewer asserts that more effort is required to assure that ANL and the GITT are not conducting overlapping or conflicting work.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had similar comments regarding proposed future work. One reviewer noted that the future work builds on the past developments in a logical fashion. This was supported by another reviewer who said that the future work or activities for the balance of FY 2012 are logical and appropriate. The reviewer went on to say that several are continuations of existing activities and the remaining are logical next steps. The reviewer added that no future activities for FY 2013 and beyond are presently identified, possibly do to the difficulty of predicting the exact future needs of the SAE standards committees in this area. This was reiterated by another reviewer who indicated that the activity is at a crossroads; looking for technology that is fully compliant with specifications. The reviewer discussed that options are being evaluated and a proper direction sought and asserted that again, this should be coordinated with the GITT to assure that the most appropriate support is being provided to the standards effort.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two out of three reviewers indicated that there were sufficient financial resources for the project. Comments from one reviewer were that resources appeared to be sufficient for the basic SAE technical support. Further, the reviewer noted that a lack of resources was not cited as an impediment to progress. In addition, another reviewer presented that testing has been conducted efficiently and on schedule. The third reviewer discussed that in general the resources for this task seem roughly appropriate, especially since several of the activities are winding down in 2012. However, the same reviewer commented that the task may be mildly under-funded given the scope of some of the technology prototype module and testing activities and time intensive nature of participation on SAE standards committees.

Development of High Power Density Driveline for Vehicles: Oyelayo Ajayi (Argonne National Laboratory) – vss058

Reviewer Sample Size

This project was reviewed by five reviewers.

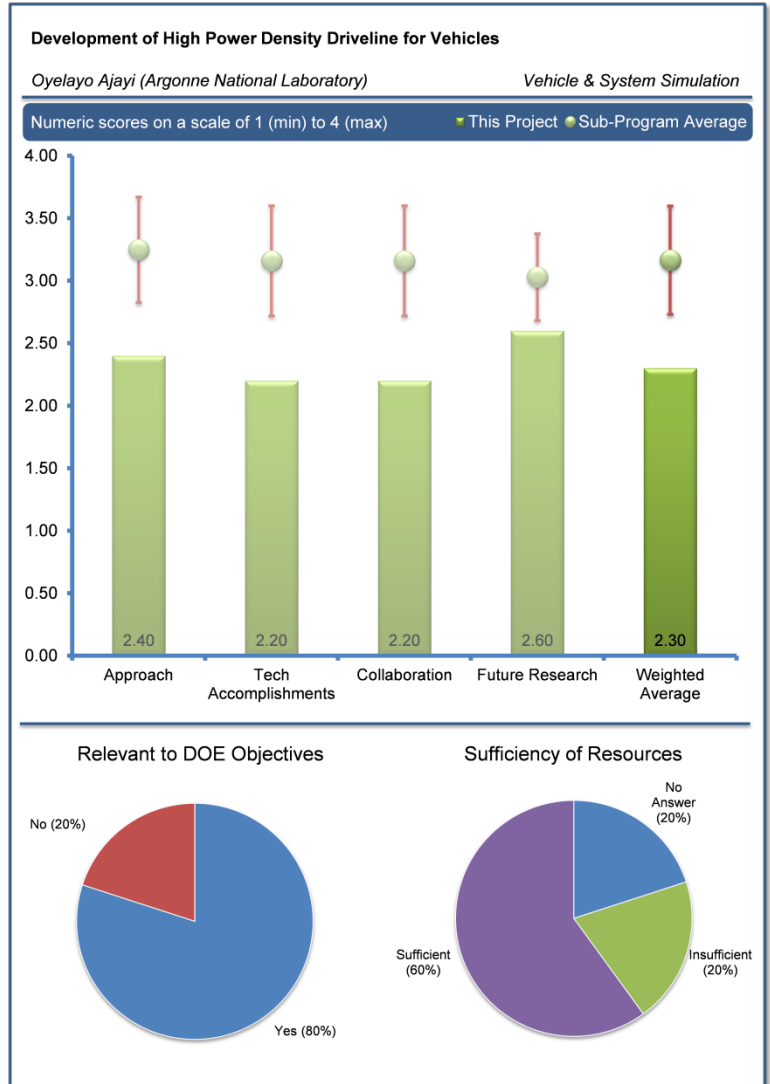
Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that weight reduction in vehicle component systems saves fuel in operation. Another panelist agreed that weight reduction of drivetrain components is a valid approach for reducing fuel consumption in passenger cars and improving freight efficiency in commercial vehicles, and positively contributes to the DOE mission of displacing petroleum. The next observer noted that this project is generally supportive of the DOE objective for reducing petroleum consumption. This observer reported that the focus is on developing surface treatments that improve surface fatigue and wear resistance, which can enable downsizing of gearing and power transfer components. The observer further noted that smaller gearing and bearings drive an overall reduction in powertrain components, thereby improving power density. The same observer explained that the resultant weight savings and smaller package can be an enabler for the design of a lighter weight vehicle that will reduce fuel consumption (e.g., a 10% reduction in weight can deliver a fuel consumption savings of 2%-5%). A different reviewer found that, in theory, high power density drivetrains will support petroleum displacement, but noted that things are less clear in practice. This reviewer was confused by the ambiguous title, and explained that because there are many aspects related to the design of a high density drivetrain, the title should have explicitly included the specific aspect addressed in this research (i.e., improved tribological capacity of gears and bearings). The final panel member agreed that the title is attractive but misleading; this is not a driveline weight reduction project but rather a program to improve the load carrying capacity of gear sets. This reviewer emphasized that this is a confused project.

This reviewer was confused by the ambiguous title, and explained that because there are many aspects related to the design of a high density drivetrain, the title should have explicitly included the specific aspect addressed in this research (i.e., improved tribological capacity of gears and bearings). The final panel member agreed that the title is attractive but misleading; this is not a driveline weight reduction project but rather a program to improve the load carrying capacity of gear sets. This reviewer emphasized that this is a confused project.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One panelist noted that the approach seemed good, as it focused on one part of the vehicle at a time while looking for weight reduction opportunities. This panelist indicated that because the potential gains in fuel economy were only theoretical, calling the project a power density development was a bit of a stretch as it is actually a weight reduction, and should be identified as such. Another panel member wrote that the presenter stated that driveline weight comprises 20% of overall vehicle weight. However, this panel member reported that the focus of this research deals with studying materials coatings and lubricant that apply to gears and bearings. This panel member pointed out that these components represent only a smaller part of the weight equation and it does not appear the remaining driveline components are in the project scope. Therefore, this panelist noted that a more realistic assessment of the weight reduction potential was needed, based on the more limited scope, and that the design of the project would be enhanced if specific weight reduction targets were specified over a baseline driveline. The panel member further recommended



the researchers pick a vehicle, quantify the baseline weight of its driveline components under investigation (i.e., bearings and gears), and set a quantifiable weight reduction target that could then be translated into gallons of displaced petroleum to quantify significance to the DOE mission. This person added that this would dictate the advanced material, coatings, and lubricants needed to be used to reach that target. The next reviewer expressed that as basic tribology research, the researchers are quite capable and methods are sound. This reviewer questioned, however, the specific utility of the research that is defined in the title (i.e., to significantly reduce gearbox sizes in typical ground vehicles). The reviewer further stated that, up front, the premise that gearboxes can be significantly reduced in size needs to be further supported, including quantified estimates for typical ground vehicles. This reviewer noted that this should involve an absolute comparison of other failure modes and design considerations and constraints for typical gearboxes, such as tooth bending fatigue for gears and static load capacity for bearings. The reviewer relayed that a relative life improvement analysis is presented for the tribological failure modes under study, but opined that even these lack an absolute comparison to understand in balance if they are significant. The reviewer noted the potential value proposition of the various coating technologies and additives, etc., being analyzed needs to be estimated. This, the reviewer continued, would help insure that the technologies and additives, etc., will be available to typical ground vehicle markets if shown to perform well because high volume markets are quite cost sensitive. The reviewer was unsure if the relative conditions of contact stress and sliding velocity used in the test are representative of, or scalable to, a typical gear or bearing application. This reviewer concluded that these questions should be addressed through better collaboration with partners skilled in the art. A subsequent observer reported that both engine oil/transmission fluid and simulated extreme pressure (EP) gear lubricant (with EP additives) were used for the testing. This observer noted an advantageous approach because the results of the program can be used for both transmission and axle redesign (the latter requires an EP lubricant). The observer indicated that, although perhaps not within the scope of this narrowly focused program, consideration should be given to other failure modes (e.g., bending fatigue, shock failures) and how these modes might become the weak link that determines overall downsizing potential. This observer pointed out that the plan did not include an understanding of how long it may take to wear completely through the coatings, and what the behavior of the gear surface will be as the coating is worn away. The same observer further suggested that this could be an important factor because performance would be expected to drop off sharply once the coating is no longer present. This observer summarized the technical approach to ultimately achieve downsized powertrain components: identify technologies that improve wear, scuffing resistance, and contact fatigue life; quantify required improvement percentage for given amount of downsizing; develop or refine test methodologies for evaluating contact fatigue, wear, and scuffing resistance; test current (baseline) processes and surface treatments as well as the identified technologies for improved surface performance; project potential downsizing that can be achieved based on test results; and identify other potential candidate technologies or processes that could yield even further improvements based on test results. The final reviewer described this project as an academic exercise, a science project, and busy work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the project had developed a test methodology that allows independent control of normal force, rolling velocity, and sliding velocity, and that final selection of parameters was intended to simulate conditions encountered in an actual transmission or axle gear set. Because the operating parameters are typically quite different, this reviewer noted that it would have been helpful to know if tests were run at enough different parametric values so as to obtain data applicable to both transmissions and axles. The reviewer went on to report that baseline friction and wear testing had been completed, along with testing of nine different surface treatments and four different lubricants. This reviewer indicated that a significant finding was that a particular coating may have vastly different effects when different lubricants are used. This reviewer concluded that this suggests an opportunity for matching surface treatment to lubricant type for optimized performance. Another person observed that significant research on tribological performance was conducted with respect to friction and wear. This person remarked that, with that data generated, there was to be a clear link made between this research performed and weight reduction, which is the justification for this project. This person further reported that oil properties (e.g., viscosity and coating properties) also influence frictional and churning losses for gears, which imposes a drag torque between the input and output shafts of drivetrain components. This person concluded that these losses amount to a fuel consumption penalty and need to be considered during the investigation. The next panelist found that the presentation had nice slides but added little value. A different reviewer characterized progress toward goals to date as mostly theoretical. The final reviewer stated that if this project were following a linear timeline, it should be twice as far

ahead as it actually is (i.e., 30% versus 15%). This reviewer noted that a lack of collaboration and project redirection has impeded progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One observer observed that work did include partners. Another panelist stated that key partnerships and collaborations included Wedeven Associates, who contributed to the development of test methodology and subsequent evaluation of various processing and lubricant technologies, as well as Afton Chemical, who was developing additive packages that will be compatible with and perhaps maximize the benefits of specific surface treatments. This panelist listed potential collaborators that included the DOE Wind Energy Program, which showed potential to interface with one of several wind turbine gearbox reliability projects, as well as Castrol British Petroleum, a lubricant supplier known to work closely with Afton Chemical. This panelist indicated that missing from the collaborators was the presence of a powertrain component manufacturer or gear design expert, and an OEM. The same panelist acknowledged that the presentation indicated that OEMs are willing to provide guidance but noted OEMs are not included as formal collaborators. The panelist concluded that such representation would be valuable in terms of their knowledge of gear failure modes, and also knowledge of what may have been tested in the past. The next reviewer observed more collaboration than in the previous period, but an automotive or commercial vehicle partner was still needed to be identified. This reviewer recommended that rather than collaborating with a vehicle OEM, a component or system supplier of drivetrain components would be more appropriate. The reviewer pointed out that commercial vehicle OEMs do not typically get down to the level of detail on a component level as an axle or transmission supplier would, and recommended the researchers try there. A different panel member noted that, as in past reviews, this project suffers from poor collaboration. This panel member noted that this project needs a partner with strong gear and bearing design and application knowledge to insure the utility of the research to industry. The panel member speculated that if industry reluctance is truly based on competitive aspects, academia or other government institutions may suffice (e.g., the GearLab at The Ohio State University would be an excellent partner). This panel member further suggested the American Gear Manufacturers Association or the National Aeronautics and Space Administration (NASA) Glenn Research Center, and mentioned that there appears to be a similar research project awarded to Wedeven in 2008 by the DOD. The panel member concluded that this research should reference and build on the DOD Wedeven project as allowable. The final person observed the presenter complaining about the OEM lack of interest, and stated that precompetitive work in this area is hard to justify, making it very challenging to find collaborators. This person also remarked that oil companies are merely providing oil formulations, but are not involved in developments.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One observer saw a plan to actually measure improvement to fuel economy from weight reduction. Another person noted the project had made a course correction for 2011 from building gearboxes to materials/surface and lubricant evaluation, which is in the right direction. This person suggested that as the project moves forward investigators should link the research back to a weight reduction goal for next year. The next panelist reported that future activity will include a continuation of the testing of each of the surface treatment options and four lubricant packages. This panelist relayed that only friction and wear testing was reported in the results section, so it was assumed that future testing will deal with scuffing and contact fatigue. The panelist also noted that a better understanding of the interaction between various surface treatments and lubricant packages will be necessary to come up with an optimum performance package, which in turn will require close cooperation with additive and lubricant suppliers. This panelist anticipated that at the conclusion of testing, the project will identify one of several surface treatment/lubricant packages that can deliver optimum performance under specific conditions. The panelist further stated that it is possible and perhaps even likely, that different packages will be required for transmission gearing versus axle gearing. The panelist went on to recommend that the investigators pursue an analysis to determine the degree of downsizing possible through use of the aforementioned packages, which requires a general understanding of other failure modes that may come into play (e.g., high cycle bending fatigue or shock load failures). This panelist concluded that this is an area where a subject matter expert from an OEM or powertrain system supplier could make a strong contribution, and help merge the empirical results from this test program into practical guidelines for component and system downsizing. Another reviewer reported that most of the planned activity has not been executed yet, and found that this section was not especially relevant. Having said that, this reviewer noted consideration should be given to other,

relevant application spaces (e.g., wind turbine gearboxes), and noted that there is a current DOE-sponsored program at NREL involving Romax regarding wind turbine drivetrains. The final reviewer called the proposed future research a nice, but aimless list of things to do, because it was broad and hard to pin down.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer found resources to be insufficient, while three found them sufficient. One reviewer noted that the funding seems generally adequate, but the progress to date has been limited, leading one to speculate that either more personnel, or test equipment, or both could help reach meaningful conclusions more quickly. This reviewer reported that according to the project end date, this program will be running another three years, and noted that with additional manpower and equipment, results could be achieved much sooner. The reviewer remarked that if this project can offer a path to significant improvement of power density, obtaining results sooner would be highly desirable. The reviewer acknowledged that adding personnel or equipment might increase the spending rate, but perhaps result in only a modest increase in overall spending, because the project could be completed much sooner. The same reviewer highly recommended that this be considered. Another panelist noted that the resources appear to be relatively lean but sufficient. This panelist added that the tribology testing appears to be relatively low overhead and specimen material cost is likely covered substantially by the collaborators. The final reviewer stated that the project appears to be adequately funded.

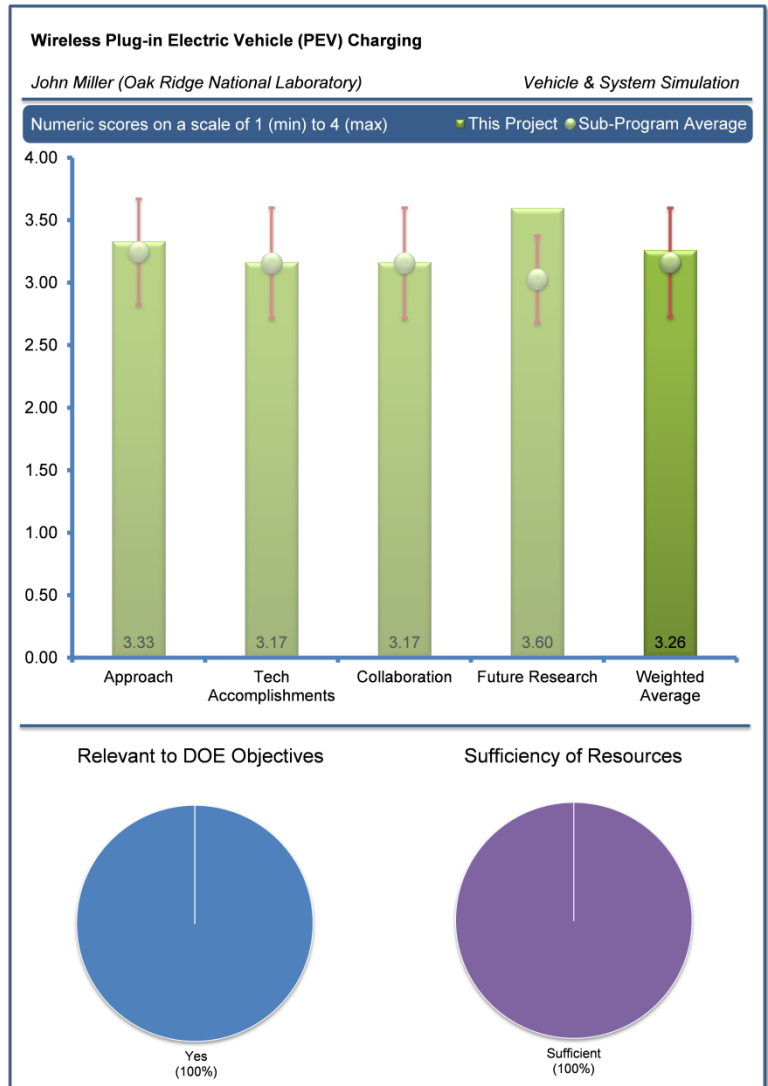
Wireless Plug-in Electric Vehicle (PEV) Charging: John Miller (Oak Ridge National Laboratory) – vss061

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers had similar comments indicating that wireless charging for EVs, if successfully adopted in large scale, could help displace petroleum, and that it has the potential to reduce petroleum consumption by maximizing the electric miles driven. Another reviewer stated that wireless power transfer has the potential to make electric vehicles less expensive to purchase and maintain, and easier to operate. A different reviewer noted that ORNL has established a foundation of knowledge and experience with wireless power transfer but while success in achieving objectives has been good, a path should be identified to translate this knowledge and experience into support for DOE objectives. Another reviewer specified that the key aspects of this project with respect to the overall DOE objectives of petroleum displacement are: for dynamic wireless charging by a reduction of the electrochemical energy storage system size in vehicle (thus reducing cost and mass), overcome range limitations (considering sufficient infrastructure penetration), and no waiting time for charging process to complete; and for stationary wireless charging, improved convenience for customer.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments regarding the technical approach/objectives to performing the work were mixed. One reviewer indicated that the project developed practical technical information on the wireless charging technology that spanned several iterations of device design. The same reviewer noted that these insights add significantly to DOE's knowledge base for wireless charging technology by identifying critical factors for performance and scalability. Another reviewer said that the key design aspects for the wireless power transfer (WPT) systems are very well addressed in the work approach. The work approach anticipates further development steps in power electronics, cost efficient and safe coil design, and mass optimization on vehicle side. This reviewer also remarked the project anticipates both stationary and dynamic wireless charging. A different reviewer expressed that the team is well integrated, and is on the right track to demonstrate Level 2 charging by the end of the FY. Another reviewer pointed out that the main technical barrier is to make the charging system smaller, more robust, and cheaper. The same reviewer added that this research is a step towards overcoming the barrier but there is a long way to go. Another reviewer said that development of hardware supporting the project's objectives are concentrated in the last few months of the schedule and may be compromised by difficulty in establishing communications. A reviewer also mentioned that since WPT has potential for larger fleet vehicles (delivery vans and transit buses), the reviewer would have liked to see a scenario, if only modeled, where the weight and bulk of the vehicle-side components were given minor consideration.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most comments regarding the project's technical accomplishments and progress were positive. In particular, several reviewers noted that solid progress or a great deal of progress has been made in the past year and that targets have been met. One reviewer in particular indicated that the system has been constructed, and power transfer has been demonstrated. The reviewer asserted that this is the type of forward-looking research that will push the automotive technology forward. Another reviewer indicated that the project appears to have accomplished its primary design goal and optimized the design performance over several iterations. That same reviewer added that the project also provides the community with useful performance data over a range of coil spacing and frequency ranges. Another reviewer said that considering that WPT is a new development in EV system design, the technical accomplishments and the progress made are very significant and can be utilized both in standardization and technology commercialization. This reviewer observed that new hardware was developed, coupling coil design is key success factor for efficiency of power transfer – performance validated, that the control strategy optimized for minimum mass and size on vehicle side, that the communication concept for WPT charging was developed (Dedicated Short Range Communications-based), and that a coil power ramp up control strategies was developed. One reviewer noted that technical targets have been meet, but no advances beyond currently available commercial hardware are apparent. The final reviewer commented that solid progress has been made mostly on the charging system. However, there is a lack of roadmap for long-term technology development and market adoption.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Three reviewers provided similar comments regarding collaboration and coordination with other institutions. One reviewer commented that through the collaboration with the industry in standards development, the team has helped move the technology substantially closer to commercialization. Another reviewer indicated that Miller is supporting the SAE standards development with this project and has provided the community with useful tutorials via IEEE and other community forums. The reviewer noted that these collaborations accelerates technology development and contributes to lowering market barriers for the technology. The third reviewer acknowledged that ORNL internal collaborations and coordination are evident. However, the same reviewer added that dissemination of information gained should be a focus in the remaining months of the project. Another reviewer said that the partnership is limited and suggested that industry participation and input is desirable. A final reviewer said that collaboration with IEEE needs to be established in addition to collaboration with SAE.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Some reviewers had positive comments on the proposed future research. One reviewer commended that Miller's work has provided timely information to the research and development R&D community and bringing the project to closure ahead of schedule. The other commenter agreed that overall, this is a solid research project. The reviewer expressed that the project was clearly defined and well-executed. However, the reviewer noted that if the researcher could provide an overview of the forest before showing the tree, the importance of this research would be better established. The third reviewer commented that collaboration with industry partners is essential to focus on the addressed areas for future research. In particular, the reviewer pointed out that research on dynamic wireless charging needs to be enforced as well as the work on fast wireless stationary charging (e.g., to be used for public transportation). The final reviewer remarked that the project will end this year.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated that sufficient financial resources were available for the project. One reviewer remarked that ORNL specialized resources appear to have been leveraged effectively. Another reviewer said that the stated milestones are sufficient. One reviewer added that in order to test dynamic wireless charging, investments have to be made in a suitable on-road test-bed. The reviewer noted that although this work is not addressed for this project, it needs to be considered for future research.

Advancing Plug In Hybrid Technology and Flex Fuel Application on a Chrysler Mini-Van PHEV DOE Funded Project: Abdullah Bazzi (Chrysler LLC) – vss063

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

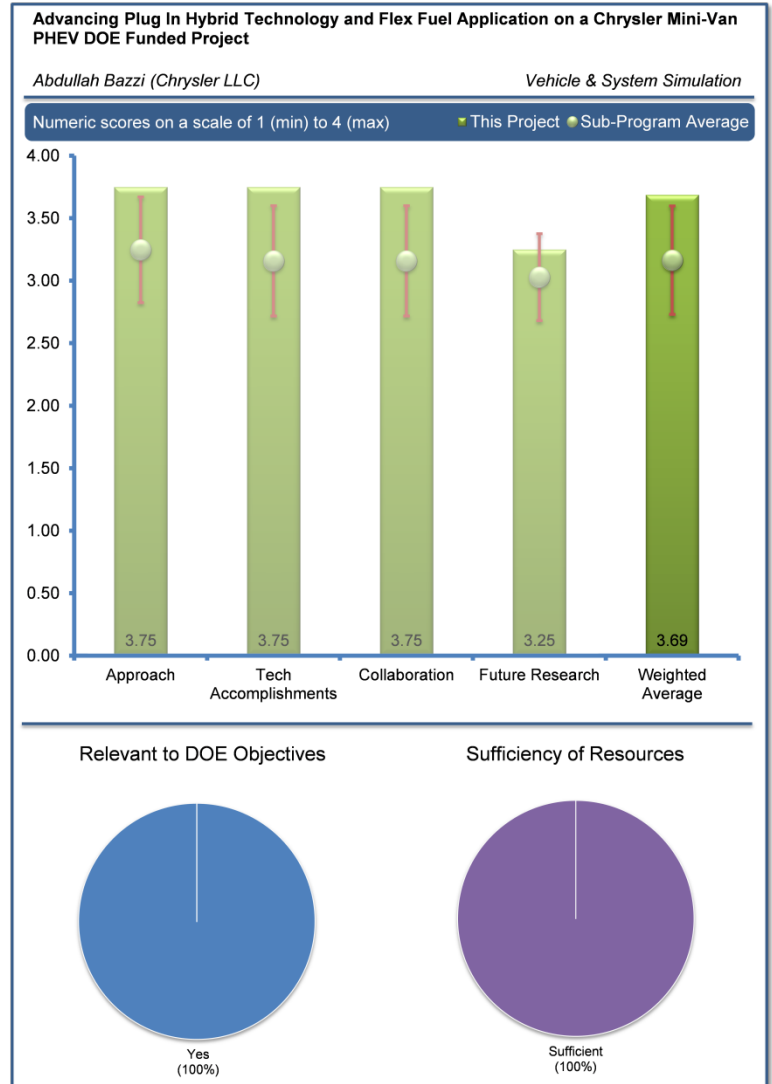
One reviewer indicated that the program supported both advanced vehicle development and education objectives. Another panelist stated that PHEVs are one of the best ways of reducing fuel consumption, which should fit the overall DOE program goal. The final panel member stated that combining plug-in hybridization and flex-fuel technologies in minivans will no doubt result in substantial petroleum displacement. This panel member pointed out that minivans are perhaps the most common family transportation vehicles, thus powering them with electricity and renewable, bio-based fuels will amount to a significant reduction in petroleum use nationally.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted the approach to be methodical and detailed, using a systematic product development process. This reviewer observed that the project was leveraging internal Chrysler and partners' core competencies, but that cold testing was not cold enough. Another panelist noted that the researchers employed a very comprehensive approach that covered many aspects of technologies. The next observer concluded that extensive vehicle testing would provide an excellent foundation for the vehicle demonstration. The final reviewer noted that the overall approach of pertinent technologies integration into a currently available product platform is an excellent approach. This reviewer indicated that this would facilitate rapid commercialization and quick benefit to the nation. The reviewer concluded that the main technical challenges and possible huddles were adequately addressed, or at least considered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person observed that the project is on schedule as planned, with adequate analysis and simulation of different components and systems. This person reported that a lot of real-world driving vehicle test data have also be accumulated. Another reviewer agreed that the program is on schedule and that there was an excellent approach for field data collection, but that some technical targets for vehicle performance had not been met. The next panelist noted that the report provided detailed status, and had some technical substance. The final reviewer requested specific details for each phase.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One observer indicated that there was good collaboration with a battery technology developer, and further reported collaboration with vehicle test sites, fleet owner, and national laboratories. Another reviewer noted work with INL on data collection was good and will assure program results are disseminated. The next panel member explained that the project was involving key suppliers and INL where needed. The final panelist suggested actively involving all partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panel member saw a clearly defined future work plan in terms of test analysis and data collection. Another panelist looked forward to the building of a field data set that can be evaluated to improve vehicle, driver, and infrastructure performance. The next person exclaimed the future work is on target to the final goal, and emphatically described work as excellent. The final reviewer noted that the proposed future research was on track and following the methodical product development gate process. This reviewer suggested that the researchers should have considered Minnesota, North Dakota, or Michigan's Upper Peninsula for cold testing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers rated the resources as sufficient. One reviewer noted that the Chrysler vehicle test resources are excellent, and that the resources assembled for field data collection appear to be working reliably.

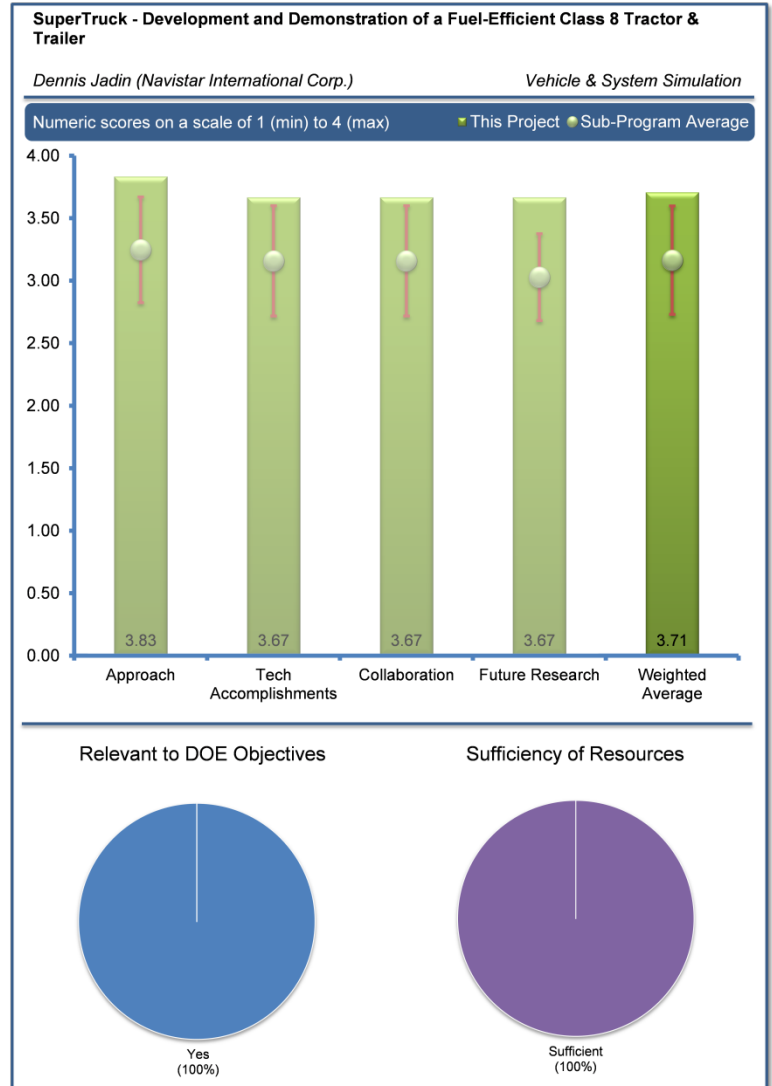
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Dennis Jadin (Navistar) – vss064

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewers agreed on the relevance of the research. One reviewer said that although the project goals are set by the SuperTruck Program, the project goals will no doubt support DOE objectives of petroleum displacement. This was further supported by another reviewer who commented that as with all of the SuperTruck projects, this project's objective is reduction of fuel use by a HD truck by 50%. The reviewer added that achieving this would make a big dent in petroleum dependence which was similarly reiterated by several other reviewers. One reviewer discussed that this project is very relevant to reducing petroleum use and that Navistar with a significant market share in over the road tractors can influence the market highly with adoption of these technologies after concepts are validated and introduced. Another reviewer reinforced that the project is targeting high fuel use vocation and employing a systematic approach to improving fuel efficiency and the final reviewer found that the project objectives are key enablers to energy efficient highway transportation.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had very positive comments on the technical approach to performing the work. One reviewer stressed that this project is extremely well-outlined. A second reviewer said that the project is well-focused, integrated, and is likely to succeed. This reviewer's reservations have to do with which technologies were chosen. For long-haul, it is unclear to this reviewer whether hybridization is worth the cost and the weight penalties. Similarly, for lightweighting, the added cost of carbon-fiber composites could raise the cost enough to make the truck more of an experiment than a viable commercial product. For this reviewer, there was also the question of whether the trailer skirts will actually get used. According to this reviewer, Walmart maintenance people have indicated they break easily and get weighed down with snow. According to a third reviewer, the approach of using four main technology buckets; namely hybridization, driveline efficiency improvement, light-weighting and aerodynamic drag reduction is very reasonable. The reviewer noted that these are all proven technologies, and that getting input from customers is also commendable. This will no doubt facilitate ready market acceptance of the final product. The reviewer felt that the use of simulation for various technology optimizations is very good. Another reviewer was particularly impressed with Navistar's voice of customer work. This reviewer was most confident that the project is tackling the bold challenge of 50% performance improvement, through a lens of commercial viability. That is, that the technologies will actually have a payback for the end users and eventually be launched onto trucks with reasonable if not full adoption. Otherwise, this reviewer found that the project's

approach was solid. Another reviewer noted the good organization and approach for addressing potential areas of improvements. This reviewer suggested that the project needs to discuss plans for hitting mass targets given the challenges of adding the HEV system (with increased mass). This reviewer noted a good example of a weighted selection matrix on Slide 13 – could show similar for other areas in the future. The reviewer noted that another good slide is Slide 14, trade-off study of battery size, mass and motor size versus freight efficiency. The final reviewer commented that a detailed technology roadmap with specific incremental efficiency improvement demonstrates the confidence in achieving the program goal.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers exhibited positive comments on the technical accomplishments and progress of the project. One reviewer in particular enjoyed the wow factor for pushing the limits on aerodynamics. Another reviewer added that the design of basic concepts and components is well on its way which is a necessary prerequisite for actual construction of a working truck. In addition, the reviewer indicated that individual systems have been demonstrated on mule trucks. The reviewer noted that this is an excellent way to isolate their impacts and prove operability and performance in a cost-effective manner and that actual on-road proof of improvements should accelerate as the project progresses. This reviewer was impressed with the project's accomplishments. The reviewer noted that of particular concern is the weight issue. The reviewer stated that weight has not been that critical for OTR tractor trailers as fleets tend to cube out or not be totally full rather than gross out but that is changing. The reviewer asserted that emissions have added weight, most fuel saving devices add weight, freight is denser, etc. and that weight is becoming very critical. The reviewer agreed that Navistar is tackling this weight issue, but it is an issue for them to meet their goals. Nonetheless, several reviewers discussed that the research's on-going vehicle test for each of the technology buckets demonstrates that they are ahead of the game. One reviewer acknowledged that the project seems to be working toward goals but much work remains. The reviewer observed that results showed better gain with aerodynamic optimization than the target – which is very good. However, gain from hybridization, the reviewer notes, is lower than the target. Similarly, the reviewer pointed out that the weight reduction only achieved 25% of desired goal. Comments to improve the presentation/ research from reviewers were to continue to break down by technology and assess progress versus targets so that it remains clear where the challenges remain. Another reviewer felt that it would be helpful to explain why the hybrid vehicle (Slide 17) can have a better fuel economy while weight is increased by 2,910 pounds and the route is more on high-speed between 60-70 mph (Slide 16).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers acknowledged the project's collaboration and coordination with other institutions. A reviewer indicated that the project had a particularly well-rounded set of collaborators, encompassing all aspects of the vehicle itself, from powertrain to cooling to body to wheels to trailer, as well as modeling and testing efforts to confirm effectiveness of design improvements. A reviewer commented that the project was well-executed with other DOE labs. A third reviewer found that Navistar has developed a solid capable team and that this generally is an area where they excel. One reviewer noted that the integration of multiple technologies, participation and collaboration between team members is essential and identified the project has many key players and participants who are the leaders in their respective technology areas on board. A reviewer suggested that it would be helpful to acknowledge project partners for their contributions with a logo on those slides that they involved in. With a comprehensive list of partners, it would not help too much for the content. The reviewer asserted that with a comprehensive list of partners, it would not help too much for the content. Another reviewer added that the project should clearly list the targeted fleets and/or targeted customers and include voice of the customer requirements or targets to show impact on design process.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewers had generally positive comments regarding the proposed future research for the project. One reviewer detailed that the project has a plan to further investigate hybridization issues as well and more work on lightweight materials. The reviewer added the plan to upgrade and optimize the various technologies in the next mule truck test is good. Another reviewer indicated that Navistar has a good plan to complete this project in the next few years. The reviewer noted that Navistar's use of the Kentucky route for real-world fuel economy testing is a good example. A different reviewer praised that this was by far the best presentation

on SuperTruck and that the reviewer would personally love to see Navistar push this even further and faster. Another reviewer stated that the future tasks are direct follow-ons to continue logical work plan that covers all aspects of the truck's and trailer's performance, and the final reviewer commented that the future work and research seems to focus on the program objectives.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All the reviewers agreed that sufficient financial resources are in place for the project. Comments provided by the reviewers were that it appears the researchers had the right resources in place. Another reviewer commented well done. A third reviewer indicated that evaluating costs of R&D was not a forte of this reviewer, but this project appears to have designed tasks in such a way as to complete all required tasks within the available funds.

Evaluation and Adaptation of 5-Cycle Fuel Economy Testing and Calculations for HEVs and PHEVs: Henning Lohse-Busch (Argonne National Laboratory) – vss065

Reviewer Sample Size

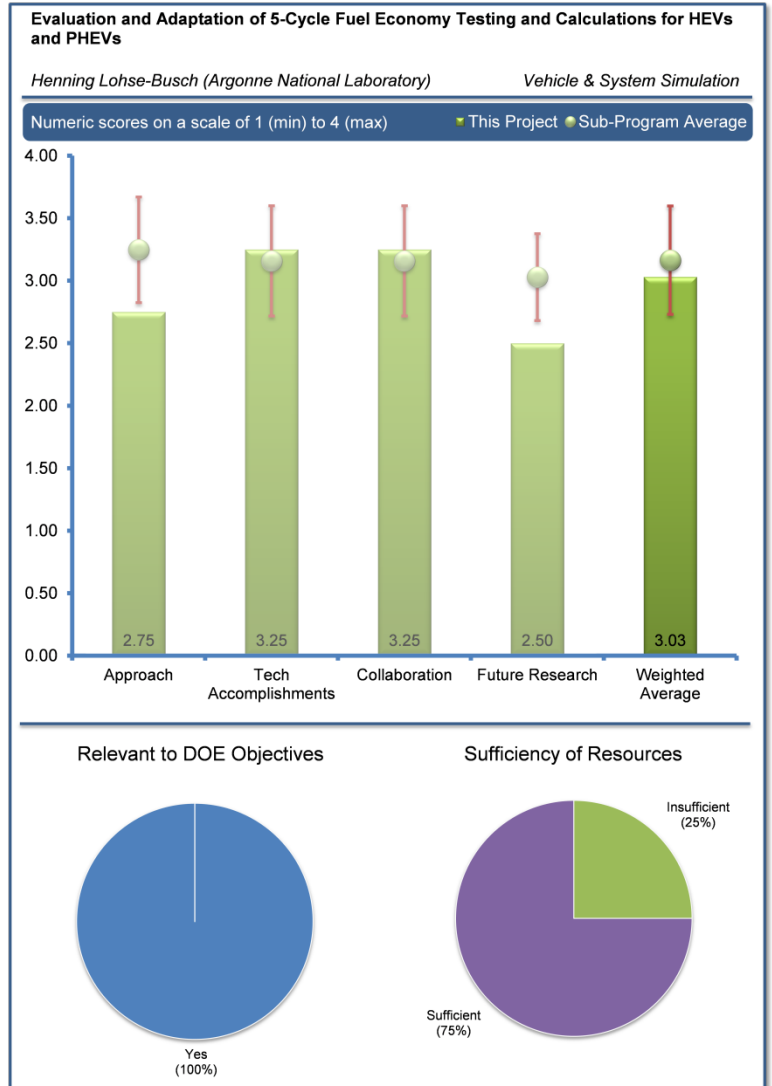
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers agreed that the research project was relevant. One reviewer acknowledged the project as directly relevant to determining the amount of petroleum reduction from use of specific hybrid vehicles. Another reviewer indicated that the project was absolutely critical to understand if certification rules create an unintended gaming for label values versus the real performance of the vehicles. The same reviewer noted that the project provides key information for DOE and EPA to collaborate on standards development tied to emerging technologies sponsored by DOE. Another reviewer commented that as the five-cycle method is derived from emission testing procedures where phase results are used for the fuel economy calculation, the charge balance is not achieved. Thus, the reviewer notes that fuel economy charge correction lines need to be determined for all the phases used (correction method according to SAE J1711). Other reviewers agreed that it is important to adapt EPA fuel economy label calculations accordingly as the penetration of hybrid-electrical vehicles is increasing. The reviewer reiterated that this project analyzes the so-called five-cycle fuel economy calculations designed to reflect real-world driving. Another evaluator mentioned that it is important to understand how stored energy in electrified vehicles affects comparative and real-world measures/ reporting of fuel economy so that consumers have reliable data for buying decisions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed feedback on the technical approach. A reviewer commented that the bulk of the work to date has been methodology development but there is some risk that this methodology development was undertaken with only one vehicle make and without access to hot/cold test facilities. The reviewer added that the methodology should be checked / confirmed by early testing of vehicles with different architectures (i.e., EV, Chevrolet Volt) and by including testing on the hot/cold chassis rolls. One reviewer said that the presentation needs to clarify what is meant by charge or discharge. The reviewer questioned if that is that energy coming from the battery, or energy coming from the APUs. The same reviewer admitted having a good understanding of the basic concept of state of charge (SOC) correction over different driving cycle phases, but found the presentation of this data difficult to follow. The reviewer asked if discharge referred to what was happening to the battery during a phase, or if it referred to the correction that needed to be made after the phase has been driven. This reviewer commented that the investigative questions cited were appropriate, but incomplete. An example provided by the reviewer is that the project should test and analyze additional



vehicles; it cannot be assumed that other vehicles will behave the same as the 2010 Toyota Prius. This reviewer noted that a resource-intensive approach – Slide 10 chart required four weeks of testing for only one vehicle. Another reviewer said that the approach appeared very sound given the limited funds and single vehicle sample. This reviewer thought that the project could highlight even more that this is a SINGLE SAMPLE indicator and not conclusive as to a broader population of vehicle architectures. According to this reviewer, the information was available in the presentation, but cautioned it could be flagged at every instance of presenting results, such as on the Summary slide, which appeared to have a broad conclusive statement. The final commenter specified that the key question is whether it would be better to develop a real-world fuel economy label for HEV/PHEV with a focus on energy efficiency itself instead of using a fuel economy label developed for gasoline vehicles with a focus on emission and adapt it for PHEV. The commenter stated that the chosen approach is valid but the explanations in the diagrams could be improved.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed comments were received on the technical accomplishments and progress of the project. One reviewer indicated that the project had good data and information given limited funding and short timeline. Another reviewer noted that the major contribution is the Charge Correction Curve. One reviewer commented that the project had useful (and fortunate) conclusion that correction required on five-cycle fuel economy label is much smaller than the corrections needed on each phase (five-cycle corrections less than 1% for the Toyota Prius). The reviewer also questioned if this result was applicable to other vehicles since it was only tested on a 2010 Toyota Prius. A different reviewer was concerned that the base method is defined but needs to be extended to the full five cycles and multiple vehicle makes. Additional comments were also that while ANL developed a set of charge correction lines, it was admittedly impractical due to the number of test points needed. This was somewhat reiterated by another reviewer who pointed out that the presenter indicated that the impact of the phase charge imbalances on the final fuel economy label was not as significant as originally expected. A question also came up with one reviewer who wanted to verify if the assumption in the calculation of the fuel economy correction line is a linearization (i.e., if the approximation was correct). Another reviewer commented that the chart on Slide 9 was confusing and questioned if the engine generally charges the battery on low-speed cycles and discharge on high-speed cycles. Another reviewer said that the presenter said that the project is on schedule to complete the study with multiple vehicle makes. The reviewer cautioned that this statement should be confirmed since no schedule was presented. The reviewer specifies that it appears that the project schedule called for work to be completed by Winter 2012 but there is significant work to be done. Another reviewer felt that the question whether the 5-cycle method encourages different design decisions than the 2-cycle method had not really been answered.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers noted that the collaborations were good including the collaboration with EPA and others for the limited time and scope of project. One reviewer noted that the research used modeling resources at ANL and used academic resources at Virginia Tech – primary developer is a co-op student. Another reviewer mentioned that the United States Council for Automotive Research (USCAR) was involved in test planning and results evaluation but the extent/value of the interactions were not very clear from the presentations. One reviewer indicated that what was missing is the participation of at least one industrial partner.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments regarding the proposed future work and proposed future research varied. One reviewer noted that the proposed future research would test different HEVs and PHEVs (which addresses this reviewer's concern from question three). Another reviewer noted that the project could make a few more statements regarding what would be good next vehicles to test with the same approach. The reviewer asked what technologies could create a larger differential than the tested Toyota Prius and what should be tested next. A different reviewer suggested that instead of further testing of the adapted five-cycle method the project work on new dedicated fuel economy labels for PHEVs and HEVs in collaboration with EPA. One reviewer felt that it was difficult to understand whether the remaining work was containable within the project schedule and budget.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer found that funding was insufficient. Three reviewers indicated that the research project had sufficient financial resources. Comments from one reviewer were that the project did good work with the limited funds provided and that the project appeared to be on track for concluding current scope with approved resources. Another reviewer added that this was a cost-effective project but it appears the hot/cold test facilities were available at the time of project execution. The reviewer noted from prior comments that the remaining work schedule and budget should be confirmed. A different reviewer indicated that what was unclear was whether the upgrade of the Advanced Powertrain Research Facility of being five-cycle capable is in any context to the resources utilized for this project.

Grid Interaction Tech Team, and International Smart Grid Collaboration: Keith Hardy (Argonne National Laboratory) – vss067

Reviewer Sample Size

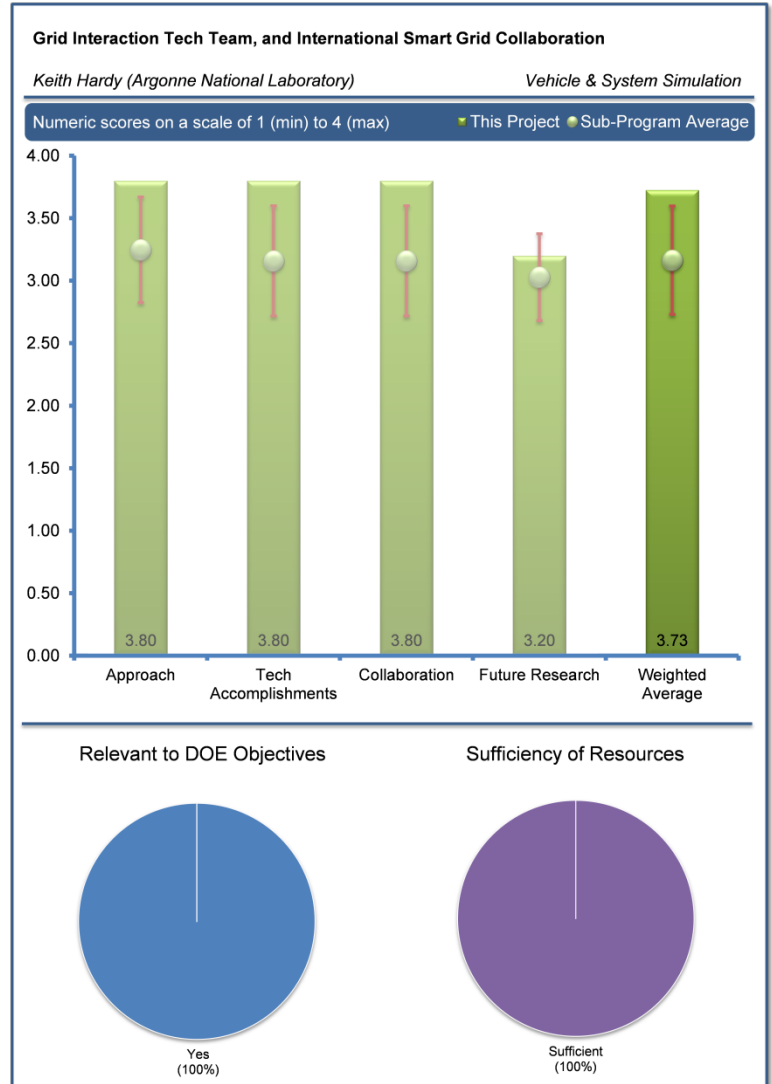
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers agreed on the relevance of the research project. One reviewer indicated that ensuring grid interaction by EVs will help EV gain market share, resulting in petroleum displacement. Similar comments were reiterated by another reviewer, who said that this project advances the adoption of EVs, which directly leads to reduction in petroleum consumption. For this reason, the reviewer notes that the project is relevant and supports DOE's objective of reducing petroleum consumption. Another reviewer described that this project is focusing on international development of standards relating to the interaction of electrified vehicles and the electrical grid. Thus, the reviewer agreed that the project impacts the efficiency and market acceptance of cross-industry producers and consumers respectively. The reviewer added that enabling Smart Grid Technology development and deployment advances the ability of consumers to charge their vehicles quickly and cost-effectively. A different reviewer reiterated praise for the relevance of the research commenting that the project had excellent relevance to light-duty vehicles and EVSE. The same reviewer had asked about medium- and heavy-duty applicability and gaps; the answers received focused on commercial versus residential rather than medium- and heavy-duty versus light-duty.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most of the reviewers provided positive comments on the approach to performing the work. One reviewer remarked that the approach is sound, whereas another commented that it seems the ANL have a world-wide knowledge of standards roadmaps for electrification and accept responsibility for their timely evolution. The project team indicated that current emphasis is placed on connections, communications, metering, and interoperability. Another reviewer commented that this project is overcoming challenges through cooperation and harmonization of other EV funded initiatives. The reviewer noted, through these efforts, significant technical assistance is provided and shared across multiple programs and acknowledged that this approach was sound and consistent with DOE goals. That same reviewer specified that the project is targeting the various levels of grid connectivity which are necessary for a fully integrated system. A different commenter commented that the project is logically organized covering the range of technical barriers with respect to grid interactions issues that need to be addressed now. The reviewer also added that the project dovetails with other related projects at other labs and the standards groups. One reviewer commented that a



lot of activities are conducted under the initiative to address various aspects. However, there is a lack of performance measures by which the team's contribution could be identified.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers provided positive comments on the technical accomplishments and progress of the project. One reviewer noted that ANL appears to be on-time in completing milestones with numerous publications and presentations. A second reviewer noted that clear roadmaps, schedules, and evidence of driving to timely completion were presented, and that effective harmonization between the United States and Europe has been achieved. This reviewer noted that challenges remain between the United States and Asia. Another reviewer remarked that excellent progress has been made in producing hardware that is ready for test on pilot projects. The reviewer added that future work must be focused on using this hardware on pilot tests for debugging and standards enhancements and noted that the cost of these units is crucial for wider adoption and must be a focus of research as well. One reviewer noted that the development of the metrology and communication hardware devices is significant. The reviewer added that the overarching support to all grid and EV developer stakeholders is helping break through multiple barriers. The reviewer alluded to the United States' and European Union (EU) agreement for EV interoperability as another example of excellent progress. Another reviewer acknowledged that the team made major progress on hardware development but on other fronts the progress is less clear.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Several reviewers recognized that the project had good collaboration or seemed very good. One reviewer noted that there was formal collaboration between DOE and the EC and alluded that Obama and Merkel pledged to work together on electric transportation. A second reviewer noted that the very nature of this work is collaboration. It appears that ANL is taking a leading role in coordinating multiple activities across multiple world-wide standards making bodies. The same reviewer added that the project is establishing interoperability validation centers in the United States and Europe. Another commenter noted good collaboration is shown between vendors, committees, and international partners. For this reviewer, potential improvement could be shown by incorporating vendors of other electric vehicles such as warehouse jitneys, forklifts, Segways, heavy-duty vehicles, etc. Another noted that the level of coordination with all the various stakeholders is significant. Collaboration with the other labs and the utility industry is also significant. The final reviewer noted a lot of collaborations or interactions. However, this reviewer felt that the coordination of efforts and responsibilities needs clarification.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The comments received regarding proposed future work and research varied. One reviewer summarized that the future plans build on the past work and are focused on near-term needs of EV developers and the standards community. Another reviewer felt that the proposed future work is well focused on ensuring continuous updating of hardware to include the latest requirements. The reviewer agreed that preparing for wireless charging and communications is highlighted and will be important. The reviewer pointed out that cyber security is shown as an area that will need work, but no defined goals are set, which should be included. This was reiterated by another reviewer who did not see details with regard to cyber security. That reviewer noted that this will be increasingly important as vehicles, EVSE, and the grid become more interoperable and should be addressed. The reviewer added that some example pathways for mischief or attacks include denial of charging, and instantaneous coordinated full-power charging (or discharging) of large numbers of vehicles resulting in high aggregate current levels that could overwhelm the grid. Another reviewer commented that the systems interoperability validation studies are of critical importance and added that it seems additional resource will be needed for these activities but 2012 budget is reduced significantly. This comment was added to by one reviewer who indicated that field tests are required and should be a larger part of this project (or part of a new project) to validate and refine designs. Another reviewer expressed that continued international harmonization will speed market growth due to efficiencies on the producer side and improved regulatory oversight. This was also commented on by another reviewer who said that China and Japan are mentioned in the international program development slide but future work does not include much about them. In addition, the reviewer said that there is a lack of partnership with these countries.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agreed that sufficient financial resources were available for the project. Several reviewers commented that financial resources were adequate for the proposed work and that the project has been meeting schedules and is predicted to continue doing so. Another reviewer noted that effective project execution indicates sufficient resource and funding. A different reviewer asserted that there was no mention of insufficient resources, therefore the amount being accomplished with the provided funding appears to be commensurate. Another reviewer observed that because the scope of work is flexible, the project can accommodate a range of budget. One commenter reported that the project closely coordinated with codes and standards and international harmonization work. One evaluator commented that the budget has been reduced for 2012 yet the project is moving into system validation trials, which would seem to require more resource. Thus, the reviewer noted that particular care should be taken to ensure the project is designed accordingly. The reviewer suggested that perhaps separate funding for the interoperability centers is planned.

Optimal Energy Management of a PHEV Using Trip Information: Dominic Karbowski (Argonne National Laboratory) – vss068

Reviewer Sample Size

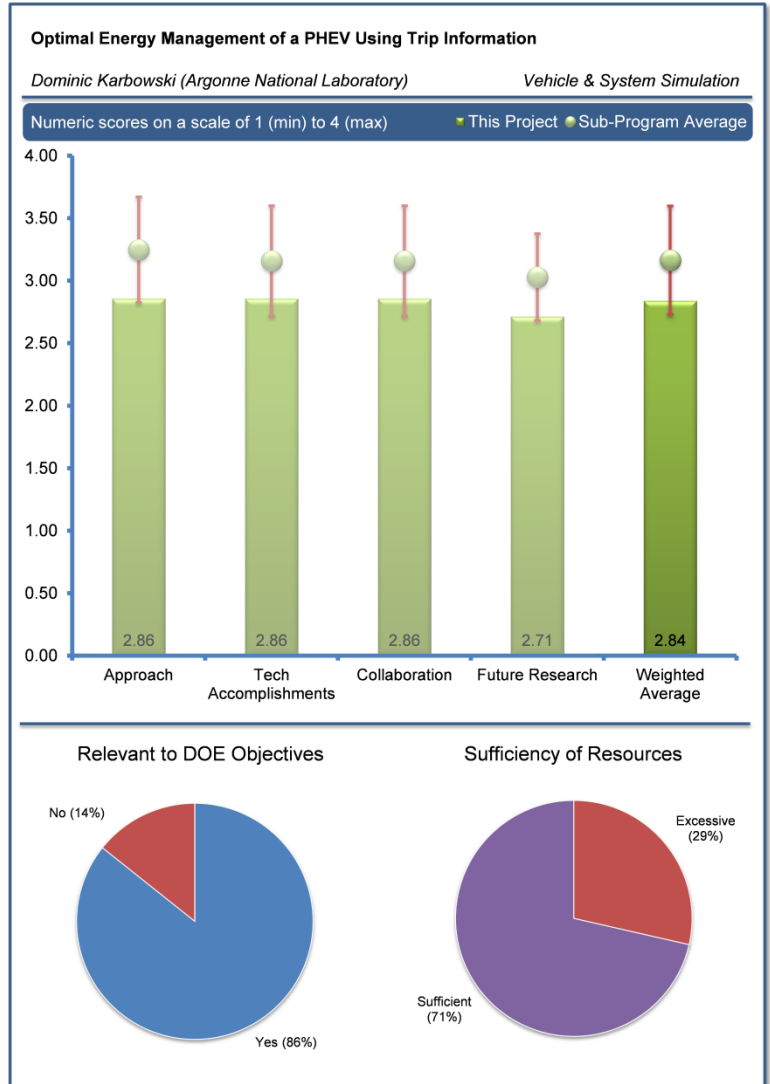
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that including trip information in the PHEV control strategies is very relevant to optimize the overall energy efficiency of the vehicle. Another panelist indicated this project addressed the subject of fuel economy gains, and although labeled as a PHEV program, a positive outcome could be applied across all transportation segments. The next commenter agreed that this approach is a precursor to a full-blown Intelligent Transportation Systems (ITS) and should offer significant fuel savings, even on vehicles equipped with conventional powertrains. This commenter stated that the benefits for PHEVs should be even greater than for conventional vehicles. A subsequent reviewer noted that if successful, this project has the potential to reduce petroleum consumption by more efficiently using the available power on the vehicle. The next panelist wrote that this project attempts to utilize destination knowledge, including road profiles, traffic patterns, etc., to optimize energy management in a short-range PHEV. The panelist indicated that using prior knowledge of these parameters can lead to implementation of conducive control strategies to maximize vehicular fuel efficiency and minimize emissions. The final reviewer found that the objective of the study matches the DOE objective but that the methodology was significantly flawed.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer was of the opinion that it is very important to leverage real time information about the true traffic speed and estimated stop locations and durations by utilizing data from vehicles via vehicle-to-infrastructure (V2I) communication (e.g., via dedicated short-range communications [DSRC]). This reviewer further commented that generation of the target speed should also be influenced by real vehicles that are driving below the speed limit. The same reviewer opined that the approach did not consider a real-world validation of the simulation results, and was completely based on simulations. Another panel member observed an interesting task that has a methodical and logical approach laid out to achieve objectives. This panel member found that the key to the approach is the use of dSPACE ADAS Research Platform Blockset to permit exporting of road data and subsequent processing in Autonomie. The panel member considered it interesting that, if successful, this concept could be utilized in a number of other applications. Such applications, continued this panel member, includes green routing and selection of optimal powertrains for specific routes, not only for light-duty vehicles but other vehicular classes as well. The next panelist relayed that the goal of the project is to develop system-level control strategies for PHEVs that use destination information to determine the optimal control strategy for a PHEV. This panelist shared two suggestions as to how the project could be improved. First, this panelist emphasized



the importance of showing that the adaptive control will not cause a reduction in fuel economy of the vehicle under any circumstances. The panelist described this as a challenging task given the substantial uncertainty in the route and destination prediction when the user does not provide destination information, and further acknowledged that the presenter noted, in the barriers section, the adversity that OEMs have to risk. Second, the same panelist suggested that the team look carefully at implementation issues in the automotive environment. This panelist further observed that the approach seems to be very data and information intensive, and the availability of traffic information may change from one area to another. This panelist finally added that the effect on control performance should be evaluated. Although another reviewer was in favor of the approach being taken, this reviewer would have used many more cycles for the purposes of strategy comparison because the results were being generated through simulation. This reviewer suggested that one option would be to use the data available in the Transportation Secure Data Center to provide real-world drive cycles from various locations in the country. The same reviewer reported that one of the questions from another reviewer was about the lack of statistical variation in the drive cycle that is being simulated, and suggested that use of Transportation Secure Data Center data would partly address that. For instance, explained the reviewer, NAVTEQ could do the routing, and the Transportation Secure Data Center data could provide the statistical variability. Another observer wondered if the baby step presented moves towards the achievement of a viable tool for possible practical applications. This reviewer indicated the research started from a step or two behind the state-of-the-art because there was no real time updating during a long trip, planned or projected in future work. The final panelist found that the study's major weakness was the prediction of a deterministic driving condition (traffic, signals, etc.) and optimization of driving accordingly, which this panelist opined is unlikely to yield significant fuel savings. Also, this panelist had not found the application of control and the human-machine interface to be well noted out.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer cautioned that the opinions submitted may be somewhat biased because this approach was exactly what this reviewer has been urging this reviewer's company to take, though the ultimate objective for the reviewer's company was to use the simulation to develop 50th percentile component and subsystem duty cycles, rather than improving real-world fuel economy. This reviewer agreed with the PI that the OEMs may be reluctant to introduce technology that does not get the OEMs credit in terms of the fuel economy number on the sticker or something equally concrete. The reviewer noted that could change, however. The same reviewer further explained that the OEMs never previously considered Consumer Reports drive cycle as something they should be looking at, but the OEMs began to consider that as well when it eventually sank in that it is exactly what most customers looked at. Now, expressed this reviewer, all three Detroit OEMs have their version of the Consumer Reports fuel economy cycle, which is used to evaluate their vehicles. It may just take one OEM to consider your approach, opined this reviewer, and the others will likely follow. The second observer indicated that technical accomplishments and progress were acceptable, in the context of the planned project plan. This observer pointed out that about half of the planned work is visiting territories that have been well covered already, and stated that all work done to date is mostly busy work which could be done on as a thesis topic of a Master's degree. The observer further stated that similar technology has been available for a few years now (e.g., Tokyo metro area and surroundings, including Yokohama, etc., offer real-time trip route optimization feedback to a driver once the arrival point has been entered). This observer pointed out that using building blocks from such technology could have saved effort, time, and money. Another panel member reported that the primary focus of the project so far has been in developing a tool that is able to generate a driving cycle given the origin and destination for a trip. This panel member noted this to be a very useful tool, but that it was unclear what the lab has done and what comes from their partner NAVTEQ. The panel member remarked that sharing this tool with other researchers in some form would substantially strengthen the impact of the project. The next observer considered the development of the dSPACE ADAS Research Platform Blockset, as well as the development of Autonomie simulation modules, to be the key technical accomplishments. This observer indicated that it was not clear whether only the Chicago trip was simulated and analyzed, or whether multiple trips were simulated and analyzed. This observer also noted the lack of explanation as to where the data sources come from for traffic pattern speed and stop locations, and related that no statements were made in terms of the actual effect on the vehicle energy efficiency if an optimized control strategy is applied. A subsequent reviewer found that while the task is a little behind schedule, a number of technical accomplishments have been achieved. This reviewer highlighted development of a dSPACE ADAS Research Platform Blockset plug-in that formats information for Autonomie, and successful processing of trip information in Autonomie in which a vehicle speed target is generated. This reviewer further reported that a trip

simulation is then developed based on speed and grade, and the output here can be fed into a distance-based driver for whole vehicle simulation. The final reviewer reported the project had made little progress, and that the majority (and the most important parts) of the research was yet to be done.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer observed that the team has demonstrated a very strong collaboration with NAVTEQ. Another panelist noted that collaboration seemed adequate for this activity, although indirect reference to discussions with OEM R&D engineers should be more detailed and elaborated. This panelist suggested that it may also be good to have discussions with medium- and heavy-duty vehicle manufacturers as their vehicles and duty cycles may benefit the most from this type of technology and subsequent control strategies. Another panel member recommended potential coordination with Jeff Gonder at NREL that may be worthwhile for this project. The next observer noted that the project showed some collaboration, but that it appeared superficial. The following reviewer opined that the researchers should consider also including telematics service companies in the collaboration stakeholder portfolio. This reviewer further pointed out that it is essential to have at least one OEM to validate the simulation results with a physical prototype. The final panel member saw no connection with the end users or other stakeholders in the PHEV domain. This panel member also mentioned that the last bullet on presentation Slide 16 is not justified and at best reflects some naiveté. The same panelist expected to read such a comment on Facebook, but not within a serious R&D program sponsored by a government agency.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that future work is relevant and challenging. Another reviewer indicated that the third quarter is the most critical building block, and is the core of the program if it is to produce something worthwhile. In fact, this reviewer considered third quarter to be the real program starting point. The next observer noted that proposed future work made sense given the scope and status of this task. This observer relayed that to provide quality control, it is being proposed to refine the derived drive cycles through added nuances to the discrete driving segments and comparing results to that of real-world drive cycles generated from global positioning system loggers or established database information. This observer further stated that subsequent to this step, efforts will focus on choosing a representative baseline PHEV for study and developing appropriate control strategies, with an ultimate goal of comparing the full trip fuel efficiency of trip-based control to standard control. This observer concluded that it will be very interesting to see what type of overall driving cycle efficiencies can be realistically and consistently achieved. Another panelist referred the reader back to previous statements, which urged the researchers to use the data available in the Transportation Secure Data Center to provide real-world drive cycles to address the lack of statistical variation in modeled drive cycles; and suggested coordinating with Jeff Gonder at NREL. The next reviewer indicated that the researchers should make major revisions to the current research plan. The final panel member suggested that the proposed future research needs to focus on the following topics: validating the simulation results with data from real-world cycles; implementing the control strategies in vehicle prototypes and measuring the effectiveness of these control strategies; generating real-time traffic data from vehicles (via DSRC-based V2I communication); and actively influencing the achievable top speed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Five reviewers found resources to be sufficient, while two found them to be excessive. One reviewer noted that the resources allocated for this task are currently sufficient, but that if the task is ultimately successful and exhibits demonstrable fuel efficiency benefits, it would be beneficial to further fund this activity to achieve its promise and subsequent implementation into conducive vehicle classes and models. Another observer agreed that the resources appear to be sufficient for the simulation related work; however the validation will require more significantly more resources for future research activities. The next panelist commented that the resources are sufficient because the work at this stage is purely simulation-based. A different commenter reported the project was mostly computer simulation with no real-world testing, and that the research funds could be better utilized. The final reviewer suggested that work to date has been covered before and appeared to be busy work of a lower academic level, lacked connection with the end users or other stakeholders in the PHEV domain, and characterized third quarter 2012 as a starting point for the project. In light of these comments, this reviewer opined that even if the entire program funding was \$250,000, it would be

considered relatively generous because a competent Autonomie user could accomplish a major part of the intended results with a small fraction of the cost.

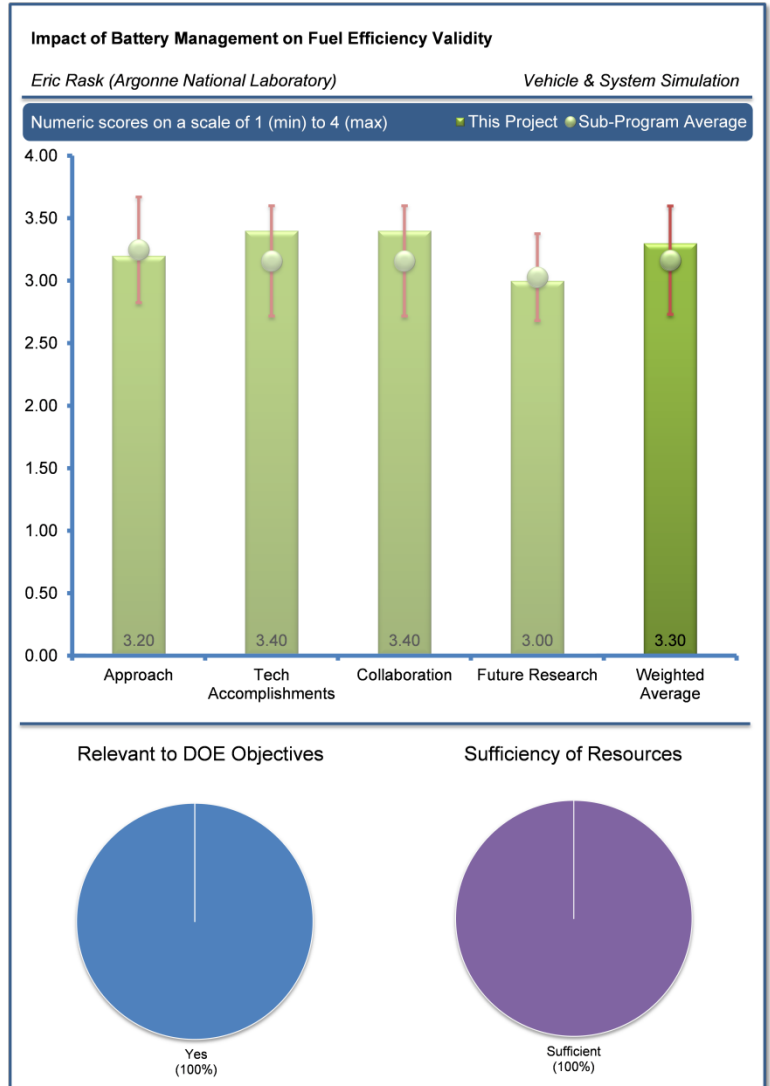
Impact of Battery Management on Fuel Efficiency Validity: Eric Rask (Argonne National Laboratory) – vss069

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewers provided similar comments on the relevance of the project. One reviewer summarized that while the project does not directly impact petroleum displacement, it allows objective evaluation of technologies that are intended to displace petroleum usage. Another reviewer said that this effort directly supports standards development which is critical for unbiased technology evaluation and assists in the adoption of advanced vehicles. Another reviewer commented that this project supports the evaluation of battery electric and plug-in hybrid vehicle evaluation and comparison to petroleum-based vehicles. The reviewer added that a successful project will advance the robustness and reduce the cost of battery electric vehicles thus encouraging petroleum displacement. A different reviewer suggested that with the consideration of EVs and HEVs, the impact of the battery energy management on the fuel economy needs to be properly considered. The same reviewer added that the project addresses the importance of the Net Energy Change (NEC) metric in correcting standardized fuel consumption tests.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that the project goal is important: improving advanced vehicle test procedures will provide more certainty in the marketplace. The commenter felt that this is a good role for the DOE to get involved. However, the objective of the project is somewhat broad, unclear and open ended. An example provided by the reviewer was that it was unclear what impact the evaluation of state of energy (SOE), SOC discrepancy will feed back to impact vehicle design and standards. Another reviewer summarized that the project is leveraging existing light-duty data to understand NEC trends and sensitivities and apply the findings for an evaluation of medium-duty/heavy-duty vehicles where data availability is very limited. The reviewer added that as this data is limited, it is recommended to collect more data which is also needed to validate the simulations. Another reviewer commented that that the approach of extensive modeling and selected testing to identify opportunities for improved models and improved testing directly addresses the barrier of test protocols. This reviewer commented direct usage for medium- and heavy-duty vehicles. The reviewer suggested that the project needs more effort on the modeling for medium- and heavy-duty vehicle energy consumption modeling. In addition, the reviewer notes that the difference in the battery and vehicle use between light-duty and the medium-duty and heavy-duty fleets are large. Thus, there needs to be more effort to interrogate the data so that there is an understanding as to what can be learned from light-duty to apply to medium-duty and heavy-duty effectively, without running down an unproductive path.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers provided positive comments on the technical accomplishments and progress of the project. A reviewer noted that a very important result is the proposed correction procedure for the net energy calculation. The reviewer added that the NEC non-linearity is addressed and that the difference between SOE and SOC is well explained. Similarly, one reviewer commended that the quantification of NEC tolerance effect on fuel economy as a significant achievement. Another reviewer commented that there has been good progress towards the technical goals. The investigations on temperature effects and the sensitivities are promising. A different reviewer added that it is not completely clear from the presentation what the expected completion date of the project is – so it was hard to judge how well the project is progressing toward completion. With that being said, the reviewer remarked that the results presented provide valuable insight into some of the issues involved in coming up with a good standard for measuring PHEV fuel consumption. One reviewer indicated that the investigations into state of charge relative to state of energy are important for improving battery control algorithms and remaining range estimates. A reviewer suggested that more efforts need to be expended on the larger battery systems likely to be used for medium- and heavy-duty applications. In addition, the reviewer added that the suite of analysis needs to be better integrated to improve the robustness of the systems and predictions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers provided positive comments on the project's collaboration and coordination with other institutions. Reviewers remarked that the mix of involved institutions and industrial partners was outstanding, and that all relevant stakeholders for the development of the SAE J2711 test procedures are involved team was involved in standard development with the SAE which was an important goal of this project. Another reviewer acknowledged the strong collaboration through SAE, DOE, Canadian groups and the software for modeling. However, one commenter observed that while the medium- and heavy-duty community appears to be well represented, the HEV/PHEV community does not appear to be involved in the project. The commenter suggested that perhaps it would help to have the automotive OEMs involved as well.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments on proposed future research were mixed. One reviewer indicated that the proposed work looks good, but wanted to know if there could be more benefit achieved by involving passenger vehicle OEMs as well. Another reviewer identified that the most important future research work is the finalization of the SAE J2711 procedural changes and the evaluation of specific medium-duty/heavy-duty issues. A different reviewer acknowledged that the future work addresses the technical issues. However, the reviewer would like to see deliverables of the future work more clearly defined. The reviewer suggested that the future work should have a direct path to inclusion in modeling and range estimates and added that the presentation identified many other issues that are not clearly addressed in the future work. Similar concerns were reiterated by another reviewer who indicated that the plan for the future work could be more focused. The reviewer mentions that in the future work outlined for light-duty vehicles, it is unclear what impact the team would like to have by the end of the project, especially with the battery monitoring work and by assessing emerging technologies through continuing testing and analysis.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that the project had sufficient financial resources available. Several reviewers commented that project resources are sufficient, appear to be sufficient, or are sufficient for the modeling efforts. One reviewer noted that the testing effort will require more resources either from the industry or DOE.

Electric Drive Vehicle Level Control Development Under Various Thermal Conditions: Namdoo Kim (Argonne National Laboratory) – vss070

Reviewer Sample Size

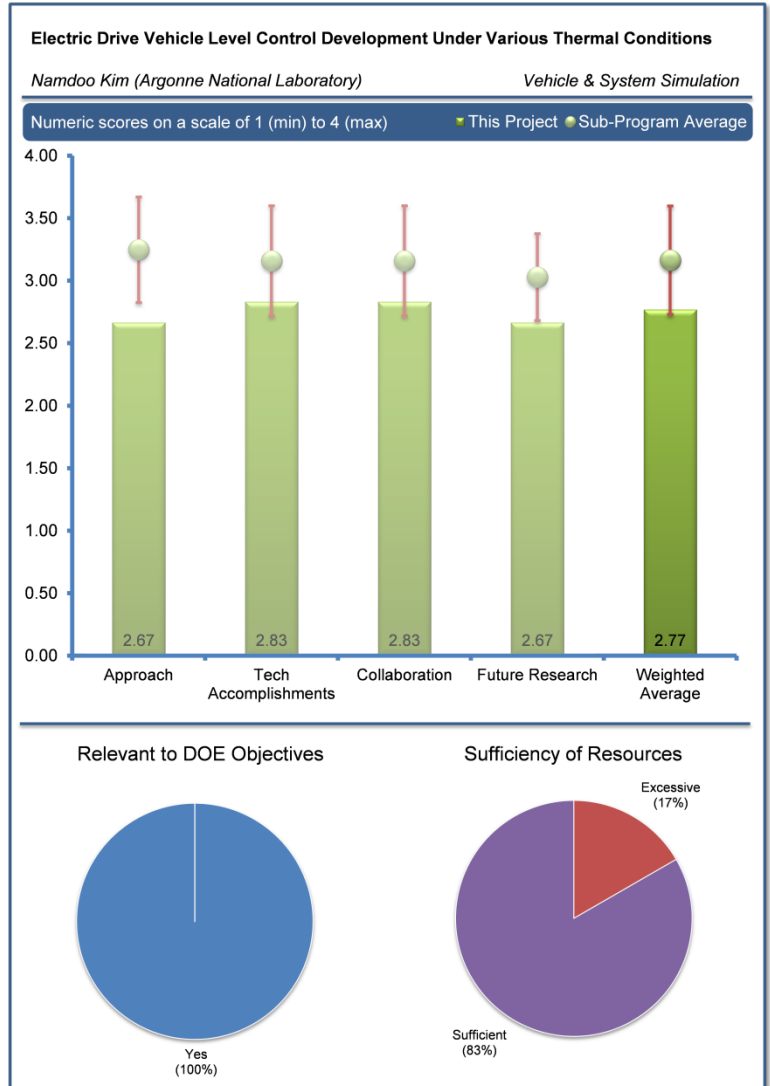
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer explained that there is a measurable benefit to be gained in terms of fuel economy by using effective thermal management, even for vehicles equipped with conventional powertrains. This reviewer expected this to be even more so in the case of electric drive vehicles. Another panel member considered thermal management system optimization of a vehicle to be helpful in increasing fuel economy, which supports the overall DOE objective of petroleum displacement. In particular, this panel member indicated that for high fuel economy vehicles such as EVs and PHEVs, auxiliary loads have a higher impact on the overall fuel economy compared to conventional vehicles, especially considering high and low ambient temperatures. The next panelist remarked that a better understanding of the thermal behavior of advanced vehicle components is of interest to the DOE. Another reviewer commented that auxiliary loads will affect range due to demands on battery, and that due to the nature of subsystem suppliers to cost optimize their particular system, it becomes difficult for the vehicle integrator to optimize all of the subsystems from the vehicle perspective. This reviewer expressed that the project could help give guidance to OEM, system, and subsystem suppliers. The final observer pondered if the industry's current technical competency is so lacking to the point that an esteemed national lab team should invest time and resources in formulating and running models (e.g., MATLAB/Simulink and Autonomie).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One panelist noted that the approach seemed logical, and that the researchers were analyzing the components under ambient temperatures and then introducing temperature extremes. This panelist found the utilization of the control model to be a good approach. Another reviewer indicated that the approach was straightforward and segmented into a vehicle cooling system and climate control system path, and further observed component validation, vehicle control, and vehicle validation. However, this reviewer wondered what could be accomplished in this project that could not be accomplished by an OEM. The next panel member explained that accurate models of both the electric machines and batteries appeared to be required to achieve the goal of this project. In addition, this panel member asserted that the impact of temperature would be indicated the most on the cold Federal Test Procedure cycle, and was unsure whether lumped thermal models of electric machines and batteries have adequate resolution to capture peak temperatures. The panel member also remarked that it appeared that the focus so far has not been on the cold cycle test. This panel member stated that it is reasonably easy to develop and validate thermal models for normal operating temperatures,



but cautioned it would be considerably harder to develop these for low temperatures because measurement of component efficiency at these lower temperatures is not easy. Further, continued this panel member, even the use of analytical models to represent temperature dependence of efficiency will require significant effort at validation. The panel member also referred the researchers to Professor Heath Hofmann's (University of Michigan) work on developing effective lumped parameter thermal models of electric motors. A different reviewer found that this seems to be a modeling exercise, and inquired about the size of the investigative or R&D portion. The final observer relayed that the goal of the project is to develop a system-level thermal management strategy to improve the vehicle fuel economy, employing an approach of developing a thermal model for each component of the vehicle as well as the system-level control strategy to be able to potentially tweak the control to improve the vehicle fuel economy. This observer found that a substantial part of the year had been spent of developing the system level control for the vehicle, which seems secondary to the goal of the project. The observer was also concerned that the proposed approach is unclear about how the models and the approach can be generalized to other vehicles and other technologies or cooling methods. Therefore, concluded this observer, the impact of the project may be limited.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One observer expressed that the progress had been quite significant, with substantial impact on fuel consumption change due to effective thermal management being seen in the cold cycle. This observer reported that the project is close to 70% complete, but that the presentation did not make clear whether the project will look at low temperature behavior of the various components (i.e., engine, transmission, electric machine, and battery pack). The observer recommended that, if developing models that are valid at low temperatures is not part of the project scope, perhaps it should have been clearly stated. Another reviewer saw good progress to date, and reported that researchers had developed the control model and are verifying it on the Chevrolet Volt. This reviewer also acknowledged the battery thermal data, loaded in Autonomie, as progress. The next panel member asserted that, barring the concerns about the project approach, the team has made significant progress towards developing the vehicle control strategy model and developing the thermal models of various components. A different panelist related that the vehicle model (Toyota Prius) and battery thermal model (Chevrolet Volt) have been validated so far, which is in line with the milestone plan. The final reviewer observed that the start of some level of investigative work in this program was promised by Slide 12. Prior to that point, this reviewer opined that the reported work could have been routine for any analyst relatively well-versed in Autonomie. The reviewer concluded that the values of various constants used in the simulations are mostly guess work, and thus, matching the simulation to the experimental data is the same old art.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that the stakeholder selection reflected the right balance between industry (OEM and battery manufacturer) and multiple National Labs, including a software partner (MathWorks). Another observer indicated that the team had formed many, meaningful collaborations, but noted a closer collaboration with the OEMs could have saved the team substantial time in developing component models and control strategies. The next reviewer explained that this project could have been rated lower by this reviewer, who scored the project higher based on the intent that the next points be addressed in future years. This reviewer perceived the partnership on Slide 2 as the usual vague and escape clause, and further described it as trying to avoid accountability, at least for the DOE Annual Merit Review audience. The next panel member would have liked to see more of an active involvement from component level suppliers and an overall OEM, especially because no specific companies were listed. Because of this omission, the panel member was unable to determine if the collaborators are planned to become involved or are already actively involved. The final panelist expressed that there was significant overlap in the area of development of component thermal models with the project vss046 (Integrated Vehicle Thermal Management - Combining Fluid Loops in Electric Drive Vehicles). This panelist recognized that the presentation does indicate cabin and A/C models were developed at NREL, but pointed out that it did not say whether the electric machine and battery pack models were developed in conjunction with the other project. The final panelist concluded that if these models were already developed for vss046, it would make sense to just use them rather than starting from scratch.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One observer reported that the proposed future work addresses development of thermal models for other powertrain configuration. This observer indicated that identifying the potential for higher energy efficiencies in component redesign will be the true value contribution of this project, but that first the model must be validated properly. Another reviewer suggested that some effort may be saved with more collaboration with other DOE funded projects, and pointed out that MathWorks may not be the best collaborator for developing an effective engine thermal model. This reviewer further suggested that it would instead be preferable to work with someone who is more familiar with the practical behavior of an engine. The next panel member asked about the other variables considered (e.g., if driver inputs affect the studies). In other words, this panel member wondered if a situation where one driver may consistently drive with the air-conditioning on, while the next driver does not use it at all, would affect the overall system performance. A different panelist expressed that it seemed difficult to develop a robust applicable thermal control strategy when there are no systems and vehicle standardization. This panelist suggested the researchers pick and stick with one throughout the entire process. In other words, continued this panelist, what the researchers are observing today may be completely changed two to three years from now. The final reviewer stated that, barring concerns about the project approach, the team has a solid plan to meet its targets.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Five reviewers found resources to be sufficient, while another reviewer observed excessive resources. One reviewer noted that this project appeared to have sufficient resources to draw from. Another reviewer agreed that the resources allocated are sufficient. The next panelist found that no information was reported on resources used or those required going forward. The last reviewer said that the excessive rating was in the context of previous comments, and further questioned if this project is a continuation of a prior year's program because it shows \$250,000 for FY 2012, but Slide 5 describes the work done in FY 2011, and Slide 6 shows intended work for FY 2013. This reviewer stated that if this project is a continuation, then full disclosure is encouraged, as presenting only piecemeal funding of a larger program should not be condoned. The reviewer concluded by asking what the value and the return on DOE investment were from traveling to Chenzhen, China to present part of the work done (Slide 21).

Hydraulic HEV Fuel Consumption Potential: Aymeric Rousseau (Argonne National Laboratory) – vss071

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

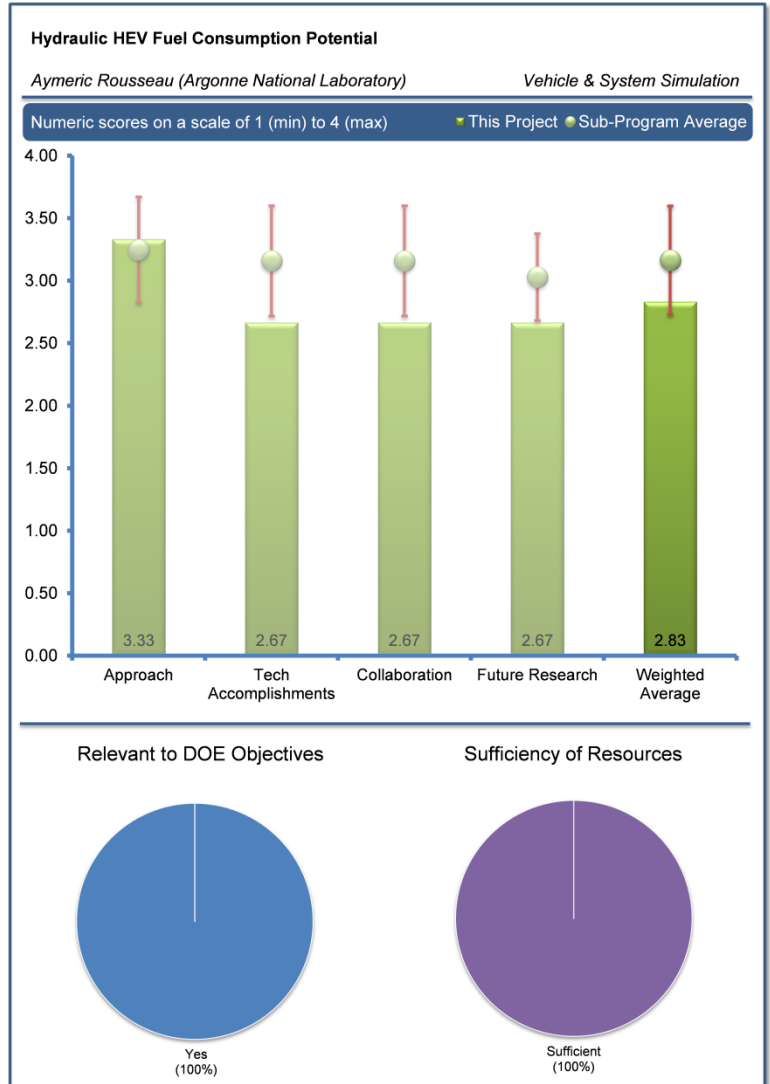
One commenter remarked that this project would help DOE determine justification for either future funding or closing of the hydraulic hybrid vehicle (HHV) efforts. Another reviewer indicated that this project produced a good trade off study of fuel consumption performance across various drive cycles between HHVs, series and parallel HEVs, and conventional vehicles. This reviewer stated that not all technologies will perform as efficiently across all applications and drive cycles, so having data that can target the system with the best possible application is beneficial. The final panelist reported that this project is looking at quantifying the extent to which hydraulic hybrids reduce fuel use. This panelist stated that several companies are proposing systems that need to have payback to be purchased in quantities or get DOE funding.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A first reviewer indicated that it was good to take a step back and review the EPA accumulated work on HHV through the past several years. Another panelist described the scope as fairly broad, and stated that comparing HHV, HEV, and conventional is an all-inclusive task, which is good. However, cautioned this panelist, keeping the data relevant and current will remain daunting as each of these different platforms improves and changes. This panelist recommended that, at the last step, researchers might narrow the drive cycle selection as the different powertrain configurations will be more appropriate and tuned for different drive cycles. The final observer agreed that the use of the EPA models was a good idea to save time and effort, as was changing control to include pump. This observer also opined that if possible, more real-world correlation would be valuable, although this would probably greatly increase the scope and budget.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer called this project a pragmatic and unbiased study, and remarked that the comparison of HHV with HEV is quite helpful to DOE and to the general technical community. Another observer reported excellent progress to date, including mapping the various configurations and comparing them across several drive cycles. The final panelist reported that both series and parallel hybrid models were developed, and that the series hybrid model correlated well with the EPA model.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One person observed that because there are existing hydraulic and electric hybrid products already in the market, the PI might try to reach out to the actual manufacturers to enlist their support in any models they have already developed and any data they have compiled. This person would have liked to see more definitive industry involvement and comments. Another panel member suggested that collaboration with hydraulic hybrid companies such as Easton and Parker would be valuable. This panel member commented that it was good that the researchers are looking to get the EPA field data to compare with the modeling results because some providers of hydraulic hybrid systems seem to be pulling back and others are saying they have a business case. The panel member further found that modeling could provide insights into why and what future systems could include in terms of components, and that more direct communication with the providers of hydraulic hybrid systems could facilitate knowledge transfer from this project to the marketplace. The final reviewer suggested that because Eaton is a stakeholder in this, it maybe should get involved, albeit Eaton would be a biased party. The same reviewer reiterated these remarks for TACOM, who have strongly supported HHV in the past (Dennis Wend and Paul Skalny) along with some funding. This reviewer opined that their input to ANL would be valuable.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One observer indicated that the FY 2012 goals seemed logical, but that the FY 2013 goals seemed too broad, with too many variables to include in all permutations and applications. For example, this observer indicated that hydraulics will most likely be limited to best use on a small subset of drive cycles, and suggested starting with those for now. Another reviewer recommended that the researchers look at correlation with field cycle data, if funding allows. The final person asked if DOE should continue to spread the budget of this section of VTP over HHV and HEV, or if it would be sound to down-select to one of them based on technical merits and value proposition. This reviewer further emphasized that there was no need to beat a dead horse.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers found resources to be sufficient. One reviewer reported that no information was provided on resources used or those required going forward. Another reviewer asked if resources were available to poll data from hydraulic system providers for MD trucks or the EPA data from those providers or fleet users.

The Meritor Dual Mode Hybrid Powertrain CRADA: Andreas Malikipoulos (Oak Ridge National Laboratory) – vss072

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

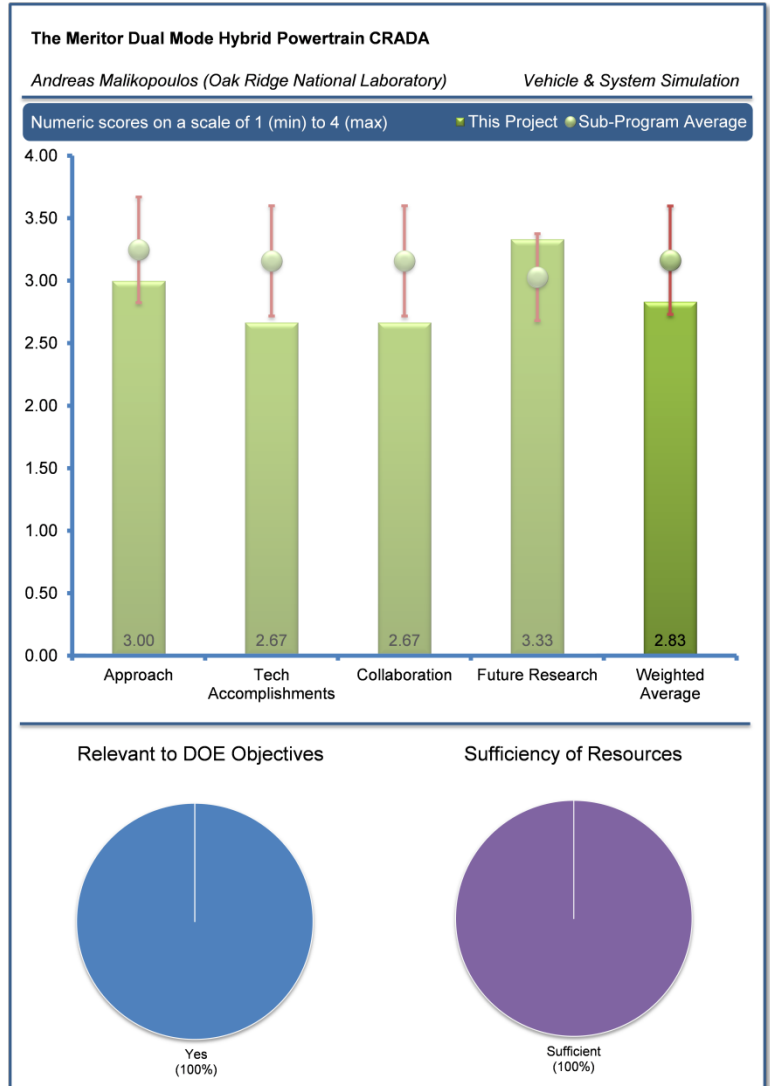
Reviewers agreed on the relevance of the project. One reviewer indicated that improved fuel economy reduces oil use. This was acknowledged by another reviewer who indicated that the aim of the dual mode hybrid is to save fuel. The reviewer added that it would provide a HD hybrid solution that might have benefit for long haul trucks, an application for which to date has not had a hybrid system that can save substantial fuel. Another reviewer liked the idea of optimizing a product that is being developed for market. This reviewer noted that while not yet launched, there is room for improvement and will enhance its potential acceptance by the various OEMs once launched, particularly in the Class 8 long-haul (LH) market, where hybrid-electric vehicles are not yet as far along as light-duty or medium-duty.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
Comments on the approach to performing the work varied. One reviewer indicated that the research was well presented. Another reviewer added that developing the model, performing dynamometer testing, and then real-world testing is the traditional and correct way to test the system and said that it made sense. A different reviewer indicated that the approach was generally very good but suggested that the optimization schemes could also consider what components are available off the shelf. Otherwise, the reviewer noted, new components would have to be developed for production and quantities for production would be less. One reviewer suggested that for optimization of components, it would be valuable to highlight the system efficiency and not just performance. Another indicated that the model needs correlation with the existing system when it is possible.

Another reviewer indicated that the research was well presented. Another reviewer added that developing the model, performing dynamometer testing, and then real-world testing is the traditional and correct way to test the system and said that it made sense. A different reviewer indicated that the approach was generally very good but suggested that the optimization schemes could also consider what components are available off the shelf. Otherwise, the reviewer noted, new components would have to be developed for production and quantities for production would be less. One reviewer suggested that for optimization of components, it would be valuable to highlight the system efficiency and not just performance. Another indicated that the model needs correlation with the existing system when it is possible.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers commented positively on the technical accomplishments and progress. One reviewer remarked that good progress was made on the models—the main goal to date. Another reviewer recognized that the project showed steady progress. Similar comments were made by a different reviewer who indicated that the project is only 15% of the way into the project but that the amount funded assumed spent seems to be in line with the project objectives. The same reviewer added that while not a lot of technical progress seems to have been made this early on in the project, it seems to be on track.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers had varying comments on the project's collaboration and coordination with other institutions. One reviewer observed that there was a close working relationship with partners identified. Another reviewer commented that with only Meritor and Oak Ridge there seems to be a missed opportunity to rely upon and incorporate data from an engine supplier and/ or truck OEM. The reviewer noted that they have a lot of data around Class 8 fuel economy performance and drive cycles and their expertise could be incorporated into this simulation and model. Another reviewer indicated that the model should be correlated to the drive cycle data off the existing truck or dynamometer powertrain with the Meritor Dual Mode System when an appropriate system is available.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Most reviewers had similar comments on the proposed future research involved for the project. One reviewer indicated that the presentation identified the next steps and looked forward to progress. This was reiterated by another commenter who said that it would be good to get and present the relation between the model and the bench data. A different reviewer commented that again, it was early on in the project, but the future plans are well thought through—dynamometer work and then real-world testing. That commenter hopes that this section will be more fleshed out at next year's report, as it relates to components, and control strategy optimization progress.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers felt that sufficient financial resources were available for the project. One reviewer indicated that no information was reported on resources used or those required going forward, while another felt that resources to date were sufficient, and next steps will require more resources.

**New York City Taxi Electric Vehicle Project:
PT Jones (Oak Ridge National Laboratory) –
vss073**

Reviewer Sample Size

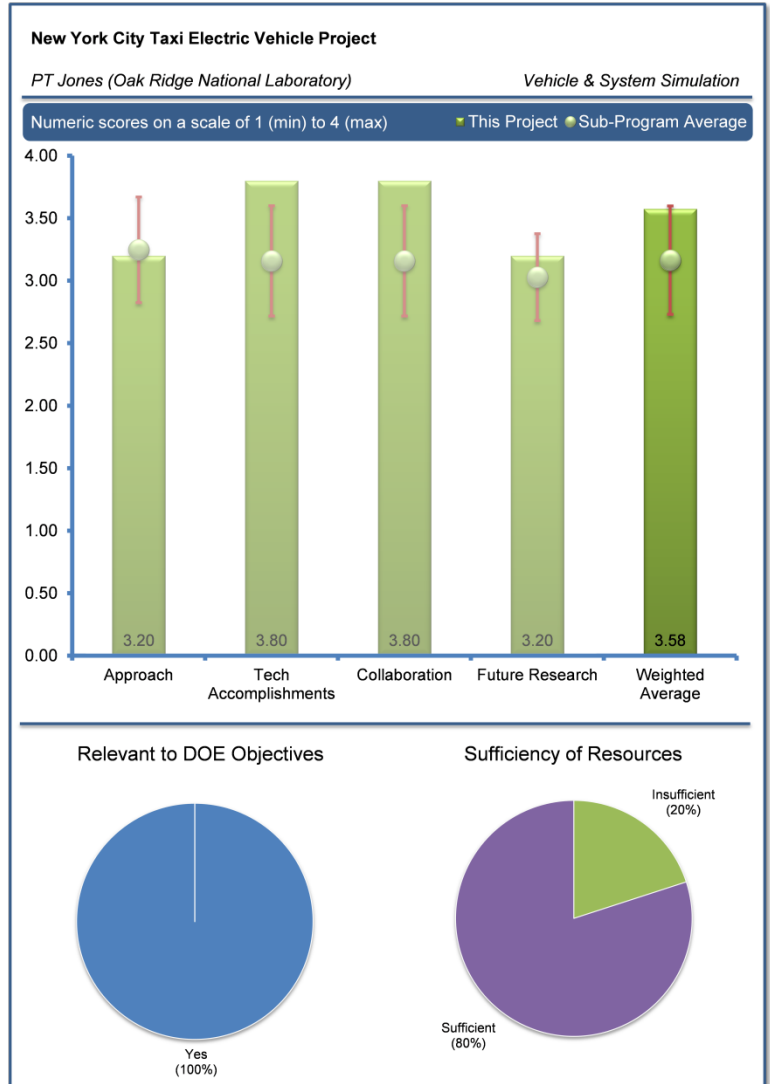
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers provided positive comments on the relevance of the project. One reviewer indicated that reducing the fuel consumption of very large vehicle fleets (such as taxi fleets in major urban areas) is an important step to reach the overall DOE objectives of petroleum displacement. The reviewer noted that the New York City (NYC) taxi fleet represents the largest taxi fleet in the United States. (several 10,000 vehicles) and that the replacement of the standard fuel inefficient Crown Victoria model by the Nissan NV 200 is a major milestone and represents an excellent opportunity to electrify the NYC taxi fleet. This was further reiterated by another reviewer who commented that understanding of a specific duty cycle for purposes of modeling future vehicle performance specifications is critical. That reviewer in particular noted that the specific generation of NYC taxi duty cycle should be viewed as a start of a broader set of duty cycles in support of nationwide understanding of vehicle use. The reviewer also added that the expansion of Autonomie models (in this case Nissan Leaf) will also forward DOE objectives. Overall, a commenter commended that the project helps to determine the feasibility of using locally clean vehicles in a large city for taxi service and that the results of this study will help vehicle designers configure powertrains that are capable of meeting the real-world demands to taxi service. A different reviewer indicated that another contribution of the project is the cycle development methodology which may be applied to other cities. This was recognized by another evaluator, that the project supports large-fleet introduction of EVs. This was supported by another commenter who agreed that the NYC taxi cab driving schedule could help NYC make electrified fleet vehicle buying and charging station location decisions. However, it is not clear that the project deliverables will be validated before NYC makes these decisions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commenter remarked that the approach or the methodology and use of tools appeared sound. A second reviewer indicated that the selected approach is a very good combination of utilizing field data (Ford Escape) and simulated NYC taxi drive cycle data (using ORNL DC Gen tool). Further, the reviewer added that a specific Nissan Leaf model is developed in Autonomie and indicated that the approach will lead to the creation of a taxi specific drive cycle that can be used for performance analysis of electrified taxi vehicles in New York. A third reviewer described that the project used a combination of new data, existing HEV data, simulation and existing drive cycle generation tools to develop a drive cycle for NYC taxi cabs. This reviewer also indicated that while HVAC loads are considered as assumptions, the results need to be augmented with data. The reviewer noted that it



seems this will be done by trying to piggy-back on future studies for other purposes. However, the reviewer cautions that there is remaining risk for this barrier. Another reviewer asserted that limited data was available to draw a complete set of conclusions (HVAC loading info absent, etc.) and that it was difficult for the reviewers to assess the urgency of developing this specific drive cycle in advance of getting more extensive dataset (e.g., from Nissan Leaf taxi demo program). The final reviewer indicated that the study of HVAC loads was considered a barrier, but this does not seem to be accounted for in the vehicle instrumentation or analysis.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed comments on the technical accomplishments and progress. The first reviewer remarked that the project appears to have met all its objectives. A second reviewer noted that major objectives of study achieved or on track to be achieved. This reviewer added that the project successfully developed an NYC taxi schedule as well as Autonomie model of Nissan Leaf. A third reviewer noted that the presenter said work is 95% complete and on schedule. The results are usable for predictive studies and can be improved when HVAC data become available. Another reviewer indicated that the project resulted in the creation of specific NYC taxi drive cycles and indicated the need for vehicle recharging during vehicle operation (lost fair). The final reviewer commented that the study of HVAC loads was considered a barrier, but little data appears to be gathered in this area.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All the reviewers had positive comments on the collaboration and coordination with other institutions. Reviewers commented the project is an excellent example of effective collaboration between the different stakeholders from DOE National Labs, industry (Ricardo i.e., OEMs) and the Taxi and Limousine commission, that the collaboration was evident and strong. A reviewer also acknowledged that the project collaborated with the appropriate partners. One reviewer felt that a significant amount of data was leveraged from Ricardo for the project and that models were also developed for Autonomie, so those results would be available to many users in the future. This was, as one reviewer asserted, a good use of existing data-sets and expertise from other groups and laboratories. Furthermore, one reviewer noted that the NYC Taxi and Limousine commission have reviewed the work.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on the proposed future research varied, with most reviewers being concerned with the ability of the project to complete in time. One reviewer noted that a critical barrier is the consumer acceptance of using EVs as taxi, which means that vehicle design parameters need to consider cost-effective operation (customer will not accept higher prices) without compromising customer convenience (such as proper air-conditioning). The reviewer acknowledged that in order to optimize these parameters, a validated simulation model is essential. Optimizing regenerative braking control algorithms, right sizing the HVAC and to optimize the charging route pattern is all addressed in the future research topic list. A second reviewer expressed concern that the proposed future work seemed to address the technical barriers required from the project, but that it was not clear if this work will be performed though since the project appears to be ending. This was reiterated by another commenter who said that the project is 95% complete and scheduled to end this month, so it was unclear how the future work would be done and asked if there were recommendations. Another reviewer felt that the presentation was not too clear on how work to date fit into overall strategy as tied to NYC taxi schedule, Nissan Leaf modeling/demo program or future priorities for other urban areas for comparison. Also, the reviewer added, how more complete datasets will be (or are proposed to be) obtained such as for the HVAC loading. The reviewer acknowledged that a little more clarity was obtained via Questions and Answers dialog. Another reviewer noted that effectiveness of future work (incorporating HVAC data) relies on modifying the scope of future studies that have different research objectives. This reviewer felt that resource/budget for on-going maintenance (more and more filed data incorporation) was not explained.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that resources are insufficient. This reviewer commented that it appears that this project would require additional resources specifically for model validation and to determine optimal charging routes. Four reviewers felt that resources are

sufficient. One commenter indicated that there were no obvious disconnects noted in resources for the project. The reviewer discussed that there was a relatively small budget for a focused scope that appears to be on track for completion. Another reviewer reiterated that the project is delivered on-time.

Vehicle Mass and Fuel Efficiency Impact Testing: Jim Francfort (Idaho National Laboratory) – vss074

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

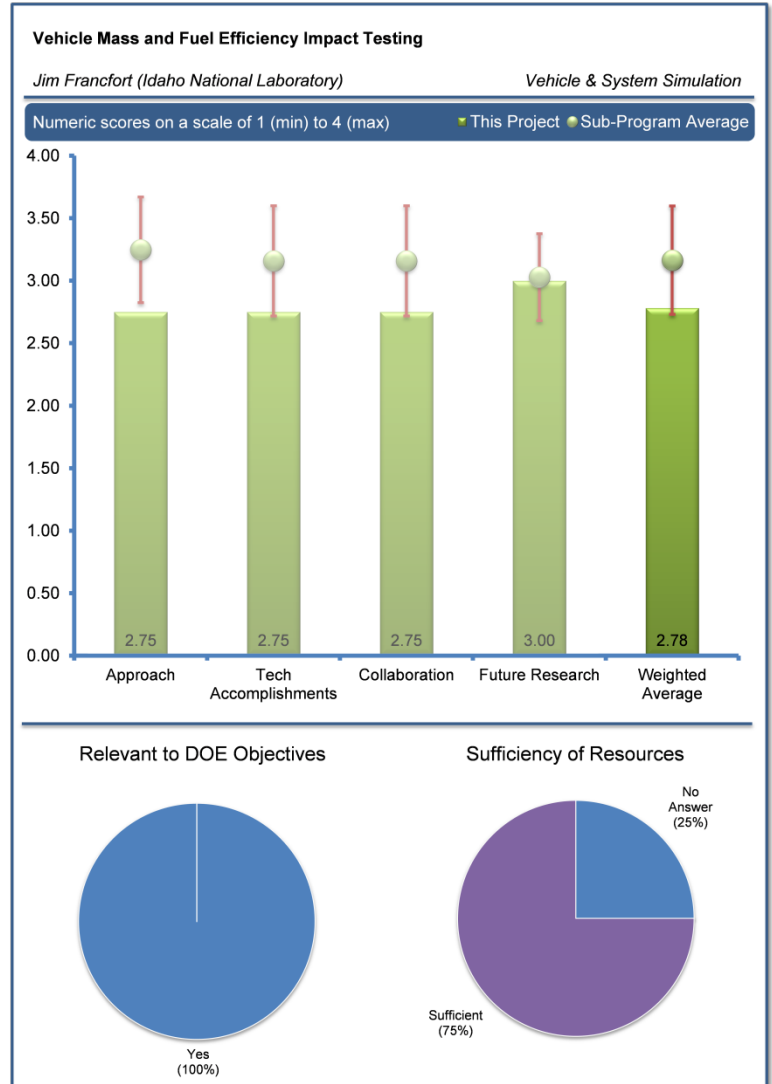
Two reviewers provided positive comments on the relevance of the project. One reviewer commented that this is a fairly simple, low-cost study, but that it does address a relevant technical issue regarding the impact of mass on PEV performance. The other reviewer indicated that translating changes in vehicle mass to fundamental resistance forces in vehicle can help designers know where to look for improved vehicle performance. A third reviewer agreed on the relevance of the project but asserted that the project did not have a huge impact and questioned why the project was being done.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Comments on the approach to performing the work were mixed. The first commenter said that based on the presentation, it appears that the team has done a good job of limiting variables to create a clear and consistent testing regimen. The reviewer noted that the project was very limited in scope and funding, so the particular study

may not have answered every question a person might have, but that it did fulfill its core objectives. Another reviewer noted that the attention to detail in performing the coast down tests looked quite good. The reviewer added that making sure ride height was held constant with mass change was a nice approach. In addition, the reviewer commended that the measurement of tire temperature seemed to suggest good attention to detail. This reviewer also asserted that the significant weakness is going into coast down testing without some analysis of what is expected. The reviewer alluded that the presenter mentioned a rule of thumb of 1% drag for 1% mass change but wanted to know where it came from. The reviewer also questioned what types of changes the basic methods for modeling rolling resistance predicted as well as what the expected impact of even the small ride height or tire temperature changes. The reviewer adds that this analysis might have helped in the final evaluation of the test results. The final reviewer strongly emphasized that the project should be ended.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two comments were provided on the technical accomplishments and progress of the project. One reviewer commented that the project team appears to have effectively achieved its technical objectives. However, the reviewer noted that it would have been helpful to have had a bit more discussion on the implications of the initial findings. The reviewer added that some of the results were not intuitive and deserved a more detailed discussion—particularly the differences in low speed drag forces between vehicle types. Another reviewer indicated that with a lot of variability expected in coast-down tests, it would have been nice to see some



results on the variability analysis. The reviewer in particular pointed out that the error bars on Slide 9 might help explain if there really is a different trend adding weight versus removing weight. The reviewer continued to say that if there is still a different trend adding versus removing some, explanation is likely needed. Without understanding the variability or having analysis to back expected results the reviewer asserted, that it is hard to know if the data represents real progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that this project did not appear to require extensive collaboration, but it has been effectively executed regardless. The reviewer did bring up one point of concern and that is that the industry engagement seemed lacking based on the presentation. The reviewer indicated that it would be surprising if OEMs have not already performed some version of this analysis, and it would have been helpful to get a sense of their findings. The final reviewer strongly emphasized that the project should be ended.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on the proposed future research varied. One commenter noted that the proposed future research seems okay. The reviewer commented that the team should definitely be careful about understanding and believing the drag change versus mass change before taking those results to the dynamometer test. Another reviewer indicated that it was not clear that the project required significant future work beyond completion of the current analyses. The final reviewer suggested ending the project and moving on to something more relevant.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers agreed that the project has sufficient financial resources. One commenter pointed out that this is a very low-funded project, but that it does not appear to need significant resources.

CoolCab Test and Evaluation and CoolCalc HVAC Tool Development: Jason Lustbader (National Renewable Energy Laboratory) – vss075

Reviewer Sample Size

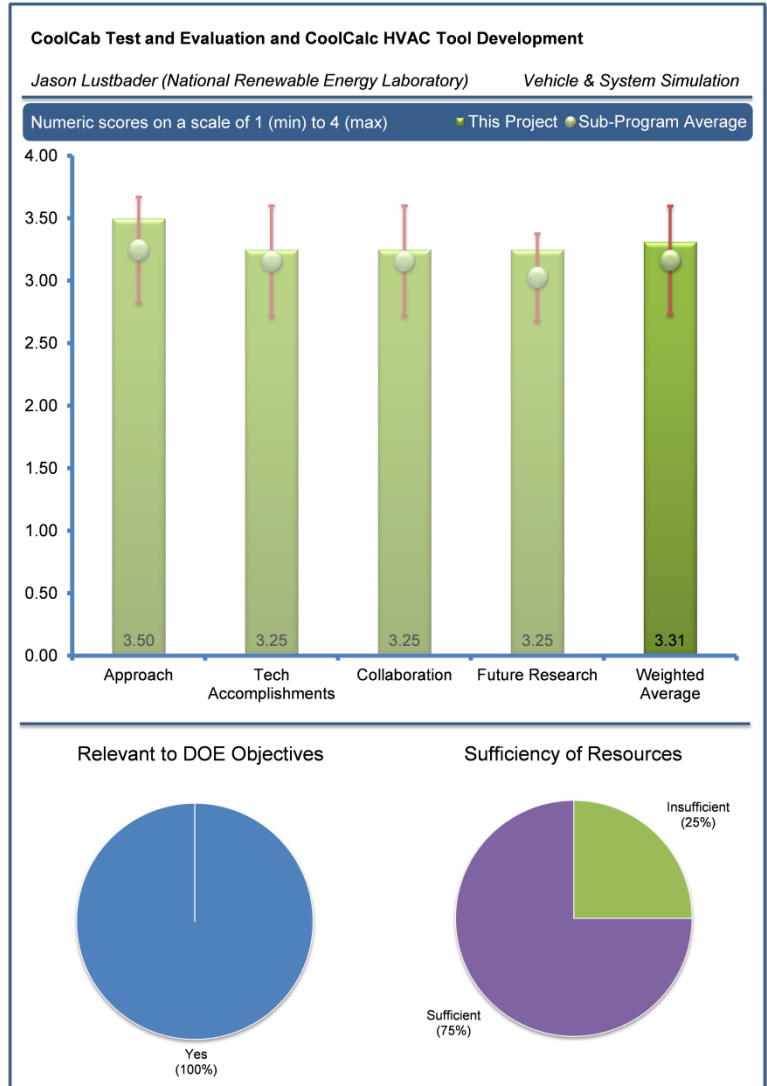
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers provided similar comments on the relevance of the project. A reviewer indicated that much fuel is used for idling purposes still and recognized that modeling improvements for less idling will help bring these technologies to market by showing how they can save fuel. Another reviewer commented that certainly reducing the air-conditioning load would help reduce fuel consumed and that was clear in the project presentation. This was further specified by a different reviewer who commented that the project has the potential for improved design of truck cabs. The project could reduce the idle time of trucks thereby reducing fuel consumption and air pollution emissions. This tool includes improved models plus verification of these models. Another reviewer stated that one really needs to identify how much this would save in fuel from a realistic perspective and baseline—how vehicles are used now, and also how vehicles could be used.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers had positive comments on the approach to performing the work. One reviewer observed that NREL has been working in this area since 2000; therefore they have the expertise and background to do the work. The reviewer added there was a logical research plan and that there was an excellent PI. Another reviewer remarked that modeling and looking for methods to reduce thermal load (and proving them out via modeling) is a good approach. This was reiterated by other commenters who indicated that technical approach seemed very good: create the right analysis tools and testing methods to be very precise in evaluating new technologies. Another reviewer commented that creating the model to represent the cab to fill a niche in the modeling tools seemed like a good step whereas another reviewer felt that correlating the models to real-world results is valuable and showed the models are working. One commenter discussed that reducing the thermal load will decrease the fuel needed for idling or energy use in anti-idle systems. A different reviewer would have liked to see how technologies were chosen. Considering the clear expectation of economic payback, the reviewer asked if there was some initial evaluation of cost of the new technologies in order to choose which to analyze first.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally had positive comments on the technical accomplishments and progress of the project. One reviewer mentioned that the Coolcab modeling program was developed and validated, that the effect of paint color was modeled and that the EAR insulation effect was modeled. Another reviewer noted that the project had realistic goals and that the barriers were well understood. A third reviewer noted that the need for modeling tool seems to have been addressed. The reviewer added that it was good to see a user's guide was released with the tool. The same reviewer added that it was certainly nice to see that the goal of 30% reduction in idle air-conditioning and heating loads had been demonstrated. Considering the clear expectation for a target payback period, this reviewer would have expected that some material related to the payback period for the technology would have been discussed (insulation). This reviewer leaves the reviewer with really no idea if the technology evaluated in detail already (insulation) will be even close to economically viable. Overall the reviewer felt that the progress is very good because the modeling approach will be worthwhile to evaluate other new technologies. However, another reviewer cautioned to be aware that there are some people that would question the need to spend \$3 million to develop a whole new modeling tool and test methods to figure out that the best way to get HVAC loads down is to insulate the vehicle. The reviewer questioned how one would tell the story that the modeling and testing tools really were needed. Thus, the reviewer noted that once the research showed evaluations of other technologies it would seem like a better argument for the development of the tools. The final reviewer indicated that this was not rocket science, but that it was an interesting project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers had positive comments on the project's collaboration and coordination with other institutions. As indicated by one reviewer, there was good collaboration with industry. Another reviewer noted that OEM partners are being utilized. In addition, this reviewer pointed out that fleet partners could help adaption. A different reviewer observed that a number of truck companies involved in CoolCalc model validation and development and also recognized that the insulation package from Aearo Technologies was used. A suggestion from one of the reviewers is that the project should expand their publications to include ASHRAE.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Most reviewers suggested up other ideas for the project's future research. One reviewer noted to keep going on this project, but to integrate with SuperTruck and weight savings and fuel savings. The reviewer said that everything should be a system approach. Another reviewer noted that future research is planned regarding the economic trade-offs which is what is needed based on the objective of the project. However, the reviewer added that it is not completely clear which new technologies are expected to be analyzed and tested. The reviewer assumes that all of the technologies on Slide 8 will be evaluated. A different reviewer suggested that it would help to devise some ways that the software can be used by fleets or other users that will encourage adaption of more advanced insulation, thermal coatings or barriers, or other items to lessen thermal load that a cab no idle or HVAC system will need to take on. The reviewer added that the software is really helping if people are using it to modify trucks from their current build. Another suggestion from a reviewer is that the project should include actual routes, road data and traffic data. The reviewer indicated that this data should be input into the program so a trucking company can determine their projected return on investment for their route. The reviewer mentioned that the United States Postal Service (USPS) should be interested in this work. This reviewer suggested including life cycle cost for evaluating alternatives.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three out of four reviewers felt that financial resources are sufficient. One reviewer commented to keep going, and also suggested that this project not be done in isolation. Another commenter indicated that resources appeared to be reasonable, while the final reviewer commented that it was hard to tell.

Mitigation of Vehicle Fast Charge Grid Impacts with Renewables and Energy Storage: Tony Markel (National Renewable Energy Laboratory) – vss076

Reviewer Sample Size

This project was reviewed by three reviewers.

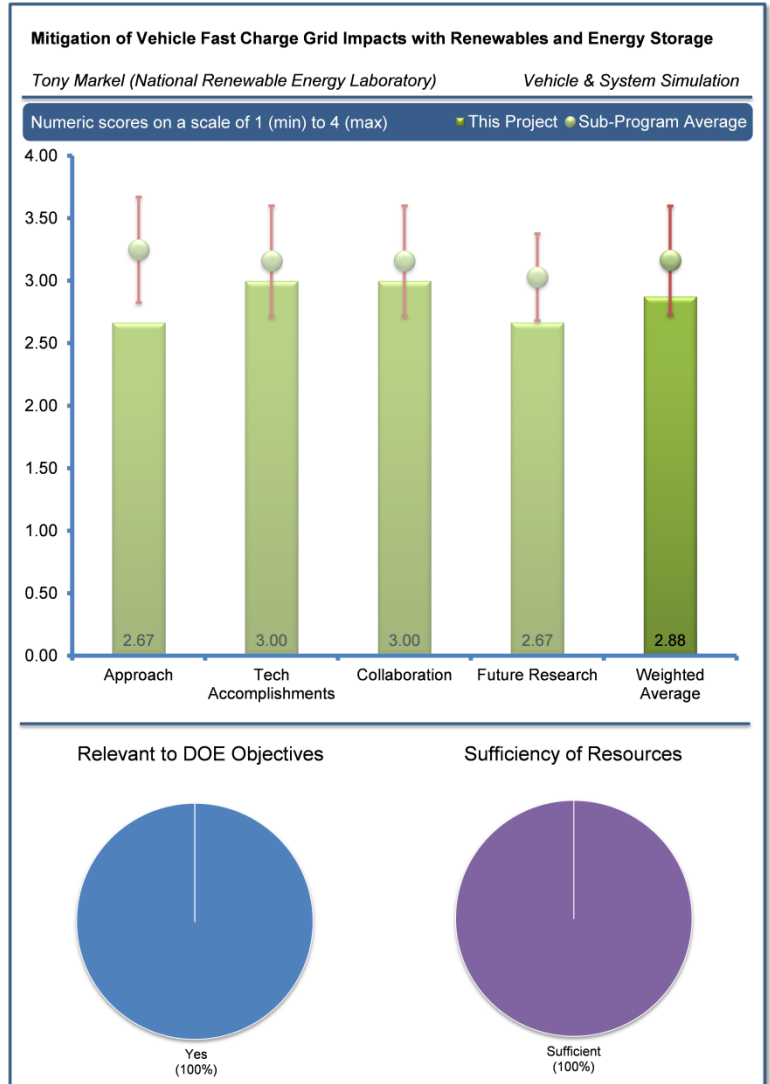
Question 1: Does this project support the overall DOE objectives? Why or why not?

Most of the reviewers agreed on the relevance of the project. One reviewer indicated that demand charges for commercial charging are a significant barrier to deployment of EVs. Another reviewer detailed that the project models electric vehicle fast charging in a fashion that would reduce grid impacts and make it more convenient to electric vehicle drivers to charge their vehicle in certain situations. Thus, the reviewer noted, the convenience would help motivate people to use electric vehicles and displace their use of petroleum. The reviewer added that probably more important with fast charging technology is projection of a normal gas station type refueling experience. The reviewer acknowledged that although most electric vehicle owners charge at their home or place of residence, most unfamiliar consumers still cling to a gas station type analogy so fast charging offers this type of visual analogy to what most people expect. The reviewer also recognized that the use of photovoltaics for providing the energy is also symbolic but asserted that it may not be the most cost-effective solution. The reviewer notes that most utilities would prefer the solar to go toward other peak loads from building or industrial usage and use off-peak renewables for vehicle charging, (nighttime wind). The reviewer indicates that suggesting that photovoltaics are necessary to reduce peak demands from charging would tend to cause a higher cost solution set versus other off-peak renewables. However, the reviewer stated that since the general consumer can actually see the photovoltaic array in proximity to the charging station, the symbolic visual solution is always popular even if it is not as cost-effective as other solutions. The reviewer concluded that both fast charging, which simulates a gas station model and the use of solar energy from photovoltaics can be used to stimulate market adoption; this helps overcome the current market barrier of range anxiety to increase electricity miles. The reviewer suggested that to the extent that this could have been quantified as additional miles traveled would have been beneficial. Another commenter agreed with the relevance of the project but points out that the industry is doing this already, and so questions the necessity of the project.

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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer commented that the approach to performing the work by using real life data as good and lends credibility to the study. However, this reviewer remarked that the use of photovoltaics as the means of providing the renewable energy for the storage system is too narrowly focused. This reviewer suggested that other types of renewable energy sources should also be incorporated such as night time wind energy. In addition, the reviewer notes that showing a cost breakout of various types of renewable energy



for the study would have been beneficial. The reviewer said that even though cost analysis was identified for future work, a preliminary cost chart would have been beneficial. Incorporating the cost data and different renewable energy sources would have moved this to an outstanding small technical study. A different reviewer pointed out that the project initial assumptions on charger use may not be valid and added that as real-world data becomes available, these assumptions should be validated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed comments were received on the project's technical accomplishments and progress. One reviewer indicated that work proceeded on schedule with results obtained as planned. The second reviewer did not really see any hard number presenting DOE goals in this area in which to make a judgment as to how effective the effort was in meeting the goals. The reviewer indicated that as far as addressing high level barriers, it was okay. The same reviewer indicated that it would have been interesting to try and quantify the barrier with regard to real market adoption. In particular, the reviewer wanted to know if the barrier could be quantified by a market survey which would pose a question such as, would one be more likely to buy an electric car if fast charging was available, and one could refuel an electric car like a normal gas station-type refueling experience. Another market survey sample question suggested by this commenter was whether one would be more likely to buy an electric vehicle if the vehicle could be recharged with renewable electricity. As far as a small dollar analysis project the effort seemed cost-effective and was able to reach some good analytical conclusions. The reviewer referred to the comments from section two, stating that the analysis could have been of more value by showing a basic cost analysis chart since the basis of going to photovoltaic array with an energy storage system was to reduce grid impacts and utility demand charges while making charging more convenient. The reviewer added that without the cost data, the financial motivation to transfer this model to adoption in the market place will be hard. Another reviewer indicated that there were big assumptions and that one should look at using a range of assumptions (i.e., three points versus just one).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers provided comments on the collaboration and coordination with other institutions. One reviewer noted that collaboration with the demonstration partners, AeroVironment and Mitsubishi, was evident in generating the test data. Going forward, this reviewer suggests that partnering with another project team installing fast chargers and a utility will be important in generating the cost data. The second reviewer commented that data from other projects has been used to provide input and support assumptions. This reviewer suggests that as actual charging data becomes available, it would be worthwhile to update assumptions.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Mixed comments were received on the proposed future research. One reviewer recognized that the project is scheduled to complete and that all objectives will be achieved at completion. Another reviewer commented that as noted in the future research chart, this is a cost analysis. This cost analysis will be the most important data to collect going forward to increase the value of this project. As this reviewer noted in another comment section, additional renewable energy sources should also be analyzed to show different cost-effectiveness strategies. A third reviewer mentioned that they were not geeked on this project. This reviewer indicated that the project was already being done in the industry, and the reviewer did not see much value-added here.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers felt that financial resources are sufficient. One reviewer commented that the NREL resources and facilities are easily sufficient to complete the project. Another reviewer thought that the work performed for the stated budget of \$120,000 was a bargain. The reviewer added that to get some test hardware, run some testing, and model that data versus the real-life data from the Puget Sound area was quite an accomplishment for this type of funding.

Fuel Consumption and Cost Benefits of DOE Vehicle Technologies Program: Neeraj Shidore (Argonne National Laboratory) – vss077

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

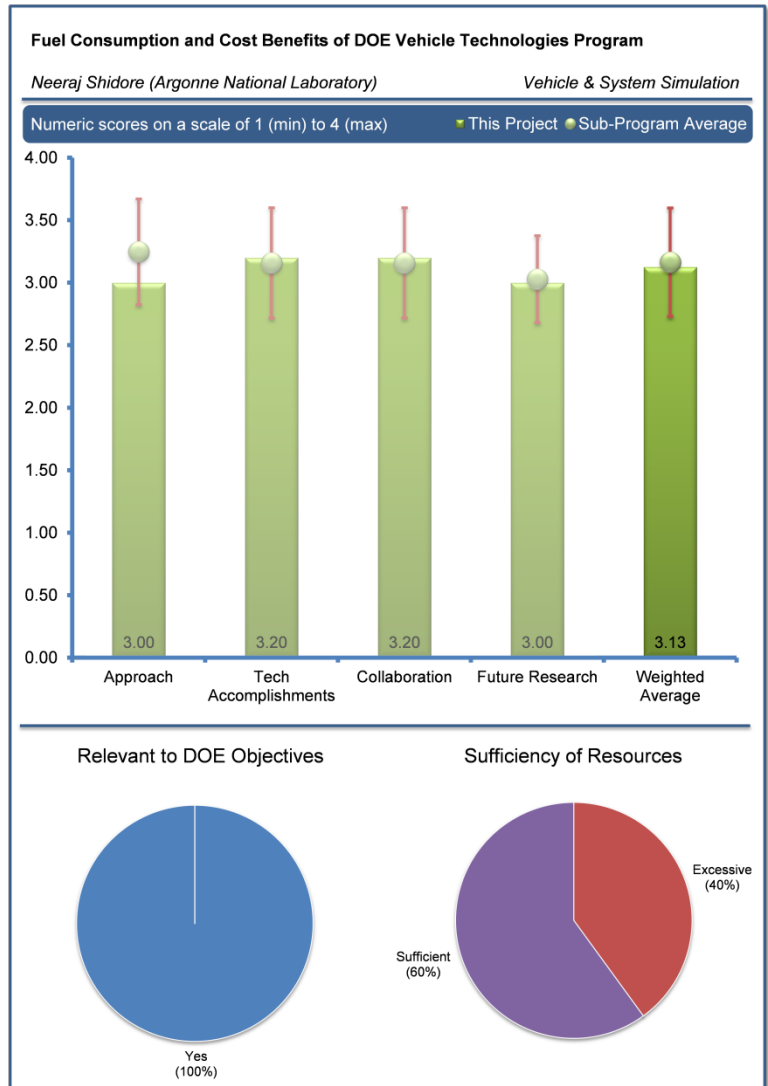
One reviewer commented that the project is designed to track the potential of research to impact petroleum displacement. Another observer reported that this project analyzes dozens of advanced vehicle, component, and fuels technologies, and also includes thousands of vehicles to provide comprehensive guidance to all DOE program sponsors in meeting the petroleum displacement objective. This observer related that this is the largest scale study of such technologies. The next panelist indicated that the relevance of this project is clear, as it addresses a congressional mandate. This panelist believed that it was beyond the intent of the review to evaluate this project against the mandate, and estimated to do so would require evaluation of the 250-page report. The final reviewer wondered what else could be said about the project if it is mandated by the Government Performance and Results Act (GPRA).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated this approach, as a result of the requirements of a congressional mandate, seems to be quite suitable to the purpose. Another panelist asked if it is mandated that a national lab or another DOE entity perform the GPRA task as an in-house project. This panelist remarked that the GPRA mandate seems to duplicate the periodic evaluations and studies of U.S. DRIVE and 21CT that the National Academy of Sciences (NAS) conducts. The panelist opined that a NAS independent commissioned study would have more credibility. The next observer described the approach as just okay, and expressed that there was a large assumption that hybrids continue to get less expensive. A different reviewer found no mention of how or whether the predictions will be validated by actual experience. The final person stated that it is always difficult and time consuming to chase data, especially from OEMs. This person suggested that, based on the significant amount of funding for the project on the order of \$390,000, it may be wise to use less technical personnel to do the data harvesting to save some money.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer queried whether MD and HD vehicles have been included in the project budget. This reviewer indicated the study could have been more sophisticated and introduced a what-if probability scheme in the simulation, but that doing so may have resulted in a significantly larger budget and manpower utilization (or waste). This reviewer pointed out that the title and claim of Slide 12 is a huge assumption, and described it as mission impossible and an unrealistic expectation. The reviewer further noted



that the titles and claims of Slides 14 and 15 are not necessarily a valid premise, and that Slide 17 was a hard sell. This reviewer relayed that the presentation claimed results were widely accessed, and suggested it may be worthwhile to compare the number of hits here to NAS, or similar, reports. Another observer's only concern was that the component sets defined on Slide 11 are not necessarily the only ones that may be available in the timeframes shown. This observer stated the evaluation was designed to address the mandate requirements; however, some potential risk may surface in showing a level of potential progress that could forestall investment in future technology development. The observer expressed concern about the availability of future funding in this area at a time when DOE investments in technology are in greatest need. This observer acknowledged that many barriers still exist to get to the goal lines in future decades so Congress needs to be shown the range of technology uncertainty that must be overcome. The final reviewer queried whether the repeated run-all-the-simulations-for-light-duty vehicles step on Slide 18 was a typographical error, or if it is an iterative process (e.g., repeating runs for quality control).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that great effort had been demonstrated. Another agreed that collaboration with the appropriate groups to complete this assignment seemed to be in order and complete. The next observer noted that there was a good team outlined on Slide 16, but pointed out that all members have an interest to put the maximum positive spin on VTP because the members are all beneficiaries of the program. This observer suggested that if possible within the GPRA guidelines, it would be far better to have an independent team, perhaps of academicians and retired industry professionals, to conduct such a study. The observer conceded that, if necessary, the simulations could be done by ANL or a commercial analysis house.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer urged the PI to continue the great job. Another person pointed out that as this is a once-every-two-years assessment, it is a contained program and does seem to be designed to properly meet the mandate requirements. The next reviewer remarked that stopping this effort, if the GPRA can be reversed by the legislators, would not result in significant loss of quality and tools in VTP's future planning and strategies. This reviewer wondered how the information in this report be viewed 5 years from now, 10 years from now, and at the end of the reported assessment period.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found the resources to be excessive, while three found them sufficient. One indicated that the over half a million dollars spent per year on this project could be put to a better use somewhere else in the VTP road map line items. Another reviewer noted that this project should be accomplished with less funding, and noted that researchers should look for ways to utilize the funding more efficiently. The next reviewer deemed the resources sufficient because staff is based on past experience in providing this information to Congress. This reviewer stated that if not, it is certain that the VTP office will not fall short of the intended deliverable to Congress.

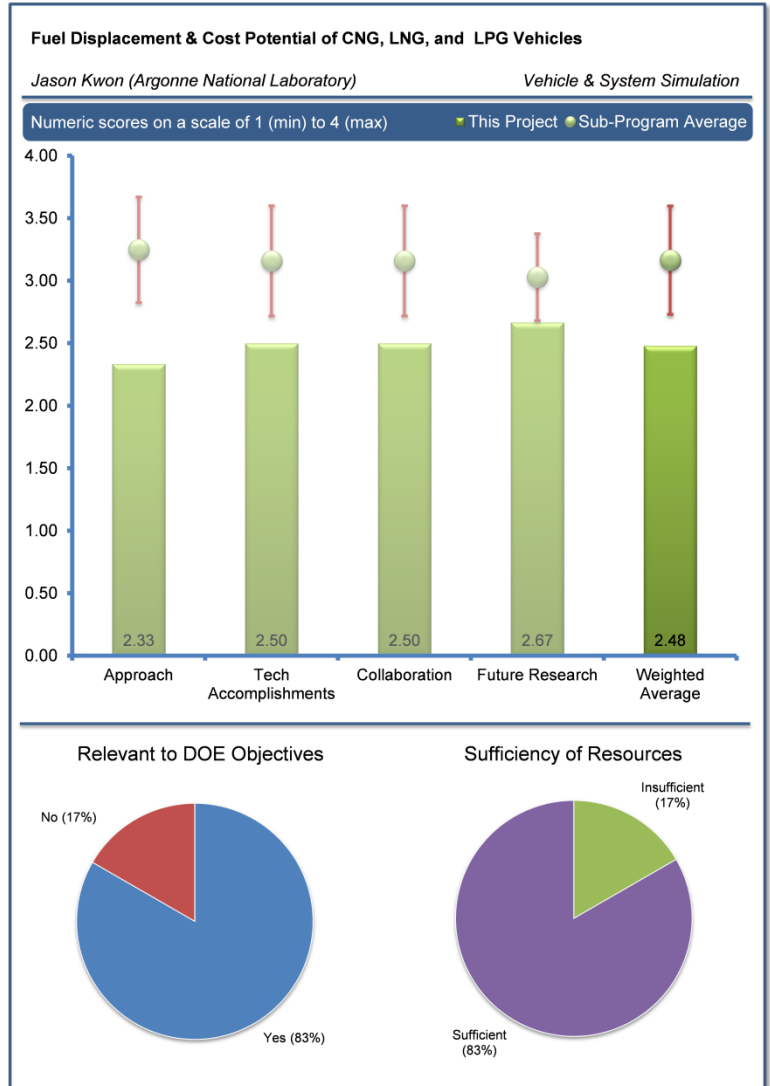
Fuel Displacement & Cost Potential of CNG, LNG, and LPG Vehicles: Jason Kwon (Argonne National Laboratory) – vss078

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviews regarding the project varied widely. One reviewer strongly commended the idea of looking hard at CNG/ LNG powered vehicles from both the fuel savings and the emissions impact and regarded that this would be an excellent future project. A second reviewer noted that the abundance of natural gas in our nation according to recent reports certainly makes the project an excellent petroleum displacement and added that this project is definitely timely. A third reviewer expressed that that the program is looking at non-petroleum vehicle fuels, albeit ones that are still fossil fuels. This was somewhat reiterated by another reviewer, who summarized that the project is designed to evaluate the petroleum displacement potential of natural gas fuels (CNG, LNG, and liquefied petroleum gas [LPG]/propane)_ to displace imported petroleum and acknowledged that this would clearly be relevant. However, the reviewer indicates that the presentation may not take the project to a calculation of imported petroleum displaced if these fuels are broadly used. The final reviewer provided more extensive comments and felt that the anomalous approach required to be taken by authors makes this study practically irrelevant. The reviewer noted that the authors were told to make specific assumptions and given a specific period of performance. One assumption that was ludicrous, according to this reviewer, was that the alternative fuel had to be used in the same engine to compare performance. The reviewer detailed that the result was that when CNG was used to displace petroleum in the same gasoline engine, acceleration from zero to 60 miles per hour (mph) took 0.7 seconds longer, which was interpreted as 12% fuel consumption penalty when the engine is re-sized to achieve the same performance. According to the reviewer, this was interpreted as a 2% fuel consumption penalty when the engine is NOT re-sized. First, it is unrealistic that a difference of 0.7 seconds would make a significant, noticeable difference to a consumer. This reviewer then questioned who buys a car based on acceleration performance. Secondly, the study failed to take into account sacrifices consumers were willing to make for a cleaner fuel, cheaper fuel, and when the use of a particular alternative fuel is lower-cost operations and maintenance than the conventional fuel. In other words, the reviewer explained, the objective of the study is buried so much into some minor, immaterial, minute detail that has no relevance to the overall scheme of things. According to this reviewer, in the overall scheme of things, what really matters for CNG, LNG, or LPG to displace petroleum is the cost of the fuel (CNG and LNG are about half the price of diesel), the availability of the fueling stations, and range of the vehicle on a tank of that fuel. The reviewer concluded that none of these were taken into consideration.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers had extensive comments regarding the approach to performing the work. According to one reviewer, the project is well defined within the tool sets that have been chosen and adds insight to how the use of CNG will affect consumers. However, the reviewer commented that the approach is stated to be one of seeing how gaseous fuels differ in performance from liquid ones. The commenter added that there was nothing stated as to what would be done with this information to develop a valid estimation of imported petroleum that may be displaced and suggested that this should be done on an individual vehicle type basis at minimum. Another reviewer acknowledged that the work is headed in the right direction, but that it was not clear how the project's results will be used to guide future DOE funding decisions. Another comment from a reviewer was that the technical barriers were not clearly stated. The items listed as technical barriers are not technical barriers. According to a different reviewer, the potential benefits of retrofitting legacy vehicles with hardware for diesel/natural gas and gasoline/natural gas should be looked at because it may be more practical in the near future and timely too during this time of abundant natural gas. Another suggestion from one of the reviewers was that the whole presentation should not get hung up on the specification of 0-60 mph because there is a lot more going on in CNG/LNG than looking at the performance specification. It seemed to another reviewer that the potential for petroleum displacement of CNG/LNG could be better determined by looking at existing applications and deployments. The same reviewer asked why the apparent focus on OEM engine data with CNG in wide use in many transport internal combustion engines around the world. The reviewer mentioned that how the fuel performs in original OEM vehicle tests seems like a minor variable easily overshadowed by numerous other variables. According to the reviewer, if the purpose of the study is potential petroleum displacement for the nation, then the study should also describe the approach to macro variables. The reviewer added that if this project is a part of a larger effort, then how it fits that larger effort seems critical to whether the approach is correct and indicated that that information was not sufficiently provided. Or, the objective of this project should be redefined as providing certain inputs into a larger model of petroleum displacement, if that is the case. One commenter rated the approach poor for several reasons. First, according to this reviewer, there was no literature search/review to see what had been done on this subject. If there was a literature search/review, then the authors should have mentioned it. Secondly, the reviewer stated that the authors did not take into account emissions and health impacts (i.e., compare the emissions of CNG, LNG, and LPG against gasoline). Third, the reviewer pointed out that the authors neither took into account nor modeled how cost of fuel, fuel infrastructure, and range would have affected market penetration of CNG, LNG, and LPG vehicles and how such market penetration would have affect displacement of petroleum. Lastly, the reviewer observed that the authors neither took into account nor modeled how much faster and more pervasive petroleum displacement would be if there was a focus first on centrally-garaged fleets such as fleets of vehicles that return to a home base every day for storage, fueling, and maintenance (e.g., urban transit buses and refuse trucks).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviews regarding the technical accomplishments and progress of the project were mixed. According to one reviewer, the project's progress is in good order and that the final report should be out as soon as possible. Another reviewer mentioned that it looks like most of the work is back-loaded in the FY. The reviewer noted that perhaps things are proceeding according to plan, but the results to date are thin. The reviewer points out that the focus to date has been only on engine technology, not on the influence of driveline and transmission (e.g., gearing ratios) on overall vehicle performance. According to another reviewer, barriers were not well described, but the approach is a sound one for the technical tasks being undertaken. That reviewer continued to point out that the whole discussion of whether an engine would be at the same or a lesser level of power is as much a marketing issue for vehicle producers as it is a technical one. Fleet vehicles such as the Honda can have a lesser level of performance and be quite suitable. This reviewer acknowledged that it may not be so for a general consumer sale product that has to compete with products powered by other fuels. The activity seems to be centered on engine test evaluations rather than on vehicles as a system that may use gaseous fuels. The reviewer opined that this seems to be too narrow to build a really valid argument for the amount of petroleum that can be displaced. This reviewer suggested that another technical approach would have been to do the entire project in simulation. Combustion simulation would have shown the engine power changes and coupled with vehicle performance simulation would have predicted gaseous fuel use such that a comparison to liquid fuels in volume and price could have been completed. The reviewer added that stretching this across multiple vehicle types and powertrain types and sizes would have

created a more comprehensive data baseline to calculate petroleum displacement. A different reviewer strongly expressed that they would have liked to see some more expertise put on this because some of the best engineering minds are now working on CNG/LNG. The final reviewer rated the technical accomplishments and progress as poor because the approach and collaboration was poor.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The project received mostly similar comments on the project's collaboration and coordination with other institutions. One reviewer noted that greater industry collaboration would accelerate this work greatly. According to the reviewer, barriers to having OEMs involved were stated without a definition of how to overcome, and these barriers were not stated as project barriers in the presentation. This was also pointed out by other reviewers. In particular, one commenter said that there is no formal relationship with OEMs, so it is not surprising that there is limited support for fueling maps and other engine performance characteristics. This reviewer also said that it is not clear how component cost data are being used on this project. Another reviewer rated the project's collaboration as poor because it appears that the authors worked only with one or two OEMs. That reviewer noted that there is a good chance that the authors could have obtained comparable or better performance with CNG, LNG, and LPG if the authors had tried more or different OEMs. Another comment was that the project may want to contact some of the retrofitters.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on the proposed future research varied. A reviewer noted proposed future research is important and strongly warned the researchers not to lose the momentum on this fuel, and another reviewer commented that the proposed future research was okay. Other commenters provided suggestions on future research. One reviewer indicated that progress is easy to understand with future work within the context of the unresolved barriers of OEM collaboration. This reviewer commented that the project needs to include additional subsystems that affect overall fuel efficiency to get to the title objective of understanding petroleum displacement potential. Another reviewer recommended a stronger focus on future engine technologies, including those fueled by CNG or electricity, as ways of displacing petroleum fuels. This commenter asked if there was an opportunity to look at advanced conventional engines (using gasoline) to assess petroleum displacement on this project. A reviewer commented that the study failed to take into account that CNG, LNG, and LPG fuel displacement could take place much faster and more easily in centrally-garaged fleets, i.e., fleets of vehicles that return to a base every day for storage, fueling, and maintenance (e.g., urban transit buses and refuse trucks). This reviewer emphasized that it is absolutely critical that medium- and heavy-duty vehicles be included in any similar studies examining the displacement of petroleum by CNG, LNG, and LPG.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer found that resources are insufficient. This reviewer commented that more technical sophistication is needed on this. Five reviewers felt that the project had sufficient financial resources available. One reviewer commented that it seems to be sufficient for the tasks described, though funds may be insufficient if a broad calculation of petroleum displacement is intended to be accomplished. A second reviewer commented that resources seem sufficient for the scope, and a third reviewer remarked that funding appears to be more than sufficient. A final reviewer remarked that funding is adequate.

PACCAR CRADA: Experimental Investigation in Coolant Boiling in Half-Heated Circular Tube: Wen Yu (Argonne National Laboratory) – vss079

Reviewer Sample Size

This project was reviewed by four reviewers.

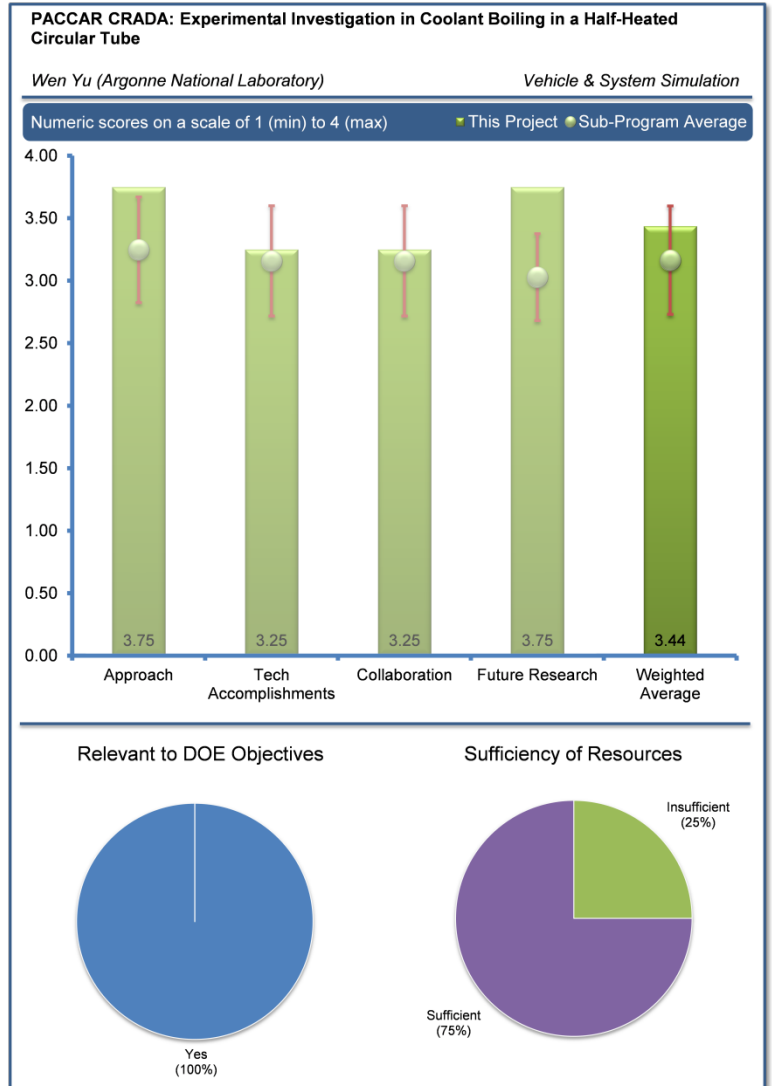
Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments regarding the relevance of the project were varied. One reviewer reasoned that understanding phase change (boiling) is very important in thermal management. A second reviewer remarked that there is a clear link to energy savings. Another reviewer remarked that this project is relevant. It is important to minimize energy losses due to engine cooling. However, this reviewer strongly takes issue with the fact that the authors failed to estimate what the ballpark (rough order-of-magnitude) benefit in energy savings to the overall scheme of things from their research. In other words, this reviewer would like to know what the payback is from this expensive, esoteric research. Nonetheless, according to this reviewer, the ultimate goals to reduce parasitic energy losses and improve engine thermal efficiency are meritorious. This reviewer has to say, pretty much, that this project is unique. The reviewer knows of no other similar project on this topic. A fourth reviewer commented that improved engine cooling is understood to have a potentially significant impact through reduced cooling system parasitic losses and weight, and/or through improved engine thermal efficiency. This reviewer remarked that quantified estimates of the impact should be established up front to better highlight the potential of this research. The commenter noted that this was brought up in the review questions and answers and that the PACCAR partnership should enable this. This commenter opined that the title of this research was somewhat obscure. The commenter noted that the project should scope in the analysis activity, and identify the intended application (e.g., Investigation of Two-Phase (Boiling) Coolant for a Heavy Duty Engine).

This reviewer remarked that quantified estimates of the impact should be established up front to better highlight the potential of this research. The commenter noted that this was brought up in the review questions and answers and that the PACCAR partnership should enable this. This commenter opined that the title of this research was somewhat obscure. The commenter noted that the project should scope in the analysis activity, and identify the intended application (e.g., Investigation of Two-Phase (Boiling) Coolant for a Heavy Duty Engine).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The project received mixed comments on the approach to performing the work. One reviewer praised that the project had excellent researchers. In addition, the reviewer indicated that the team presented a reasonable timeline, tasks and goals. Another reviewer felt that the project did superb technical work on a shoe string budget, noted great collaboration with PACCAR, and mentioned that it would be great to bring in additional collaboration partners but funding restrictions appear to be a barrier. A second reviewer opined that the approach involves a pragmatic combination of empirical and analytical methods. In particular, the reviewer noted that the test setup seemed well-designed, being simple and flexible. This reviewer expressed that the review covered the experimental plan relatively well but more information should be provided on the analytical activities planned in the CRADA, including the coupling of the experimental and analytical activities. The reviewer noted that this should be possible without



divulging anything proprietary. The final reviewer pointed out that the design of the experiment is good for obtaining heat transfer rates and heat transfer coefficients for modeling purposes. The reviewer added that the graphs were missing the keys or legends, and that points consisting of different colors and shapes (rectangles, circles, and triangles) were not defined. This reviewer feels that this presentation should have shown why the PI took the chosen approach. In fact, not enough high-level or high-altitude or overall picture material was presented. The approach taken seems to make no sense to this reviewer. However, continued this reviewer, there should have been some literature search or review to show that the author was not repeating something that had already been done and to show that the PI had taken advantage of the results of the previous research and not wasting taxpayer's dollars in starting from scratch.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments on the technical accomplishments and progress of the project were mostly positive. A reviewer commented that the project had very nice experimental work and had excellent progress to plan. Another person indicated the project had a well understood test section. One of the reviewers summarized that the design, procurement, fabrication, and assembly of the experimental facility have been completed. The reviewer went on to say that single-phase heat transfer tests and analyses have been conducted as well as two-phase (boiling) and that the project's progress appears to be on schedule. This reviewer did not anticipate any major obstacles or shortcoming to further progress. A different reviewer expressed concern, that the project's progress seems slightly low based on a linear project timeline but the project plan seems end loaded so this may not be an issue. The reviewer explained that funding could be a drag on this project in 2012 and that additional comments were provided in the financial resources section. A general comment was provided by this reviewer on the presentation of results; the reviewer noted that the lack of keys and explanatory information on some of the plots caused some unnecessary confusion.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments on the project's collaboration and coordination with other institutions were mostly similar. One reviewer noted that the project had great collaboration with PACCAR. In addition, the reviewer expressed that it would be great to add other partners if resources permit. Another reviewer mentioned that the project work has a CRADA and that the researchers are working with industry. This was referenced by another reviewer who indicated that the collaboration on this project is limited and that it was the nature of a CRADA. However, the reviewer acknowledged that it seems reasonable that this research will generate valuable non-proprietary information. Another commenter did not expect that collaboration and coordination with more than one other organization (an OEM) was necessary on research of this type. In fact, the reviewer noted that collaboration and coordination with more than one other OEM would hinder the project and raise suspicions.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to one commenter, the authors will continue to collect more boiling heat transfer data, compare experimental results to predicted, theoretical results, and fine-tune as well as validate the computer model for heat transfer. This reviewer remarked that the authors know what they are doing. Another reviewer commented the proposed future research was solid and that it would be nice to have an opportunity to use this equipment to explore additional fluid mixtures and surfaces beyond cast iron. A different reviewer added that future work mainly consists of planned activities with no major decision points or foreseen barriers. Minor changes could include different mixtures of water ethylene glycol and different flow rates than planned depending on results of upcoming tests. This reviewer indicated that the flexibility of the test set-up apparently lends itself to testing a variety of other components, coolants, materials, and surfaces. The reviewer explained that many specific suggestions have been provided by past reviewers for follow-on research. The final commenter suggested that the project can be used to evaluate nanofluids.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that there was insufficient funding. Three reviewers indicated that there were sufficient financial resources. One commenter expressed that funding was too low for the potential of this work. Another reviewer indicated that resources appeared to be adequate. A third reviewer indicated that the budget for this research was lean but the project seemed focused and effective.

The reviewer also stated that the project was a good example of cost-effective research. The project plan seemed end-loaded and the planned budget reflected this, increasing every year. However, the reviewer observed that the 2012 payout so far is reported as only half of planned and cautioned that this could impede progress during the critical phase of the project. This reviewer mentioned that the contribution of the CRADA partner is noted as in-kind cost-share but is not explicitly quantified (i.e., it is assumed everyone is doing their fair share).

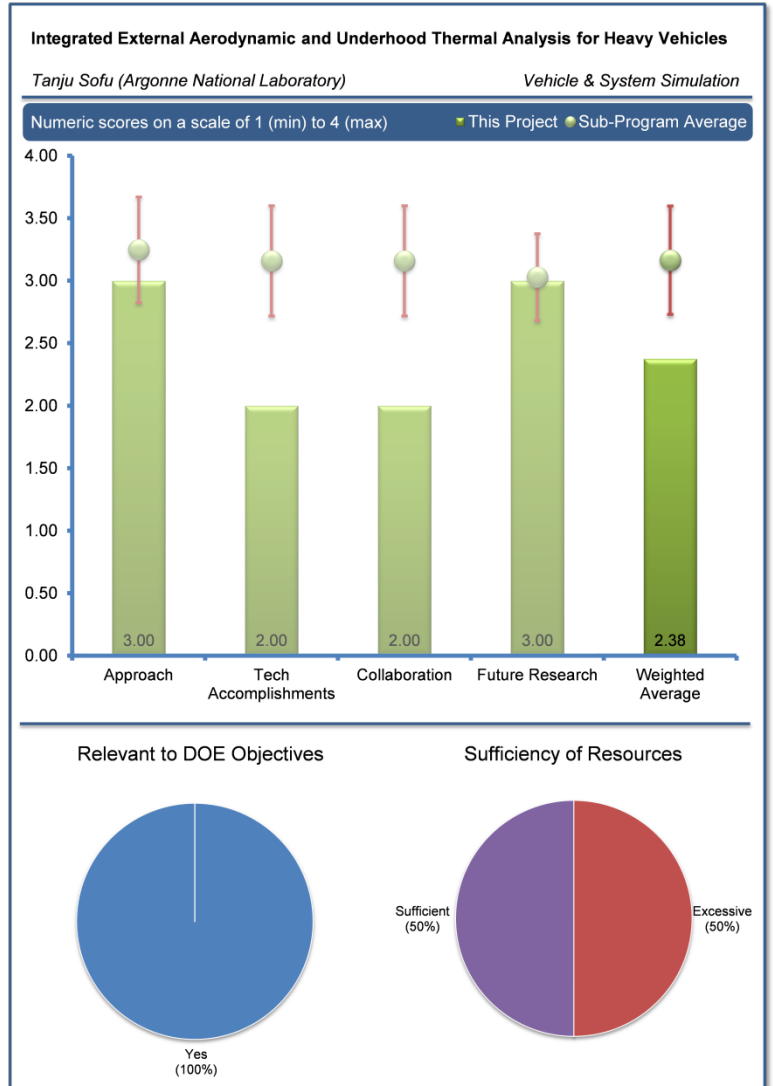
Integrated External Aerodynamic and Underhood Thermal Analysis for Heavy Vehicles: Tanju Sofu (Argonne National Laboratory) – vss080

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers had mixed comments on the relevance of the project. One reviewer felt that the optimization of a cooling package and hood design can lead to significant fuel saving in terms of aerodynamic drag reduction, which is in line with the DOE mission. Another reviewer asserted that this question needed a maybe option. The reviewer pointed out that the subjects of this research are understood to support the objectives of petroleum displacement (aerodynamic drag, engine cooling, selective catalytic reduction system optimization), and associated coupling merits system level analysis. However, the reviewer noted that system optimization as an objective is a little vague. The reviewer indicates that specific deliverables should be clarified to insure relevance to the DOE (i.e., it is foreseeable that this research could result in a sophisticated application engineering tool or methodology of commercial value that may or may not necessarily be used to optimize fuel economy). The reviewer also mentioned that clarification should be provided as to what specific new information the proposed research offers above and beyond the similar past research noted.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments on the approach to performing the work for the project varied. One reviewer felt that the analytical approach involves a pragmatic combination of inexpensive one-dimensional (1-D) thermo/flow analysis and computationally expensive CFD analysis and offers high potential. Apparently, this research plan builds on successful results from similar past research. This reviewer expressed that some of the plan is vague and needs clarification. The reviewer explained that it is not clear whether a GCD vehicle model or a specific truck configuration of a foreign manufacturer is being used and why. In addition, the reviewer mentioned that it is not clear if vehicle wind tunnel or track testing is also involved. This, the reviewer cautioned, has implications not only to the plan but to the resource requirements and funding. With regard the project's intent to develop a custom interface to couple the CFD and 1-D flow model, this reviewer suggested that the project should verify that applicable commercial solutions are not available. Another reviewer indicated that the design of the project is correct directionally; however, it needs to be more scrutinized in detail. The reviewer asserted that the benefit of optimized cooling packages is with aerodynamics, not necessarily thermodynamics. As such, the reviewer warned that care should be taken to identify and quantify the benefits in the correct disciplines. This reviewer observed that there appears to be sufficient planning and resources on the thermodynamic side; however,

more resources and expertise on the fluid dynamics side must be planned (external aerodynamics, under hood thermal and airflow).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Both reviewers acknowledged that the project is new and that it is in the planning phase. One reviewer remarked that because of this, it is difficult to gage the project's progress. This reviewer, however, is concerned with the fact that the CRADA has not yet been formalized over the last couple years. Another reviewer mentioned that the initial work (setting up a 1-D and three-dimensional [3-D] CFD environment) is headed in the right direction.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments on the project's collaboration and coordination with other institutions varied. A reviewer commented that the CRADA has not been formalized yet so technically there is no collaboration to date. In addition, the reviewer pointed out that no vehicle OEM or fleets have been identified yet. This reviewer felt that pulling in the involved commercial CFD and 1-D flow software suppliers as partners seems compelling, especially since a custom interface to couple the CFD and 1-D flow models is to be developed. Another reviewer indicated that the engine partner is identified, but that a vehicle OEM partner is missing and that identifying one should be a priority at this point of the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Mixed comments were received regarding the project's proposed future research. One commenter noted that as this is a new activity this section is not especially relevant but that the planned activity builds on successful past research. The other reviewer expressed concern about not having an OEM partner, which to a certain extent can pose problems. This reviewer notes that the bad news is that OEMs do this work as part of their design process; however, fuel economy is a minor factor in the design. The reviewer remarked that the good news is the project can look at this design work with a sharp focus on fuel efficiency and has the potential to generate promising results. The reviewer concluded that it may be good to approach this program with a clean-slate and with minimal OEM support.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Comments received on the adequacy of financial resources for the project were mixed. One reviewer felt that financial resources were sufficient, while another reviewer felt that financial resources were excessive. One reviewer commented that the budget proposed seems reasonable for the scope of work. Another reviewer indicated that the subject is compelling but the budget for this program seems generous, especially considering that the CRADA has not been formalized yet. This reviewer stated that the formalization of the CRADA and more detail on planned vehicle testing is necessary in order to justify the resources.

A Complete Vehicle Approach to the SuperTruck Challenge: Pascal Amar (Volvo Trucks) – vss081

Reviewer Sample Size

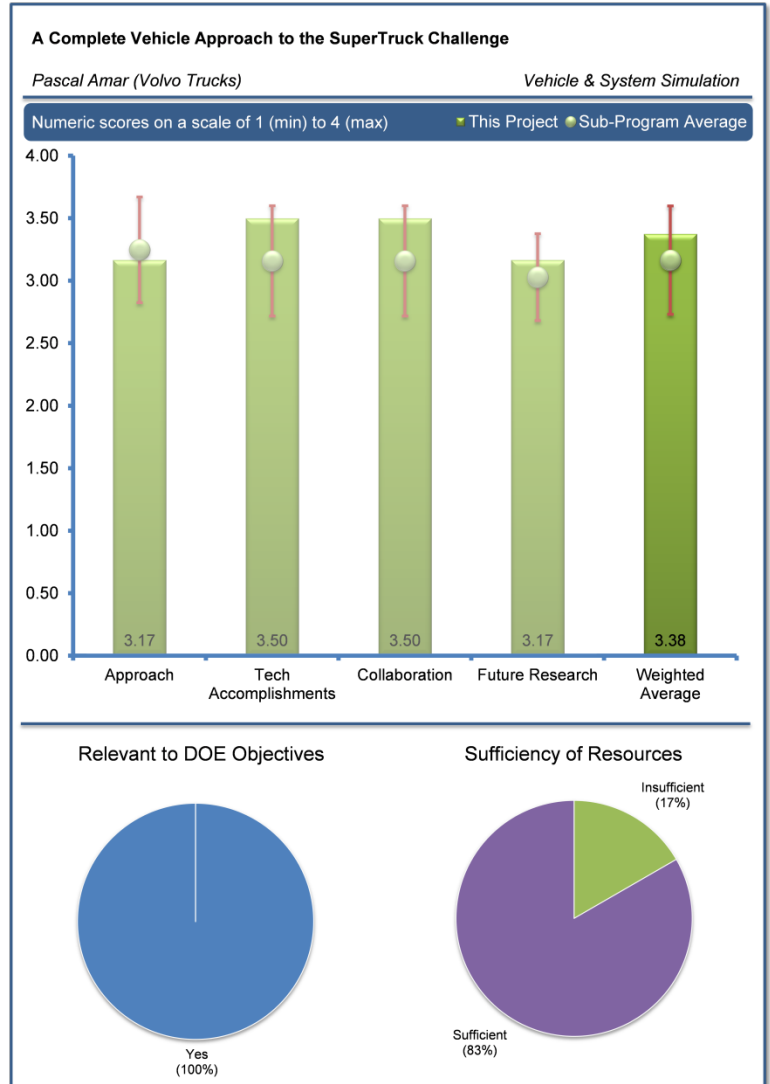
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewers provided similar comments regarding the project's relevance. One reviewer commented that the project objectives are key enablers to energy efficient highway transportation. A second reviewer noted that this project is relevant as it improves the high petroleum using tractor trailers. A third reviewer pointed out that the project is addressing the largest commercial fuel use segment (Class 8 OTR trucks) and is targeting appropriate fuel efficiency improvements. Another reviewer adds that the Class 8 highway heavy vehicles use a lot of petroleum-based fuel (diesel). Successful attainment of the SuperTruck Program objectives will certainly result in significant petroleum displacement. The final reviewer echoed these comments, remarking that successful completion of this project would achieve the petroleum reduction goals established by DOE for the SuperTruck.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments on the approach to performing the work were varied. One reviewer felt that the formulation of technology roadmap coupled with simulation and analysis to identify possible technical pathways to meet the program and project objectives is very good. The four key technology approaches of weight reduction, parasitic losses reduction, aerodynamic loss reduction and powertrain improvement were found to be reasonable; however, the reviewer cautioned that simultaneous integration of multiple technologies can be susceptible to serious complications. The second reviewer pointed out that Slide 6 was good and suggested that it could show methodology and selection criteria as to why technologies were chosen or not chosen by one commenter. Another reviewer found that the project had a good use of analytical tools to concept solutions for these challenges. This reviewer found it impressive that the project chose to delay concept selection for anti-idling. The reviewer noted that this area is changing significantly and has little integration opportunities. It is an area that can be delayed somewhat and not affect other decisions. This reviewer asked if there was an opportunity for Volvo along with DOE, to select areas of interest not being worked by the other companies, given that Volvo was behind about a year from the other three SuperTruck projects. The fourth reviewer summarized that the approach in this project is multi-faceted, so that improvements in several areas contribute to achievement of the goals. For example, not only do the light-emitting diode (LED) lights and novel lighting design reduce lighting energy; they also enable additional light-weighting because of the reduced use of copper. The reviewer added that there is significant light-weighting, directly reducing fuel use, and also enabling additional freight to be carried, thus reducing fuel use per ton-mile. This reviewer expressed concern regarding the idling-reduction plan having not yet been revealed and hopes that it involves an integrated, non-



duplicative system. The final reviewer expressed that not many details are offered in aerodynamic improvement and pointed out that the statement is a little bit vague.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Several reviewers had similar positive comments on the project's technical accomplishments and progress. One reviewer noted although the project is building on previous projects, satisfactory progress was made during the first year. With the exception of one item, all the project milestones for the first year were either completed or on track. Another reviewer stated that the project seems to be on track towards achieving the overall goals. This reviewer indicated that several of the elements of the program (e.g., lighting) seem to be elegant and innovative. This reviewer was a bit concerned (for all of the projects, actually) with the skirts. This reviewer referred to interviews with maintenance personnel who indicated that these are not cost-effective, due to snow collection on them and frequent breakage in use. A third reviewer commented that the simulations seem to indicate that progress and targets are possible. Another commenter believed that the project is making technical accomplishments as expected, and observed that significant decisions and progress will be made in the next year. The final reviewer indicated that with one year into the program, the technology roadmap with analytically defined efficiency improvement map should be available.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments on the project's collaboration and coordination with other institutions were mixed. One reviewer expressed that Volvo has created a strong team and this will enable good project success. Another reviewer recognized that this project includes contributions from a broad set of partners, covering all aspects of vehicle design and construction. This was supported by another reviewer who felt that the project had many technical components and would no doubt require close collaboration with many key players. The reviewer observed there was clear evidence of collaboration among team members. A different commenter suggested that the project should include a commercial fleet partner and include some voice of the customer information to help justify technology selections and customer requirements. A comment was also made that it was not clear how the partners help the program in more technical details.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed comments on the proposed future research. One reviewer indicated that this project has solid plans surrounding the various technical opportunities and is particularly interested in the project's approach to weight savings opportunities. Two reviewers expressed similar opinions. One reviewer asserted that this probably would have been a four if the presenter had been at liberty to disclose the idling reduction plan. This was somewhat reiterated by another reviewer who said that while the future work plan looks good, it would be useful if the PI would address contingency plans for resolving unexpected technical problems. The same reviewer explained that a project with as many changes to the vehicle systems as this will encounter unexpected technical issues, for example, lower viscosity and lower lube level may have detrimental effect on driveline system reliability and durability. In contrast, one reviewer expressed disappointment with this project, reasoning that Volvo seems behind on the simulation. The reviewer realized that they came to the party late, but that all of the other OEs have had extensive modeling in the past on this type of project. Another reviewer identified the need for more quantitative statements on the future work. The reviewer explained that the proposed future research is too general, and does not offer too many insights.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that financial resources were insufficient. Five of six reviewers felt that resources are sufficient. One reviewer indicated that resources appear to be sufficient and capable. Another reviewer indicated that given the progress, compared to funds already expended, the researchers appear to have allocated their funding appropriately for achieving their stated goals. A different reviewer commented that the goal is too aggressive with half funding of their competitors.

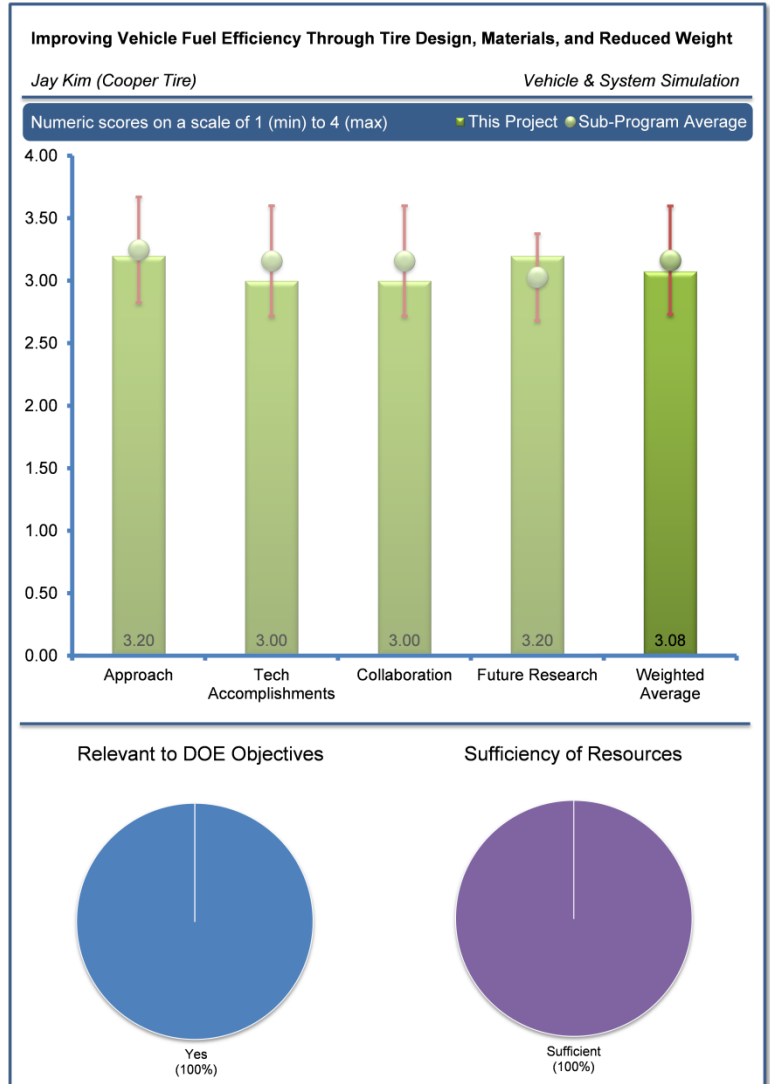
Improving Vehicle Fuel Efficiency Through Tire Design, Materials, and Reduced Weight: Jay Kim (Cooper Tire) – vss083

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE's objectives. The first reviewer stated that there is a direct relationship between tire fuel efficiency and energy consumption that was well-established in the presentation. Another reviewer added that by addressing rolling resistance of replacement tires, a significant portion of the tire market, a reduction of fleet fuel consumption is possible. This could have an efficiency impact on a portion of the existing fleet with a simple tire retrofit, added the expert. A third commentator added that an achievement of at least 3% fuel efficiency through tire improvement is aligned with DOE's petroleum displacement goals. This person suggested that the PI should characterize how much each of the six approaches would contribute to the greater than 3% goal. The expert also noticed that the performance impact was not clearly predicted in the briefing charts. The final reviewer assured that any reduction in the overall tire weight would reflect positively on the fuel efficiency of the tire. The expert observed that the project has identified six potential areas to reduce tire weight, which could help improving tire fuel efficiency by 3%. These possible fuel savings would support the DOE project objectives, stated the expert.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the approach strategies and milestones were basic for such a research project. No significant issues were identified, added the expert. The second reviewer to respond noticed that the approach was very wide-ranging, examining a number of technologies to reduce tire rolling resistance such as tread compounds, tire construction (i.e., weight), and air pressure maintenance (i.e., inner liner materials). This person felt that there is an ambitious work plan given the project's identified resources and timeframe. A third commenter was unsure whether there would be decision points that would determine which of the six approaches would be incorporated into the new class of tires (assumed to be one tire construction design). This person asked whether there would be an independent validation test or combined validation tests on the evolving tire design. This expert was looking forward to more detail as the project evolves. The last reviewer to respond felt that the project seems a bit like a let-us-try-everything-we-can-think-of-and-hope-something-works approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer explained that project had recently begun, and noticed that the expenditure of resources is currently small. The reviewer added that the project has made progress in six separate areas of investigation; out of the six progressing areas the Nano-fiber reinforcement, low hysteresis tire profile, and barrier film lining projects are showing promise. The expert felt that it was good to see which of the PI's identifying research areas that had not been successful, as well as reasons why (e.g., fiber-reinforced thermoplastic polymer bead materials). Another reviewer commented on the various approaches, stating that in regard to approach one, nano-fiber reinforcement, it is known that the main two issues with nano-fiber fillers are the dispersion of filler, and the filler-polymer interfacial bonding. The expert added that, based on the concerns raised in the document, these issues should have been addressed first. Otherwise, offering to use conventional materials may not be unique subject for this research, added the expert. This person also suggested that in approach two (the use of thermoplastic polymers), the light weight bead bundle may have not been necessary. The expert also observed that in approach six (the barrier film liner), the lab test showed equal-to-improved air permeation resistance. This person observed that the next step mentioned that arrangement for production trials of the barrier film were made. The expert suggested that it would be more beneficial to have substantial improved properties before running a production trial. This reviewer felt that by developing tire fuel efficiency while sacrificing other tire performance parameters, there may not be an adequate outcome of this project. The following reviewer felt there had been limited progress and it seemed commensurate with the amount of money spent so far. The last reviewer to respond felt that there was good progress through each approach. The expert observed that approach six described a test program in future tense (is planned for) but identified a past time period (1Q 2012).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback on collaborations. The first reviewer to respond felt there was somewhat limited collaboration because only NREL was listed as a collaborator. This reviewer added that suppliers of materials for the various tire components were noted, but were not identified specifically as partners. The second expert to respond stated that the project is finalizing subcontract with NREL, having initial meetings, and the development of plans and strategy with partner shows good collaboration in one area. However, according to this reviewer, in other areas the work is based on buyers' and sellers' relationship. The reviewer suggested that this could have been improved by having more involved collaboration with manufacturers in developing materials for this project. The following commenter observed that there was no real evidence of collaboration beyond in-house or proprietary contacts with suppliers. The last reviewer to comment suggested that in future reviews, the insight into voice of the customer priorities (fuel efficiency, durability, performance, maintenance, etc.) should be included, along with described OEM input/interactions.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, as long as clear decision points are reached for each concept and some rationale are developed for why, combining successful approaches makes sense. One commentator felt that the future work was on a logical path – completing development and analysis for each technology for down select in Phase II. This expert reiterated that, as indicated (in slides), the project will continue to develop promising technologies to address any performance deficiencies that may hinder commercialization. A third expert believed the future plans lacked any consideration of performing analysis on the cost of materials, specifically costs of nano-fiber material and processing. The last reviewer to respond asked whether there were any interdependencies between the six approaches that might cause future work delays (this gets back to the comment of not knowing if any of the six approaches are parallel or sequential efforts).

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five of the reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer felt that there was sufficient funding available for the completion of the project. A second added that there was an excellent cost-share balance. The last reviewer felt the resources appeared sufficient, but believed that the amount of work (number of technologies to be examined) was ambitious given the budget.

Materials Approach to Fuel Efficient Tires: Timothy Okel (PPG) – vss084

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

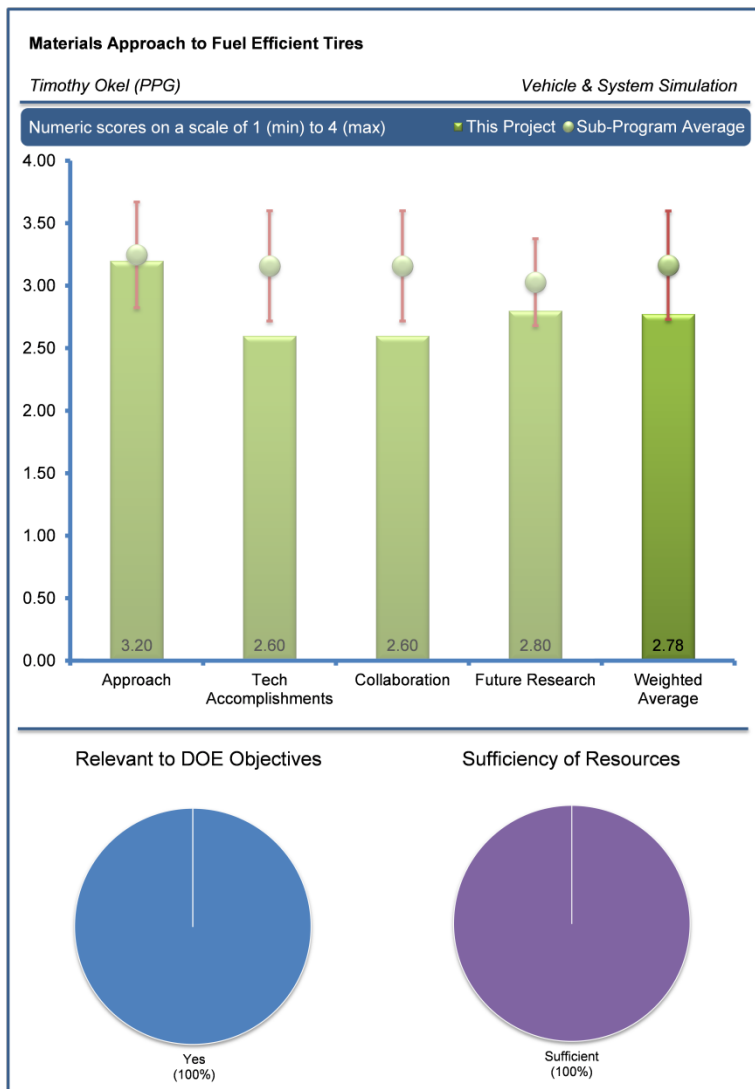
Reviewers found that the project supports DOE’s objectives. One reviewer stated that the achievement of at least 2% fuel efficiency through tire improvement aligned with DOE’s petroleum displacement goals. This expert added that there was an excellent characterization of the problem in support of why the two technologies were being investigated. A second commenter stated that the project addressed DOE goals through reducing tire rolling resistance: addresses material technology for rolling resistance and tire pressure maintenance (reducing air leakage). A third reviewer stated that tire fuel efficiency directly relates to tire inflation pressure and added that their energy consumption was well-established. The final commentator to respond stated that the project objective stated that it will design, develop, and demonstrate fuel efficient and safety regulation compliant tire filler and barrier coating technologies that would improve overall fuel efficiency by at least 2%; this should be in-line with the DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to respond stated that the targeted issues were well-outlined and the approach seeks to identify the best solutions. A second commenter noted a logical approach for evaluation and development of filler and barrier materials, resulting in actual tire testing. The approach seeks to improve tire rolling resistance as well as durability and manufacturability – will produce a more commercially-relevant product. The next expert felt that there was a good indication on the approach/strategy on the development of fillers. The project has identified five combinations of fillers that show potential for improving tread wear while maintaining fuel efficiency. This expert added that the standard technical approach/strategy consisted of the development of the tire’s inner layer. The last reviewer to respond stated that the project used key strengths of principal. However, it was a little vague to this reviewer what was different from on-going work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress considering how recently the project began. The first reviewer to respond stated that the early progress appeared to support project objectives. This reviewer suggested having more measures on anticipated milestones. The review presumed a clear milestone progression toward demonstration but lacks any appreciable detail on schedule. The following respondent felt that the accomplishments were good, given that the project had recently begun. The expert explained that the filler materials had already been synthesized in small batches, and were being characterized before submission to tire partners



for further testing. The inner layer films have also been synthesized, with novel dispersion materials to reduce gas permeation. This person stated that the accomplishments to date indicated that further success will be achieved in this project. The following expert said that there were several experiments underway and that significant progress had been made with fillers and the development of the inner layer films at the lab scale, which suggested that barriers could be overcome. This reviewer noted that several experiments are underway. Additionally, this reviewer noted significant results with the development of the inner layer films have been accomplished. The last respondent to comment felt that there was not much data to judge to project on and that the project seemed in-line with 17% completion noted.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the project was limited to principal and current customers and that a great deal of parallel work was on-going at universities (and obviously competitors). The following expert added that the collaboration with a major tire manufacturer (Goodyear) was appropriate – they will incorporate the developed materials from Pittsburgh Plate Glass Company (PPG) into prototype tires for testing. The next reviewer reiterated that Goodyear was identified as a subcontractor, but added that, other than incorporating the new materials into one of their tires, it was unclear exactly what the advisory role entailed. The last commenter felt that the presenter showed good collaboration with a partner, a major tire manufacturer, on building tires for testing using the developed technologies, and suggested that the project could have more coordination with current and other partners in addressing manufacturability issues.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert felt that the future work plan was reasonable – materials analysis and testing for down selection of final materials to be incorporated into prototypes. This person noted that the schedule leaves only about nine months to develop prototype tires, and inquires if this will be enough time to test the completed tires. The next commentator stated that the review only offered one milestone per assessment and included a vague two-phase approach with a tire demonstration in the last nine months of the project. Another reviewer observed that the future plan identified the main parameters for the manufacturability, processing and performance of the fillers; the future plan on inner liners has identified the key metrics and milestones for designing and formulating the coatings; and the risks have been identified but no mitigation plans have been provided. The last reviewer suggested showing the ancillary benefits for increasing knowledge if project approach does not succeed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five of the reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. Two reviewers commented that the resources appeared to be sufficient in order to complete the work identified.

System for Automatically Maintaining Pressure in a Commercial Truck Tire: Robert Benedict (Goodyear) – vss085

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

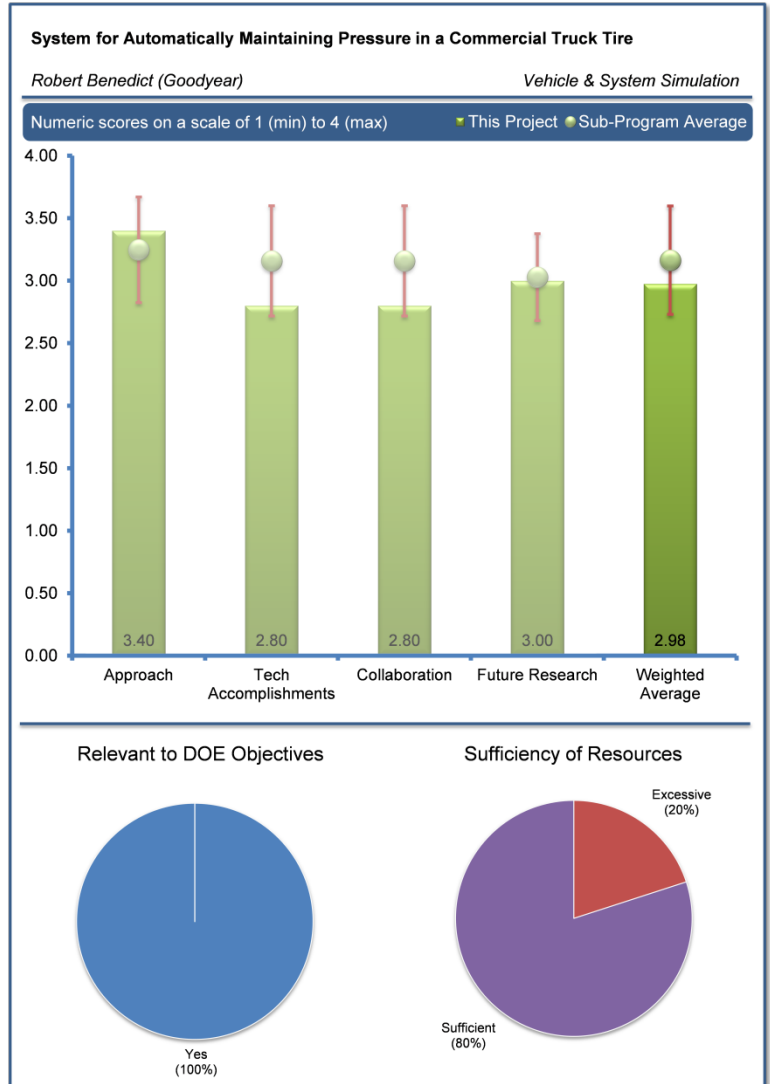
Reviewers found that the project supported DOE objectives. The first reviewer stated that this project would address fuel efficiency improvements in commercial trucking through automatic tire air pressure inflation and found it was relevant to DOE objectives. This expert added that there is a significant importance of tire inflation to fuel efficiency for commercial trucks. A second reviewer commented that keeping commercial tires at a prescribed pressure would be ideal for fuel efficiency and was well aligned with DOE goals for petroleum displacement. The following commentator believed that the developed system, as claimed, could maintain constant tire pressure, resulting in fuel savings and improved safety by maintaining proper tire inflation. The expert believed that this aligned with the DOE objective on reducing fuel consumption. The last reviewer reiterated that the direct relationship between inflation pressure and fuel consumption is well-known.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that there was a very clear timeline/plan for developing the design and eventual validation. The second reviewer stated that the approach consisted mainly of a description to the steps taken to develop the system, adding that it was consistent with typical technical system development methods. Another expert noted that this approach involved a novel self-contained air pressure maintenance system, completely contained in the tire. The reviewer believed that this would be appealing to commercial truck owners and that if it worked well, would be preferable to more complex central tire inflation systems for tire pressure maintenance. The next respondent felt that the design and prototypes were properly done and noted that there was a demonstration of a working concept. The last reviewer observed minor variance on the approach known for decades as well as that used on current commercial systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers found that the project has made good progress. The first reviewer said that progress seemed in line with funding spent to date. A second reviewer stated that the project was on target with the project management plan. The following expert felt that the progress was very good, given that this is the first year of the project. This person explained that simulations have been performed showing that the system is projected to pump more air than the target pumping rate. The next reviewer stated that the



presenter showed progress in system design, modeling, and partial tire prototype development. The last reviewer suggested that the reliability of this product needed to be researched further.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers noted that the project has ongoing collaborations. One reviewer stated that the project was very well coordinated with partners and industry. The following expert said the project captured all stakeholders from vendors/suppliers to customers. A third reviewer added that Goodyear was leveraging work done in Europe on a similar system for passenger car tires and that partnerships with local businesses to fabricate test equipment and molds were made. The expert explained that there were no partners specifically identified as part of project, but collaboration appeared to be good nonetheless. The final reviewer stated that the collaboration so far consisted of discussions, visits, request for quotes, and contracts currently in progress with three vendors/suppliers. This person suggested that further coordination with partners would improve the results of the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent stated that the future work plan was detailed and was in a logical progression for proving out the components of this tire concept. The expert explained that vehicle tests would begin in approximately 18 months, leaving sufficient development time for proving tire components. The following reviewer explained that this project is not really research, but rather just the evaluation of a design. The next reviewer is going on the assumption that the light-duty version of this system is progressing towards commercialization. The only comment for future work is how Goodyear has accounted or planned for risks, i.e., this reviewer inquired if might there be design/application modifications that do not scale to commercial vehicle tires. The final reviewer commented that the future plan should consider evaluating the effect of introducing holes and grooves in the sidewall or the structure of the tire. These design modifications may lead to faster tire failure. Additionally, the future plan should consider mitigation alternatives in case the regulator fails, since over pumping may occur and can lead to tire failure. The plan should address the ability of the developed system components, tire, and associated costs to be repaired. Finally, this reviewer suggested that the future plan could review consumers' acceptability.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of the five reviewers to respond felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer thought the resources were excessive. The first reviewer stated that the resources appeared sufficient for completing the work – significant cost-share from Goodyear to complete work. Another reviewer commented that there are sufficient resources available for the completion of the project, mainly funding. Another reviewer noted excellent cost-share from the recipient; this clearly suggests intent to commercialize. The final expert was unsure why DOE would fund a plethora of Goodyear patents in this area.

Next Generation Environmentally Friendly Driving Feedback Systems Research and Development: Matthew Barth (University of California at Riverside) – vss086

Reviewer Sample Size

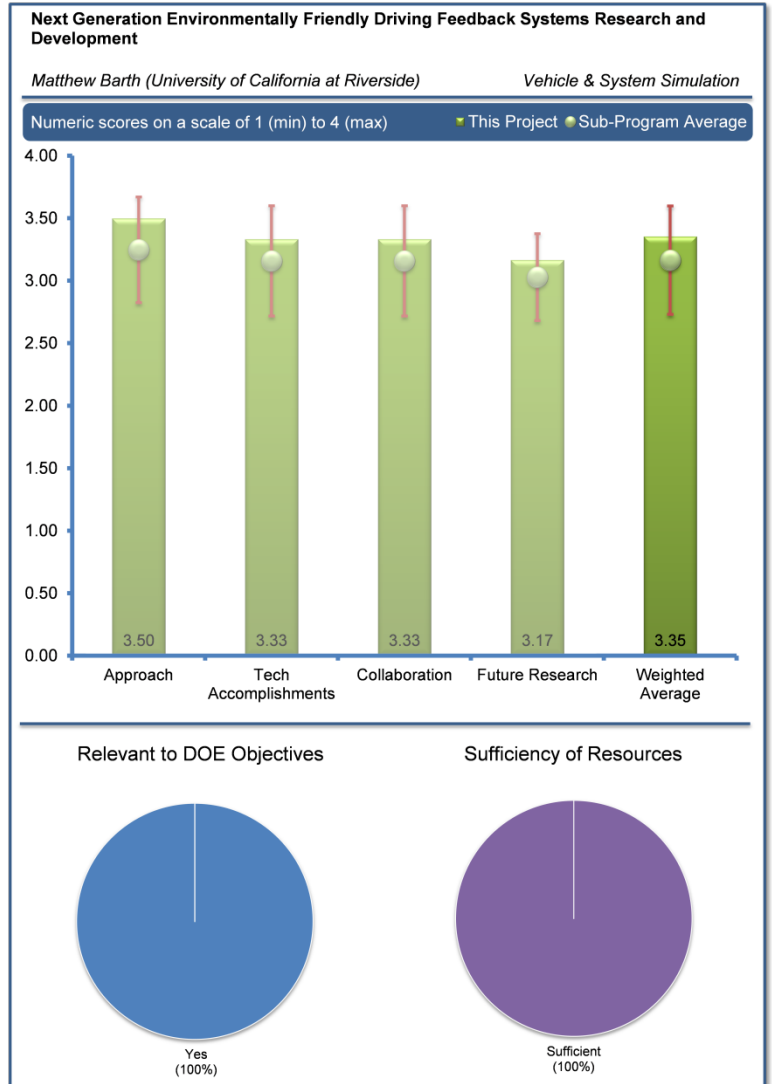
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer found that driver feedback for fuel efficiency is a relevant concept for improving vehicle fuel efficiency and thus is relevant to DOE objectives. This reviewer reported the research team was projecting potential benefits that go significantly beyond the 2% goal for the activity. Another panelist stated that the proposed next-generation driving feedback system has the potential of meeting the DOE goal of reducing fuel consumption by at least 2%. The next person relayed that the project was focused on reducing fuel consumption of fleet vehicles. Another panel member thought the objective to be complementary to many other programs. The final reviewer concluded that operator choices (routing and performance demand) are key attributes that contribute to fuel efficiency and ultimately to DOE petroleum displacement objectives. This reviewer felt that successful integration and demonstration of this system would offer an important tool to both the commercial and light-duty operators.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers had positive feedback on the approach, and some offered suggestions. One reviewer said the project appeared to be well-designed and well-coordinated. Another agreed that it seemed to incorporate advanced technology well, with a usable interface. The next person thought that this was generally a good project approach that covered several areas of the project development; however, no information was presented about the specifications, capability or design of the navigation system/equipment that will be available to the driver and passengers. A subsequent reviewer felt that an information aggregator that could aid the operator in achieving fuel efficient driving would be an important tool for both operator and fleet. This reviewer was not clear on how the system would address incomplete information (i.e., how the system will weigh the information that it is trying to aggregate when incomplete real-time information is not available). The reviewer asked if the system will archive hourly or daily trends. The final panelist relayed that the researchers approach combined several separate driver feedback and eco-driving concepts into one project, and that work will extend driver feedback concepts (eco-driving, eco routes) to legacy fleets. This panelist thought it ambitious to develop and refine this set of four tools, but the team was starting with some existing resources (traffic services, maps, etc.) so it should not be a problem. The panelist considered the present focus on fleet applications a good thing, and thought that the concept could be extended to personal vehicles. This panelist noted that the feedback system was fairly



portable, requiring only some tuning (especially for the eco-driving modules) to be transferred among vehicles, and concluded that this would be good for retrofit/legacy vehicle applications.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panel member reported that the project was progressing according to milestones. Another thought the project appeared well organized and on track. The next reviewer pointed out that the project only presented initial data, so there was little to judge on, but that the progress seemed to be in-line with the funding to date. A subsequent panelist agreed that the review only offered past progress/milestones and offered no insight into future timing (other than on a FY timescale). This panelist remarked that the review did not identify integration risk and how overall objectives might be compromised if system integration is encounters issues. The next person found limited accomplishments to date, but work on the project has only just started. This person thought the work on estimating intersection delays was interesting, and appeared to show promise in improving routing times for ecodriving. This person concluded that it would be interesting to see what accomplishments will be made in 2012/2013. The final reviewer observed that some barriers were not yet addressed, one being driver acceptance, since no scientific study has been done in this aspect. This reviewer felt the questionnaire was not enough, and that it was biased. The reviewer reported that safety concerns were not specifically assessed and answered, and listed a final unaddressed barrier as having unknown cost-effectiveness.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Some reviewers offered suggestions for possible collaboration. One panel member reported that there were many collaborators on this project, and felt that there were good partners on the technology end of the spectrum. This reviewer pointed out that fleet partners include only state and local government, and felt that it was unfortunate that the PI was not able to secure a private fleet. The panel member noted that it can be difficult to secure the participation of a private fleet (like a trucking fleet) in a research project such as this. Another panelist remarked that there were a lot of partners identified, but that it was not so clear if they are subcontractors that have a stake in making this project a success or if they are merely providing in-kind integration support. The next person thought that even though there are several partners collaborating in this project, collaboration with a commercial trucking fleet could have significant impact. The final reviewer suggested that if not done already, the project should check with the NHTSA on minimizing potential driver distraction issues.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that much future work needs to be done to complete these modules, but that the work plan seems reasonable, including system integration and several months of vehicle testing. Another observer commented that the review offered an outline of future work but did not identify a distinct timeline/milestone schedule or interdependence between modules/systems. The final reviewer thought that the future research needs to identify clearly the class(es) of vehicles that can use this system, that the future research needs to identify the usability of the system between different vehicle types, that the future research should include costs and benefits analysis on the fuel savings that can be achieved by the system, and that the future plan needs to include development options for the navigation system.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Six reviewers found resources to be sufficient. One thought that given the parameters of the work, the funding seemed reasonable to complete the project. Another panelist said that available resources should be sufficient for the completion of the project, mainly funding. The last reviewer questioned how much of the work will be proprietary, and cited the low cost-share by the contractor.

Look-ahead Driver Feedback and Powertrain Management: Zwick Tang (Eaton) – vss087

Reviewer Sample Size

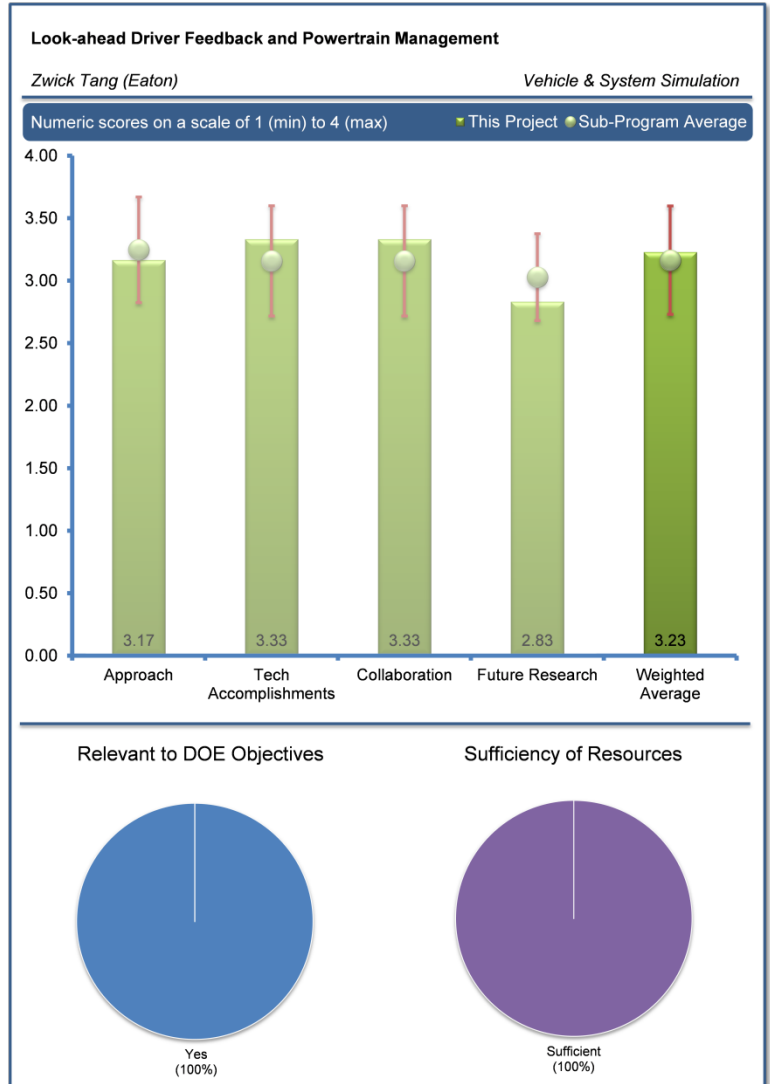
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that by seeking to reduce fuel consumption by at least 2%, this project aligned with the DOE petroleum displacement objectives. Another person concluded that improvement of commercial truck fuel efficiency is relevant to DOE fuel efficiency goals, and that there is significant opportunity for uptake into the market if the technology is cost-effective and functions well. This person noted that driver feedback is an important component for commercial vehicle fuel efficiency improvement, as driver actions contribute a considerable variability to fuel efficiency. The next panelist concluded that the project would support the DOE goal of reducing fuel consumption by improving commercial fleet fuel efficiency by at least 2% through advisory feedback and power control strategies. A further reviewer related that the project objective was focused on reducing the fuel consumption of fleet vehicles, and that the project appears to be on track to meet the objective. A final observer wrote that this project is complementary to several other projects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers provided a range of responses concerning the project’s approach. One observer felt there was good progress in this project. Another person pointed out that driver behavior is an important factor contributing to fuel efficiency. This person felt that combining various vehicle information systems to offer operator feedback, which would result in improving fuel efficiency, should offer an excellent tool to drivers that have little or no driver training. The person further thought that it may also provide feedback to operator who exhibit poor driving habits, but that there was not assessment of project risks. The next reviewer found the approach to be logical, and reiterated that it would identify requirements and opportunities for fuel savings, then develop systems to address these opportunities. This reviewer related that the project built on existing sensor technologies and results from driving studies. The reviewer further stated that this system can take a more active role in vehicle operation as the system is connected to engine/powertrain and does not depend solely on driver feedback interface for fuel efficiency improvement, which is important for commercial trucking. This reviewer thought that it appeared to be more integrated with the truck than other project systems, which required consideration of tradeoff of benefits versus difficulty in integration with existing vehicles. This reviewer concluded that minimizing distraction on commercial vehicle applications will be very important. A subsequent observer reported that the presenter mentioned in the approach that they will build upon the exiting and next-gen sensor and information technology, for example, the U.S. DOT V2I communications for safety program. This observer thought this approach could provide them with a step ahead in the development stage and big savings in the project costs. This observer also commented that the first objective of the project, providing advisory feedback, should be achievable with no concerns; however, the powertrain control approach could



have safety related issues, which require more considerations during development. The observer further expressed that the approach should include costs and benefits analysis for each approach. The final reviewer understood that most of the testing will take place in fairly flat driving terrain, and concluded that it would be better if the terrain could be varied. The reviewer also remarked that the interviews they conducted with trucking firms were only with management, and that it would have been better if they could have interviewed drivers also. This reviewer additionally found that it was not clear what the approach is to handling safety issues related to driver distraction and driver workload. The reviewer concluded that otherwise, the approach looked good.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally observed that the project is on track. One person thought that preliminary accomplishments seemed good. Another panelist felt the presenter had shown good progress and accomplishments in several tasks of the project. The next panel member reported that the project appears on track and is being well managed to deliver results. A further reviewer remarked that the PI was progressing toward the project objectives, but there was little insight into details of the planned task schedule. This reviewer reported that discrete task numbers are offered in the review (2.1, 2.2, and 3.1) but only notional phases without milestone dates are discussed. The final observer felt that much of the groundwork had been laid for this project with work completed so far; incorporating information from customers on what they would be interested in seeing. This observer relayed that the project used analysis to narrow down possible fuel consumption scenarios to a small selection of high impact situations where driver feedback can be important. The observer concluded that look-ahead systems offered promise for improving fuel efficiency by responding to environmental factors like traffic and road grade.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that the presenter had good collaboration with several partners including institutions, state and federal government, and commercial companies. Another panel member thought that the collaborations were good, having involved the University of Michigan Transportation Research Institute (UMTRI) and ORNL, along with a commercial fleet. This panel member also reported that the researchers were working with the Michigan V2x test bed to incorporate look-ahead features into system. The next panelist felt that the review did not clearly identify to what level the collaboration, exchange, or support is offered. This panelist asked if any of these partners are subcontractors and therefore are project stakeholders. The final observer suggested that using relatively few links with broad scope for each seems more appropriate than many links with little data transfer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter thought the future work plan would complete the project effectively, and that field testing of prototype system would be valuable to prove out benefits. Another panelist reported that the presenter had provided information on the first two phases of the project, but that there was no information on Phase III. This panelist noted that the future plan did not identify possible barriers and risk mitigation alternatives; for example, addressing road safety could be an issue. This panelist concluded that the plan needed to include information on the possibility of using the system in current or only future fleet. The final reviewer commented that the future work is only in outline form, and again does not offer any timeline definition.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Six reviewers rated the resources as sufficient. One stated that resources appeared to be sufficient to complete the work as described. Another person thought that available resources, mainly funding and data, were sufficient to sustain the project. The final reviewer wrote that there was low contractor cost-share contribution, about 25%.

Improved Cold Temperature Thermal Modeling and Strategy Development: Forest Jehlik (Argonne National Laboratory) – vss088

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

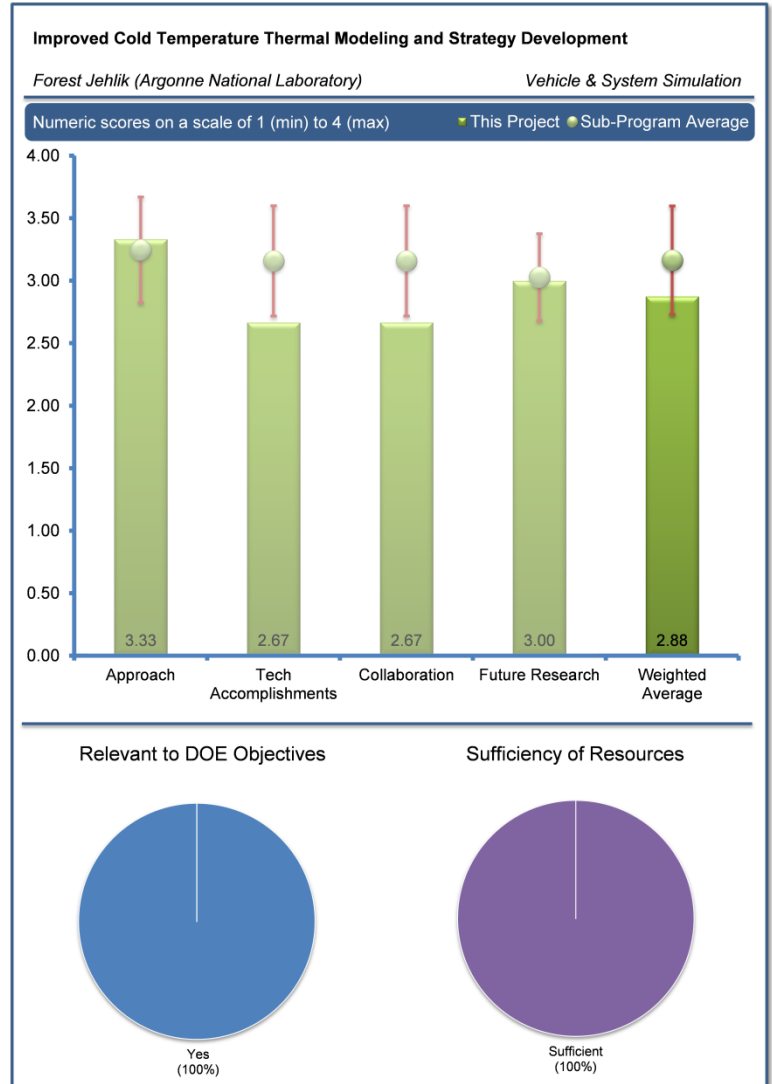
One reviewer felt that this project supported the DOE objectives of petroleum displacement but that it must be expanded to include hot temperature modeling. This reviewer pointed out that the sunbelt cities of Phoenix, Houston, and Las Vegas consume lots of petroleum for air-conditioning in their vehicles. Another panelist remarked that as vehicles become more and more efficient, it becomes harder to squeeze out efficiency improvements necessitating examination of areas to date which have been largely overlooked. This panelist thinks that comprehensive examination and understanding of the effects of ambient temperature on fuel efficiency across the drive cycle has the potential to uncover areas to further fuel efficiency improvements. The panelist further stated that, according to the PI, implementation of better heat transfer characteristics and/or waste heat utilization using knowledge of ambient temperature effects has the potential to unlock an additional 10-15% improvement in fuel efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One panel member concluded that every key element had been covered in the modeling. Another observer found the approach to this task to be reasonable and well implemented, utilizing proven instrumentation techniques and model development (leveraging existing fueling and temperature prediction models and capabilities at ANL). This observer reported that the empirical data and modeling efforts are then used to correlate with one another. The observer found that tests are conducted over broad ambient conditions using a number of thermal channels – engine oil, transmission fluid, etc. – and that presently only two vehicle models (two model years of the Toyota Prius and Ford Fusion) have been examined.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers found that progress has been made, and also provided suggestions. One reviewer felt that good progress has been achieved, but that it would be a great opportunity to repeat the data obtained in Canada using the updated ANL Advanced Powertrain Research Facility (APRF). This reviewer noted that in Slide 4, make it clear that A/C was off or on at 35°C during testing. The next observer remarked that task accomplishments include close correlation between cold temperature start-up and lost efficiency which is not surprising. This observer reported that progress has been made in determining thermal signals



providing useful insight into fuel efficiency for cold temperature warm-up including oil temperature and heater core impact, which provides a basis for constructing a portfolio of appropriate thermal signal points and parameters to accurately reflect the effect of ambient temperature on fuel efficiency over broad driving cycles or conditions. This observer further noted that idling efficiency is dramatically affected by cold temperatures which are especially relevant to assessment of hybridization benefits. The observer reported that testing has indicated that ambient temperatures do not significantly affect fuel efficiency once stabilization has been achieved. The observer found that models have been developed to determine fuel efficiency oil temperature dependency; flow rate has been estimated as a function of rpm/ load/ oil temperature with good accuracy after catalyst light off. This observer wrote that at low temperatures, it has been determined that fuel consumption at a given load point greatly decreases as oil temperature rises. The observer concluded that, overall, the steady, broad technical accomplishments that have been achieved are laying the groundwork for further advances.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One panel member urged researchers to get an OEM excited about this work in the near future. Another reviewer related that there has been limited collaboration with other entities including internally with ANL for modeling support, and Environment Canada for thermal modeling chamber usage (until ANL acquired five cycle, full temperature testing capabilities at the APRF this year). This reviewer reported that the PI indicated there has been informal discussion with previous colleagues at GM with regard to the efforts of this task. The reviewer thought that it would be beneficial to expand upon these discussions in a more formal way, including other OEMs, to help channel near-term and future task activities and determine pathways and research that could support commercially viable implementation strategies to improve fuel efficiency through waste heat utilization and improved heat transfer characteristics.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person suggested that hot temperature study be included in the near future. Another commenter reported that one of the items identified for future work is defining potential for engineered solutions to reduce real-world fuel consumption. This commenter would suggest putting primary effort into this area in the near-term (in collaboration with OEMs) as this really determines the overall value of the effort. In this commenter's opinion, the potential for fuel efficiency improvements seems to exist given research to date but confirmation and correlation with business realities from the OEMs standpoint is now essential. The commenter further thought that once interest is achieved from the business community (optimistically acquiring cost-share for future activities), it would be logical to incorporate other modeling elements (passenger comfort at NREL and catalyst light off and waste heat utilization at ORNL, as well as assessment of transmission thermal sensitivity) into the efforts of the task.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers found resources to be sufficient. One reported that this task appeared to have sufficient resources with regards to current technical accomplishments achieved and proposed future activities. Another reviewer added that the funding level is reasonable, but the reviewer would like to see an added bonus for fast deliverables.

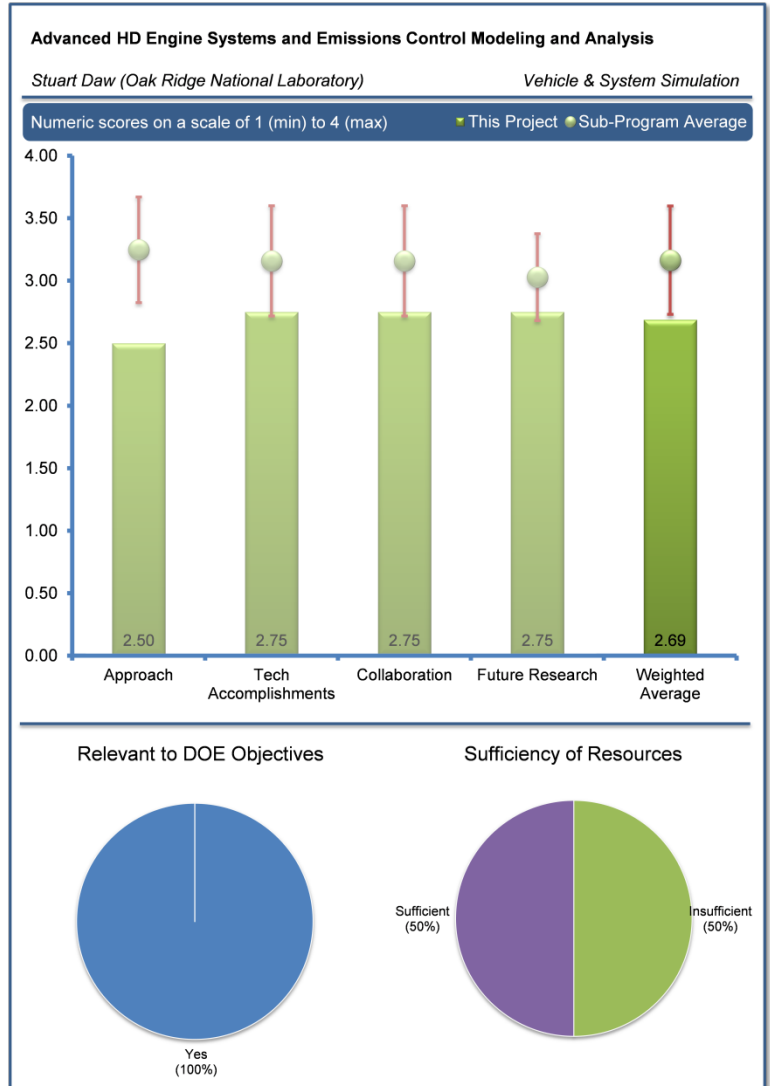
**Advanced HD Engine Systems and Emissions Control Modeling and Analysis:
Stuart Daw (Oak Ridge National Laboratory)
– vss089**

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent reported that the purpose is to better understand fuel consumption of medium-duty and heavy-duty vehicles, especially as they become hybridized, while also maintaining overall criteria pollutant compliance. A second reviewer described that the project considers emissions effects in MD and HD hybrid trucks. The project will provide tools for design strategies, emissions controls and uses real-world drive cycles as requirements. Decreasing petroleum use requires balancing trade-offs for satisfying multiple criteria simultaneously. The examination of these trade-offs will be more complete and more affordable using the simulation tools that the investigators are developing. This project is developing the tools that allow vehicle designers to predict fuel use effects for alternative emissions control strategies. These tools will help to reduce the time and money required to discover optimal strategies for reducing both emissions and fuel use. An optimal design of MD and hybrid trucks that employ homogeneous charge compression ignition (HCCI) and premixed charge compression ignition (PCCI) strategies can help minimize the cost of vehicle components necessary to improve emissions and fuel economy. The third reviewer stated that whether HD HEV would have significant fuel consumption advantage over conventional diesel is not well known. If in fact it is true based on simulation with enough credibility, then this project would certainly support the DOE petroleum displacement objectives. The final commenter explained that this project will develop simulations that help designed high efficiency powertrains for heavy and medium-duty vehicles. The consideration of aftertreatment devices in the proposed models will ensure that the results are reasonably realistic.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments included suggestions concerning the project’s approach. One reviewer acknowledged that the approach is well integrated with other projects at ORNL, including a CRADA with Meritor, in order to get good model input data. This reviewer stated that the modeling effort, however, did not seem to be focused on system cost, which is one of the barriers identified by the team. A second respondent felt that the approach is reasonable to date in that the researchers are establishing the model components and interfaces between components and validating operation of the models. A task that may help reduce project risk is to go through the formal exercise of designing some of the investigation experiments so that they can use the planned experiments to derive requirements for their model development. This will help ensure that the project's simulation suite will perform all aspects of the investigation requirements. The project will be stronger with development of complementary pre and

post processing tools to enhance full analytic capability of the tool suite. Example of tools that may be useful are a pre-processing experiment design tool that would allow analysts to structure their planned investigations, and a post-processor that provides results of key metrics. The third reviewer stated that this is a new project but a good start so far. This reviewer suggested that the project needs to fast forward to HD hybrid because there is a general belief that fuel economy gain would be minimal for long haul HD HEV. The reviewer remarked that the project team would become a big hero if you could convince the community with your study. The final reviewer observed the building of a model that is 2007 compliant, but this is 2012. An effort should be made to incorporate an engine model that meets the emissions requirements needed when one of these vehicles could be introduced (e.g., five to ten years from now). Most emissions occur during transient conditions, so it should be made clearer how this is modeled. In correct handling of transient conditions will likely lead to high uncertainty in the final simulation results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent stated that it looks like the technical team has made good progress on the development of computational modeling tools and methods, especially for estimating transient engine out emissions and transient emissions control system effectiveness. It was not clear how the team was addressing costs or cost modeling in their work. Another respondent observed that the project has made good progress during its first year by establishing the individual component models. A third respondent commented the technical accomplishments were okay. The fourth reviewer noted that the model building appears to be on-schedule, but a more modern engine concept should be integrated.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that most of the collaboration appears to be with other project teams at ORNL. Meritor appears to be the most significant external partner, but the team did not document the interaction with the DOE Advanced Engine Crosscut Team or Cross-Cut Lean Exhaust Emission Reduction Simulation (CLEERS) participants. The second reviewer indicated that the collaboration and coordination with the partners is described at a high level and seems appropriate. There could be more detail provided to document the level of engagement and progress review by the partners (e.g., requirements and design review events/milestones for the project). The third reviewer reported that by nature this project will bring many entities together, collaboration seems to be outstanding. Another reviewer suggested bringing more OEMs on board.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed input on proposed future research. One reviewer stated that the future plans presented seem like a logical progression of the project. The second commenter commented that the investigator's verbal description of the plans reflected that the project had clear plans for future research, but the written documentation of the poster presentation did not provide as much detail. Another reviewer emphasized again that HD HEV should be the timeliest focus. The fourth and final reviewer felt it is not clear if the future work is feasible within the next year. The future work should also be clearly linked to project technical barriers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found that resources are insufficient, and two found that resources are sufficient. One reviewer commented that resources seem sufficient. The other respondent stated that it was not clear who, besides Co-PI Zhiming Gao, is contributing to the project.

Electric Drive Vehicle Climate Control Load Reduction: John Rugh (National Renewable Energy Laboratory) – vss090

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent noted that this project addresses HVAC issues that adversely affect vehicle cost and range. Advancements in thermal management are needed to improve acceptance of electric vehicles in the market. Another reviewer pointed out that a better understanding of passenger comfort will help to better direct battery energy to the passenger cabin, increasing vehicle range. This project could make a significant impact on penetration of EVs in the marketplace. This reviewer expressed that it could also be used to reduce HVAC loads and improve fuel economy of traditional vehicles too, although this project does not seem to consider this aspect.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commenter indicated that the CRADA with automobile manufacturers to assemble a team of OEMs to participate in the investigation increases the chances that this project will result in a commercially viable

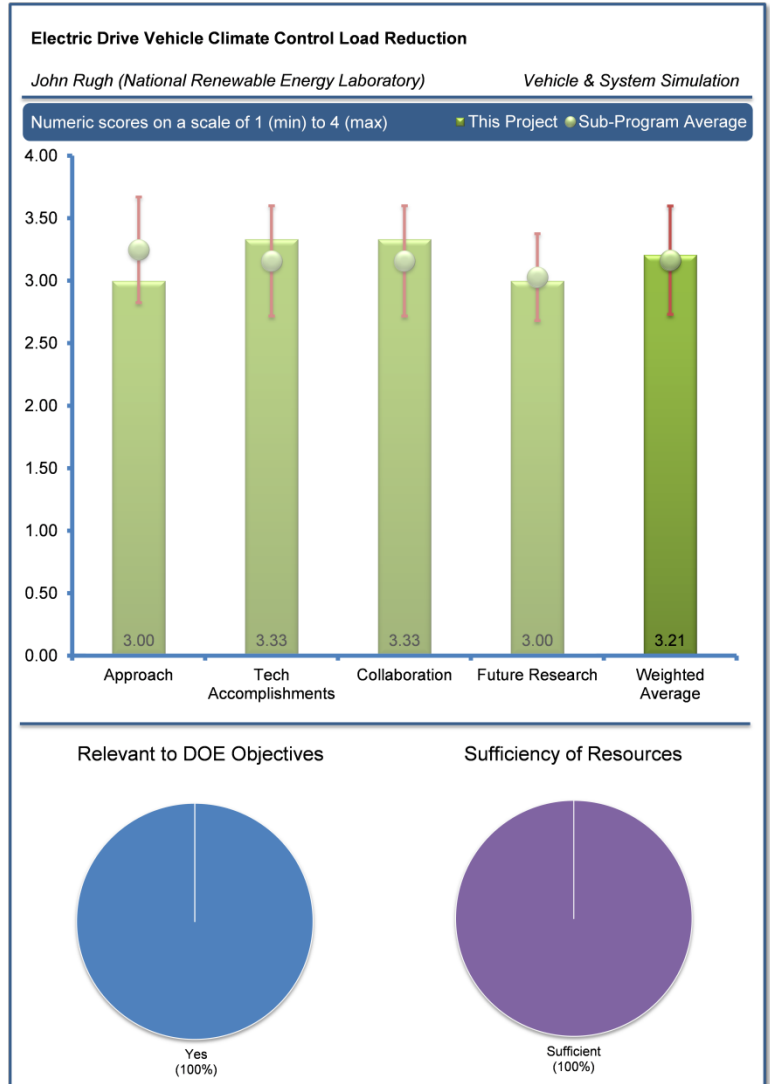
solution to the problem. Balanced approach of modeling and lab testing provides capability to investigate a wide range of combinations that can minimize the cost of the solution. The second reviewer reported that it is not clear what is new and different about this project. Motivation for the project seems strong, but there are not a lot of ideas presented as to how to address the issue technically. Basically, it is not clear what the technical outcomes of this project will be (e.g., a new passenger comfort model, etc.).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter indicated that the investigator has clearly defined the project goals and quantitative measures of effectiveness. The CRADA formalization appears to be making strong progress. The second reviewer stated that it seems as if little progress has been made, according to presentation. Results were not presented, it is just stated that there was collaboration. This reviewer suggested that the PI should be more specific as to what technical accomplishments were made.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the collaboration of the project with a diverse team of OEMs is one of its strongest attributes. The other reviewer stated that collaboration seems to be sufficient, but it should be made clearer how the collaborations will help to accomplish the technical barriers.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer indicated that this is a strong approach because modeling and analysis during FY 2012 will narrow down the most promising solutions for validation and comparison in FY 2013, with incorporation of the most promising technologies into production vehicles during FY 2014 and FY 2015. The future research builds methodically to commercialization and increases the chances that this project will lower barriers for EV acceptance in the market place. The second reviewer stated that future work is not clearly defined. It is not clear what will be done, and how it will address the technical barriers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All respondents indicated sufficient resources for this project. One respondent added that resources seem sufficient.

Defining Real World Drive Cycles to Support APRF Technology Evaluations: Eric Rask (Argonne National Laboratory) – vss091

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

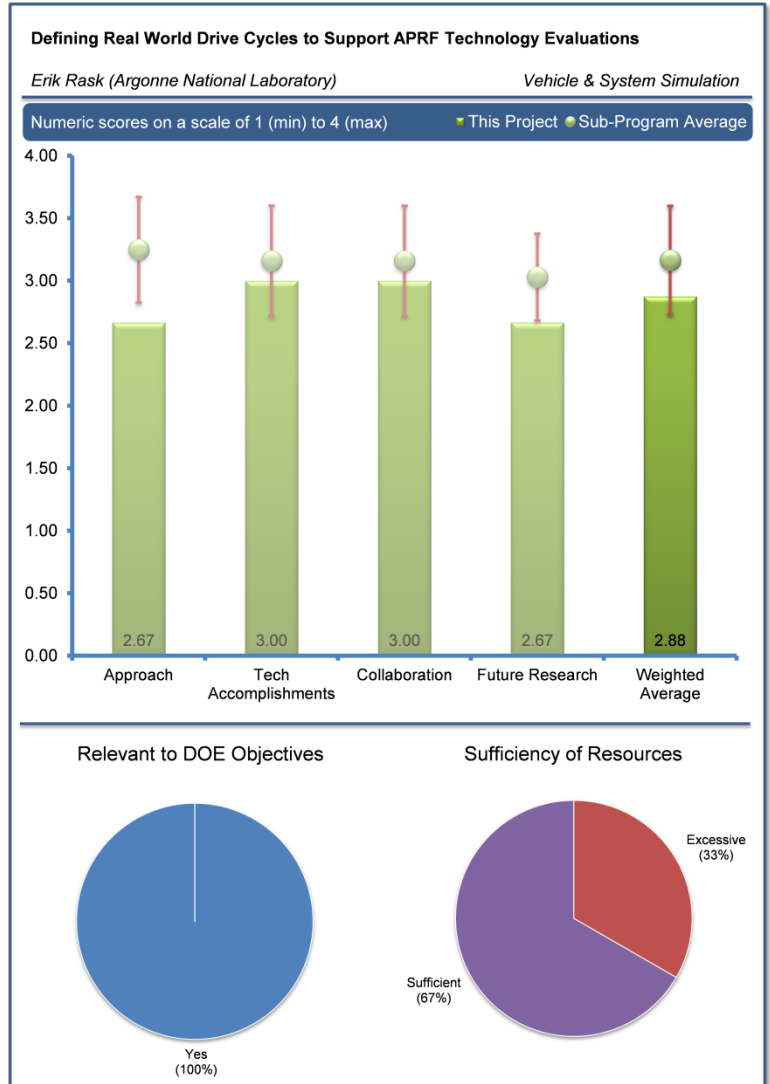
The first commenter agreed that this project helps with understanding vehicle demands under real-world driving conditions. The results of this project, if properly disseminated and accepted, could help vehicle manufacturers develop high-efficiency vehicles with better customer acceptance. A second reviewer described that the long-term measure of success of technology development is its impact that is proportional to degree market penetration. This project seeks to develop standardized test procedures that minimize resources required to accurately estimate vehicle performance in response to a range of drive cycles to include five real-world cycles. If the project can accomplish this goal, then it should help the community save money in predicting the impact of design alternatives and enhance cross organization consistencies. Unfortunately, it is unclear how project results are extensible or useful outside of ANL.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent stated that this is a good start with some interesting insights shown for results; however, the approach should be expanded to include calibration procedures and random validation tests that employ the APRF. The validity of the test procedures should be validated by other Labs. Another reviewer reported that this project will only make an impact on energy vehicle design/energy usage if the drive cycles developed are adopted by regulatory agencies. Vehicles are currently evaluated under a very specific set of drive cycles, and it is potentially risky for a manufacturer to optimize around a non-regulated drive cycle. With that said, it is important to develop a strategy to test vehicles in real-world conditions to determine the true impact of new technologies. It is already known that the regulated cycles do not match real-world conditions, so maybe this project should have focused more on making a real-world cycle part of the compliance process (or at least providing the data to support this action).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that the accomplishments seem to be in-line with objectives/barriers. Another respondent acknowledged some interesting initial results but cautioned that they have not identified a structured method for measuring estimation error as a function of the APRF sampling characteristics that would be necessary/sufficient for accurately determining a minimal set of APRF measurements for any given vehicle architecture.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer observed that a significant amount of work and data is leveraged through collaborations. This part of the project seems to be strong. The second reviewer reported that little evidence was presented regarding the role of other national labs and other partners in providing constructive review and/or validation. When one is developing standard procedures to address cross organization inconsistencies, it is critical to have stakeholder participation. This project comes across as insular to ANL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer indicated that future testing plans are very good, and the data the tests will supply should be useful. Wider acceptance of the newly proposed drive cycles should be pursued in some way though. Another respondent stated that future work does not indicate that the project will result in structured, transparent test procedures that are defensible and extensible outside of ANL. Future work statements should be re-evaluated in scope of utility to the broader goals of Vehicle Systems and VTP.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers indicated that resources are sufficient. A reviewer commented that resources are sufficient, and existing facilities are being used. One reviewer indicated excessive resources. This reviewer said it is unclear whether this project requires less or more resources because the usefulness and validity of the results outside of ANL are unclear at best.

Autonomous Intelligent Electric Vehicles: Andreas Malikopoulos (Oak Ridge National Laboratory) – vss092

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

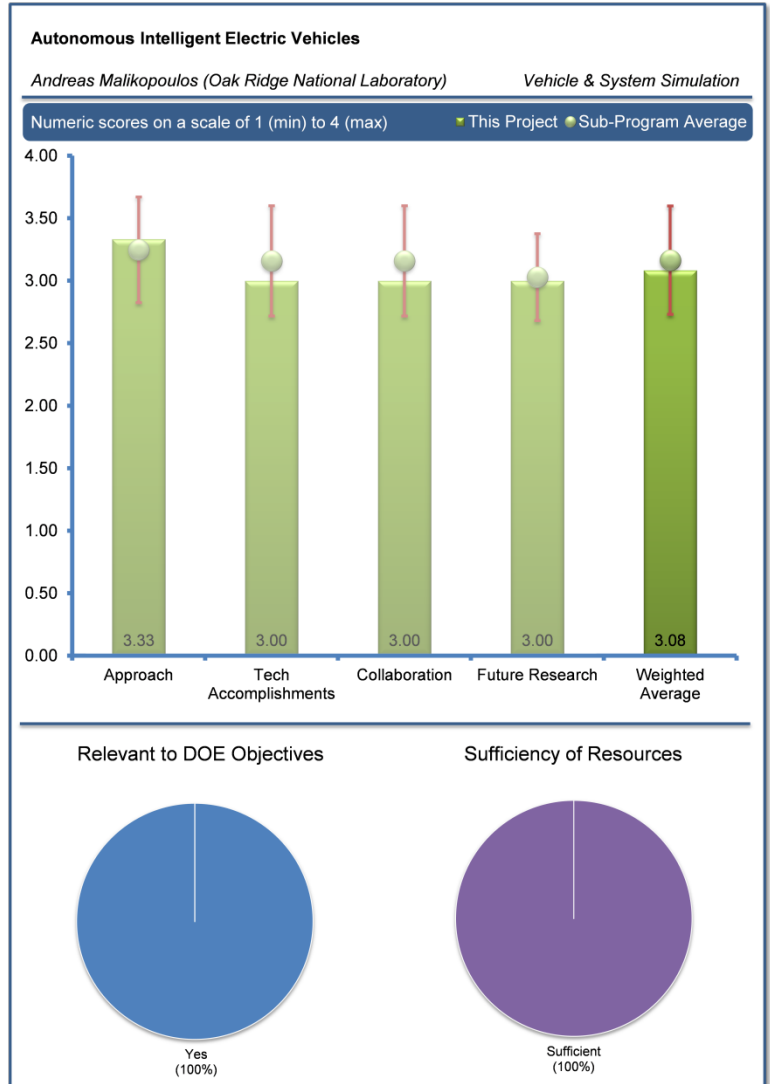
The first respondent said yes, this project will help optimize energy usage of hybrid-electric vehicles by developing control optimization methods. The second reviewer also stated yes, the goal is to improve the fuel efficiency of hybrid vehicles. A third reviewer described that innovative control algorithms can help further the fuel efficiency and emissions performance of HEVs and PHEVs. This task takes the approach of optimizing not only the entire engine/vehicle control system but additionally potentially incorporating means to apply controls that proactively adapt to individual driving styles and road conditions. In short, to be able to optimize the entire trip efficiency by adapting control strategies to driver acceleration, braking, and speed tendencies, as well as driving cycle and terrain attributes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments on the approach received mixed results from reviewers. The first reviewer felt that the approach to this task is excellent, proceeding rationally from an extensive literature review to assess state-of-the-art power management systems, to the development of a PHEV simulation model in Autonomie, to implementation of stochastic control algorithms to maximize PHEV operation in real time. This task draws from discrete time control Markov processes to achieve instantaneous equilibrium operating points throughout the drive cycle. The approach, if successful, has potential application across all vehicle classes. A second reviewer was not sure how this is different than other control strategies. The limitations of the individual components/subsystems to switch to a dramatically different operating point in real time would likely limit the ability of the system to maintain optimal system efficiency. Perhaps the introduction of stochastic-based control methodologies is the main contribution. The final reviewer suggested that the efforts to make a real-time optimization strategy that can be used on a physical prototype should be mentioned. The methods employed for this project are not new, so the reasons for them not being adopted by manufacturers should be briefly mentioned.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent noted that the project appears to be on-track. A second reviewer indicated that strong progress has been made performing the background research, establishing project partners, and developing the control algorithm. The third respondent commented that this task is a relatively new start, having begun in December 2011. Given its relatively short duration so far, technical accomplishments have been solid with respect to the extensive literature review, establishment of a series/ parallel PHEV



model in Autonomie including implementation of prototypical power electronics and electric machines (PEEM) and supervisory control model architecture, and the derivation and submission of the stochastic control algorithm.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Generally comments on collaboration and coordination are positive. One reviewer said that collaborations are appropriate for this stage in the project including an industrial Class 8 truck equipment manufacturer, the CLEERS Consortium, and various other elements within ORNL. This reviewer also recommended staying in coordination with ANL with regards to Autonomie model development aspects. If the approach looks promising, it is suggested to seek an additional private sector vehicle entity in which to test this approach for Class 3-6 or light-duty vehicles. It would also be a good idea to reach out broadly to the vehicle industry as a whole and assess commercial interest in this approach and objectively convey it. Another reviewer stated that collaboration seems strong, but should be more clearly defined. This reviewer questioned what Meritor is providing and whether they will implement these strategies in test vehicles. The final reviewer reported that some collaboration has been established with industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter stated that future research follows through with the original plan in a logical manner. The second reviewer reported that proposed future work is on point. As indicated in proposed future work, it is very important to proceed now with work to assess and quantify the potential benefits of this adaptive control approach and compare it to existing power management control algorithms. This should be done as much as possible in an apples-to-apples way to fairly assess the pros and cons of this approach and should be verified by industry. The final reviewer indicated that the implementation of this work into a real-world application is a very critical aspect. More detail regarding this process should be included in the presentation. Hardware in the loop integration is a significant task, and a clearer and focused plan should be presented for this work. For example, this reviewer questioned if the models developed during year one can be directly implemented into a controller and run real-time. A clear plan of this transition would help give confidence that the project will finish on time.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated that resources are sufficient. One reviewer stated resources seem sufficient. Another reviewer noted that resources appear to be sufficient for this effort. The final commenter pointed out that resources for this task are sufficient at this point, although if success is strongly demonstrated additional resources may need to be considered to maximize applicability.

ANSI Electric Vehicle Standards Roadmap: Jim McCabe (American National Standards Institute) – vss093

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said that this was really well done in terms of finding the holes in standards. This reviewer would love to see this extended to medium-duty and heavy-duty truck applications, and thought that Smith and Navistar were willing to participate based on the Question and Answer Session at the end of this presentation. Another respondent stated that great value added work – very relevant to the future of both commercial and passenger car EVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
The first respondent felt that not only was the approach solid, but the report out was solid as well. This respondent emphatically stressed to keep this going. The second reviewer said organized for short-, mid-, and long-term issues.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said project is lightly funded, yet receives bang for the buck return on setting standards. Another reviewer stated that this is more coordination than technical accomplishments, which is why the reviewer rated this Good versus Outstanding.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

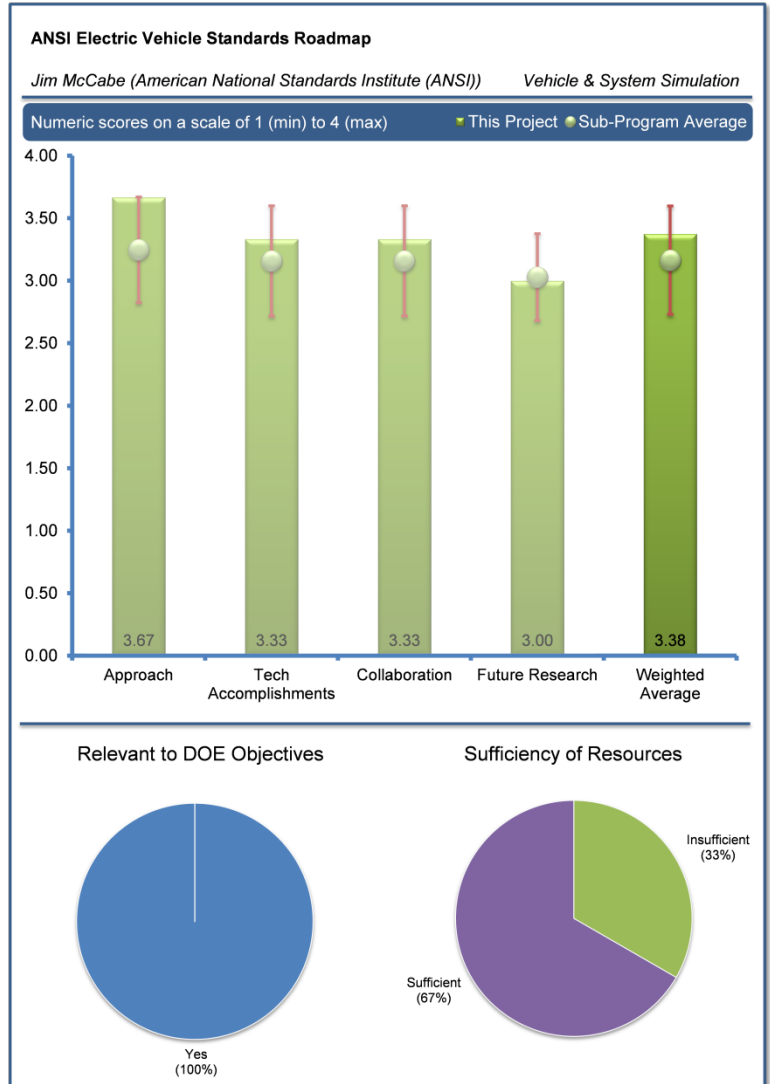
One respondent stated that it is hard to herd cats; they seem to do it well.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One respondent strongly suggested pushing this to MD and HD truck segments. This reviewer suggests keeping this updated.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Most of the commenters indicated sufficient resources. The only respondent to elaborate felt that this project requires additional support as it is pivotal to the success of the EV industry.



Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
AC	Alternating Current
A/C	Air-Conditioning
ADA	American with Disabilities Act
AEV	All Electric Vehicle
AFRL	Air Force Research Laboratory
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
APEEM	Advanced Power Electronics and Electric Machines Program
APRF	Advanced Powertrain Research Facility (ANL)
APU	Auxiliary Power Unit
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BEV	Battery Electric Vehicle
C_d	Coefficient of Drag
CFD	Computational Fluid Dynamics
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CNG	Compressed Natural Gas
CRADA	Cooperative Research and Development Agreement
DC	Direct Current
DOE	Department of Energy
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
DTNA	Daimler Trucks North America
EAR	E-A-R Thermal Acoustic Systems
EDV	Electric Drive Vehicles
EP	Extreme Pressure
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESS	Energy Storage Systems
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
EVSP	Electric Vehicles Standards Panel
FMVSS	Federal Motor Vehicle Safety Standards
FY	Fiscal Year
FOA	Funding Opportunity Announcement
GEN2	Generation 2

Acronym	Definition
GITT	Grid Integration Tech Team
GM	General Motors Corporation
GSA	General Services Administration
GPRA	Government Performance and Results Act
GHG	Greenhouse Gas
HAN	Home Area Network
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy-Duty
HEV	Hybrid Electric Vehicle
HHV	Hydraulic Hybrid Vehicle
HVAC	Heating Ventilating and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation Systems
INL	Idaho National Laboratory
ISO	International Organization for Standardization
LD	Light-Duty
LH	Long-Haul
LED	Light-Emitting Diode
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
MIT	Massachusetts Institute of Technology
MD	Medium-Duty
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NEC	Net Energy Change
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NiMH	Nickel-Metal Hydride
NREL	National Renewable Energy Laboratory
NY	New York
NYC	New York City
1-D	One-dimensional
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
OTR	Over The Road
PCCI	Premixed Charge Compression Ignition
PEEM	Power Electronics and Electric Machines
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator

Acronym	Definition
PLC	Programmable Logic Controller
PNNL	Pacific Northwest National Laboratory
PPG	Pittsburgh Plate Glass Company
R&D	Research and Development
SAE	Society of Automotive Engineers
SOC	State Of Charge
SOE	State Of Energy
SOFC	Solid Oxide Fuel Cell
3-D	Three-dimensional
TRU	Trailer Refrigeration Unit
UK	United Kingdom
UL	Underwriters Laboratories
UMTRI	University of Michigan Transportation Research Institute
USCAR	United States Council for Automotive Research
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability
USPS	United States Postal Service
V2I	Vehicle-to-Infrastructure
VTP	Vehicle Technologies Program
WPT	Wireless Power Transfer

2. Energy Storage Technologies

Energy storage technologies, especially batteries, are critical enabling technologies for the development of advanced, fuel-efficient, light- and heavy-duty vehicles, which are critical components of the U.S. Department of Energy’s (DOE’s) Energy Strategic Goal: “to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy.” The program’s vision supports the development of durable and affordable advanced batteries covering the full range of vehicle applications, from start/stop to full-power hybrid electric, electric, and fuel cell vehicles. Much of this work will be applicable to energy storage for heavy hybrid vehicles as well. Energy storage research aims to overcome specific technical barriers identified by the automotive industry and the Vehicle Technologies Program. These include cost, performance, life, and abuse tolerance. These barriers are addressed collaboratively by DOE’s technical research teams and battery manufacturers.

In August 2009, DOE announced the selection of 26 projects (totaling \$1.5 billion) for expanding U.S. manufacturing capacity for advanced batteries and advanced battery components. These American Reinvestment and Recovery Act (ARRA)-funded projects support establishing a significant domestic capacity for batteries that will, in turn, help commercialize advanced electric drive vehicles. Twenty of those ARRA projects focus on developing manufacturing capacity for advanced batteries and battery components (including the production of lithium-ion cells and polymers), production of polymer separators and other components, and battery recycling. The six remaining projects focus on the creation of new battery facilities, or the upgrading of existing facilities, to enable researchers to test batteries, improve battery safety, and increase the throughput of specialized thermal testing.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† A High-Performance PHEV Battery Pack	Mohamed Alamgir (LG Chem, Michigan)	2-5	3.25	2.50	2.50	3.00	2.75
† USABC LEESS and PHEV Programs	Leslie Pinnell (A123Systems)	2-8	2.67	2.33	2.33	2.33	2.42
† JCS PHEV System Development-USABC	Avie Judes (Johnson Controls-Saft)	2-10	3.33	3.33	3.33	3.00	3.29
† Multifunctional, Inorganic-Filled Separators for Large Format, Li-ion Batteries	Richard Pekala (Entek)	2-12	4.00	3.75	3.75	3.00	3.72
Engineering of High Energy Cathode Materials	Khalil Amine (Argonne National Laboratory)	2-14	3.25	3.00	3.00	3.00	3.06
New High Energy Gradient Concentration Cathode Material	Khalil Amine (Argonne National Laboratory)	2-17	3.20	2.60	2.60	3.20	2.83
Development of High-Capacity Cathode Materials with Integrated Structures	Michael Thackeray (Argonne National Laboratory)	2-20	3.25	3.00	3.00	3.00	3.06
Developing A New High Capacity Anode With Long Cycle Life	Khalil Amine (Argonne National Laboratory)	2-22	2.00	2.25	2.25	2.25	2.19
High Voltage Electrolytes for Li-ion Batteries	Richard Jow (Army Research Laboratory)	2-25	3.25	3.00	3.00	3.25	3.09
Development of Advanced Electrolyte Additives	Zhengcheng Zhang (Argonne National Laboratory)	2-28	2.75	3.25	3.25	2.50	3.03

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range	Marshall Smart (Jet Propulsion Laboratory)	2-31	4.00	3.75	3.75	3.25	3.75
Novel Phosphazene Compounds for Enhancing Electrolyte Stability and Safety of Lithium-ion Cells	Kevin Gering (Idaho National Laboratory)	2-34	2.67	3.00	3.00	2.67	2.88
Screening of Electrode Materials & Cell Chemistries and Streamlining Optimization of Electrodes	Wenquan Lu (Argonne National Laboratory)	2-36	2.60	2.80	2.80	2.80	2.75
Scale-up and Testing of Advanced Materials from the BATT Program	Vince Battaglia (Lawrence Berkeley National Laboratory)	2-39	2.80	3.40	3.40	3.40	3.25
Fabricate PHEV Cells for Testing & Diagnostics	Andrew Jansen (Argonne National Laboratory)	2-42	3.00	2.67	2.67	3.00	2.79
Electrochemistry Cell Model	Kevin Gallagher (Argonne National Laboratory)	2-44	3.00	2.75	2.75	2.25	2.75
Diagnostic Studies on Lithium Battery Cells and Cell Components	Dan Abraham (Argonne National Laboratory)	2-46	3.33	3.67	3.67	3.00	3.50
Electrochemistry Diagnostics of Baseline and New Materials	Robert Kostecki (Lawrence Berkeley National Laboratory)	2-48	4.00	3.33	3.33	3.33	3.50
Diagnostic Studies to Improve Abuse Tolerance and Life of Li-ion Batteries	Xiao-Qing Yang (Brookhaven National Laboratory)	2-50	3.33	3.00	3.00	3.33	3.13
Develop and Evaluate Materials and Additives that Enhance Thermal and Overcharge Abuse	Zonghai Chen (Argonne National Laboratory)	2-52	2.67	2.67	2.67	2.67	2.67
Evaluation of Abuse Tolerance Improvements	Chris Orendorff (Sandia National Laboratories)	2-54	3.67	3.67	3.67	3.33	3.63
Overcharge Protection for PHEV Batteries	Guoying Chen (Lawrence Berkeley National Laboratory)	2-56	3.33	3.00	3.00	3.33	3.13
† Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes	Wesley Henderson (North Carolina State University)	2-58	3.67	3.33	3.33	3.67	3.46
† Molecular Dynamics Simulation and AB Initio Studies of Electrolytes and Electrolyte/Electrode Interfaces	Dmitry Bedrov (University of Utah)	2-61	4.00	3.67	3.67	3.67	3.75
† Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes	Prashant Kumta (University of Pittsburgh)	2-64	4.00	3.00	3.00	3.00	3.25
† Metal-Based, High-Capacity Lithium-Ion Anodes	Stanley Whittingham (Binghamton University-SUNY)	2-66	3.00	3.50	3.50	3.50	3.38
† Electrolytes - Advanced Electrolyte and Electrolyte Additives	Khalil Amine (Argonne National Laboratory)	2-68	3.67	3.00	3.00	3.00	3.17
† Development of Electrolytes for Lithium-ion Batteries	Brett Lucht (University of Rhode Island)	2-70	3.50	3.50	3.50	3.00	3.44
† Bifunctional Electrolytes for Lithium-ion Batteries	Daniel Scherson (Case Western Reserve University)	2-72	3.50	3.00	3.00	3.50	3.19
† Polymers For Advanced Lithium Batteries	Nitash Balsara (Lawrence Berkeley National Laboratory)	2-74	3.00	3.33	3.33	3.33	3.25

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† Electrolytes - R&D for Advanced Lithium Batteries. Interfacial Behavior of Electrolytes	John Kerr (Lawrence Berkeley National Laboratory)	2-76	4.00	4.00	4.00	3.33	3.92
Diagnostic Testing and Analysis Toward Understanding Aging Mechanisms and Related Path Dependence	Kevin Gering (Idaho National Laboratory)	2-79	3.40	3.00	3.00	3.00	3.10
Overview and Progress of United States Advanced Battery Research (USABC) Activity	Kent Snyder (Ford Motor Company)	2-82	3.67	3.67	3.67	3.33	3.63
Progress of DOE Materials, Manufacturing Process R&D, and ARRA Battery Manufacturing Grants	Chris Johnson (National Energy Technology Laboratory)	2-84	3.00	3.00	3.00	3.00	3.00
† Electrolytes and Separators for High Voltage Li Ion Cells	Austen Angell (Arizona State University)	2-86	3.33	3.00	3.00	3.00	3.08
PHEV Battery Cost Assessment	Kevin Gallagher (Argonne National Laboratory)	2-88	3.67	3.00	3.00	3.33	3.21
High Voltage Electrolyte for Lithium Batteries	Zhengcheng Zhang (Argonne National Laboratory)	2-90	2.75	3.00	3.00	2.75	2.91
Spherical Carbon Anodes Fabricated by Autogenic Reactions	Michael Thackeray (Argonne National Laboratory)	2-92	3.00	2.75	2.75	2.50	2.78
Novel Composite Cathode Structures	Christopher Johnson (Argonne National Laboratory)	2-95	2.50	2.75	2.75	3.00	2.72
Overview of Computer-Aided Engineering of Batteries (CAEBAT) and Introduction to Multi-Scale, Multi-Dimensional (MSMD) Modeling of Lithium-Ion Batteries	Ahmad Pesaran (National Renewable Energy Laboratory)	2-97	4.00	3.67	3.67	3.33	3.71
Development of Computer-Aided Design Tools for Automotive Batteries	Steven Hartridge (CD-Adapco)	2-99	3.50	3.50	3.50	3.00	3.44
Development of Computer-Aided Design Tools for Automotive Batteries	Taeyoung Han (General Motors)	2-100	4.00	3.67	3.67	3.67	3.75
Development of Cell/Pack Level Models for Automotive Li-Ion Batteries with Experimental Validation	Christian Shaffer (EC-Power)	2-102	4.00	4.00	4.00	3.00	3.88
Open Architecture Structure for CAEBAT	Sreekanth Pannala (Oak Ridge National Laboratory)	2-105	3.67	3.00	3.00	3.33	3.21
Energy Storage Monitoring System and <i>in situ</i> Impedance Measurement Modeling	Jon Christophersen (Idaho National Laboratory)	2-107	3.67	3.00	3.00	3.00	3.17
Battery Ownership Modeling	Jeremy Neubauer (National Renewable Energy Laboratory)	2-109	2.33	2.67	2.67	2.33	2.54
Developmental and Applied Diagnostic Testing	Kevin Gering (Idaho National Laboratory)	2-111	3.67	3.33	3.33	3.67	3.46
† Electric-Vehicle Battery Development	Herman Lopez (Envia)	2-113	3.67	2.67	2.67	3.00	2.96
† EV Battery Development	Nick Karditsas (Cobasys)	2-115	3.00	2.67	2.67	3.00	2.79
† LEES Battery Development	Kimberly McGrath (Maxwell)	2-118	3.00	3.33	3.33	3.00	3.21
† Novel High Performance Li-ion Cells	Keith Kepler (Farasis)	2-121	3.67	2.67	2.67	3.00	2.96

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† 3-D Nanofilm Asymmetric Ultracapacitor	Fraser Seymour (Ionova)	2-123	3.00	3.33	3.33	2.67	3.17
† Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells	Suresh Sriramulu (TIAX)	2-125	3.33	2.33	2.33	1.67	2.50
† Novel Anode Materials	Jack Vaughey (Argonne National Laboratory)	2-127	3.50	3.50	3.50	3.50	3.50
† Development of Si -based High Capacity Anodes	Ji-Guang (Jason) Zhang (Pacific Northwest National Laboratory)	2-129	2.50	3.00	3.00	2.50	2.81
† Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes	Anne Dillon (National Renewable Energy Laboratory)	2-131	4.00	4.00	4.00	4.00	4.00
† New Layered Nanolaminates for Use in Lithium Battery Anodes	Yury Gogotsi (Drexel University)	2-133	3.50	2.50	2.50	3.00	2.81
† Synthesis and Characterization of Polymer-Coated Layered SiOx-Graphene Nanocomposite Anodes	Donghai Wang (Pennsylvania State University)	2-135	3.50	2.50	2.50	3.50	2.88
† Wiring up Silicon Nanoparticles for High-Performance Lithium-Ion Battery Anodes	Yi Cui (Stanford University)	2-137	3.50	3.00	3.00	3.00	3.13
† Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries	Kwai Chan (SwRI)	2-139	4.00	3.00	3.00	3.50	3.31
Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials	Anthony Burrell (Argonne National Laboratory)	2-141	3.80	3.60	3.60	3.40	3.63
Development of Industrially Viable Battery Electrode Coatings	Robert Tenent (National Renewable Energy Laboratory)	2-144	3.00	3.00	3.00	3.00	3.00
Design of Safer High-Energy Density Materials for Lithium-Ion Cells	Ilias Belharouak (Argonne National Laboratory)	2-146	3.00	3.00	3.00	3.25	3.03
Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes	David Wood (Oak Ridge National Laboratory)	2-148	3.00	2.67	2.67	2.67	2.75
Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries	Claus Daniel (Oak Ridge National Laboratory)	2-151	2.33	2.33	2.33	2.67	2.38
Post-test Cell Characterization Facility	Ira Bloom (Argonne National Laboratory)	2-153	3.50	3.50	3.50	3.25	3.47
Process Development and Scale up of Advanced Cathode Materials	Greg Krumdick (Argonne National Laboratory)	2-155	3.50	2.75	2.75	3.50	3.03
Process Development and Scale up of Advanced Electrolyte Materials	Greg Krumdick (Argonne National Laboratory)	2-157	3.25	2.25	2.25	3.00	2.59
Overall Average			3.31	3.08	3.08	3.06	3.14

† denotes poster presentations

A High-Performance PHEV Battery Pack: Mohamed Alamgir (LG Chem, Michigan) – es002

Reviewer Sample Size

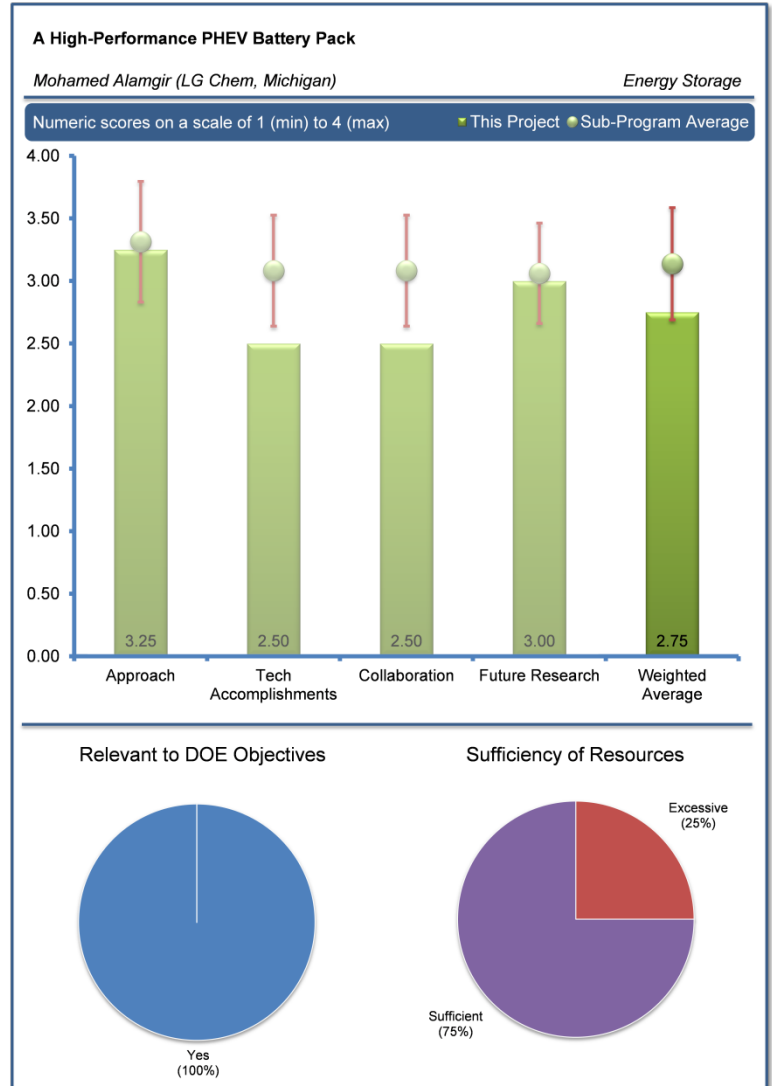
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Only one of the four reviewers directly addressed this question, saying that the relevance to DOE goals and petroleum displacement is clear. There is a substantial need for higher capacity and energy for lowering the cost of the 40-mile system. Comments of the other reviewers were much more narrowly focused on the internal goals and barriers of this project. One reviewer cited that the goals of this work were to implement higher-energy materials for improved Li-ion batteries (greater range) and to lower costs, one of the main barriers to the acceptance of this technology. This work was focused on the battery pack design, thermal management issues and on devising a complete product. It would form a framework for commercialization of new advances in materials and design. The other two comments were similar. One noted that the battery pack design determined the effectiveness of the pack in meeting the demands of the application. The other asserted that both high-voltage cathodes at the cell level (to maximize the energy and thus reduce the cost) and cooling systems at the battery pack level (to optimize performance, lifetime and safety) were crucial for pack development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

With the exception of the first comment (which termed the design excellent, incorporating attention to the essential details of the needs), reviewer comments, while generally positive, were tempered with suggestions for the modification of the work approach. One reviewer noted that the development of a cold-plate refrigeration system was quite important and was proceeding on schedule. The work with a high manganese (Mn) cathode system, however, was far from complete with two-thirds of the time gone. The approach of lowering the upper and lower cutoff voltages has improved the cycle life at the expense of severe attrition of capacity. The use of additives has not shown sufficient improvement in the cycle life. The reviewer suggested that the principal investigator (PI) contact vendors of cathode materials to determine if better materials were now available. Continued work with Samples A and B was unlikely to result in the successful conclusion of the work. The third reviewer observed that the specified approach was to characterize high-capacity, Mn-rich, layered-layered cathode materials (obtained from several sources) in terms of performance, durability (cycle life) and abuse tolerance. A second project goal was to optimize a refrigerant-to-air cooling system developed earlier in the United States Advanced Battery Consortium (USABC) program. It was unclear to the reviewer why these unrelated tasks were included in the same project rather than being separated into two different projects. Nonetheless, the reviewer deemed both highly relevant to the successful development of viable battery packs for electrified vehicles. The last reviewer noted



that LG Chemical has developed a proprietary separator material that can enhance safety for large cells that will be used for electric vehicle (EV) batteries and the like. LG Chemical was also one of the first major companies to scale up and be ready to provide real batteries for this business. This work focused on the pack design and on switching to an air-cooled system from one that required a more costly and complex refrigerant system. LG Chemical was sampling Mn cathodes from commercial suppliers. Such materials were likely to be scalable and more relevant to production in the near term. However, they may not necessarily represent the leading edge of this technology. The techniques being used were fine (gas sampling, impedance, Mn solubility measurements and cell testing).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

In this section too, one of the four reviewers commented simply that the design had been implemented and battery packs performed as required, while others called attention to the pressure of a tight schedule for accomplishing final project goals and to other perceived shortcomings. One reviewer reiterated a concern from the previous section, saying that as noted in the approach section, the accomplishments to date were far from meeting cycle life/capacity goals and the problem of voltage fade had not yet been addressed. The latter was an important feature of the high-manganese material, especially when discharged to below 2.5 volts as revealed in this review. The PI should consult with Argonne National Laboratory (ANL) personnel as well as with vendors to upgrade the program or there was little chance of achieving the goals. The third reviewer noted that cathodes from two different vendors were evaluated. The limited data provided suggested that the discharge cut-off (low) voltage significantly impacted the cycle life (4.4 V to 2.0 V is much worse than 4.4 V versus 3.2 V). The reviewer found this interesting, but noted that no indication was provided of why it was the case. The upper charging voltage (4.1 V to 4.5 V) also dramatically impacted the cycle-life due to severe Mn dissolution and considerable gas evolution. The well-known need for an improved electrolyte was noted. A rapid increase in the cell resistance was also noted at low state-of-charge (SOC), which may limit the usable SOC for a battery pack, but again the reviewer found no mention in the presentation of why this occurs, and wondered if it was under study. The rate capability (at 1°C) also seemed to strongly limit the obtained capacity. Electrolyte additives were noted to improve the cycle life, but the improvements were quite limited, with the lifetime extended from about 80 to 160 cycles before rapid degradation. The capacity degradation profiles suggested that some form of degradation event was initiated and then propagated in each subsequent cycle, leading to a rapid decrease in capacity with each subsequent cycle. The reviewer asked what diagnostics were being performed on this degradation mechanism, and what studies were underway, such as those done by Daniel Abraham (of ANL), in which cells were disassembled, the electrodes washed and new cells prepared with the electrodes and fresh electrolytes to determine if the degradation was due to irreversible changes in the electrodes or instead due to changes in the electrolyte, loss of lithium, etc. It was unclear from the information provided what advances had been made in the cooling system. The last reviewer felt that the project team had done some nice design work and developed an air-cooled pack with good temperature control. The reviewer mentioned that the team had also explored the performance of new materials and identified some shortcomings (in rate) and the severe trade-off in cycle life by going to too high a charge voltage to boost driving range per cycle. The project team has studied and done a good job of characterizing the vendor cathode materials, although the project did not appear to have made any significant improvements (this is consistent with plans). The reviewer called attention to the fact that this program was well positioned to take advantage of improvements made by other material suppliers. Costing information from this program on actual packs should also be valuable.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The pattern established in previous sections was continued in this one. One reviewer noted simply that the pack met the requirements of the customer and did not elaborate. The other three reviewers commented at considerably greater length, identifying perceived shortcomings in the extent and depth of collaboration in this project. One said that the program seemed to have utilized the national labs mainly for testing purposes. The evaluation of a new material with serious deficiencies, such as the high-manganese material, needed a broad-based collaboration with those studying the material deficiencies. A second reviewer found nothing in the review document that indicated that collaborations and coordination with other institutions were part of this project, except for the mention of partners including Idaho National Laboratory (INL), Sandia National Laboratories (SNL) and the National Renewable Energy Laboratory (NREL). What form of partnership had occurred this past year, however, was not evident. The "Future Work" notes that cells would be delivered to the national laboratories for testing, and external validation was

highly desirable. It was likely that most of the work was done in-house, although the cathode materials had been provided by two vendors, so perhaps some exchange of information had occurred to better understand the material properties. The fourth reviewer noted that this was a commercial company, so collaboration was typically never going to be as open as with an academic institution or national laboratory. Even recognizing this, however, the reviewer was struck by the poor communication of needs to LG Chemical by the USABC companies with regard to the need for the cooling work. It was unclear to the reviewer (and the reviewer believed, to LG Chemical) whether having to incorporate cooling into the actual pack was really essential at this stage of development. Greater clarity by DOE and USABC on what was really needed could help clarify the mission and focus efforts on the truly critical needs of this program. This was especially important, the reviewer felt, in view of the large amounts of time and money spent on engineering work for these large pack modules. This criticism, the reviewer pointed out, was aimed at DOE/USABC, not LG Chemical.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the project team had demonstrated the ability to successfully design and deliver battery packs with the required performance. Another reviewer felt that the emphasis on improving high-voltage cathodes through surface modification and electrolyte composition/additives was a reasonable means of deriving further improvements, but since no details were provided, could venture no further judgment. The testing of battery packs both in-house and at the national laboratories was welcome, as noted above. The third reviewer noted the plans to look at surface modifiers for the cathode and new electrolytes and/or electrolyte additives to improve cathode stability and considered them good, although striking a common theme. Obviously, the reviewer acknowledged, LG Chemical could not share details of such plans publicly. One of the reviewer's concerns regarding coatings was that this material already had rate issues and while the coatings would likely greatly improve cycle life, that the coatings may also aggravate the rate problems. Suggesting that emphasis be placed on ensuring such coatings are kept very thin, the reviewer said LG may wish to evaluate ALD-coated materials, and that LG and others also try to evaluate Envia Systems' cathode material if that was possible from a business confidentiality and commercial viewpoint. The last reviewer commented that no details had been provided regarding the additives or electrolyte compositions to be tested. Furthermore, the approach to surface modifications of the cathode material was not revealed. The reviewer then suggested that the PI should try to take advantage of work already done in the surface modification field by several DOE contractors and national laboratory workers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers considered the project resources to be sufficient. One called the project well-planned and executed. The other found it difficult to estimate if the funding provided was appropriate, as the full range of activities was not specified and only limited results were described. LG Chemical, however, was cost-sharing the project, indicating a contribution of considerable resources. Given the company's standing in the lithium battery industry, it could be assumed that the provided funding was on target to achieve the DOE's goals. The fourth reviewer termed the resources excessive, noting that this was a substantial award, but at least LG had to match this (presumably with in-kind staffing). Pack design work was obviously a lot more expensive than cell design as at least prototype molding/tooling for many components was needed to provide actual samples. Thus, the funding level seemed not too bad, although basically product development work was being subsidized here that normally would be funded internally by such large corporations.

USABC LEESS and PHEV Programs: Leslie Pinnell (A123Systems) – es003

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

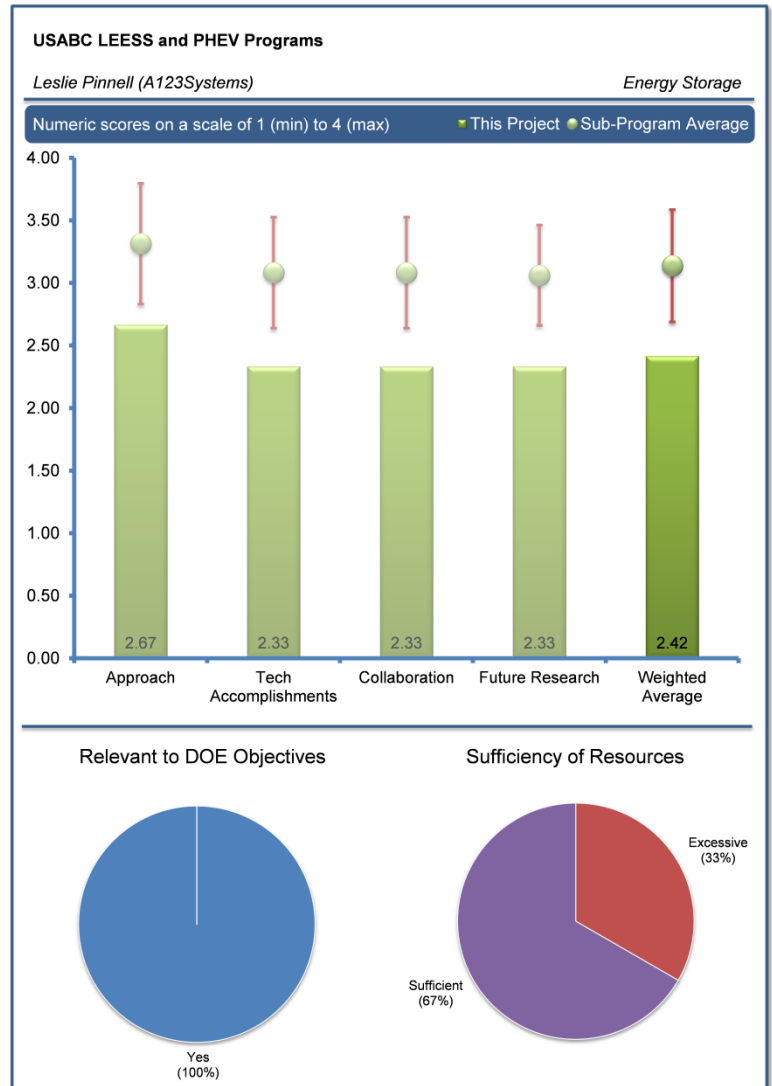
None of the three reviewers mentioned the overarching DOE goal of petroleum displacement, although one referred to DOE’s goals without specifying which goals the reference was to. That comment was that the development of prismatic pouch cells with long cycle life, long calendar life, high energy density and reduced cost was crucial for achieving the DOE’s goals. The second reviewer spoke to the internal project goals, saying that the overall performance goals seemed within reach for the hybrid-electric vehicle (HEV) battery, even though the plug-in hybrid-electric vehicle (PHEV) program did not meet the cost and volume goals. The lifetime issues were still somewhat cloudy, particularly at elevated temperatures. The third comment was similarly focused. The reviewer said the goal was to improve cells and packs with the lithium iron phosphate (LFP) and graphite chemistry per the relevant metrics.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer cited an aspect of the work approach for particular praise, finding it gratifying to see that the PI was paying some attention to thermal issues for the HEV battery, as the high pulse requirements, particularly for a small battery, were likely to raise the temperature substantially. It appeared there was no provision for cooling this battery - even through air cooling - which may be a real shortcoming in the approach. The cost goals would still be difficult to meet, as neither of the PHEV batteries met these goals in the previous program. The second reviewer expressed skepticism concerning the focus of the project, and doubted that the LFP would be a major player for automotive applications in the long term. Also, this reviewer claimed, information regarding the approach taken was completely absent. The third reviewer voiced a similar criticism, saying that the review document provided was not in the format specified by DOE. It was therefore difficult to determine what the approach used to address the technical barriers was. The reviewer noted that this was likely considered to be proprietary. A second program (LEESS) was now underway which aimed to optimize materials, electrodes, cell design and module design. Again, few details were provided.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewers cited a lack of adequate detail in the presentation to support an assessment of technical accomplishments, although the first reviewer also noted that project deliverables had been provided. The reviewer said that little in the way of details had been provided due to the information being considered proprietary. Evidently, for the PHEV10 goals, the cells performed well, except for the low-temperature cold crank performance and cost. For the PHEV40 goals, the system weight, volume and cost were noted



as problematic. It was unclear why the low-temperature cold crank performance for these cells met the DOE goals, but not for the PHEV10 cells. High-temperature (55°C) operation also was a challenge. The deliverables for the project had been met and the project had been completed. PHEV cells developed during this program had been commercialized. The second reviewer noted that the project was behind schedule. The HEV spending was behind plans due to a delay in cell building activities. However, no reason for the delay was given, nor was a plan presented to make it up. This gave concern about completing the contract on schedule. Very little information -was provided- regarding the materials selected, the cell design considerations or the cell builds, not to mention results to date on cell tests, so it was hard to comment on progress in these areas as well. The last reviewer said the gap analysis showed mostly green, with some red. This reviewer further opined there was not enough data to judge this more clearly.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that cells and packs from the PHEV program were being tested at the national laboratories. Cell modeling partners (University of Texas at Austin and Khon Kaen University) were noted for the development of 3D electrochemical and low-temperature kinetics models, suggesting that some collaboration has occurred or would occur. Although not explicitly mentioning collaboration or coordination, the second reviewer welcomed the addition of the thermal modeling efforts to the program. The company had said little about the effects of temperature, but the testing results at 55°C for the PHEV program emphasized the need for such an effort. The last reviewer felt that minimal collaboration was evident.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer voiced particular concerns with the cycle life and calendar studies due to the delays in the program. These studies required considerable time and there was no room for course correction. The cost picture was also a concern for this program, especially for the larger batteries to be made – 3.8 and 6 Amp-hours (Ah). Most HEV batteries were considerably smaller and it suggested that cycle life may not be sufficient for a normal HEV operation. The other two reviewers both cited a lack of sufficient information in the presentation on which to judge the proposed future work. One noted that the PHEV program was complete and that the HEV LEES program was in progress, but no information was provided regarding future activities for the coming year except that it would focus on cell testing and module assembly. The last reviewer said simply that very little information was given, so this could not be clearly judged.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers called project resources sufficient; one deemed them excessive. The first reviewer assumed that whatever was responsible for the delay was now rectified and that the resources were now adequate, but no statement regarding this was presented. The second noted that extensive funding had been provided, with half of the project funding cost-shared. It could be expected that A123 was well-equipped to conduct the work specified in the project. For the LEES project, the actual funding spent seemed to be well below the projected expenses due to a delay in cell build activities. The reviewer who believed resources to be excessive expressed the belief that funding was more than enough for the goal.

JCS PHEV System Development-USABC: Avie Judes (Johnson Controls-Saft) – es005

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

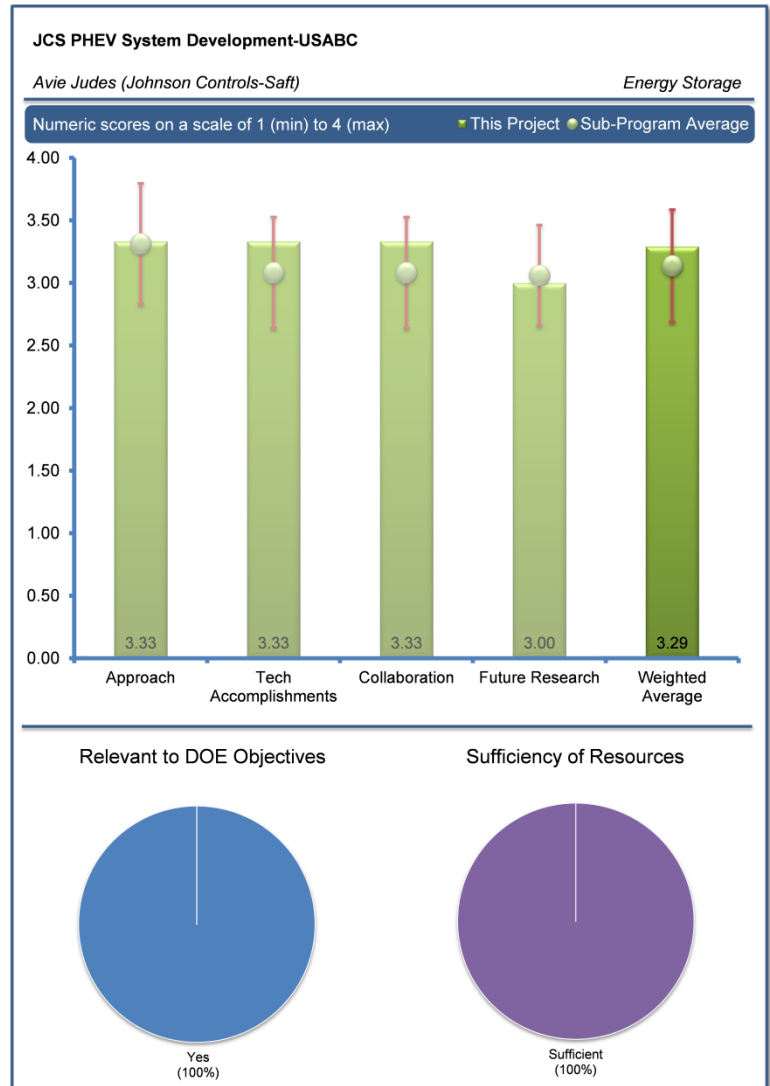
One of the three commenting reviewers called the project relevant to all of the USABC and DOE goals, but did not mention petroleum displacement specifically. The second noted that the JCI project, now completed, focused on improving a lithium-ion battery system for a PHEV. The resulting battery system design would enable a PHEV to go 20 miles without using gasoline before switching to a charge-sustaining mode, when the car would again use gasoline for propulsion. The work led to a battery with better cell energy, power densities, and capacity retention during cycle life testing which, if installed in a new PHEV, would help to make these vehicles more attractive in the commercial market. The third reviewer said that the objectives were met in a timely fashion, resulting in a PHEV pack with excellent performance.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer approved the approach of using a proposed standard cell size (EUCAR/VDA) for the work to assess the capabilities of the size and dimensions. Since the add-on program was just beginning and the previous project was completed, the reviewer continued, evaluation of- the approach was limited to consideration of proposed future work. The investigation of higher-capacity materials and higher charge voltages was a good one. However, the limitations of the discharge cut-off voltage should be kept in mind by the investigators. It was assumed that the general approach for the previous program would be continued. Also noting that the project was completed (in June 2011) and a follow-on project had just begun, the second reviewer felt that it was clear that the project succeeded. The one place in which it appeared to this reviewer to have fallen short of initially stated objectives was that lithium-ion systems were supposed to have been developed for both 20-mile and 40-mile all-electric range applications. However, in the end, it was only a 20-mile range system that was delivered, and a design study for a 40-mile range system. The reviewer was unsure of the original wording of the objectives, but wanted to note this possible discrepancy. Otherwise, the group had successfully delivered its battery system to the national laboratories for testing, which was underway. The last reviewer's comment was that the project team had demonstrated professional capability in creating the design and building of a battery pack that met the objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer called the improvements in the cell and system performance over the course of this study significant, citing a five percent increase in cell energy, a 28% increase in power density, and a 21% decrease in resistance over the course of four builds of



the system. The second noted the successful design of a battery pack for PHEV applications and the third simply noted that a follow-on program was just beginning.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said it was helpful to work directly with suppliers such as Entek on separator development to bring in a cost-effective element to the cell. This was the only comment that implied a judgment of the quality of the collaboration in this project. The other two reviewers mainly noted the collaborating institutions. One said JCI was collaborating with ANL, NREL, SNL and Entek International and expressed the understanding that most of the national laboratory collaboration consisted of the tests these labs were carrying out now that the 20-mile PHEV system had been delivered. The second said that the project team had utilized facilities at ANL, SNL and NREL, along with the separator developer Entek.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer referred to comments provided under the topic of Approach to Performing the Work, in which the reviewer had expressed approval of using a proposed standard cell size. The second reviewer cited the follow-on project launched in April 2012 that would focus on the cells only. This was not elaborated on in the posters, the reviewer noted, but rather shared by the presenters. The last reviewer also cited the just-commenced follow-on program, for which little detail was available.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers believed resources to be sufficient. One said the funds appeared to have matched the needs of the project. Another said the project was well planned by a professional organization.

Multifunctional, Inorganic-Filled Separators for Large Format, Li-ion Batteries: Richard Pekala (Entek) – es008

Reviewer Sample Size

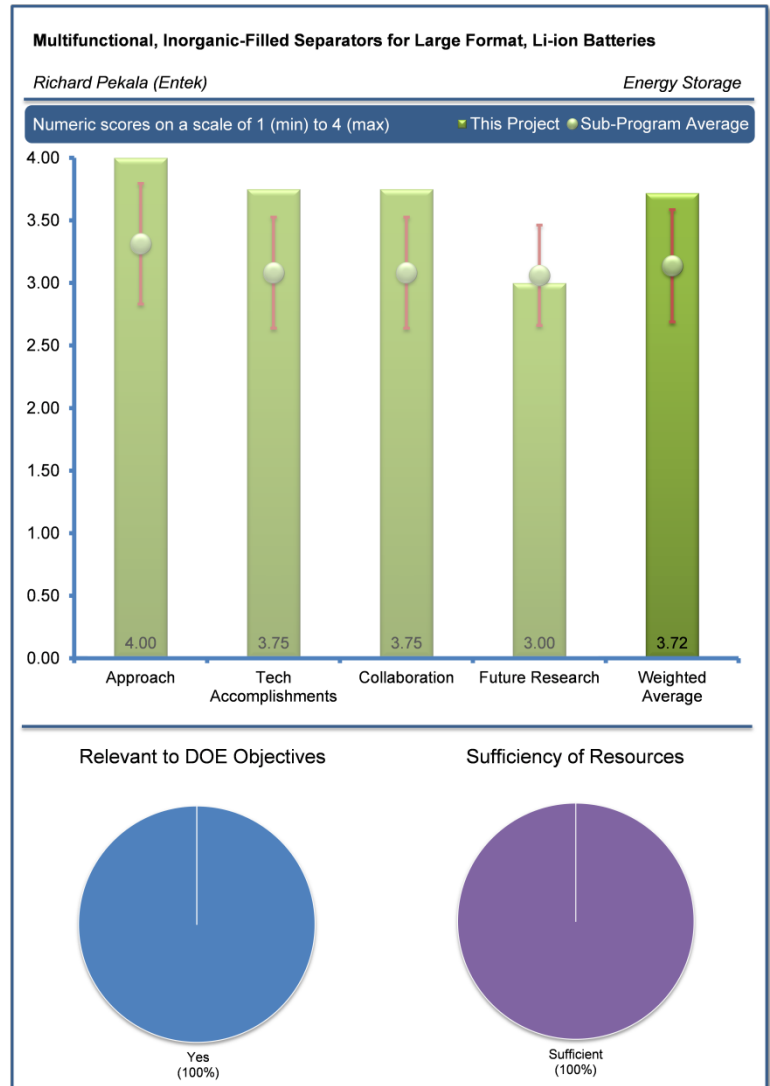
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of the four reviewers endorsed the project's support of DOE's petroleum displacement goal. One said Entek's development of an advanced separator design that would increase abuse tolerance, ruggedness and reliability while reducing cost would support the continued introduction of plug-in electric vehicles to U.S. roads, which would indeed support the DOE objective of petroleum displacement. Yes, said another, it supported the overall DOE petroleum displacement. The project moved battery technology closer to real-world situation. Nail penetration tests performed on cylindrical cells were very encouraging. The third reviewer, while not mentioning petroleum displacement explicitly, said that the objective of a low-cost separator that had excellent performance and safety was very compatible with goals. The last comment was that the reliability and life of batteries with robust separator technology for the electrified vehicle had been addressed during the poster presentation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

In the view of one reviewer, this was a very novel project with a good chance of success. The approach to limit silica inclusion in an ultra-high molecular weight (UHMW) polyethylene separator was valid on a cost basis and the observed properties compared to other inclusions tried. The second reviewer noted that the abuse testing, which was so critical for these batteries, was showing nice progress. The overcharge test, oven ramp, short circuit and nail penetration tests were very encouraging. At some point the authors should give additional details about cost, about how this separator compared with standards ones. It seemed that the goal was \$1 per square meter. The remaining two comments were largely descriptive of the approach, without offering explicit assessments of its appropriateness. One reviewer said Entek was focused on making variations of its novel, inorganic-filled separator design that would be highly porous but would operate safely. After it makes its test separators and puts them into production runs of 18650 cells, it characterizes certain properties of these and sends the separators to the national laboratories for abuse testing to check their durability. The fourth reviewer observed that by employing different inorganic fillers in their separator, Entek has tried to improve life, safety and cost of lithium-ion batteries. The inorganic (ceramic) fillers help improve electrolyte adsorption, provide better mechanical integrity against high temperatures, and reduce the overall cost of the separator (depending on the choice of the ceramic fillers).



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

There has been important progress, said one reviewer. The improved cycle life, lowered self-discharge and higher rate capabilities were important milestones. It could be of great interest, this reviewer said, to know if those variables translated also when tested on prismatic cells. The second reviewer noted that the silica-filled separators do offer some improvement in performance over the control separators to which they are compared, but in other respects, the performance has not changed. Thus far, the new separators did not shut down and would not prevent cell over-pressure on overcharge, nor would they prevent thermal runaway. But they did increase the margins before failure. It was reported that cell cycle life was improved in some cases with use of this separator. The project had accomplished interim goals and was on track to continue, in the opinion of a third reviewer. The fourth reviewer observed that full cell tests had shown better life and performance of the cells. However, the ceramic filler separator did not offer dramatic improvement in terms of safety compared to Entek's current state-of-the-art separator.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers gave this project generally high marks in this category. One reviewer called the collaboration outstanding, as all the major U.S. battery manufacturers were being supplied material and structural experiments were carried out as appropriate by non-battery producer collaborators. Another cited good collaboration with universities, national laboratories and large cell makers for the full evaluation of the separator developed under this program. The third reviewer agreed, saying that the group had shown good collaboration. It was not easy to get industrial partners, but strong effort in that direction was important, in particular with battery companies. The fourth observed that Entek listed several partners who helped in some of the testing and measurements after Entek manufactures its separators. The bulk of the collaboration appeared to come from Mobile Power Solutions and SNL, both of whom were conducting abuse testing of the batteries containing the novel separators. These results were key to gauging the success of the new separator design.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Noting that different precursors and treatment methods would be further evaluated, one reviewer predicted that the evaluation of ceramic filler separators with a large format cells would provide useful information on this separator technology. Two reviewers offered suggestions for future research. One expressed interest in seeing some prismatic cell work done with wound electrodes to see if the separators could stand up to the small radius of curvature of the inner windings of this type of cell. Also, stacked cells with separator folds should be evaluated (e.g. Z-fold or wrapped units). Another noted that the authors mentioned pilot production in their presentation and wondered if they foresaw potential surprises if the process had to be scaled up. Cost issues, this reviewer said, should be mentioned with additional detail. Noting that a lot of results were presented with cylindrical cells, this reviewer also believed, with the presenter, that future results on prismatic cells may end up being very important. The last reviewer observed that the proposed future research continued along the same lines of trying new materials and then testing the cell performance and abuse testing. Entek will play with the parameters of its manufacturing process and then follow this with measurements and testing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The four reviewers were unanimous in terming project resources sufficient. Two offered supplementary comments. One noted that the funding given to this project was comparable to the funding for a similar project developing inorganic separators for large-format lithium-ion batteries that Entek completed during 2010-2011. The other felt that with the resources that the project had received so far, the authors had shown good progress and a variety of testing and results. If the project scaled up the process, additional resources would be needed.

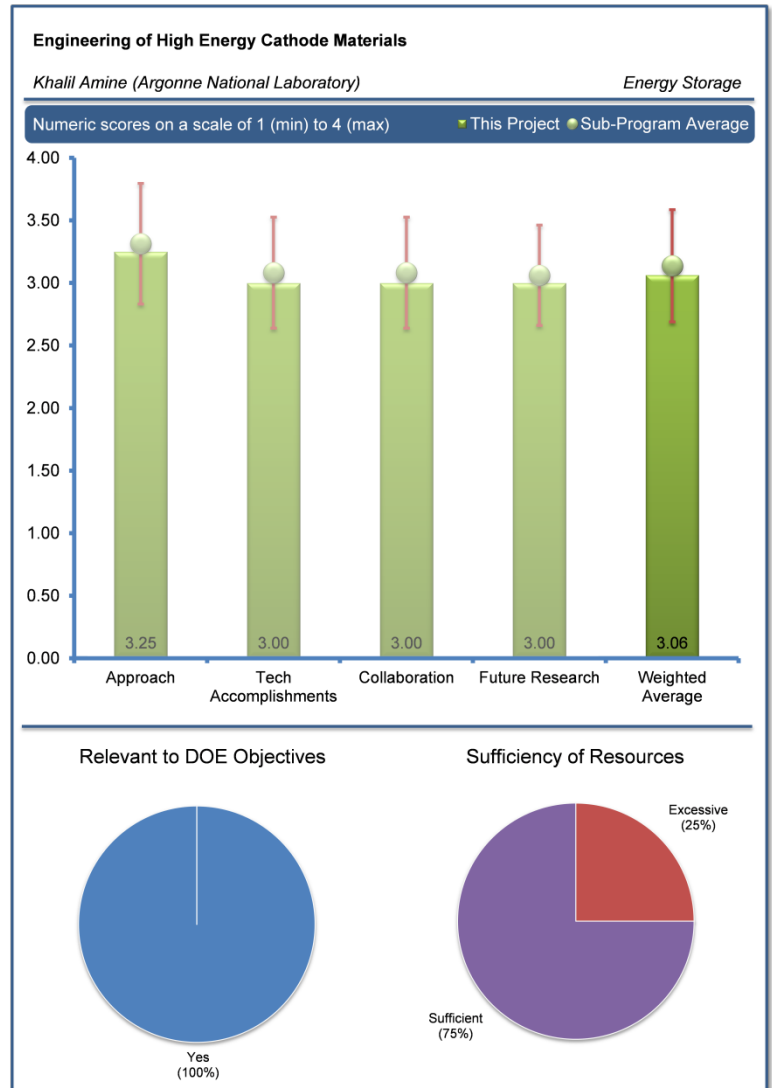
Engineering of High Energy Cathode Materials: Khalil Amine (ANL) – es015

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three of four reviewers considered this project to be highly relevant to DOE’s petroleum displacement goal. One said development of reliable, high-performance positive electrode materials was a critical element in the national effort to reduce petroleum consumption (provided the electricity comes from non-petroleum sources). The ANL materials for lithium-ion battery (LIB) cathodes were considered to be the current state of the art. This project, said the second reviewer, was very relevant, because it strongly addressed one of the top five technological barriers to reducing petroleum dependence, effectively targeting one of the key materials that need to be optimized for commercialization: high-energy, layered cathode materials. This project had correctly identified the key issues for this material, and the approach was excellent for finding solutions. The aluminum fluoride (AlF₃) coating was a step into a promising direction. The third reviewer agreed and said that the project was very relevant to the overall DOE objective of petroleum displacement. High-energy composite cathode materials were badly needed so that goal can be achieved. The last reviewer called it imperative for the success of the program to have good high-energy cathode materials, but did not directly address petroleum displacement.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments on the work approach were generally positive. One reviewer said that the group was doing a good job in focusing on technical barriers. The cracking of particles produced through carbonate precipitation was a good example. In the future, it could be of interest if the project team offered additional details on that issue. The authors have shown great flexibility, the reviewer went on, and quickly moved towards the hydroxide precipitation process. In the view of the second reviewer, the project approaches were fairly well-organized in material synthesis/variation, scale-up and testing. The material characterization and scale-up partners looked very strong. However, the material had some issues concerning voltage loss and cycle life. The reviewer asked who was providing the fundamental understanding of the electrochemical properties. The third reviewer termed the AlF₃ nanoparticle surface decoration a step into a promising direction. Optimization of lithiation, transition metal ratios, crushability, and precursor route were all the right controls to address. The reviewer remarked that coordination of large-scale material production with a major cathode material vendor would be nice, and perhaps that was already happening. The fourth reviewer urged that the cost also be included as a factor. There was no point, the reviewer said, in pursuing cathode materials with high-cost raw materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers offered some positive comments on the project's progress and technical accomplishments achieved to date, but overall, seemed to have more questions than opinions. One reviewer noted that both the voltage drop and cycle-life have been improved, but that both needed further improvement. The investigator believed that an electrolyte additive could solve the fade (i.e., manage Mn dissolution and plating on graphite), and that this may be corrected. The analysis and testing were very thorough, and very impressive. The second reviewer commented at considerable length, noting first that steady progress had been made in variation of synthetic processing and characterization, but felt that the effort lacked some fundamental understanding. For example, according to the formula as written, the first charging capacity could not exceed 200 mAh/g. However, the first charge injection/activation was about 300 mAh/g. The reviewer asked what was being oxidized at the 4.6 V plateau. X-ray absorption spectroscopy (XAS) data from Brookhaven National Laboratory (BNL) did not show any transition metal oxidation in that region. The reviewer continued to ask if oxygen was evolving from the material; if there were any gas detection plans; what the consequence of AlF₃ coating at two weight percent (2 wt%) was; and what the capacity trade-off in a given volume was. The scanning electron microscope (SEM) images showed rather thick coatings due to the relatively low density of the coating material. In the full cell test, the cell was losing about 33% capacity even with AlF₃ coating at 300 cycles, which fell far short of the PHEV target. The reviewer questioned what the degradation mechanism, dissolution of TM or particle cracking was. Moderately elevated temperature test hardly constituted an abuse tolerance test. The reviewer went on to question if there had been any examination of material degradation at 4.6 V for a prolonged time. The third reviewer noted that the authors were trying different approaches to address the difficult issues the researchers encountered as the project moved forward. Coating with AlF₃ was one of them. The stability issues were difficult to study and to solve. The high-energy powders were very important and badly needed in the industry. The reviewer suggested that at some point, the authors should mention the cost issue and some of the barriers that the project may encounter as it is scaled up. This reviewer asked if it would be easier to scale up a carbonate precipitation process compared with the hydroxide precipitation. At some point the authors should mention the minimal tap density the project can tolerate for these powders in practical applications. It seemed that tap density was an important variable when working with these powders. The final reviewer's comment was brief, observing that it would have been appropriate to compare dry nano-AlF₃ addition to other, more conventional procedures for coating with AlF₃ and decide whether this method was better, worse or the same.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers commented positively on project collaboration. One said the project team had shown good interaction with other institutions, and added that it was not easy to find industrial partners. The second noted that the project included a good combination of national laboratories and industry. The third comment was that the project appeared to need some help on fundamental understanding from electrochemists. There were enough material scientists in the team. The fourth reviewer was unable to understand how the collaboration worked, namely, what contribution was made by the collaborators. The reviewer acknowledged that the collaboration may be good, but was unable to determine that.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Voltage fade seemed to be the critical issue, one reviewer observed. This was a difficult project because there was a lot of basic research and development activity mixed with a strong effort toward practical applications, scale-up work and the important issue of cost. At some point the authors should treat the last item in more detail. The second reviewer said simply: Good. The third, said that although the material appeared to be a very good candidate, it was not yet fully validated. Both the coating materials and the coating thickness must be optimized. The reviewer asked why the earlier carbon coating approach was abandoned. Also, this reviewer indicated that a plan to understand the degradation mechanism was needed. Overall, the reviewer suggested, DOE effort in this area (not just this project) may need a standardized protocol for material evaluation, including the abuse test.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers who commented thought the resources were sufficient; one termed them excessive. Two of the former three reviewers said, respectively, that this seemed reasonable – perhaps a little low, and that resources were probably sufficient. That could change if a promising solution was found for the voltage fade issue. If that happened, additional resources would be required to scale up. The reviewer who deemed the resources excessive noted that the ANL resources and those of the collaborators were enormous and mused that the project had the most resources in the world.

New High Energy Gradient Concentration Cathode Material: Khalil Amine (ANL) – es016

Reviewer Sample Size

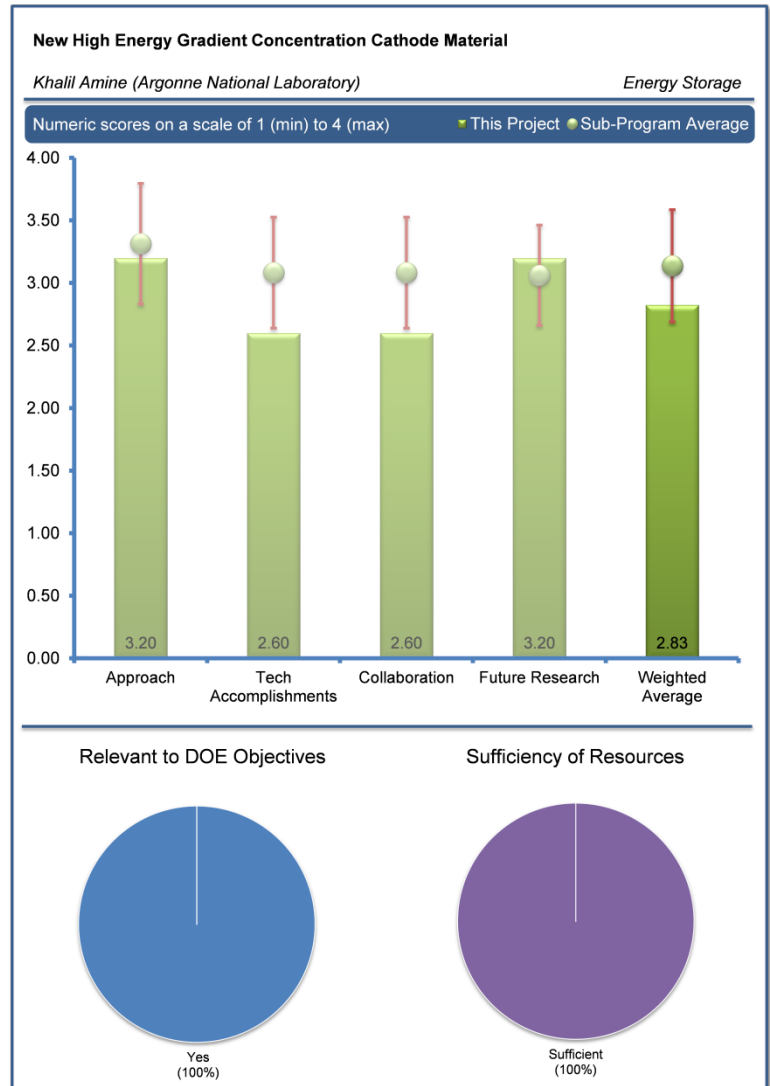
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most of the project reviewers provided similar comments regarding the project’s relevance. One reviewer commented that new battery material development was good for petroleum displacement and that the ANL positive electrode materials were aligned with this effort. Another reviewer described the project as very relevant to the DOE objectives of petroleum displacement as the project concentrates its efforts on the cathode—one of the most important areas of lithium batteries—and on a novel powder for that cathode. This was reiterated by two other reviewers including one who explained that cathode materials (i.e., electrodes) with high capacity were one of the most promising approaches to reducing the overall cost of battery packs. The same reviewer noted that such materials must have high rate capability, durability (high stability) and safety (abuse tolerance) and that the gradient materials appeared to meet these demanding criteria. The other reviewer reinforced that development of high nickel (Ni) containing safe cathode materials was critical for the success of the plug-in electric vehicles/electric vehicles (PHEV/EV). The reviewer explained that the current battery chemistry was very conservative and only a low level blending of Ni-containing cathodes was utilized. A different reviewer acknowledged that this project was a well-known concept, but that work needed to be done in this promising area.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers provided similar comments on the project’s approach to performing the work. One reviewer commented that this was an extremely creative approach to cathode modification to achieve the combination of properties (high energy density, high tap density, high rate capability, longer cycle life and improved safety) sought. This was partially reiterated by another reviewer who agreed that the approach was very innovative and appeared to have very good potential for high-volume manufacturing. Another individual acknowledged the researchers’ strong effort to overcome barriers. In particular, the reviewer noted that the authors knew the problems that the project was facing, and that those problems were not easy. The reviewer claimed that it seemed that the most pressing one was to improve the stability of these powders to be able to scale up the process and cautioned that the scale-up process may provide some surprises; the amount of powder that may be out of spec should be kept to a minimum. Another reviewer asked the length of time that was required for the synthesis or how the project compared to the production of commercial cathode materials. The reviewer went on to question if it was reasonable to expect that this process could be commercialized at a reasonable production cost, which was also referenced by another reviewer. That reviewer suggested that the PI may want to consider the material manufacturing aspects of this approach such as cost and practicality. One of the reviewers



also mentioned that much of this work was and is being done by Dr. Sun in Korea and suggested that efforts should be made to describe how this work was different. A different reviewer pointed out that at this stage of the development, it might be necessary to not only focus on the optimization of the composition, but also to demonstrate the effect of the possible variability in the full gradient materials on the cell performance and safety and to define process parameters that must be controlled to reduce variability. Another reviewer pointed out that the approach of gradient shelling may improve the material stability by alleviating mechanical stress built in the particles/crystal lattice. On the other hand, one reviewer noted that the approach may not solve the issue of transition metal dissolution.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most of the reviewers provided similar comments regarding the project's technical accomplishments and progress. One reviewer said that the project clearly demonstrated the benefits achieved using the gradient approach to cathode synthesis including a better cycle life, lower impedance growth and improved safety (due to lower heat generation). The reviewer particularly referenced that the cells performed well, even at 55°C. A reviewer indicated that the results obtained were very good for this time period and pointed out that the full cell cycling at high temperature was very impressive. Another reviewer commented that the technical accomplishments were numerous, and pointed out the high tap density powder reported for the core-shell with concentration gradient A (CSCG A) material was one of them and very interesting. The reviewer cautioned that one important challenge was to be able to scale up that process. The reviewer also added that the dynamic stress test reported for the core and full gradient material was very impressive. The same reviewer commented that the batch process implemented for the full gradient material seemed to be an important innovation; however, the reviewer expressed eagerness to learn additional details about the process (i.e., additional details related to the tap density of these powders). The reviewer commented that it was surprising to see the high tap density values observed for the gradient precursor obtained via CSTR. Another reviewer reiterated that the team had achieved amazing feats as demonstrated in the gradual atomic composition changes and the improvement in the cycle life. However, the reviewer also had some questions. One question was whether the presenters had any comments regarding the SEM images also showing material density gradient. The reviewer added that the presentation needed an explanation of cobalt role in the structure since its composition also changed from the core value. Another point mentioned by the reviewer was that the transition electron microscope (TEM) and electron diffraction (ED) data showed clearly different structures, but that TEM and ED were extreme local probes. Thus the reviewer questioned how much such a structure represented the overall material and opined that SEM micrographs covering a larger area could be more convincing. The same reviewer also remarked that the x-ray diffraction (XRD) pattern for the full gradient material was hard to understand. The reviewer noted that the shell lattice parameter was expected to be slightly different from that of the core and that diffraction peaks may be convolved and show some broadening. The reviewer questioned why the peaks were sharp and singlets. Other questions posed by the reviewer included what the charge-discharge rate for the full-cell tests were, if the PIs had projected energy density in the full cell configuration, and how it fit with DOE targets. Another reviewer observed that the researchers had addressed recommendations provided during previous reviews and had pursued a more advanced approach and shifted their focus from core-shell to full gradient materials.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments regarding project collaboration and coordination with other institutions varied. One reviewer felt that the team seemed to be very strong and pointed out that it was nice to see industrial partners involved in the project. In contrast, other reviewers criticized that the project had only a few collaborators, mainly foreign, and that more U.S.-based collaborations were desired. Another reviewer referenced that Hanyang University and ECPRO were noted as partners for the project, but that there was no information given with regard to what their role in the project was. The reviewer stated that no other mention of collaborations was made beyond the use of the ANL cathode scale-up facilities. The reviewer questioned if the materials had been shared with others for more extensive characterization. The reviewer cited as an example that sharing the material with the thermal safety team at SNL (i.e., Chris Orendorff - ES036) may be fruitful. A different reviewer also asserted that the PI may want to hear opinions on the practicality of the synthesis method from experienced material manufacturer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on the proposed future research were mostly positive. One reviewer summarized that the suggested work, including cathode synthesis with different surface concentrations and different gradient concentration slopes, tuning the thickness of the gradient and the Manganese (Mn)-rich shell, calendar and cycle life testing, safety testing and scale-up of the synthesis process were all well-aligned with the project goals. This was reiterated by another reviewer who indicated this was more critical since the approach generated promising results. Another reviewer indicated that the team seemed to be focused on the important issues of optimization of the hydroxide process, coatings, and voltage drop. A different reviewer recommended that a sample be coated with AlF_3 for comparison to other work being performed by ANL, even though more very good electrochemical performance was expected from the proposed work. Another reviewer suggested that in order to convince the industry to use this innovative technology it was important to compare performance/safety data versus industry baselines. For example, the reviewer questioned how $\text{LiMn}_2\text{O}_4/\text{NCA}$ blend would compare to the full gradient composition having the same average composition as the current cathode mix composition and noted that the industry wants to see that simply coating or doping will not give the same results as the ANL technology. A different reviewer also suggested that to further address the density of these materials it might be important to evaluate the hydroxide versus carbonate route not only for the transition metal precursor but for the solid state lithiation reaction as well. One reviewer asked if once the material was prepared in larger amounts, it would be shared with other laboratories for testing. A reviewer also asked to have tests with fully configured cells and numbers on energy density.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that sufficient financial resources were available for the project. Two reviewers indicated that the project funding and resources available appeared or seemed to be sufficient for the work. However, one reviewer noted that if the authors came up with important developments that may overcome some barriers, that those may need additional funds. The reviewer noted that scale-up, for example, could be one of them.

Development of High-Capacity Cathode Materials with Integrated Structures: Michael Thackeray (ANL) – es019

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

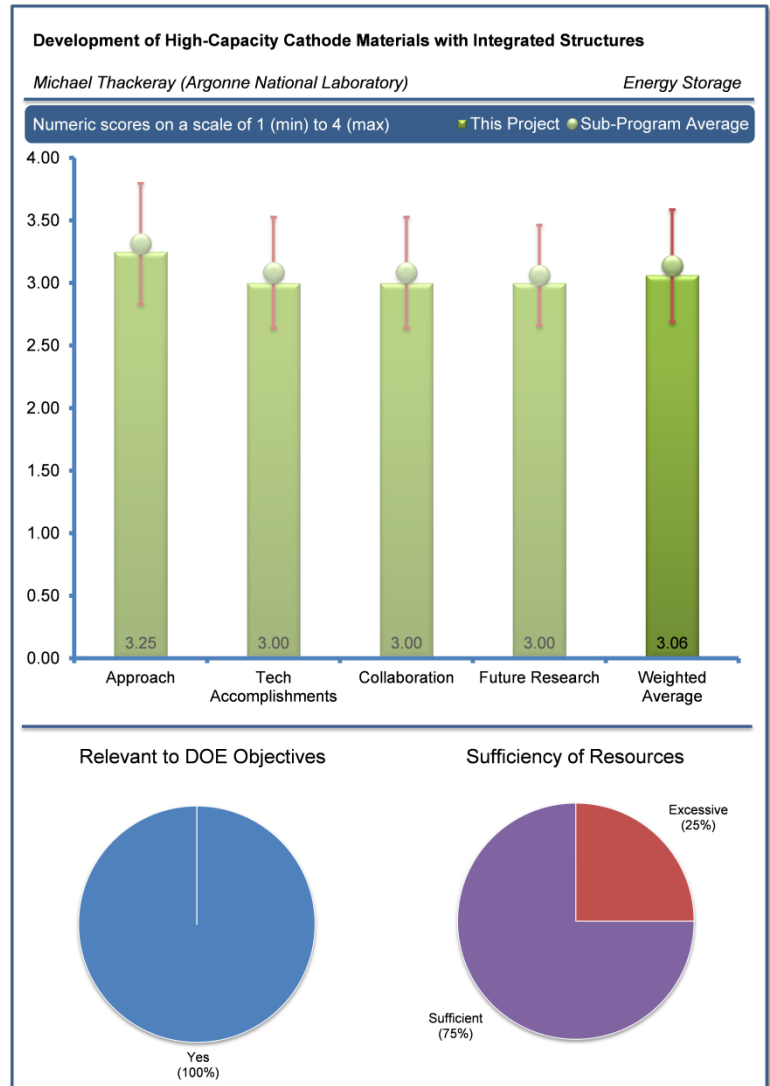
Three out of four reviewers provided similar comments on the project’s relevance. One reviewer indicated that the development of reliable high performance positive electrode materials was a critical element in the national effort of reducing petroleum consumption if the electricity came from a non-petroleum source. The same reviewer noted that the ANL Li-excess material and its family were considered as the current state-of-the-art for lithium-ion battery (LIB) applications. Another reviewer pointed out that this project was addressing one of the key technology barriers for improving cell capacity, reducing cost, and reducing dependence on petroleum: improving high-energy layered cathode materials to make them commercially viable. Similarly, another reviewer commented that yes, the project objective was very much in line with petroleum displacement and that high capacity cathode materials played a critical role in this objective. The fourth reviewer indicated that the voltage fade issue needed to be resolved for these materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most of the reviewers had similar comments regarding the project’s approach to performing the work. One reviewer in particular commended that the project had a sound and methodical approach. Another reviewer mentioned that the synthetic efforts were first class; very interesting ideas designed to confront a very challenging problem such as the voltage fade phenomena. These comments were reiterated by another reviewer who commented that the ANL materials were known to be superior to others in the capacity. The reviewer mentioned that according to the PI’s presentation, rate capability decays had been observed and suggested that a tactic to moderate the decay, particularly when the material was coated with AlF_3 may be needed. The reviewer also pointed out that fundamental understanding the degradation mechanism with charge-discharge cycles may accelerate the optimization effort in addition to the approaches such as coating or doping. A different reviewer suggested that looking at optimizing the composition with respect to adjusting the spinel content may be a fruitful direction. The reviewer however, expressed concern that it may be too constrained in terms of optimizing the ratios of the metals and the degree of oxidation of the initial material.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments on the project’s technical accomplishments and progress varied. One reviewer noted that the project exhibited good progress. Another reviewer pointed out that the voltage fade issue was difficult but that the team was strong. A different reviewer



mentioned the loss of (ex-team member) Dr. Kang may impact the pace and hoped that the gap has been or would be filled by an equally capable investigator. A reviewer commented that it was excellent to examine area-normalized impedance and hoped that others to do the same in the impedance studies. A different reviewer pointed out that for the material formula as written, it was not possible to explain the first charge capacity of 250~300 milliamp hours per gram (mAh/g) but that despite such unknowns, the ANL layered material and its variation with spinel were superior positive electrode candidates for advanced LIBs. The same reviewer questioned if there was a significant oxygen deficiency that introduced Mn(III) in the pristine material or if oxygen was coming off at 4.6 volts. One of the reviewers indicated that it seemed that a lot of basic research was taking place now. At some point, the reviewer suggested that the authors should start mentioning some practical issues such as scale up procedures and cost. In addition, the reviewer recommended that the tap density measured on these powders be mentioned in future presentations as those values could give a hint on what to expect in terms of capacity on real battery electrodes. Another question posed by a reviewer was if there were any tactics to moderate the rate capability loss in the case of AlF_3 coatings or taking approaches of trade-offs among stability-capacity-rate capability. Another reviewer questioned if it would be helpful to add an electrochemist in fundamental understanding on the voltage loss mechanism. Other questions posed included whether or not the voltage loss related to transition metal-rich spinel phase accumulation and/or gradual Li-ion site changes from octahedral to tetrahedral. Also, one reviewer felt that the description of the results was a little ambiguous and unclear.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two of the reviewers provided positive comments on the project's collaboration and coordination with other institutions noting that the collaboration team was well organized with external characterization resources and collaborations with other institutions seemed to be strong. One reviewer suggested that at some point, if the voltage fade issue gets partially resolved, that the authors should try a stronger interaction with industrial partners—the reviewer understands that those partners are not easy to find. One reviewer asked if it would be better to add a nascent electrochemist. Another reviewer reported not being able to tell clearly how the collaborators contributed to the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments on the proposed future research varied. One reviewer commented that the future proposal was nicely focused on the issue. Another reviewer reiterated that the future direction was good, but was worried that continuing to work on composition optimization at the same time as exhaustively evaluating two leading compositions may be difficult. A different reviewer noted that there was a strong emphasis in understanding the main barriers related to these powders. The reviewer noted that at some point, as more progress was made on the mechanism involved on the voltage fade phenomena, additional efforts into the more applied field could be of great interest. One of the reviewers suggested that the project should also add Mg, and coat with AlF_3 to compare with similar ongoing ANL projects.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three out of four reviewers felt that the project had sufficient financial resources available for the project. One reviewer felt that the project had insufficient financial resources. One reviewer thought that the ANL resources to develop advanced Li-ion materials are perhaps the best in the world. Another reviewer indicated that the resources appeared to be sufficient; however, warned that if important new developments were disclosed, that the authors may need additional resources to scale up or to test the powders in larger format batteries. The same reviewer remarked that this was a very important high energy cathode powder.

Developing A New High Capacity Anode With Long Cycle Life With Long Cycle Life: Khalil Amine (Argonne National Laboratory) – es020

Reviewer Sample Size

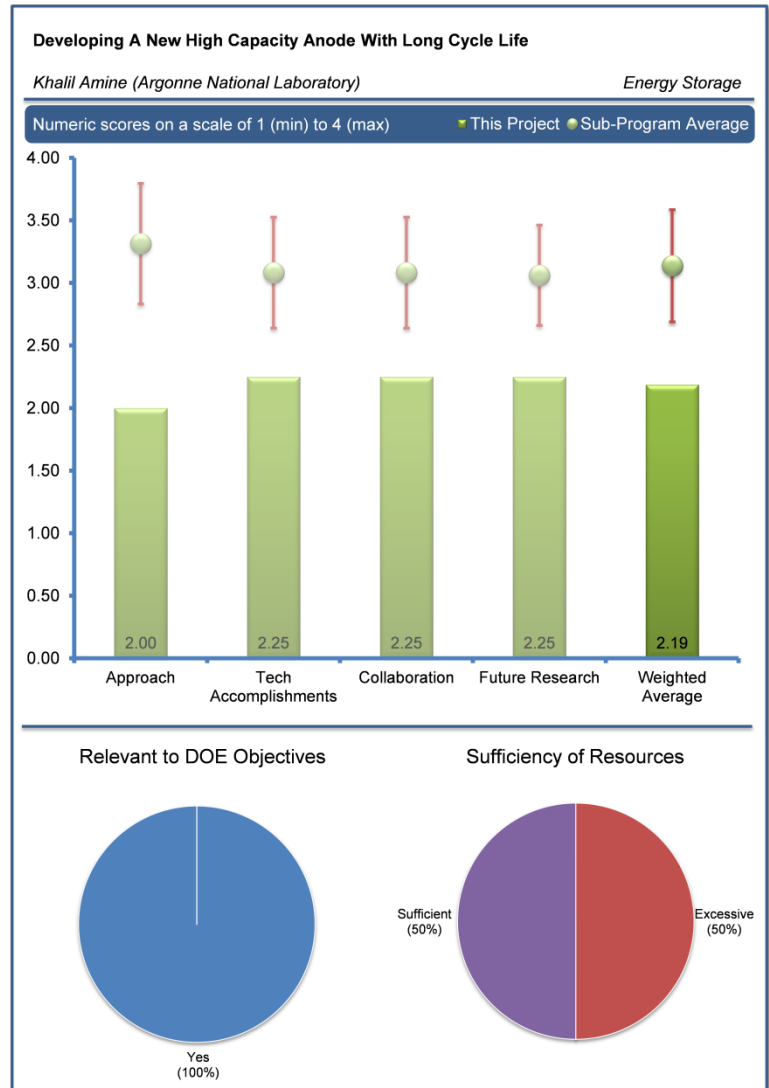
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers expressed similar comments regarding the project’s relevance. One reviewer indicated that large format batteries were required for the electrification of transportation and is one of the ways to reduce petroleum. Another reviewer mentioned that developing new anodes and understanding the details of its role in vehicle battery activity was important for optimized design and for real-world evaluation. A different reviewer summarized that the concept was to develop a new high capacity anode that would eventually lead to higher energy density batteries. The reviewer specified that tin and silicon were the most likely new anode materials to significantly improve battery energy density (run time) and that this work was mostly focused on tin.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments on the project’s approach to performing the work were mixed among reviewers. One reviewer acknowledged that the project’s focus on silicon (Si) and tin (Sn) was good, but that of course everyone else was doing this as well. Another reviewer commented that the results were promising, i.e., the capacity retention and cyclability of anodes made using ball-milled mixtures of few elements such as Sn, antimony (Sb), Si, carbon (C), and oxygen (O). The reviewer also suggested that as the materials preparation approach was somewhat fixed, the project looked at two of its aspects to improve the overall materials discovery approach further: develop a combinatorial approach to accelerate the understanding; and develop a rational basis for some of the targeted alloys through a number of means. A different reviewer mentioned that the PI had chosen carbon and oxides (MO)-Sn_xCo_yC_z (MO=SiO, SiO₂, SnO₂, MoO₃, GeO₂) anode materials and tested them for possible application as battery anodes. The reviewer noted that the presenters claimed that Sn_xCo_yC_z alloys would provide a capacity of 400-500 mAh/g for hundreds of cycles and MO anodes could provide more than 1,000 mAh/g with poor cyclability. The reviewer added that the project approach, the formation of Sn_xCo_yC_z and MO composite that could lead to the increase in the capacity, reduce the amount of cobalt in the material and improve the cyclability since Sn_xCo_yC_z could play a role of buffer against the MO volume expansion had to be justified. The reviewer felt that the presentation results did not seem to show either high capacity or long cycle life time. Another reviewer indicated that the project basically seemed to be using a more concentrated (lower carbon content) variation of the Sony Sn/Co/C anode used in the Nexelion product characterized by Dr. Whittingham in 2006 as it essentially used the same Sn/Co approach. The reviewer added that while using more Sn/Co would indeed boost the energy of the system, the approach in the reviewer’s view was flawed on two grounds. The reviewer pointed out that the cost of the cobalt in such an anode was far too high for the electric vehicle market to



absorb. As such, the reviewer opined that the approach was commercially a non-starter. Moreover, the reviewer asserted that the PIs did not explain just what the role of the cobalt was, presumably a stabilization effort. The reviewer reported that the presenters did talk about reducing the cobalt amount, but that this should have been a focus from the beginning, not when the project was about 70% complete. The reviewer reinforced that one of the goals was having a low-cost synthesis method, but that this would be pretty futile when using an expensive metal such as cobalt.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments on the project's technical accomplishments and progress varied. One reviewer noted that the project's technical accomplishments indicated reasonable results. Another reviewer reiterated that the data showed progress (i.e., developing alloys for high energy density anode). Another reviewer commented that the presenters were able to demonstrate good cycle life and that the possibility of having a Sn and Si alloy composition was potentially valuable, but only if the researchers could avoid the Co that goes along with the tin. The reviewer noted that capacities were decent, especially in view of the much better tap density of these anodes over carbon; however, the presenters did not provide or add any insight as to the role that Co played and/or how the same results could be achieved with less expensive elements. Another main concern of one of the reviewers was regarding the reproducibility of the materials proposed (i.e., as the materials were obtained in a manner that was probably not very reproducible, e.g., ball milling of mixtures of compounds). The reviewer asserted that this was because people may not be able to produce similar types of alloys (also not sure of the final state of alloys) even if people started with similar compositions of feed materials. Therefore, the reviewer suggested looking at alternate methods of obtaining alloys of such compounds (beyond ball milling) and/or running several trials to prove that this was something that is highly reproducible in terms of both electrochemical behavior (including voltage profile) and the alloys obtained. Additional comments were provided by another reviewer who indicated that certain specific comments were not addressed: the PI should clarify whether it was an alloy or a composite; the presenters needed to thoroughly characterize their system; having Co_{30} in $\text{Sn}_{30}\text{Co}_{30}\text{C}_{40}$ system was not cost-effective; ultra-high energy ball milling machine (UHEM) did not seem to be cost-effective as well; the researchers needed to address the cost-effectiveness since the project's major goal was to develop a low-cost anode; the full cell test showed low specific capacity; and the researchers needed to explain how nanomaterials could decrease the solid electrolyte interphase (SEI) resistance and lead to higher specific capacities at high charge/discharge rates.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed comments on the project's collaboration and coordination with other institutions. One reviewer remarked that the collaboration and coordination seemed to be fine. Another reviewer pointed out that it would be good to specify the nature of the work or what components of research were performed by the collaborators. Another reviewer commented that this project or work could easily benefit from interactions or collaborations with academic institutions. The reviewer suggested the following: develop interaction with strong materials research teams at an academic institution to develop a fundamental understanding of processing and final alloy produced. A different reviewer had different opinions and commented not seeing much evidence of significant collaboration, and acknowledged viewing collaboration as a means to an end (results) not an end in itself. The reviewer added not being sure that the project really warranted a lot of collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on the project's proposed future research varied. One reviewer recommended that in addition to what was proposed in the presenter's original plan, the above suggestions (i.e., working with an academic partner for process-property relationship and/or developing some sort of rational understanding of the behavior) should be implemented. The reviewer noted that the project proposed to understand the causes of the first cycle charge discharge irreversibility and tried to reduce it, but that the project should also have to address how to improve the specific capacity. A different reviewer considered additional work on materials containing such high levels of Co worthy of intellectual curiosity only, and found it hard to support additional work in this area. The reviewer commented that this work needed to be redirected to look at commercially viable anodes, and in fact that this should

have been done much earlier in the program. The reviewer added that continuance of this project should occur if the project aggressively refocused on non-Co anodes.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Mixed comments were received regarding the adequacy of financial resources available for the project. Two of the reviewers felt that sufficient financial resources were available while the other two reviewers felt that financial resources were excessive. One comment made on the project's financial resources was that this work, from the reviewer's view, has not been very worthwhile and it was opined that funding should focus on work on anodes with little or no Co content.

High Voltage Electrolytes for Li-ion Batteries: Richard Jow (Army Research Laboratory) – es024

Reviewer Sample Size

This project was reviewed by four reviewers.

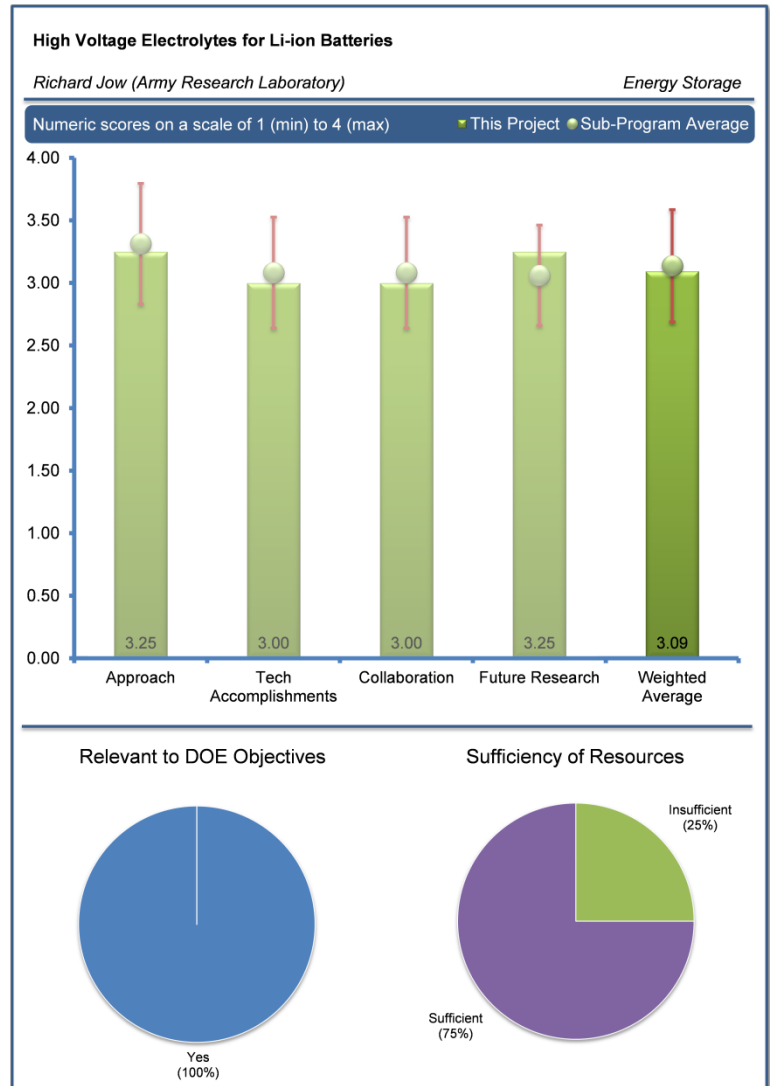
Question 1: Does this project support the overall DOE objectives? Why or why not?

Most of the reviewers provided similar comments on the project's relevance. One reviewer indicated that electrolytes capable of withstanding higher voltage environments are key to enabling the use of high voltage cathode materials for improved energy density. Likewise, the reviewer remarked that high voltage electrolyte should allow extension of battery life given electrolyte decomposition at voltage is a contributing mechanism of cycle life failure. Another reviewer pointed out that the investigation of high voltage electrolytes was very important for development of high voltage cathode in Li-ion battery technologies for increase in their energy density to enable compact, light, and cheaper electrified vehicles. This was somewhat reiterated by other reviewers. One reviewer indicated that higher performance (voltage and or capacity) are essential for future battery systems. The reviewer noted that present electrolytes lacked stability for higher voltage, higher performance systems. Another reviewer similarly remarked that stable electrolytes that could handle all the voltages that the electrode fabricators could come up with are clearly desirable. The reviewer added that whether 5V should be a target was not clear as illustrated by the lack of reliable electrode supply and that it was not clear that 5V electrolytes were sensible. One of the reviewers also observed the project's need to identify additives as well as understand pathways and mechanisms.

One of the reviewers also observed the project's need to identify additives as well as understand pathways and mechanisms.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments on the project's approach to performing had mixed reviews. One reviewer expressed that there was a good balance between the computational and experimental studies to better understand interfacial chemistry between a high-voltage cathode and electrolyte. Another reviewer remarked that the project involved the abilities of several people with excellent ability to identify new high energy materials, and further noted the double intercalation of each electrode. Other reviewers expressed similar sentiments in additional comments. Among those reviewers, one indicated that ultimately the section on additives for improvement of electrolytes in high voltage environments was interesting, but failed to cogently discuss mechanistic outcomes for the results. Another person stated that modeling of the solvent oxidation process seemed like it could be quite useful, however it was somewhat difficult to follow the logic train and conclusion in the presentation. A different reviewer felt that a huge amount of work had been done and a sensible balance of experiment and theory established. The reviewer pointed out that clearly the project was trying to do too much for the resources allocated and it should narrow down the areas of work. The same reviewer also pointed out that the anode theory work seemed to be out of place and that obviously more collaboration was required to leverage



this work. A different reviewer questioned the inclusion of high-voltage cathode as a key element of the program and suggested that it might be better to take SOA high-voltage cathode from within the DOE/Army research infrastructure and just use best available. The reviewer noted that if the goal was to develop a high-voltage electrolyte, it might be best to just focus on that.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed reviews were received regarding the project's technical accomplishments and progress. One reviewer discussed in detail that the project delivered the main reason for the decomposition of electrolyte solvent at high voltage and showed the effect of electrolyte additives on the battery life through this work. The reviewer noted that the information on the main degradation mechanisms in Li-ion battery technologies could be used for the development of robust electrolytes for better life and performance of cells and also was very useful to develop a semi-empirical battery model which gave a more accurate indication of battery life. The reviewer also suggested that verifying the reaction pathways and electrolyte degradation mechanism through this project could provide very useful information for the development of the next generation of lithium-ion battery technologies. Another reviewer indicated that computational efforts have identified a path to obtain better material performance. One reviewer in particular pointed out that the additives HFIP significantly enhanced cycle life and Sldo strengthened SEI. A different reviewer remarked that the project identified a new material high energy intercalation phosphate cathode with improved performance capability and an additive that further improved performance. The reviewer added that the research stabilized LiCoO_4 . One of the reviewers suggested using LiCoPO_4 as high voltage cathode material doped with Ferial to compare the stability results. In addition, one of the reviewers acknowledged seeing positive empirical results of the electrode additive on cycling performance but not getting the mechanistic tie-in. The reviewer questioned if it was due to the electrolyte stabilization, the anode stabilization or the cathode stabilization. The reviewer also commented that the mechanistic interpretation of stabilization could be stronger. A reviewer stated that it was a very productive project generating a lot of good data and theory, but noted that it was trying to do too much. Another reviewer agreed that the concept of a double intercalation cell is interesting but did not understand how the researchers got there, or more importantly, whether this was being well- understood. The reviewer suggested a significant review of previous work in this area and evaluation in order to suggest it as a viable direction.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments on the project's collaboration and coordination with other institutions varied. One reviewer felt that the project had good coordination and collaboration with national laboratories, universities, and large battery makers for fundamental research and evaluation of new materials with large cells. Another reviewer felt that the project accomplished the goals with help from an excellent group of collaborators: ANL, University of Texas, University of Utah, University of Maryland, and Saft. This was reiterated by another reviewer who indicated that the collaboration options seemed adequate. One reviewer expressed that collaborations needed to be expanded greatly and beyond ANL, particularly for the theoretical underpinning.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments regarding the project's proposed future research varied. One reviewer felt that the investigation of reactions occurring at both positive and negative electrodes' interface would provide very useful information for the further development of lithium-ion battery technologies. Particularly, the reviewer noted that *in situ* characterization of SEI layer would give key information for the enhancement of battery life and performance. Another reviewer indicated that the project would continue with suggestions for successful implementation of new technology. A different reviewer had no major comments and hoped that future work would uncover reasons behind improved cathode stability with additives. A fourth reviewer felt that the future plans involved more of the same approach as before, which was not good. The reviewer added that the project should develop more collaborative work with a wider variety of partners or significantly narrow the scope and objectives.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Comments regarding financial resources varied. Three out of four reviewers felt that the financial resources were sufficient for the project. One reviewer indicated that the financial resources were insufficient. One reviewer indicated that the project had sufficient

resources and used them effectively. However, another reviewer felt that the financial resources for the project were not nearly enough to do everything. The reviewer added that this project needed to leverage other resources or should be much increased in funding.

Development of Advanced Electrolyte Additives: Zhengcheng Zhang (Argonne National Laboratory) – es025

Reviewer Sample Size

This project was reviewed by four reviewers.

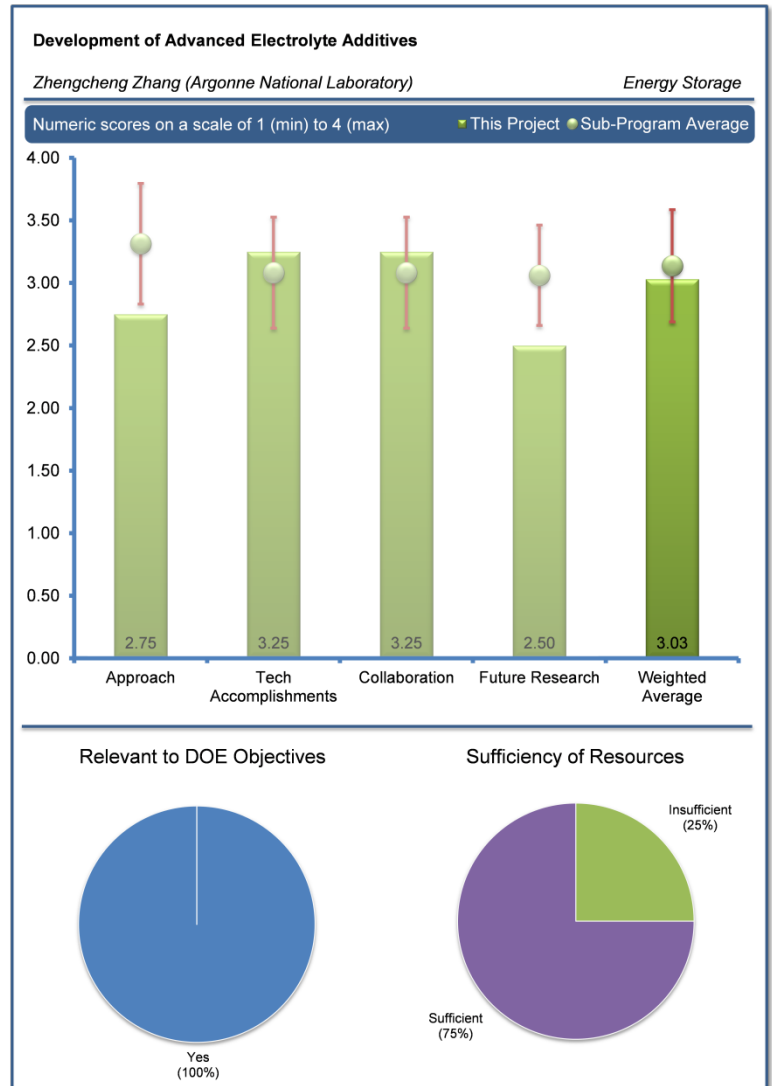
Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments for this section were mixed. One reviewer considered the answer to be a qualified yes. This reviewer felt that the goal of improving various performance parameters outlined in the discussion was of course relevant to the overall goal of the DOE. This reviewer questioned, however, whether additive development was the path that would provide the best outcome in the search for improved electrolytes. Another panelist remarked that discovery and application of additives that could improve the cycle and calendar life of the Li-ion batteries without having to make extensive changes to the present technology would be very valuable and help launch their use in the transportation arena where the lifetime issue was a major barrier. This panelist observed that the work involved trying to develop some simple rules combined with more fundamental considerations to develop methods of additive selection and screening that, if successful, would help the technology. The next observer wrote that electrolyte additives largely affected the life and performance of lithium-ion batteries. This observer recommended that, to enhance the life and performance

of lithium ion batteries, investigation of electrolyte solvents and additives needed to be carried out, since that would finally affect the cost of battery system. The final reviewer stated that the project objective was to develop an efficient, inexpensive functional electrolyte additive technology to address the barriers existing in the current Li-ion battery system, such as poor cycle life, calendar life and battery abuse tolerance. This reviewer suggested establishing structure-property relationship and calculations.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One reviewer thought that the approach was fine, stating that the candidate generation and screening characteristics were laid out well. This reviewer reported that two different paths (enablement and improvement) were described in the presentation. Another panelist related that electrolyte manufacturers usually made DOE (Design of Experiment) tables and evaluated new electrolyte components (solvent, salt, and additive) by running various life and performance tests with many samples cells containing new electrolyte chemistries. This panelist felt that electrochemical analysis, physical analysis, and theoretical approaches for better understanding of each electrolyte component's effect needed to be done, but suggested that making sample cells and evaluation of various electrolyte components was more practical and gave direct information on the effect of the electrolyte composition/chemistry changes. This panelist concluded that a lack of experiments for characterization (i.e. low temperature performance) of the proposed chemistry was evident. The next observer found that the approach was appropriate for a technology-based project. This observer reported that there was an attempt to combine fundamental theoretical considerations with



more empirical rules to guide the selection and application. This observer thought that the idea of screening a variety of related compounds to develop structure-function relationships was valuable and should be further pursued. That being said, the observer qualified that this approach was from classical physical organic chemistry which was a field that this reviewer knew personally and had examined some of the reduction reactions of these compounds. The observer further found no mention of the presenter consulting the very extensive literature developed back in the 60's and 70's, which would inform the selection. Similarly, this observer felt that the mechanism speculation was just that in the absence of proper product analysis and identification, much of which would be helped by reading the classical literature. The observer finally concluded that the project needed to build upon previous research and not try to reinvent the wheel. The final reviewer explained that work was directed at developing a new additive for the SEI layer formation. This reviewer also observed using the degree of unsaturation and heterocyclic compounds used for screening. The same reviewer also made note of the following: identifying four new compounds for further work; ANL-SEI-1 additive for SEI; and the synthesis of new additives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments for this section were generally positive. One reviewer thought that the approach was well-thought out, logical and rigorous. This reviewer observed a good use of available tools to help build the data. This reviewer's only concern in the conclusions was that the additive benefit was displayed within an electrolyte which had no additives. The reviewer concluded by questioning if it was possible that already existing additive technology could provide the same (or higher) benefit. Another person found that it was hard to figure out tradeoffs with the proposed chemistry and again its effect on the battery life and performance needed to be validated without running the full spectrum of performance evaluation, even though new electrolyte additives showed an improvement in capacity retention. This person concluded that the AC impedance results indicated that the proposed chemistries may not improve the power capability of the cells. The next panelist reported the project had identified and produced additives effective in improving cell performance. The final observer stated that much work had been completed and much useful data had been generated. However, this observer found that the lack of cohesive theory to guide the work was impeding its usefulness, and that better controls were in order. The observer listed oxalato salts as an example as all the salts provided some reductive activity at about 1.6-2.0V, which EC did on its own. The observer explained that the commonality for this would be CO₂ reduction, and that controls using CO₂, formate³⁻, oxalate etc. would answer some of these questions. This observer concluded that the results were still very empirical and may be erroneous.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One panelist found no major causes for concern, citing good use of various analytical tools that all seemed to be focused on the same question. Another panel member commented that there was considerable collaboration, but that some collaborators such as URI were not even listed. The next observer expected more collaboration with cell makers for a full evaluation of new chemistries. The final person reported that the project had engaged ANL DFT capability as well as the University of Utah, ARL, Conoco Philips, and Saft to help on particular segments of the work.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments for this section were mostly negative. One reviewer found the proposed future research to be more of the same, expanding into cathodes. This reviewer considered this not to be a good idea until a better understanding was gained. The reviewer suggested that perhaps this was a project where stronger links to BATT projects would be in order to gain a deeper understanding. Another panelist agreed that more of the same was proposed, and that a better baseline for success should be established first. The next observer felt that the researchers needed to make a decent DOE table for a more practical evaluation of new chemistries. The final panel member reported that the researchers would continue the development of new materials using quantum calculations and compound preparation for evaluations of new materials for overcharge protection and cathode additive materials, and that research would extend to overcharge protection and cathode additive.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers found resources to be sufficient, and one rated them insufficient. A reviewer felt that a lot of work had been accomplished with small amounts of resources, and that resources actually may be insufficient if better understanding was desired. Another reviewer agreed that if anything the project could use more resources.

Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range: Marshall Smart (JPL) – es026

Reviewer Sample Size

This project was reviewed by four reviewers.

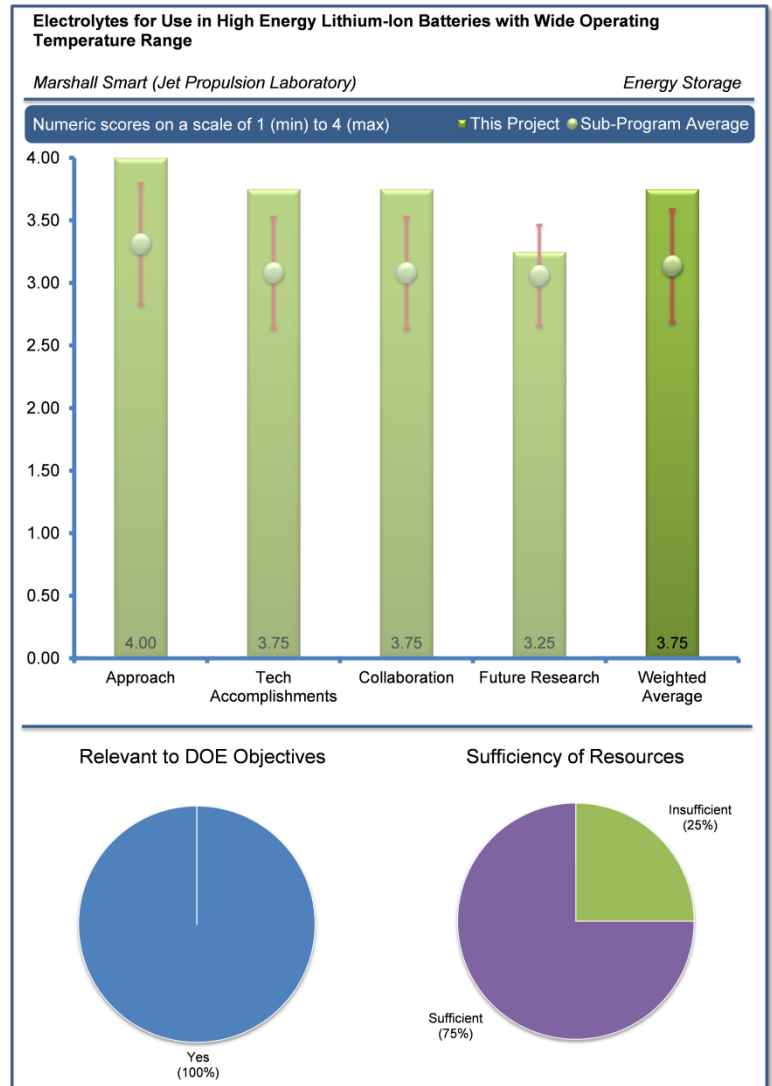
Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments for this section were positive. One reviewer found this project provided an extremely effective testing capability for the evaluation of all kinds of electrolytes, modifications and additives in a proven cell system with reliable reproducibility. This reviewer felt that it was an essential component of electrolyte development necessary to expedite introduction of new and better electrolytes into the technology. Another panel member noted that for successful electrification of vehicles, batteries should be operated without compromising performance and life. This panel member explained that this work addressed practical issues most of lithium ion battery technologies faced such as poor performance and life at both high and low temperatures by employing novel electrolyte solvent blend and salt. The next panelist pointed out that cold temperature performance could get ignored in the discussion of Li-ion for motive power, but that it did matter and research that addressed this issue and provided some understanding of the options to mitigate was relevant.

The final observer reported that the project identified stable electrolyte systems for a 5V Li-ion cell at high and low temperatures and defined life-limiting mechanisms needed for advanced systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were positive. One reviewer had no issues with the project, and called it well-done, comprehensive, and logical. This reviewer thought that it was probably the most comprehensive and well-presented talk of the session. Another reviewer remarked that the approach clearly defined the scope of work and characterized electrolytes through a range of electrochemical analyses. This reviewer found the researchers had finally evaluated the proposed electrolyte with both small- and large-scale lithium-ion batteries with different chemistries. The next panelist remarked that the project had a proven, reliable test system that allowed for evaluation of electrolyte changes in a reproducible fashion. In this panelist's opinion, the right experiments were done both in terms of cycle and calendar life combined with rate variation and impedance data. The panelist concluded that the data was very usable for the modeling community and hence provided an invaluable output. The final reviewer characterized the research as having defined 5V system requirements; having optimized carbonate solvent blends, fluorinated esters, and fluorinated carbonates solvents of low viscosity, low melting ester-based co-solvents coupled with novel, alternative lithium based salts (with USC, LBNL); and having ionic conductivity and cyclic voltammetry measurements. This final reviewer further reported the following as related to ionic conductivity and cyclic voltammetry measurements: performance characteristics in 300-400 mAh



three electrode cells MCMB/LiNi_{0.8}Co_{0.2}O₂, MCMB/LiNi_{0.8}Co_{0.2}AlO₂, Graphite/LiNi(1/3)Co(1/3)Mn(1/3)O₂, and Graphite/LLC-LiNiCoMnO₂; use of high specific energy; Electrochemical Impedance Spectroscopy (EIS) Measurements as function of temperature, high temperature storage, and cycle life; DC Tafel and linear (micro) polarization measurements on electrodes; ex-situ analysis of harvested electrodes (URI and Hunter College); performance characteristics in coin cells Evaluation of electrolytes in conjunction with high voltage cathodes; and performance evaluation in prototype cells Yardney, A123, Saft, and/or Quallion Cells (0.300 mAh to 7 Ah size prototype cells).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers left positive comments in this section. One panelist thought that an outstanding amount of data was generated. This panelist felt that the fundamental understanding was clearly not present in the project, but that it provided large amounts of data in a reliable fashion that could be used by the entire community to understand the most variable of the components: the electrolyte. Another reviewer commented that the proposed electrolyte compositions seemed to work well with LFP chemistry but showed room to be improved for NCM chemistry. The last panel member thought that cold temperature performance enhancement looked promising as compared to baseline electrolyte performance on nickel based cathodes. This panel member noted that iron phosphate results were also interesting and useful to have an understanding of. This panel member concluded that this was a pretty good talk filling an interesting niche, and appreciated the rigor and quantity of the data presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were generally positive. One reviewer reported that the researcher had partnered with certain well-known groups in battery electrolyte area. This reviewer saw a close collaboration with large battery manufacturers, other national labs and universities for a thorough evaluation of proposed electrolyte chemistries. Another reviewer found no issues with the project. This reviewer stated that a wide variety of chemistry from several different sources, both commercial and laboratory, were evaluated. The next panelist said that the project was clearly developing a client base so that developers of new electrolytes could have their new materials rapidly and accurately tested. This panelist thought that this was a major plus for both the DOE and the NASA programs. The next person listed collaborators as Dr. Lucht from the University of Rhode Island; Khalil Amine (ANL); and team members from NREL, SNL, and the Hunter College. The final reviewer reported that the researchers had performed electrochemical characterization of Graphite/Toda 9100 LiNiCoMnO₂ three-electrode experimental cells with methyl butyrate-based electrolytes; evaluated a number of methyl butyrate-based electrolytes in Conoco A12 Graphite/Toda HE5050LiNiCoMnO₂ three-electrode cells (Argonne materials); and evaluated Methyl propionate and Triphenyl phosphate additives. This reviewer further reported that the MB-based formulations containing LiBOB delivered the best rate capability at low temperatures, and that the use of lithium oxalate as an additive gave the highest reversible capacity and lower irreversible losses. This reviewer further reported that at lower temperatures and higher rates, the advantages of utilizing the high voltage system diminished when compared to a standard NCA material. This reviewer further reported that LLC-NMC electrodes (received from Argonne) displayed much slower lithium de-intercalation kinetics.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments for this section were mixed. One reviewer believed that the search for alternative salts could have a higher priority in the overall scheme of electrolyte research, and hoped that this area of future work was followed diligently. Another observer felt that future research would be more of the same, which was all that could be expected for the current level of funding. The next panelist thought that it would be better to run more tests with large format cells to further evaluate the proposed chemistries. In particular, this panelist recommended running abuse tolerance tests with a cell larger than the 18650 format cell. The final observer reported that the project had evaluated a number of methyl butyrate-based electrolytes in Conoco A12 Graphite/Toda HE5050LiNiCoMnO₂ three electrode cells (Argonne materials): The MB-based formulations containing LiBOB delivered the best rate capability at low temperatures, which was attributed to improved cathode kinetics. The final observer further reported that the use of lithium oxalate as an additive led to the highest reversible capacity and lower irreversible losses. The final observer further reported that at lower temperatures and higher rates, the advantages of utilizing the high voltage system diminished when

compared to a standard NCA material, again attributed to the relative cathode kinetics. The final observer concluded that, of the different cathodes, the LLC-NMC electrodes (received from Argonne) displayed much slower lithium de-intercalation kin.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers rated the resources to be sufficient, while one found them insufficient. One reviewer exclaimed that the value for money here was astonishing. This reviewer felt the project was obviously badly underfunded, and that the way forward was to either have the system replicated at a national laboratory or to increase the funding. Another panelist recommended identifying stable electrolyte systems for a 5V Li-ion cell at high and low temperatures-defined life-limiting mechanisms.

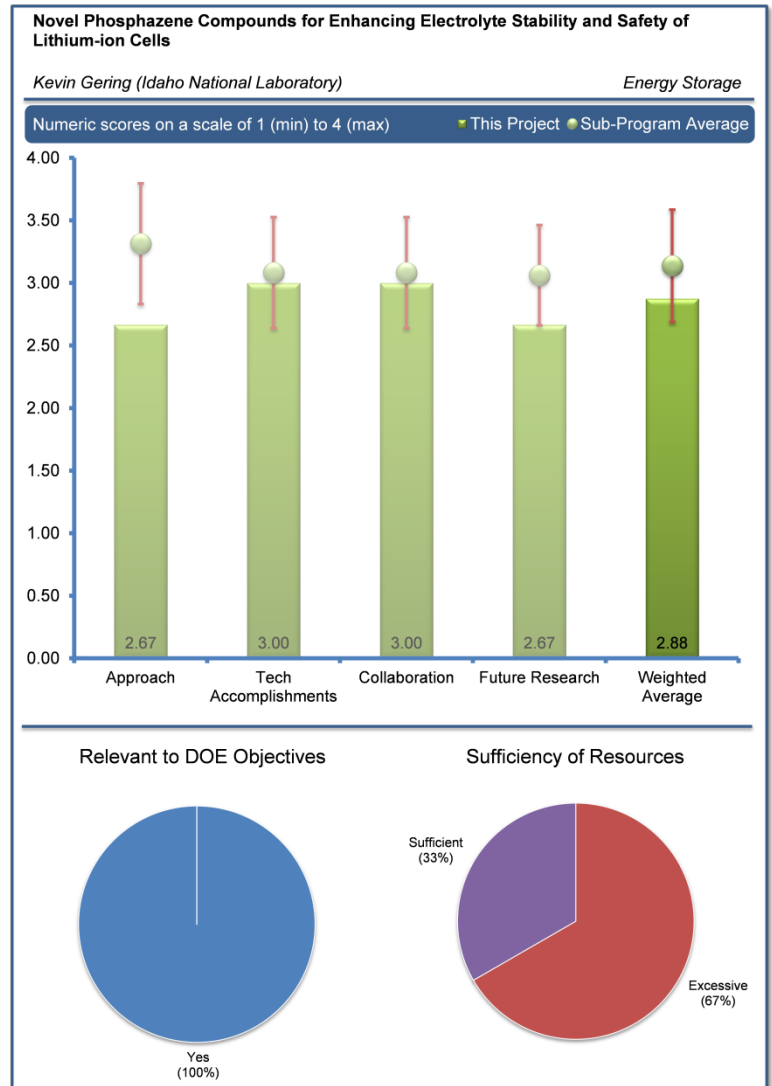
Novel Phosphazene Compounds for Enhancing Electrolyte Stability and Safety of Lithium-ion Cells: Kevin Gering (Idaho National Laboratory) – es027

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. One reviewer felt that, consistent with the DOE goals of reducing petroleum consumption and greenhouse gas emission by replacing the conventional automobiles with battery-powered hybrid and electric vehicles, this project addressed the safety of Li-ion cells by developing novel electrolyte solutions with reduced flammability and compatibility with high voltage (5V) cathodes, based on various phosphazene compounds. This reviewer noted that the current Li-ion battery electrolytes were flammable and thus played a significant role in the thermal runaway. This reviewer explained that phosphorus - containing compounds, specifically phosphazenes, on the other hand, were known to have reduced flammability. The reviewer further found that the objective here was to synthesize novel phosphazene-based solvents that had good stability at high (5V cathode) voltages and high temperatures, and also formed desirable SEI characteristics on carbon anode on aging. Another observer stated that electrolyte flammability was a major source of safety concern in current Li-ion systems. This observer felt that impacting this attribute would be quite relevant to battery adoption, especially in large format, mobile battery applications.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question tended to be negative. One reviewer thought that the approach was somewhat disjointed. This reviewer explained that the electrolyte approach seemed to focus on the flammability topic, albeit with somewhat marginal results, and that very little characterization of the flammability improvement was presented. This reviewer observed that the second topic of using the family of materials as an alternative anode may or may not be interesting, but in either case was not closely related to the topic, and completely unrelated to the task of developing a non-flammable electrolyte. Another panel member related that a high voltage stable electrolyte may improve the energy density of various Li-ion systems. This panel member reported that the concern with Ionic Liquid was low temperature performance (e.g. -30°C power capability). The final panelist characterized the adopted approach as based on the following: synthesizing and characterizing new phosphazene-based solvents with various functional groups in the pedant arm (i.e., ether groups, their unsaturated and fluorinated analogues, and even ionic liquids); performing DFT calculations for solvent-Li binding energies; and assessing their performance as electrolyte additives in Li-ion cells, especially those with ABR couples. This panelist found that there were considerable challenges here in terms of achieving desired interfacial stability at both the electrodes with the proposed solutions containing phosphazene additives, based on the earlier studies with the

phosphazenes as flame-retardant additives, which had not been quite successful. Nevertheless, this reviewer concluded that the project was well-designed and well-integrated with the other material development efforts under DOE, evident from the on-going tests with the ABR-relevant couples.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were mixed. One person considered flammability reduction through additive addition to be a very challenging approach to the issue. This person was not clear if the abuse results projected a significantly positive outcome. This person pointed out that there were a number of electrolyte level tests that could guide the direction of whether an electrolyte was showing improved flammability, but that these were not mentioned. This person concluded that the results from the effort to develop alternative material electrode material were too early for evaluation and would be complicated in development. Another panelist found that there was no low temperature performance data to meet USABC goals. The next reviewer decided that reasonable progress had been achieved here, and categorized that progress as follows: synthesized several new phosphazene compounds, especially fluorinated and ionic liquid substituted compounds; completed DFT calculations, which showed lower binding energy (with Li) upon increased fluorination; performed cyclic voltammetry studies that this reviewer emphasized did not support the argument of expanded voltage stability; carried out electrochemical assessment in coin cells with Toda HE5050/carbon couple, which showed the compatibility of electrolyte additives; and performed safety tests at SNL. This reviewer acknowledged that the safety tests at SNL showed slightly reduced heat rates in some cases, but noted that the effect was not significant because of low proportions of the additives. This observer felt that the electrochemical performance was difficult to judge because it was not normalized to the cathode capacity. The observer further considered the performance (mAh/g, and possibly voltage) of alternate anode materials being developed here based on phosphazene chemistry equally unclear. This observer recommended that the safety improvements from the phosphazene additives be demonstrated in conventional low-voltage systems to start with, rather than the 5V systems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reaction to this question was mixed. One reviewer felt that there were good ongoing collaborations with ANL and SNL in the demonstration of the compatibility and safety with the phosphazene additives in advanced Li-ion chemistries being developed in the ABR program. This reviewer recommended some collaboration with universities that worked in the past on phosphazene compounds for similar applications.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments on this subject were generally negative. One observer still questioned if additives were a viable way to reach relevant flammability reduction levels. Another reviewer reported that future plans were to continue the synthesis of new phosphazene compounds with low binding energy with Li (from DFT studies) and evaluate them in coin cells with advanced ABR Li-ion couples for compatibility and electrochemical performance, and finally demonstrate their improved safety in 18650 cells from the abuse tests at SNL. This reviewer felt that the development of alternate anode materials based on this chemistry looked less attractive and feasible.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers rated the resources excessive, while one found them sufficient. One panelist thought the resources were a little excessive for the project, based on the facts that the PI had several other tasks from ABR and the effort on alternate anode materials did not look as promising. Another panel member suggested that perhaps resources could be trimmed back a bit.

Screening of Electrode Materials & Cell Chemistries and Streamlining Optimization of Electrodes: Wenquan Lu (Argonne National Laboratory) – es028

Reviewer Sample Size

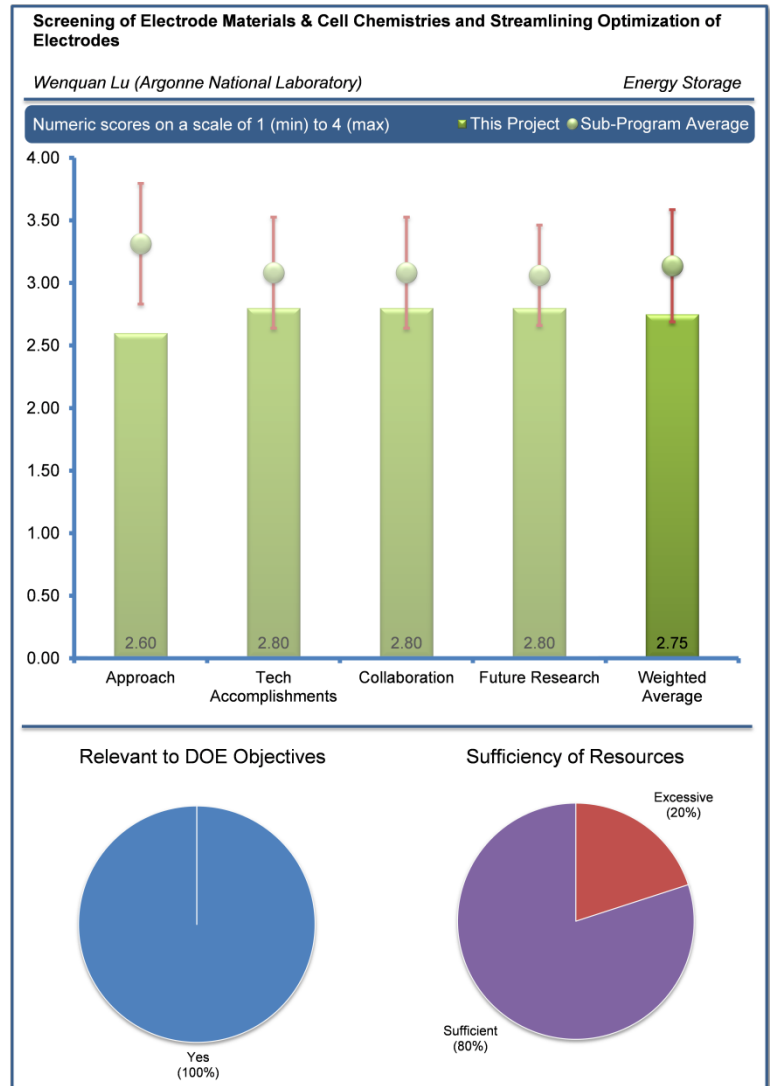
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the tasks were aligned with the overall objectives. A second person added that it was an important contribution to the overall DOE objectives because the research focus was not only on one electrode or problem but on the battery in general. The next reviewer said that the optimization and standardization of electrochemical testing was essential for a proper comparison of different projects within government labs. The next reviewer noted that, with several advanced materials of cathodes, anodes and electrolytes being developed in the ABR program as well as elsewhere, it was essential to have their performance independently assessed against the PHEV performance targets in standard test vehicles and environment. This person added that the objective of this project was to conduct independent screening tests using standardized test procedures to: streamline the lithium-ion electrode optimization process; enhance the understanding of these advanced materials; and select promising advanced materials and cell couples for an internal cell build and further testing. By completing a successful verification, this project would serve as a bridge between the material development and the scale up/cell fabrication activities in the ABR program as well as lead to an infusion of the high-energy materials in PHEV cells and batteries, added the reviewer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer observed that the approach adopted here was quite similar to two other projects, ES029 and ES030, in the following ways: material characterization through XRD, SEM, EDAX, particle size distribution, etc.; optimization of electrode fabrication process; and cell fabrication and testing for electrochemical performance including reversible and irreversible capacities, ASI and cycle life; and thermal stability. Even though some additional work was performed in optimizing the electrode composition in terms of binder/conductive diluent contents, this project overlapped closely with individual material development projects as well as with ES029 and ES030, added the reviewer. The reviewer believed it to be redundant and thought that it was not critical to the material development and its infusion/demonstration in large cells. The reviewer continued, explaining that, like in some of the material development efforts, there appeared to be some disconnect and lack of coordination among the ABR/BATT projects, resulting in some duplication/redundancy, which would, hopefully, be eliminated in the upcoming restructuring of the ABR program. A second reviewer believed that this was a very important program that tested not only cathode powders. This person mentioned that it could be of interest to mention the tap density of the cathode powders being tested. The capacity unit that was



often used is mAh/g active material, and some of the values could be very impressive; however if the material did not load well, the powder may not have practical applications, added the reviewer. This reviewer also mentioned that failure analysis was also important, and could provide important information and suggest better electrode formulations. The next reviewer thought that the researchers had developed an overall good approach, but would have liked to have seen more attention given to high and low temperature performance as well as a slide showing the variability of cell performance to be assured this was minimal. The next reviewer felt that it was truly important to develop an effective and efficient tool to screen electrode materials and streamline optimization of the electrodes. It seemed that investigators had done a lot of work but added that it was difficult to understand the difference from what the industry did or to separate this work from the work of other groups within ANL. This reviewer suggested that the investigator should clearly state what were (from the PI's perspective) the most important characteristics of the material that needed to be tested, in addition to the routinely-tested properties; as well as include why the PI's approach to the optimization of the electrodes was streamlining. The final reviewer liked that the focus in recent times was going forward, unlike the focus in previous years, consisting of a variety of subjects.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commentator to respond felt that, in general, the studies were of high quality, systematic, and well-presented. A second reviewer added that reasonably good progress had been achieved in evaluating several high energy couples and electrolyte formulations (with additives). The reviewer noted that some of the significant findings included the following: good rate capability and cycle life of 5V LMNO in carbonate-based electrolytes; high energy density from the ANL Li-excess composite $0.33\text{Li}_2\text{MnO}_3 \bullet 0.67\text{LiNi}_{0.5}\text{Mn}_{0.5}\text{O}_2$, but only at low rates and high states of charge; possibility of reducing binder/carbon content in cathodes; and good cycle life of Si-C cathode with a stable, approximately 450 mAh/g capacity in FEC-containing electrolytes, with little impedance gain. This expert added that some of the other miscellaneous studies included the study of redox shuttles, effect of carbon coating of Al, separator, and etc. These results were consistent with the findings from similar projects, without many new and significant findings, mentioned the reviewer. The third reviewer to comment stated that some of the measurements performed on batteries similar to commercially available ones were of great interest. At the moment, as indicated by the authors, the focus was on electrodes and cell fabrication, added the reviewer. The reviewer suggested that, at some point, it would be of great interest to design accelerated tests to study the failure mechanism of these batteries. It could be important, for example, to see if the Si composite anode changed the mechanism of failure of a battery, added the reviewer. Furthermore, since the authors have or would have access to practical batteries, it could be of great interest to report data in terms of mAh/g total electrode and not only in relation to the active material, suggested the reviewer. Another commentator believed that, since life was a very important issue with all Mn-based systems, the authors should have studied this aspect of the materials. The reviewer stated that Fluorinated Ethylene Carbonate (FEC) is known to have gassing/high temperature stability issues and suggested that this material be used in other similar studies. The last reviewer felt that there needed to be more emphasis on high temperature and low temperature testing and that a comparison with 5% carbon black would have been interesting.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer to respond felt that there was good collaboration across many groups having complimentary expertise. The second commentator said that, as expected from the nature of the project, there were several contributors and collaborators to provide electrode electrolyte materials. A third reviewer explained that many people understood that it was not easy to collaborate and communicate with other institutions and that for obvious reasons companies usually preferred not to share technical information. This person wondered if at some point the project team may allow some disclosure of the data and asked if it would be possible to test commercial batteries and have the information shared with the companies involved in close door meetings. Another reviewer added that the screening of the industrial materials was desired and that it seemed that other groups within ANL were able to procure such materials. The final reviewer to comment believed that PIs, not just for this project, needed to talk to each other and take advantage of the talent pool as well as network with industry that ANL as a whole, has done.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the proposed future research was to continue the assessment of next generation materials from the Applied Battery Research (ABR) partners, external partners. The reviewer also mentioned that there were plans to study the voltage fade issue of the Li-excess layered composite materials, which was the focus of the ABR. A second reviewer thought the focus should be narrowed in on screening/improving key technologies that could bring significant improvements to the state-of-the-art; hence, focusing on composite-cathode or Si systems was okay. The reviewer added that the work on redox shuttles, binder, and etc. brought incremental improvements and should not have been funded. One reviewer suggested including additional work in their testing, including the use of high and low temperatures. Another reviewer observed that there had been a lot of progress and a variety of materials tested and hoped that the authors would engage more with battery manufacturers in the future. The final reviewer to comment felt that the future plans were inconsistent with the objectives of this project.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers to respond felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion, while another reviewer felt that the resources were excessive. The first commenter to respond felt that the budget of \$750,000 (i.e., \$450,000 for screening and \$300,000 for optimization) looked a little excessive when the lack of significance and uniqueness of this project was considered. The second reviewer believed that there were probably not enough resources if the authors wanted to fully expand the cell fabrication capabilities. The reviewer further noted that the program seemed to be ending this year. A third reviewer expressed difficulty in assessing the project resources.

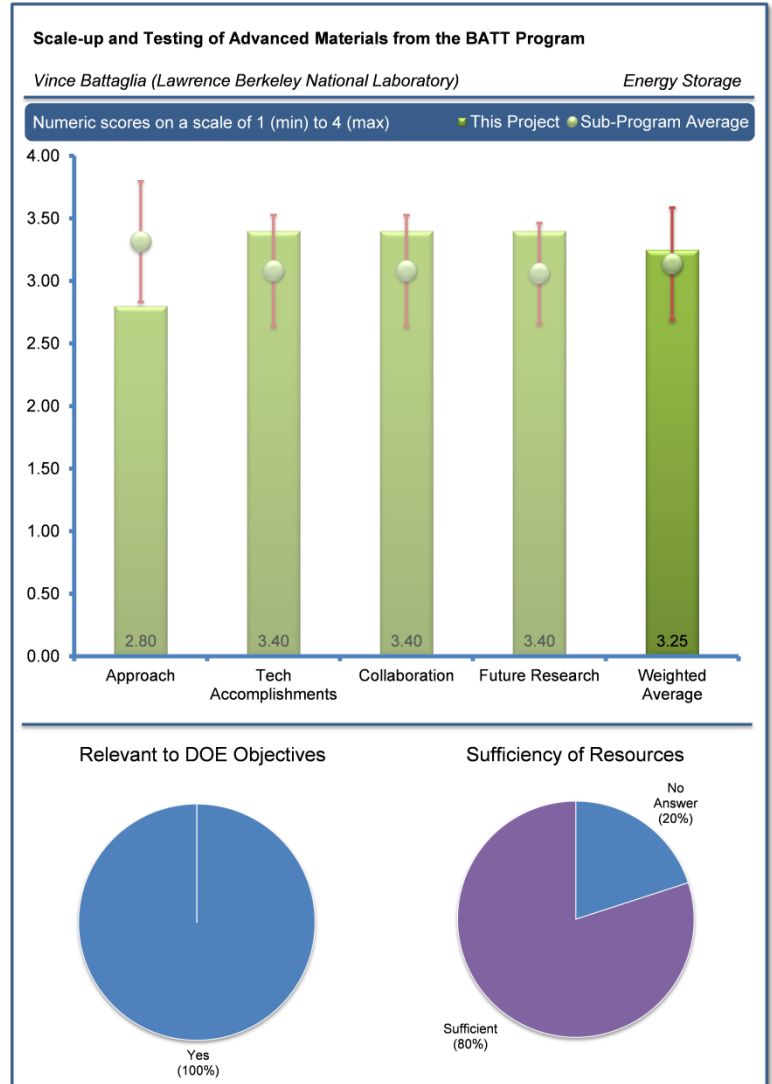
Scale-up and Testing of Advanced Materials from the BATT Program: Vince Battaglia (Lawrence Berkeley National Laboratory) – es029

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that it was very relevant for the overall goal. Another reviewer elaborated, saying that it supported the overall objective of petroleum displacement by focusing on the mechanism of failure of batteries, electrolyte composition and additives, electrode fabrication and testing. A third reviewer explained that, with several advanced materials being developed in the BATT program, it was essential to have their performance independently assessed against the PHEV performance targets in standard test vehicles and environment. The reviewer stated that the objective of this project was to support the material development efforts in BATT by testing these materials as well as materials from industrial collaborators in half and full cells and comparing their performance to a baseline chemistry and thus identifying the failure modes. This person added that a successful verification would lead to further development of those materials in ABR or redirected research efforts under BATT. Another reviewer felt that it was important to have independent evaluations to validate the performance of materials developed under the BATT program. The last reviewer believed the work to be relevant and expressed that other groups were doing similar tasks.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to respond noted that the approach adopted here was to obtain new materials from BATT PIs and industrial collaborators, assess their key physical characteristics for particle size distribution, morphology and microstructure, and test their electrochemical reversible and irreversible capacities, and rate capability in half cells and full cells, and finally understand their performance-limiting processes. The reviewer added that, even though individual PIs already assessed their own materials, this project would provide a standardized platform to assess the materials for proper comparison against the baseline and within themselves, and also to examine these materials in a system environment much like what ABR intended to do. A second reviewer observed that a lot of progress had been reported by the team, most of which was strongly focused on the voltage fade phenomena and the side reaction on the cathode on charge. These were critically important issues that had to be resolved for the potential implementation of those powders in the next generation of batteries. This reviewer suggested that authors should focus a little on trends; even if the absolute values may be off a little, they may provide trends to clearly show the strong and weak areas of different powders, separators, or electrolytes. The next reviewer felt that there was good focus on a number of materials but that the project could have been improved by focusing on materials of higher impact. The next reviewer to respond agreed that the

project was good, but thought that additional attention should have been paid to review the baseline observations. The reviewer thought the baseline results were strange (as shown in Slide 10 of the presentation) and suggested that the project leader use a second NCM from a different source and/or use a different baseline electrolyte. The best baseline electrolyte would have been from Daikin 1.2MLiPF₆ in FEC/EMC, added the reviewer; furthermore, the use of standard Novolyte was not recommended for use at 4.5V. The next responding reviewer believed that it was important to have independent evaluations to validate the performance of materials developed under the BATT program. However, it was more important to develop testing procedures focused on identifying the sources of failure and having a feedback mechanism in place to help the PIs improve/modify their materials, added the reviewer. The next reviewer wondered how the materials were being selected for testing under this project. Another question brought forth by a different reviewer was whether there were protocols that were consistently used or if each PI provided the best procedure for the material to be tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer to respond stated that the project had evaluated a considerable amount of new materials potentially useful to the overall DOE goals and added that the database was quite useful. The second reviewer felt that good progress had been accomplished in terms of evaluating several BATT samples and external (industrial) materials, which included NMC333 and LMNO (Ni-substituted manganese spinel oxides) cathodes in different electrolytes (three high voltage electrolytes) containing proprietary co-solvents, additives or salts. The reviewer found the effects of electrolyte on the irreversible capacity (side reactions), and of cathode on the anode impedance to be very interesting. This person added that some combinations (for example, the MIT cathode with FEC-containing electrolyte and CGP-G8) appeared to be quite good in terms of capacity retention and the effects of such electrolyte variations on the individual electrodes as well as the effects of cathode on the anode impedance would be better understood with three-electrode cells. The next reviewer explained that a variety of tests were implemented and suggested that it could be of interest if in the future some data was presented in relation to the mechanism of failure (for different cathode powders, for example). As mentioned by the author, measurements with a reference electrode (which are not easy to do) may give important new insights, added the expert. The next two reviewers agreed that the project showed a good in-depth analysis of the observed results. One reviewer added that much of this explanation may not have been needed if changes to the approach had been implemented. Another reviewer added that it would be desirable to see more effort spent on testing that was beyond what industry could do to take advantage of the unique instrumentation base of the national laboratories. The first reviewer recommended having the laboratory be able to evaluate the materials at high temperatures (say 50°C) so that the life aspects of the materials could be looked at. Mere room temperature work does not tell the true story, added the reviewer. The reviewer had heard many times within these programs that this or that material (and many of them) looked very promising, but never heard about them anymore. The second reviewer was unsure what the next step would be with the successful electrode/electrolyte combinations identified here. The reviewer asked whether there was any plan to demonstrate their enhanced performance in prototype cells with industrial battery manufacturers or if they would be absorbed in ABR. The last reviewer to respond felt that it would be interesting to know the correlation between doping/coating approaches versus electrolyte/additives approach to mitigate interface reactions on both positive and negative sides.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that it seemed like the team managed to build a strong collaboration with different institutions and companies. The next two reviewers added that there were a good number of extensive collaborations with well-known researchers and companies. Another commentator stated that, as expected from the nature of the project, there were several contributors and collaborators providing electrode electrolyte materials. This reviewer added that the project would probably benefit more from some collaborations with an industrial battery manufacturer in scaling up/verifying these materials. The last reviewer to respond asked if the feedback loop existed to help partners improve on their products, and suggested that it would be great to see an example presented next year.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that this project provided an excellent channel for many researchers to get their materials evaluated per advanced testing protocols. This reviewer believed that the bulk of the focus should be on high impact materials such as the next generation cathodes and anodes that could bring costs down significantly or make the cells abuse-tolerant. The same reviewer opined that topics such as binder and use of electrolyte additives only brought about incremental improvements to cell performance and should not receive focus. The following reviewer noted that the proposed future research included: continuing the assessment of next generation materials from the partners; seeking correlations between performance and electrode/electrolyte properties; working towards scaling up the LMNO cathode; and carrying out three electrode measurements to better understand the anode impedance rise. This person added that there were plans, consistent with the program goals, to develop proposals to the next phase of ABR on the same concept. The next reviewer noted that the project was ending this year. This reviewer suggested continuing the future research with the good communication the project team had developed with partners and industry. Analysis of batteries at the end of life should also be considered, added the reviewer. The next reviewer suggested getting an appropriate baseline electrolyte from Daikin 1.2MLiPF₆ in FEC/EMC, or requesting a similar formulation from Novolyte. The last reviewer to respond stated that the PI clearly showed an understanding of the issues and the path forward and had addressed them during the oral presentation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. The first reviewer to respond considered the importance of the project and supported increasing its funding. Another reviewer felt that the budget looked adequate; if not slightly lower, for these studies. A third commentator believed that the resources were sufficient; however, the expert added that it was hard to know since the project was finishing. This person added that the authors had done a great job based on the amount of resources they received. The last reviewer felt that this was a difficult question to answer. This person suggested increasing this project's resources in order to provide independent testing for all BATT-funded materials.

Fabricate PHEV Cells for Testing & Diagnostics: Andrew Jansen (Argonne National Laboratory) – es030

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

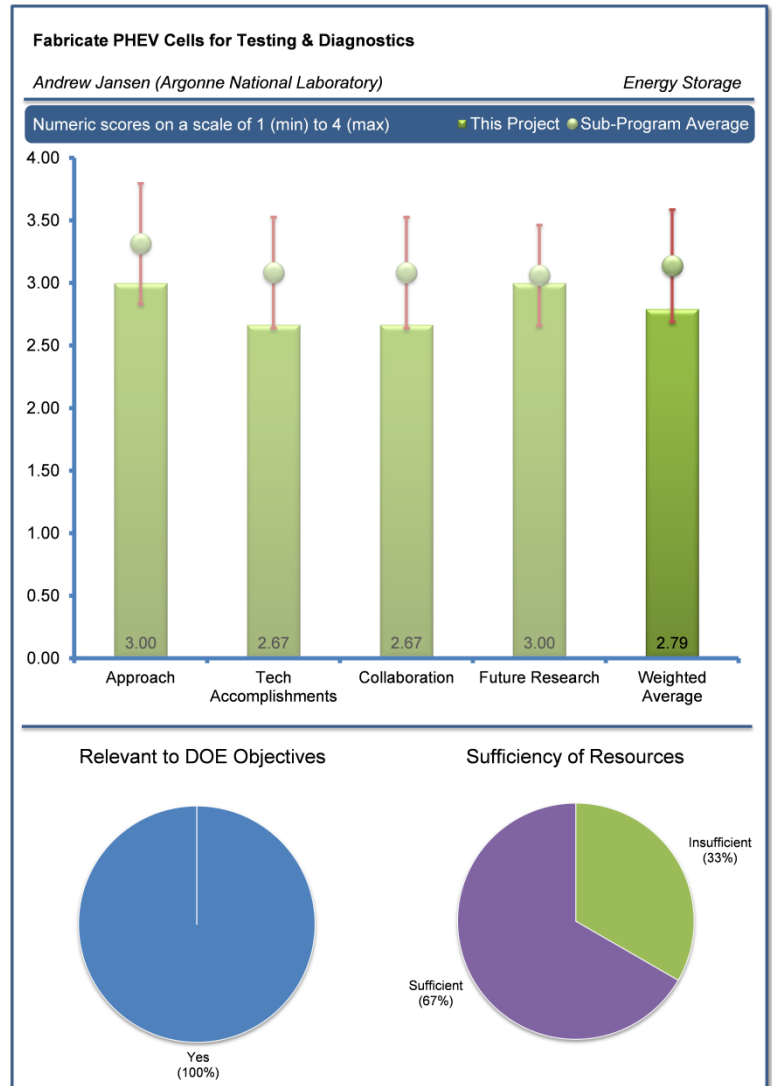
The first reviewer noted that this project covered the cell level test for material evaluation. Another reviewer felt that it was important to get a measure of material capability in finished cells which were well sealed. This reviewer also noted that this facility allowed experimentation on mix formulation, mixing conditions as well as material sources in validated cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that this group was making a dedicated effort to bring the facility into operation and replicating the manufacture of sealed cells utilizing pilot line equipment. Another reviewer felt that if the validation was successful, runs with test materials would be much more useful to material developers. A third reviewer noted that the cell design and validation lacked the development for the standard cathode for the anode evaluation and the standard anode for cathode evaluation, respectively. This reviewer expected other material companies to get the benefits from this testing facility as well as ANL-developed material does (DOE-funded cathode, anode, electrolyte and separator developers). The last reviewer added that, while several details were lacking in the presentation, it appeared that a full evaluation of the equipment had not yet been carried out. The reviewer suggested that a material in current production such as LCO, LMO or NMC cathode material should be utilized with a common formulation for that material used in industrial cell making. This person added that the coater should be tested for uniform loading from side to side and from front to back by sampling either with simple punching and weighing of samples after drying or by the use of a beta gauge to determine loading in real time. The electrodes should then be made into cells of both cylindrical and pouch types to test assembly methods, added the reviewer. The reviewer also believed that the performance after standard formation should be measured appropriate to the electrode and cell designs and then compared to comparable production cells, after the standard electrolyte fill was validated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer to respond felt that the accomplishments were good in the sense of setting up an entire pilot line production facility. The reviewer added that there was a lot of validation required (as noted above), however. The reviewer believed that the group should focus on this matter before launching new material assessment as there would always be questions regarding the accuracy of the cells as made. Another reviewer did not think that the SOP and quality criteria for each assembly process step were set up yet. This person also noted that the capability of 18650 cells was also not yet set up.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the project needed to get help from the company for setting up the SOP and pass criteria for each step of process. Another reviewer suggested working with a consultant with cell-making experience to assist in the validation work and in the accurate alignment of all the machines. Coaters, winders, pouch cell placers and other equipment all required accurate settings which should be tested regularly, added the reviewer. This person stated that this work would result in SOPs that would assure a quality product.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that this facility should be more open to DOE-funded materials companies.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two of the three reviewers felt that the project resources were sufficient to achieve the project milestones in a timely fashion. One reviewer felt that the resources were insufficient. Another reviewer suggested hiring operators for a higher production capability.

Electrochemistry Cell Model: Kevin Gallagher (Argonne National Laboratory) – es031

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

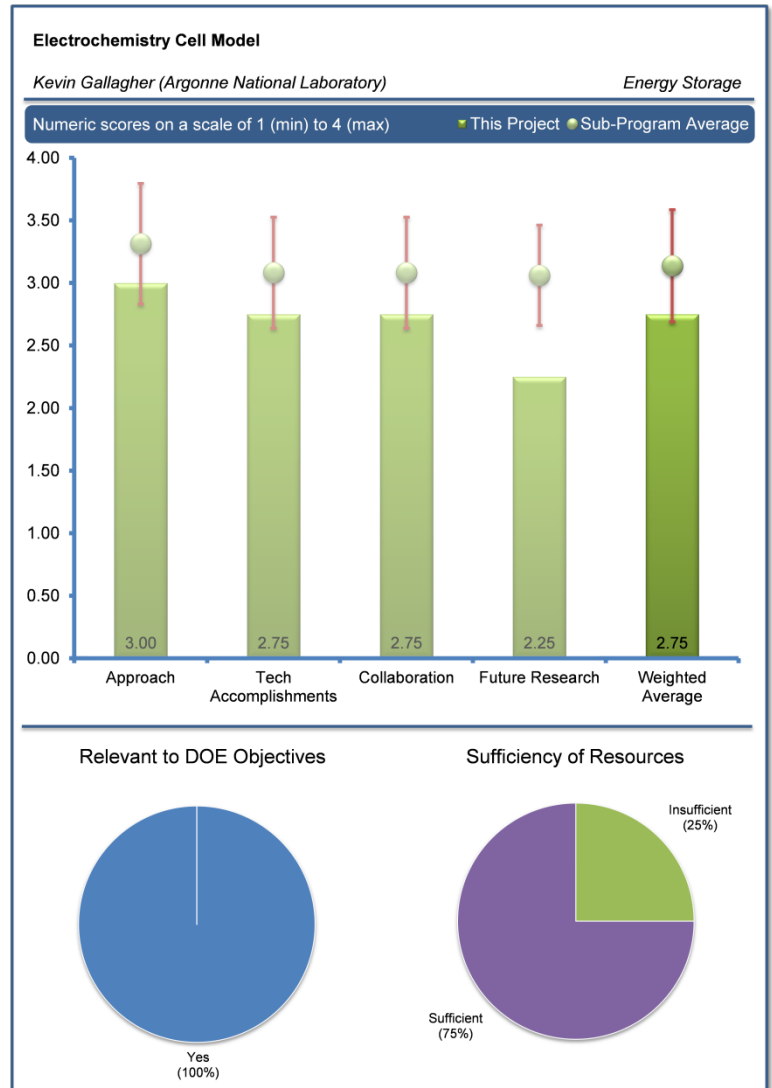
The first reviewer to respond felt that modeling may provide insights regarding battery performance and the mechanisms for degradation that are unobtainable through experimental methods while another reviewer suggested that the team should focus on the important issues.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commentator noted that the approach was to link experimental work with the developed electrochemical model to identify performance limitations and aging mechanisms. The next reviewer stated that by homogenizing all material properties, any degradation due to local inhomogeneity would be automatically ignored. The last reviewer to respond suggested using better input parameters when applying the Newman model to the positive electrode. This person asked what else was different and new.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer to respond stated that the studies of aged electrodes were good, but added that this sort of approach had been used for many years. A second reviewer felt that the model indicated that the most likely source of impedance growth (i.e., interfacial contact resistance between LMR-NMC particles and the conducting carbon additive) occurred in the cell upon aging. The electrolyte parameters were supplied by Kevin Gering's Advanced Electrolyte Model, added the reviewer. This reviewer wondered if this information had been (at least partially) experimentally validated and noted that the model was now being used as part of the effort to understand the open-circuit voltage (OCV) fade of the cathode upon aging. Some hypotheses have been suggested for the OCV hysteresis including two sets of vacancies (sites) or reversible structure change, added the reviewer. The reviewer felt that another potential difficulty noted by the model and this work was that the lithium diffusion coefficient in LMR-NMC was much lower than for NMC, but one is unsure of the reason for this. The reviewer asked how the results from the modeling work would be validated experimentally to confirm their accuracy. The next commentator observed that the project had used (ANL's) Dennis Dees' physical model to interpret impedance and believed that there was no statistical significance or cross correlation information. The next reviewer to respond found it interesting that the hysteresis depended strongly on the voltage, but was also unsure of the explanation. The reviewer added that fitting a GITT experiment to get the diffusion coefficient was probably impractical because the assumption of perfect bulk diffusion was implausible. The last reviewer to respond suggested that with all of the micro-scale information now available, future models should go beyond homogenized material properties.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The only reviewer to respond noted that collaboration included working with Daniel Abraham and Andrew Jansen (among others) at ARL and Kevin Gering at INL. This person added that more collaboration would be established from the PIs' participation with the voltage-fade team.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the future work would include participation in the team of researchers examining the problems of voltage fade and the refinement of the negative electrode SEI growth model. The next reviewer was unsure how this level of modeling could contribute. The reviewer added that Newman's model had always been very successful in modeling battery performance, but not so with degradation. This person explained that people have made *ad hoc* patches to the model and fit coefficients of additional terms to reproduce the degradation data, but added that this was hardly predictive. The last reviewer to respond suggested that a more selective focus on materials-specific topics would be helpful.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers to respond felt that the project resources were sufficient, while another noted that the resources were insufficient. The first reviewer felt that there were sufficient resources, which appeared to be available for the proposed work. This person added that it was difficult to gauge this without a full budget. A second reviewer stated that a much larger effort would be required to go beyond Newman's homogenous approach.

Diagnostic Studies on Lithium Battery Cells and Cell Components: Dan Abraham (Argonne National Laboratory) – es032

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

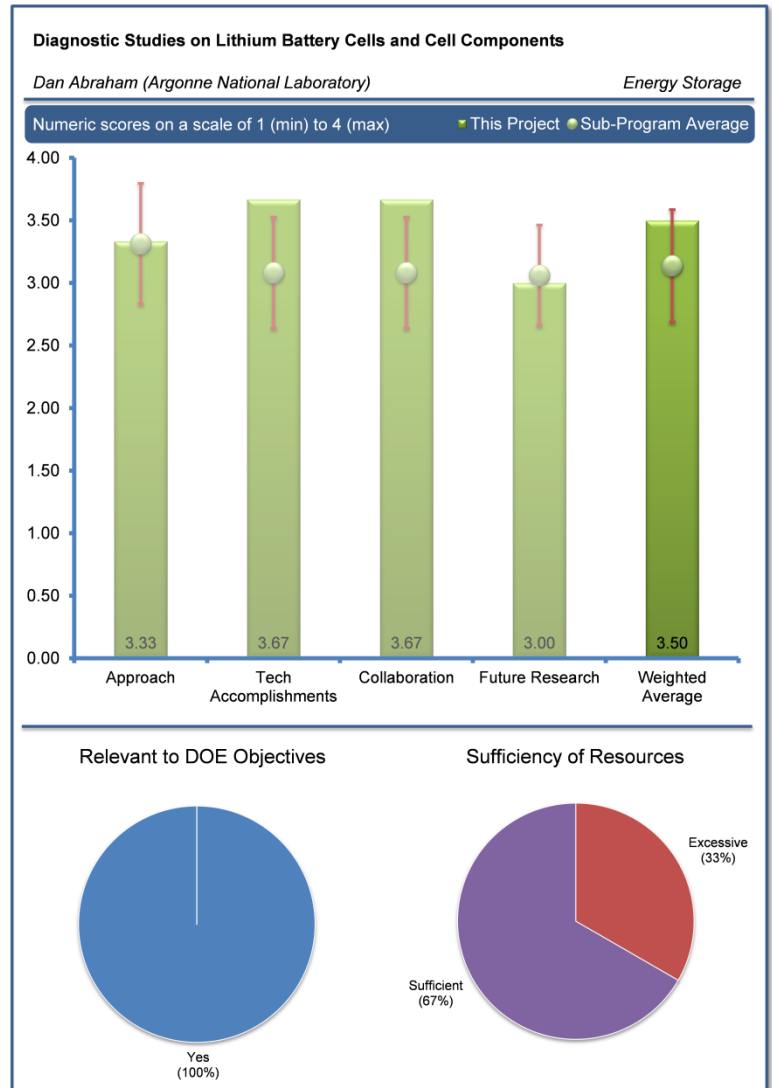
One reviewer described that the project involved advancing the general understanding of degradation mechanisms in Li-ion chemistries. Another person simply stated that high energy couples were of high relevance. The final reviewer acknowledged that diagnostics facilitated the identification of mechanisms and challenges at the material, electrode, cell, and battery pack level. Such studies were crucial and should be pursued in parallel with material, cell and pack development. In some instances, the diagnostics provided key information about widely-recognized problems. In other instances, however, the reviewer cautioned that the diagnostics studies indicated potential problems/difficulties of which researchers may be unaware thus pointing to new research directions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
Reactions to this question were mixed. One person described that the approach was to identify the causes

(either materials or mechanisms) responsible for cell performance and degradation in performance through the use of advanced characterization tools. Another evaluator explained that the approach included the disassembly of new and aged cells and analysis with a very wide range of diagnostics. The reviewer added that the use of reference electrode cells was vital, and not everyone did that. The reviewer did not see how the TEM and XPS analysis/diagnostics results could be converted, even in principle, to specific, actionable recommendations to the rest of the team. The final reviewer commented that the approach to this project's work was generally good but could easily be farther-reaching.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All responses to this question were positive. One person remarked that the project had a number of accomplishments which may be ground-breaking and of great value towards advancement of Li-ion battery technology, while at the same there were a number of accomplishments which could be easily arrived at within typical industry activities or by a large number of less well-equipped and less well-funded institutions. Another reviewer pointed out that the researchers determined that the upper cut-off voltage was an important determinant of the ABR cell life, which is important, but is already known. The reviewer added that what was new was that the oxide-carbon contact was where the problem was. The reviewer also highlighted that the cross-talk between electrodes and the fact that the positive electrode impedance rose was the common feature in all couples were both important and new. The reviewer felt the recommendations were good, but some, such as the additives and coatings could be helpful, were already well



known. The reviewer would have liked to see the researchers make an attempt to take advantage of the new knowledge about the oxide-carbon interface. The final reviewer had detailed comments, describing that the researchers: concluded studies of PHEV baseline materials (NCA/graphite); began characterization and aging experiments on electrodes and cells for new materials; and concluded that electrolyte oxidation at the positive electrode contributed significantly to the impedance rise and that lithium trapping in the negative electrode SEI was the main contributor to the cell capacity fade (not the cathode, or at least not directly). The reviewer reported that possible solutions included positive electrode reformulations (altering carbon and binder contents, mixing procedures, and calendaring conditions) to reduce impedance, electrolyte additives, and positive electrode coatings (i.e., Al_2O_3). The reviewer highlighted that the use of reference electrodes for the full cells was demonstrated to be very informative for this work. The reviewer offered one critique – that very little of the crucial diagnostic information (i.e., performance degradation) obtained from the work associated with this project has been published in open, easily-accessible scientific literature. The reviewer concluded by explaining that such information would be very much welcomed by the battery research community because there was very little of it available at this time.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were positive. One person mentioned that numerous organizations were listed as partners for this project and that the characterization work was distributed throughout these institutions, although the bulk of it seemed to occur at ANL. The other person to comment expressed that the collaboration was excellent for universities and national laboratories. The reviewer pointed out that adding battery or chemical companies would make the collaborations even better.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed. One person felt that this part of the talk was quite vague. While another person described that future work would include the continuation of the evaluation of the ABR-1 electrochemical couple and cell constituents, initiation of work associated with the next set of ABR couples and work linked to the voltage fade for LMR-NMR oxides. The reviewer added that all were worthy of pursuit in order to advance the DOE's goals.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, with two reviewers stating that the resources were sufficient while one thought they were excessive. One person added that the project appeared to be well-funded and that ANL was well-suited in terms of resources for this project. The other reviewer to comment observed that almost every possible diagnostic technique was available to this team.

Electrochemistry Diagnostics of Baseline and New Materials: Robert Kostecki (Lawrence Berkeley National Laboratory) – es033

Reviewer Sample Size

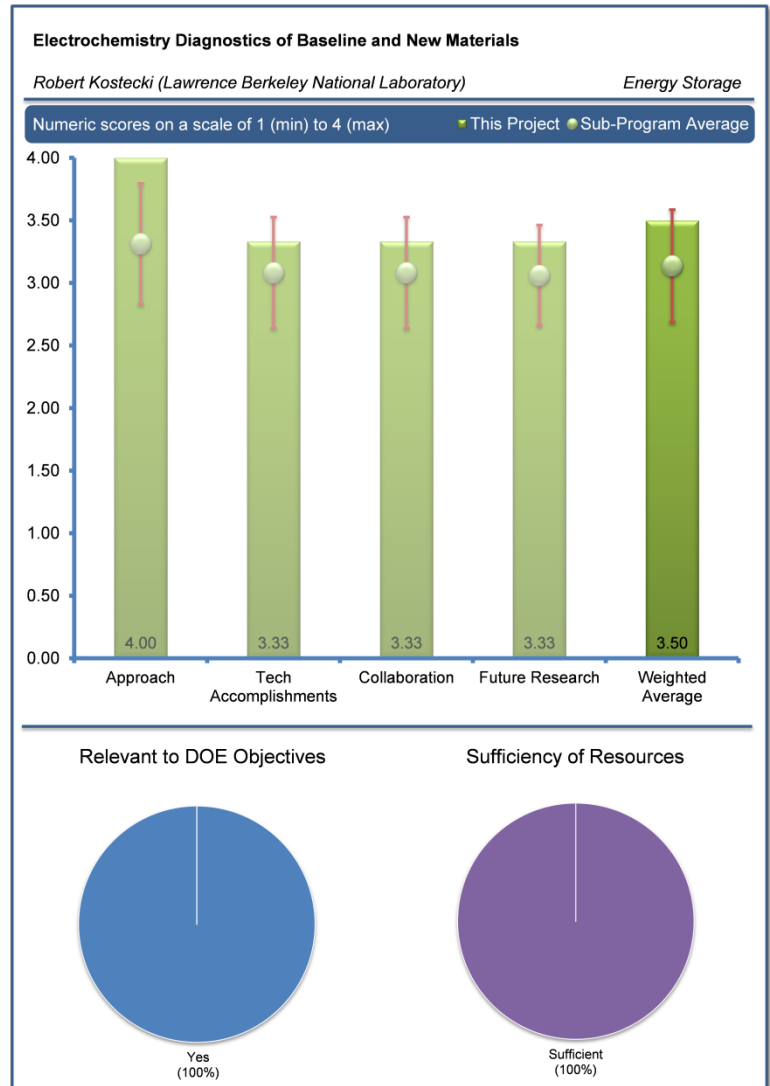
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that the project activity identified key Li-ion battery degradation mechanisms using unique applications of diagnostic methods. The reviewer added that this project provided a pioneering illumination of the opportunity paths for improved Li-ion battery performance, and that these paths were unlikely to be so usefully identified by any other research entity within the U.S. in the near future. Another reviewer described that the project included high cell capacity, degradation, and SEI formation; which includes most of everything that is important. The last reviewer provided detailed comments explaining that diagnostics facilitate the identification of mechanisms and challenges at the material, electrode, cell, and battery pack levels. Such studies were crucial and should be pursued in parallel with material, cell and pack development. In some instances, the diagnostics provided key information about widely recognized problems; in other instances, however, the diagnostic studies indicated potential problems/difficulties of which researchers may be unaware thus pointing to new research directions. The reviewer concluded by stating that degradation was, of course, one essential area of research to meet the high demands required from batteries for traction applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All responses in this section were positive. One person commented that the focus of the purpose and scope, and the targeted approach of the crosstalk studies, and the carbon black (CB) additives studies were outstanding and should be seen as models for the Advanced Battery Research for Transportation (ABRT) activity in general. Another reviewer felt that it was good that the project team went beyond determining mechanisms to investigating mitigating treatments, and that post-test diagnostics were good. Researchers applied new diagnostic techniques to the battery field, especially *in situ*. This reviewer felt that it was very important that the author showed micro-scale inhomogeneity, which may be the ultimate source of most degradation, and added that very few studies recognized, let alone analyze inhomogeneity. The reviewer really liked that researchers designed unique cells to get answers, for example making electrodes just out of CB. The reviewer also considered it very good to model the experimental results. The last panel member characterized the research as: having examined the impact of high potentials on the carbon black added to cathodes; having determined the key factors that contribute to the component and cell degradation (PHEV couples); and having characterized SEI formation on model electrode surfaces to improve the understanding of the interfacial phenomena.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were generally positive. One reviewer felt the accomplishments of this project were outstanding and should be viewed as among key highlights in the entire ABRT program. Another panel member considered analysis of carbon black additives important and the new information on mechanism of CB very nice. This panel member thought it was really great that the researchers identified an approach to solving problems that could work at industrial scale CO₂. The panel member stated that fluorescence analysis needed to be connected to performance, and thought it was very important to demonstrate that carbon blacks were electrochemically active, even allowing PF₆ intercalation. The final observer pointed out that although the use of fluorescence imaging to detect electrolyte decomposition was demonstrated, no mention was made regarding controls. This observer questioned what the comparable data was if the same cells were cycled to a lower voltage. Further, the observer questioned what the influence of additives or surface layers was, and stated that it seemed that only a limited amount of work was done. It was determined that the degradation products from the cathode affect the anode (SEI layer) and the side reactions producing these products may affect lithium availability (inventory). In particular, the anion may intercalate into carbons leading to degradation (as reported during the last year). A surface treatment with CO₂ was demonstrated to reduce this phenomenon. This observer was unclear if it was therefore deemed crucial to modify the baseline high-voltage cathodes currently being tested as part of the BATT program with treated carbon. The observer went on to question if this information was being applied to improve the work of other battery research, and pointed out that most of the work had been disseminated in presentations rather than in widely available scientific publications. The observer concluded that, given the importance of this work, it was desirable that the work be published in one or more prominent battery research-related journals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments on this section were mixed. One reviewer saw good collaboration among national laboratories, but suggested that it would be better if it also included universities and industry. Another reviewer acknowledged that the significant challenge of collaboration from within the ABRT programs with international institutions and/or international industrial partners could not be underestimated, but suggested that this would be one key area for potential future expansion of utility of outstanding projects such as this one. The final reviewer thought that LBNL seemed to work closely with ANL and BNL, both in terms of cell preparation (at ANL) and characterization, but that it was not clear from the work presented what, if any, of the work was done through collaborations this past year. There was a note on Slide 5 that indicated that no test cells had been sent to LBNL in FY 2011 and FY 2012. This reviewer questioned what the significance of this was, and what work, if any, had been done in conjunction with companies to facilitate their diagnostic needs for high-voltage electrodes.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were positive. One person found that the aims were related directly to end use, which is better than if they were just aimed at understanding. This person thought that the planned future work would lead directly to achieving DOE objectives. Another reviewer suggested that a further study of a wider variety of CB additives and treatments could be beneficial. The final observer reported that the proposed future work would continue searching for a means of decreasing the irreversible capacity losses during cycling through surface treatments. Post-test characterization would be performed on ABRT cells to examine electrode composition, structure and surface films. Work would continue to examine the degradation mechanisms in cells. This observer felt that there was no indication of what specific additional testing would be done or what new materials would be studied.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers found resources to be sufficient. One felt that all required resources were available, and another stated that the funding seemed to be quite high (\$600,000) based upon the amount of work reported, but perhaps that other work had been performed as part of this project that was not reported.

Diagnostic Studies to Improve Abuse Tolerance and Life of Li-ion Batteries: Xiao-Qing Yang (Brookhaven National Laboratory) – es034

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

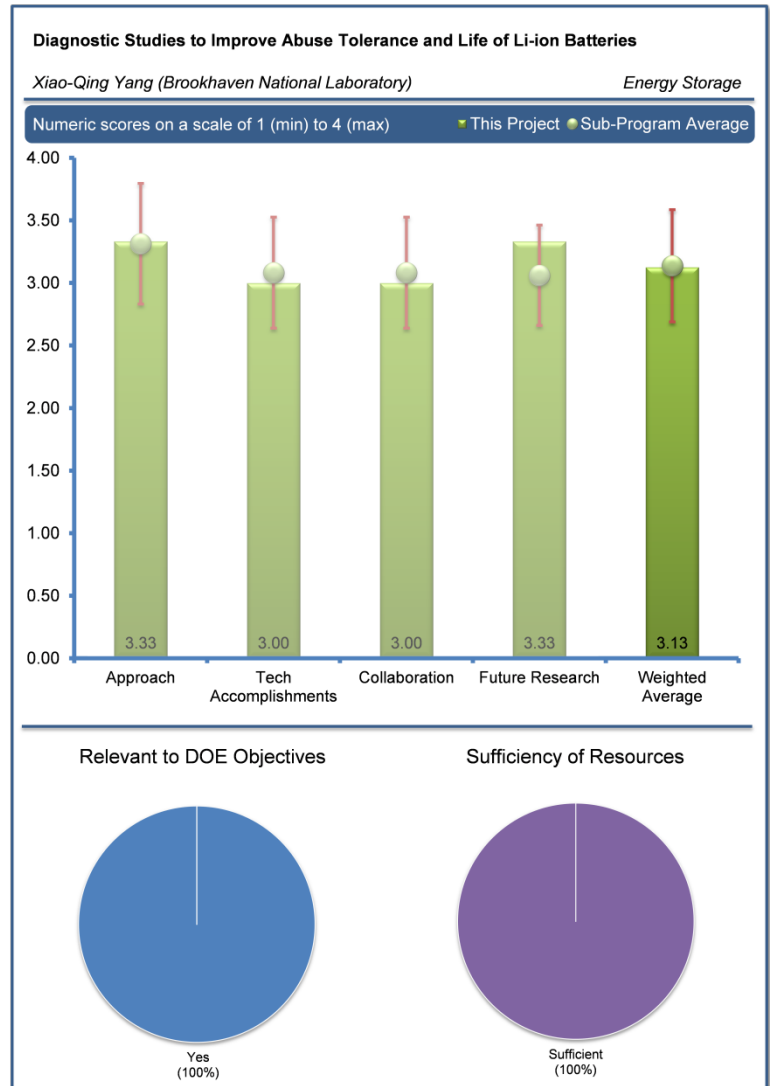
Comments for this section were generally positive. One reviewer felt that this work provided useful insight in many fundamental mechanisms involved with a number of important materials of interest to vehicle electrification in industry. Another person thought that projects reducing costs were especially valuable, and that understanding failure was good. The last reviewer explained that diagnostics facilitated the identification of mechanisms and challenges at the material, electrode, cell and battery pack level. This reviewer felt that such studies were crucial and should be pursued in parallel with material, cell and pack development. In some instances, the diagnostics provided key information about widely recognized problems. In other instances, however, the diagnostics studies indicated potential problems/difficulties of which researchers may be unaware, thus pointing to new research directions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions in this section were generally positive. One panelist felt that the project made excellent and creative use of BNL's relatively unique equipment and experience capabilities. This panelist also thought that the choice of materials to be studied was understandable from a DOE perspective but that the materials could be improved if the automotive industry and its real-world applications were of prime importance. Another observer reported that the overall approach was to make structural measurements on materials of interest. The final reviewer observed that this project utilized time-resolved x-ray diffraction (TR XRD) and mass spectrometry, together with XAS (XANES and EXAFS) and TEM to examine the thermal stability of electrode materials. Cathode materials had been surface modified with ALD, whereupon the materials (LMR-NCM) with and without the coatings were studied to determine the voltage and capacity fading mechanisms. This reviewer concluded that it was evident from the work presented that a lot of insight was gained from the methods used into the mechanisms for thermal degradation, as well as material transformations upon cycling.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Commentary on this question was mostly positive. One observer reported that a new *in situ* technique was developed in which TR-XRD was combined with mass spectrometry. The thermal stability (phase changes, gas loss, etc.) of different electrode materials was then analyzed with increasing temperature to determine the mechanisms of thermal degradation. This observer thought that



using the two methods in concert was extremely helpful, and that the use of XAS to aid in deconvoluting the origin of the voltage drop seemed to be very informative as it pointed to slowly evolving structural transformations. Finally, this observer remarked that the methods used provided key information about the role of surface coatings on stabilizing the electrodes. Another reviewer observed good progress towards project-specific goals. The final panelist pointed out that although new diagnostic techniques were developed, and these studies provided a new understanding, the project team needed to show how the project led in some way to ideas that would produce solutions. The panelist questioned, for example, what new information was obtained from the oxygen evolution experiments that was not already known. The panelist similarly questioned if measuring bond length and local structure helped solve problems, and if so, which ones, and how. The final panelist did not see progress towards the barriers that were supposed to be addressed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reaction to this section was mixed. One reviewer felt that overall level and nature of collaboration was excellent. Another observer characterized that collaboration was extensive, with a diverse range of national laboratories, universities and companies. A different reviewer found that this project was unusual in having industry, laboratory, and universities. This reviewer thought that this project needed better coordination with the rest of the ABR program; i.e., these diagnostic techniques needed to be employed in a more targeted way, rather than answering vague questions. This reviewer suspected that there were connections, but they were not made clear. The reviewer concluded by suggesting that this project belonged in BATT or BES. One of the panel members noted that collaboration with a single automotive OEM on this specific topic was conspicuous and of concern.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments for this section were mixed. One person thought that expanding collaborations, including with industry, was good. Another panelist urged researchers to continue and expand upon the existing work. The final reviewer felt that the choice of materials to be studied in future research could be improved to better reflect automotive industry as a whole.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers rated resources to be sufficient. One thought that the funding was relatively modest for this project relative to the information gained.

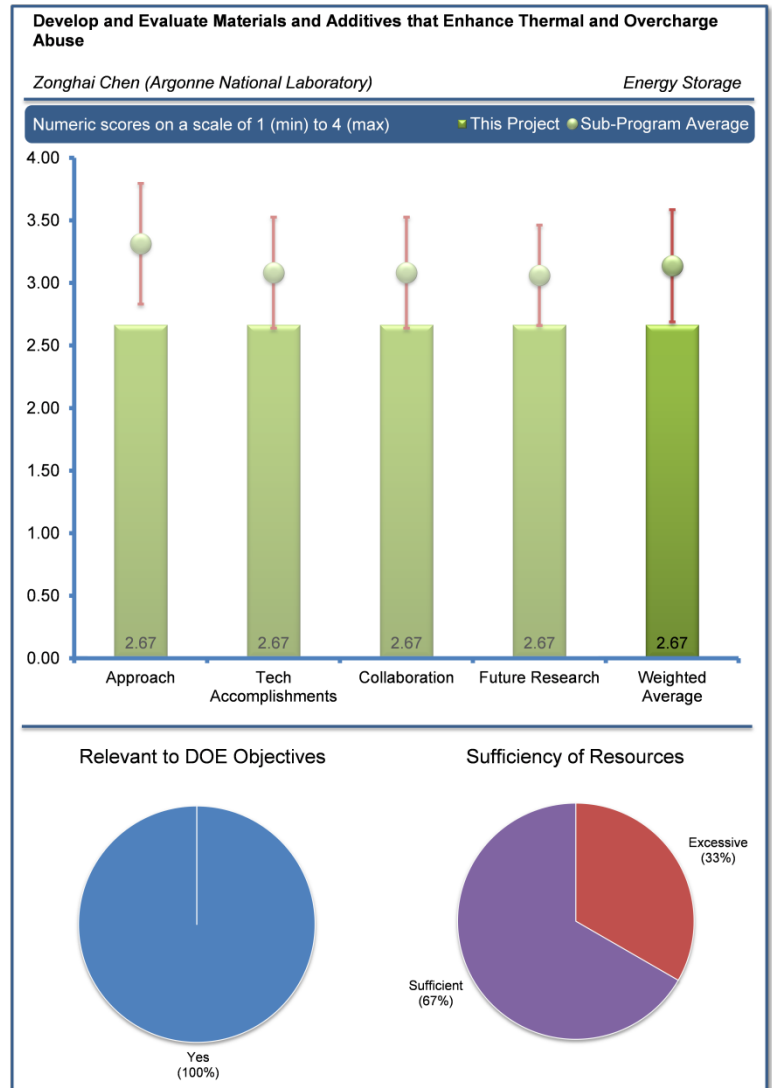
Develop and Evaluate Materials and Additives that Enhance Thermal and Overcharge Abuse: Zonghai Chen (Argonne National Laboratory) – es035

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments for this section were positive. One reviewer stated that the role of safety performance in the commercialization scheme of Li-ion batteries was a critical factor in the potential adoption curve. Another panel member found that if the development of overcharge protection or prevention was successful, that would simplify the BMS and reduce the cost of the energy systems. The final reviewer reported that Li-ion cells could pose safety problems (thermal runaway) upon electrical or thermal abuse attributed to the thermal instability of the materials. These problems were somewhat aggravated with the advanced cathode and anode materials being developed for the PHEVs. The objective of this project is to identify contributions from each of the cell components of different chemistries to the abuse characteristics, and utilize this understanding to develop new abuse-tolerant materials and provide them to SNL for validation of safety benefits in 18650 cells. This reviewer concluded that it was essential to improve the safety characters of Li-ion batteries for them to be used in widespread applications, such as PHEVs and EVs.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One reviewer explained that the approach targeted improvements in all the cell components for increased safety, e.g., safer anodes and cathodes, additives for stable SEI, surface modification for cathode, safer electrolyte components (solvents and salt) and redox shuttles for overcharge protection. Materials were being obtained from in-house researchers, external partners and commercial sources and assessed for electrical performance as well as safety improvements, which were subsequently verified in 18650 cells. The thermal stability of the cathode materials had been particular addressed here with and without the electrolyte components and using *in situ* High Energy XRD for understanding the evolution of new phases upon heating. This reviewer believed that this approach was very similar to another project ES 37 (Yang et al), where more comprehensive studies were being carried out and that there should be some coordination between these two projects. The reviewer concluded that the approaches looked reasonable and feasible and would lead to a further understanding of safety issues of each component and later to safer cell components. Another reviewer found that the development included critical cell chemistry components and their potential for heat release, and thought the *in situ* measurements would be beneficial. The final reviewer wrote that the examples given of technical accomplishments did not suggest a coordinated approach to the issue of individual material safety considerations; in other words, a bit of a hodge-podge of areas was under investigation. The reviewer

admitted, however, that the single detailed example was comprehensive in nature and represented quite an interesting investigation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments for this section were positive. One panel member thought the technique for development of High Energy X-ray Diffraction used in the following cell reactivity was quite an interesting accomplishment. The validation of the technique was not presented in detail, but this panel member hoped this had been investigated fully in terms of reliability, accuracy and repeatability as it could become an important technique which would produce good information. The other observer reported that reasonably good progress had been accomplished in terms of evaluating various cathode materials for their structural changes during electrochemical cycling and thermal abuse. Specific accomplishments noted by this reviewer included the following: *in situ* HEXRD study on charged $\text{Li}_x\text{Ni}_{0.9}\text{Co}_{0.1}\text{O}_2$ with and without gradient composition, and $\text{Li}_x\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$ cathode materials during heating; confirmation of the poor reproducibility of DSC data for delithiated cathodes; and investigation of the effect of salts (LiPF_6 , LiBF_4 , LiTFSI and $\text{Li}_2\text{B}_{12}\text{F}_{12}$) as well as pure solvents on safety. This reviewer found it interesting that LiPF_6 reduced the onset temperature from approximately 310°C to about 200°C as compared to other salts. This observer also pointed out that studies were ongoing on the ANL redox additive as well as on amorphous carbon covered graphite from Superior Graphite. The reviewer concluded that all these studies were matched the overall goals, but their significance was not clear yet.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responses were neutral for this section. One reviewer reported that there is some collaboration within ANL and with external partners. The other reviewer stated that the project had planned to re-scope to merge with voltage decay project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were somewhat positive. One reviewer repeated that re-scoping to merge with voltage decay project was planned. Another panelist concurred that consistent with the increased emphasis in ABR for the voltage slump in the LMR-NMC cathode, future efforts would be rebalanced between the safety and the voltage fade of lithium-manganese-rich NMC materials. Specifically, these studies were aimed at investigating the structural evolution of LMR-NMC during and after electrochemical activation using synchrotron-based *in situ* techniques. Also, the effects of surface chemistry on the SEI over carbon anode its thermal stability would be examined. This panelist found the planned studies helpful in mitigating the technical barriers of safety and increased energy density for Li-ion cells. The final reviewer believed that full development and evaluation of the technique of HEXRD should be pursued as a technique development capable of being accessed by the wider community.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found resources to be sufficient, while another one found them excessive. One person repeated that re-scoping to merge with voltage decay project was planned. Another thought that the budget of \$500,000 per year looked quite slightly excessive for this effort.

Evaluation of Abuse Tolerance Improvements: Chris Orendorff (Sandia National Laboratories) – es036

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

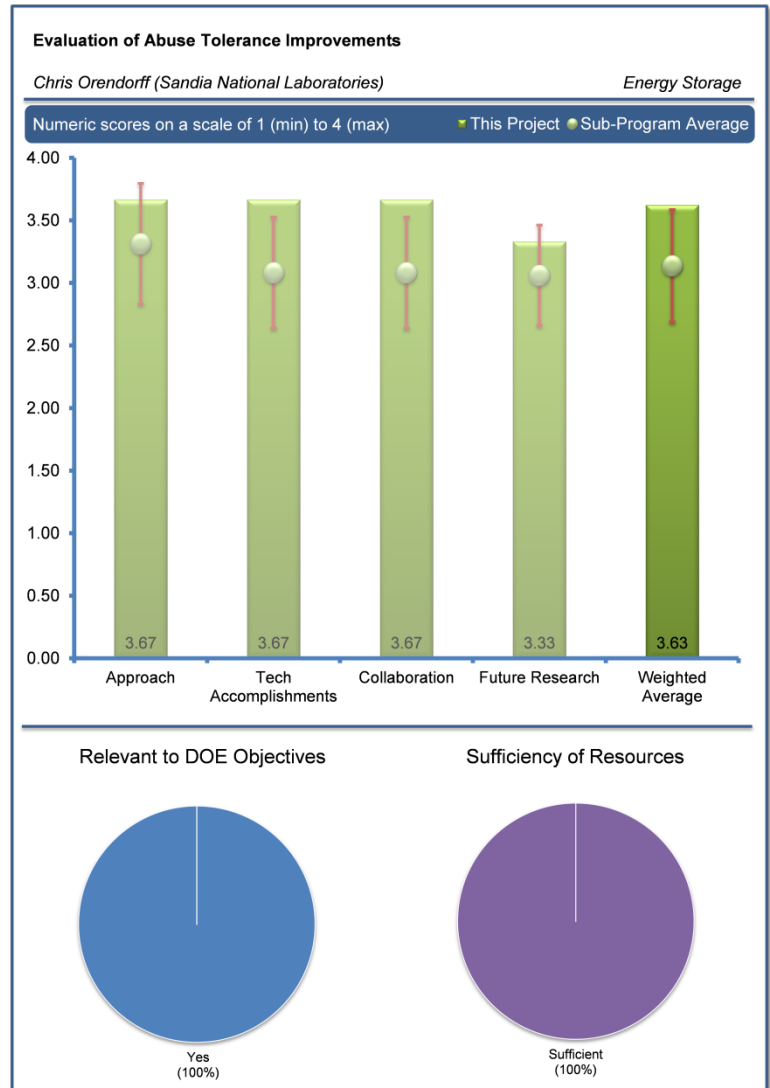
The first reviewer said that this project was one of the important programs because it ensured the safety of Li-ion cells and batteries. The second reviewer felt that this project would provide a good tool for the selection of safer and cost-effective materials. Safety of batteries was definitely an important factor for realization of a broad adoption of Li-ion batteries for electric vehicles and overall DOE objectives. Higher energy batteries without the right and multiple safety protections might cause an unacceptable number of incidents. Using inherently safe materials was the most reliable protection method. Another reviewer stated that issues related to the safety of Li-ion cells which were identified and probed through the SNL's abuse tolerance studies needed to be solved in order to promote the mass commercialization of plug-in electric vehicle technologies. In addition, the same reviewer commented that an increased market share of plug-in EVs in the U.S. would lead to petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that the Orendorff group (at SNL) had an extensive program addressing many aspects of abuse tolerance in Li-ion batteries and provided numerous sets of data to support this. Another reviewer stated that to evaluate the safety of batteries with 18650 cells was a legitimate approach. Additionally, comparing various technologies by using the same equipment and conditions was also a vital and convincing approach. This reviewer acknowledged that the goal of new electrolyte development, especially Ionic Liquid, was rather aggressive and cause for concern regarding dilution of effort. On the other hand, continued this reviewer, toxicity of gases generated from thermal abuse condition should be evaluated in addition to flammability of batteries. The same reviewer added that at least decomposition materials erupted from cells during abuse tests needed to be analyzed as this analysis would also provide insights for the degradation process mechanism.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

In general the testing was commended by the reviewers. The first reviewer stated that great progress was demonstrated for a quantitative evaluation method (isothermal calorimetry) with 18650 cells, including establishment of the fabrication capability and further noted that this method was broadly applicable to other new materials development. In addition, the results of RS2 were impressive as the effect of RS2 was clearly demonstrated and its limitation for higher current was quantified. The first reviewer also observed very good validation of the concept for LiF/ABA. The second reviewer said that it was clear that the test capability



was set up well to what was wanted, while the safety test could be done combined with the gas analysis tool including the cell fabrication. The final reviewer stated that the measurements conducted in this lab supported investigations of materials created in collaborating labs. Additionally, this reviewer felt that while there did not seem to be a major breakthrough in this batch of results, the research approach and data sets seemed solid and thorough.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that collaborations to obtain various materials were well planned and performed, though there may be room for further collaboration regarding analysis for decomposed gases and cells after abuse tests, such as with ANL. The second reviewer felt that the Orendorff lab appeared to be the go-to place for other national laboratories to understand how batteries and their constituent materials could be made to withstand expected abuse conditions. Furthermore, its relationship with these other groups was symbiotic, resulting in the need for deep collaboration. The final reviewer suggested that the DOE team consider how it can deliver its knowledge to cell developers and manufacturers in the United States.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that all remaining milestones and future plans described were reasonable. For the remaining project years, this reviewer requested that a specific plan be presented to understand the mechanism explaining why the non-HF generating electrolyte does not give runaway type decomposition while the LiPF_6 electrolyte does on the thermal abuse test. With that, continued this reviewer, material selection of ABA would be performed more logically. The same reviewer asserted that in addition to overcharge and thermal abuse, other failure modes should be analyzed and their priorities should be considered. Additionally, although no specific plan was described and the reviewer was uncertain whether these were planned, mechanical abuse and nail penetration tests were example areas of concern from a safety perspective. The second reviewer said that the researchers were looking at the results from the current studies to give direction to the next steps in the various projects in which these laboratory studies played a role.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers agreed that the funding resources were sufficient. The first reviewer observed that after establishing equipment and its protocol, rearrangement of the budget would be required for the next fiscal year. This reviewer further stated that the current budget level should be sufficient to further expand the types of abuse tests, and that the budget was not excessive. The second reviewer said the activities in the laboratory seemed congruent with the level of funding.

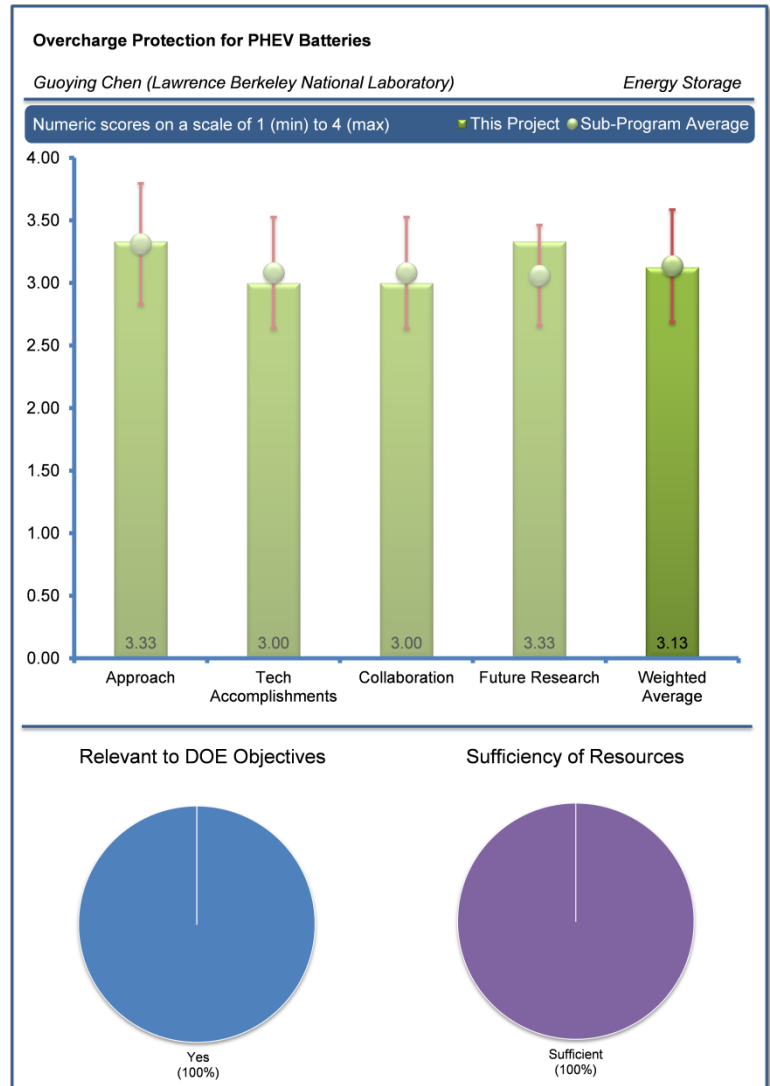
Overcharge Protection for PHEV Batteries: Guoying Chen (Lawrence Berkeley National Laboratory) – es037

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that if the development of the overcharge protection was successful, then it would simplify the BMS and reduce cost of the systems. The second reviewer described that Li-ion cells were intolerant to overcharge, unlike the aqueous rechargeable system, which may lead to either reduced cycle life or more importantly a thermal runaway. Li-ion cells were thus required to be well-matched to start with, and further, protected and balanced during cycling using sophisticated electronics. Attempts to achieve built-in overcharge protection through redox shuttle have not been quite successful yet, due to limitations from the solubility, diffusivity and compatibility of the redox species. The objective of this program was to develop a reliable, inexpensive overcharge protection system using electro-active polymer for internal, self-actuating protection. Improvement in safety and enhancement in cycle life were crucial requirements for the widespread use of Li-ion batteries in PHEVs. The third reviewer indicated a reserved yes. Overcharge protection on the individual cell level would be of some advantage to pack level safety and even performance. As noted, there were competing approaches (electronic, shuttle) that this approach would need to be compared with. Ultimately, the reviewer was not sure this was the highest priority issue being faced. On the other hand, this was not a highly funded effort so the value was not out of line.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the approach seemed well thought out and logical, within the scope of the program. The first reviewer suggested that while at this stage the development was quite fundamental, that it would be prudent to establish some level of success criteria on a commercial level to make sure that competing approaches did not hold some unobtainable cost or processing advantage. The second reviewer stated that the approach sounded interesting and overall, was feasible and quite relevant to the activities of ABR. The reviewer summarized the approach in several statements that followed. The approach focused on developing electro-active polymers that could switch from a non-conducting to conducting state at potentials slightly higher than the cathode charge potential. The conductivity in the polymer changes by several orders of magnitude and the changes were fairly rapid and reversible and the cell voltage regulated the resistivity of the polymer shunt (e.g., polythiophene). Such a polymer layer could be placed in series or parallel to the anode and cathode stack, which would provide a bypass or shunt for the charge current. In cases where the polymers did not have the oxidative or reductive stability, a bilayer arrangement was adopted with individual high-voltage and low-voltage polymers for the cathode and anode side, respectively. However, due to the polymer sandwiched

between or shunted across the anode and cathode, there would be some enhanced self-discharge through this polymer. Also, the energy efficiency in the absence of overcharge would be reduced by this polymer switching. Possibly having the polymer from conducting to non-conducting phase (like PTC in 18650 cell) and have one for the anode to prevent lithium plating would be interesting options here. The last reviewer said that the use of self-discharging conductive polymer may not interfere with the cell chemistry.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said good progress had been accomplished in terms of: identifying an electro-active polymer (PFOP) with an extended stability to 4.25 V (its stability at the anode appears to be poor), which was tested against three cathodes (LiFePO₄, NMC₃₃₃ and 4V spinel oxide); modifying the electroactive polymer to increase the sustainable current density; developing process for preparing the electro-active polymer-fibers and their composite mats were prepared by an electro-spinning technique; and characterizing the behavior of the fibers as charge carriers in Li-ion batteries in an *in situ* optical cell. In addition, this reviewer stated that a more comprehensive set of performance data, for example on the ASI and power densities of the cells with such electroactive polymer as a function of state of charge, the penalty in energy efficiency etc., are to be assessed to establish the viability and feasibility of this approach for overcharge protection. The second reviewer felt that technical data at the cell level was quite interesting and suggested that it would be important to characterize the physical handling properties of the material if it was contemplated to be inserted as a separator material replacement.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated there was some useful collaboration within LBL and with external partners on polymer synthesis. Collaboration with a battery manufacturer, to demonstrate these materials in an 18650 cell for instance, would be beneficial at a later stage. The second reviewer agreed that collaboration with a cell developer would add to the value of the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer stated that future studies involved continuing efforts to: demonstrate the benefit of such electroactive polymers in cells; examine other modes of deploying the polymer within the cell; develop high voltage electroactive polymers for lithium-excess high voltage cathodes; and scale up the effort through industrial partners. The reviewer felt that these studies were well directed towards the project goal of providing efficient and low-cost overcharge protection for Li-ion cells.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agreed that the project funding was sufficient. The first reviewer stated that the budget looked reasonable for this effort. The second reviewer was in agreement and stated this was a very academic environment right now, which was fine for this current stage. This reviewer suggested that if the project were to receive any significant commercial interest that it would need to move up through the system to a more commercially focused area. Finally, this reviewer noted that this was a modestly funded area (correctly so) and the work had shown good use of these modest resources.

Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes: Wesley Henderson (North Carolina State University) – es057

Reviewer Sample Size

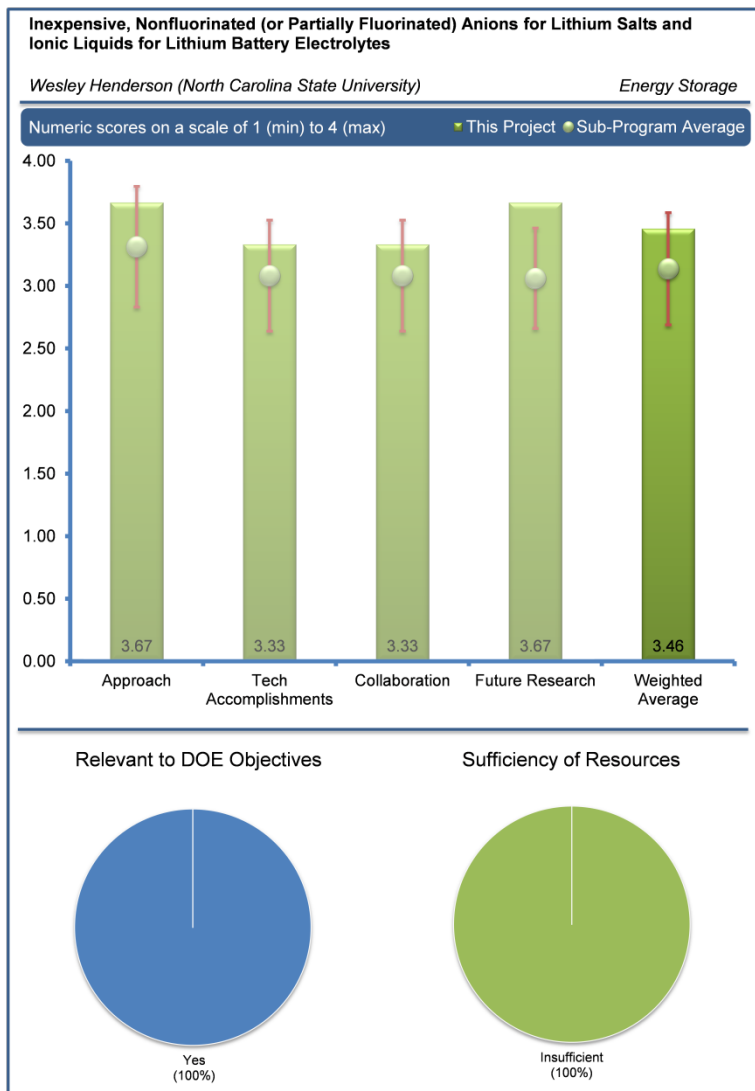
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that this approach showed promise and stated that for improved cell performance a new electrolyte with a wider voltage window, thermally stable as well as forming a protective layer on the surface of the anode, was essential for the next generation Li-ion battery system. The second reviewer was pleased that cell making and testing equipment was now available in the PI's laboratory as this would increase the relevance to DOE goals. Additionally the second reviewer said that without an electrochemical evaluation it was very difficult to see the relevance and suggested the voltammetry of the test electrolytes on platinum and glassy carbon would be a valuable initial screening technique that could be simply done would also increase the relevance of the work, particularly towards high voltage systems. The final reviewer commented that the project team was looking at new electrolytes that used a combination of new salts and also much higher concentrations than usual, and that this work also involved development of ionic liquids for Li-ion batteries. This reviewer said success in this area could help modify and stabilize the interfacial properties of the electrodes, which could improve cycle life and lifetime of high energy batteries. In addition, some of this work could reduce electrolyte flammability and stability.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer affirmed that the basic approach was sound for seeking new electrolytes for lithium batteries. The ideas were novel and had a good chance of success in chemical terms. The reviewer observed that the difficulty would come in addressing such issues as validation and costs. The validation issue should have a broader focus as suggested under relevance. Electrolytes should be subjected to voltammetric tests after the conductivity/structure screening, followed by cell tests for successful candidates. In addition, the ideas of mixed ionic liquid (IL)-salt-solvent should be pursued aggressively as these solvents presented a truly novel approach to new electrolyte scenarios. In this vein, the viscosity of the electrolyte should be assessed as well as wetting properties toward electrodes evaluated to assure compatibility with electrode structures (a simple drop spreading test may be sufficient for wetting). This reviewer pointed out that the dianion approach seemed to be a difficult one with little payback. The closoborane dianions were carefully evaluated some years ago with no particular advantage shown. The simpler dianions generally have very low solubility in most aprotic solvents. The second reviewer indicated that the investigators have chosen electrolytes with chelated and - anions such as LiBOB and TFSI and solvents such as nitriles and lactones. This reviewer felt as though nitriles



had shown good promise. The final reviewer expressed that this group was using a variety of experimental and modeling work to better characterize and understand the physics and interfacial chemistry of concentrated solutions. The early emphasis on acetonitrile as a solvent remained somewhat questionable as the reviewer did not believe this had much relevance to Li-ion batteries. However, the project team felt that this was a good model system that enabled it to hone its techniques for more recent work that was more relevant to EV applications. The reviewer remarked that the project's technical approach has been outstanding and the use of modeling in close collaboration with experimentalists has worked out extremely well.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer pointed out that the progress in the past year has been very good. The IL approach seemed very interesting. Some of the new anions looked promising as well. For continued progress in the coming year it was essential to activate electrochemical tests in the PI's laboratory, as mentioned above. The reviewer suggested that less expensive ILs should be considered. The second reviewer acknowledged that the synthesis of new materials had been developed and electrolytes with LTDI showed good potential for use as new electrolytes with high stability and good conductivity. The final reviewer asserted that this group had significantly advanced the state of the art in terms of understanding the molecular interactions in concentrated salt solutions, which had much broader implications beyond the battery world. This was difficult work, but, through the project team's close collaboration and meticulous data analysis, the project team had provided new insight into these poorly understood materials. Moreover, the researchers also found several cases where the literature interpretation of data was in fact wrong. This reviewer mentioned that while such concentrated solutions were very viscous, the high salt content could make up for this to some extent, and the researchers have studied these materials in their liquid state down to very low temperatures (-100°C). The PI showed an extremely impressive grasp of these complex materials, along with a gratifyingly high level of enthusiasm. The researchers had done a lot of work together and have been able to explain their results, something often found more valuable than the results themselves. The reviewer added that the project was moving from physical studies into cell testing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer expressed the need for an increased level of collaboration, particularly in the electrochemical area. The BATT cell building should be activated as suggested by the PI as well as working with Dr. Whittingham and others such as Robert Kostecki. The reviewer suggested that by all means the project should continue the NMR collaborations as much as possible as this was a complementary technique to the Raman work. The second reviewer remarked that the project had reached out to strengthen its choice of path to new materials. O. Borodin in particular provided quantum mechanical calculations and molecular dynamic calculations to help direct the path for success. This reviewer added that Zhi-Bin from Wuhan supplied the LiFSI for use in ionic liquid solvents and V. Bataglia supplied cathodes for test cells. The final reviewer pointed out clear evidence of very close collaboration between NCSU and the modeling folks (including the University of Utah and Oleg Borodin at the United States Army). This reviewer added that the project was moving from physical studies into cell testing and so would need to leverage their linkage to the LBNL testing program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed the need to expand the electrochemical testing with voltammetry on platinum and glassy carbon. Another reviewer commented that the characterization of the new electrolytes and search for new electrolytes would be continued. The reviewer stated that work would concentrate on ionic liquids as the solvents with the molecular calculations and ragman studies to understand the interaction of ionic liquids with the electrolytes. The final reviewer observed that in addition to adding to their existing physical studies (conductivity, viscosity, etc.), the project team had good plans to characterize the chemical nature of these materials for use in an actual battery – looking at chemical stability, corrosion, performance in actual cells. While the PI was well aware of the drawbacks of ionic liquids as practical electrolytes, the project team had identified some very promising approaches going forward.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agreed that funding for this project was insufficient. The first reviewer suggested that if the voltammetry equipment was not available, then this should be added to the laboratory. The second reviewer remarked that, given the success of the project, a funding increase should be considered due to the more rapid progress on this important finding on new electrolytes and their potential. The final reviewer fully supported this work and believed that it was actually underfunded. This reviewer recognized that it was not at all clear that these electrolytes would make it to commercialization for EV batteries, but the reviewer felt that this PI was extremely well-placed to explore this space in a designed, scientific exploration, rather than the empirical approach that was so often seen in this area. The final reviewer would very much like to see the PI's work continue and expand to see what the PI could come up with. Ionic liquids and the concentrated blends offered a whole new class of electrolytes that could have a major impact on future batteries. This reviewer asserted that these were the folks to explore that space and wanted them to be given the chance to run with their ideas and to see what the researchers could come up with.

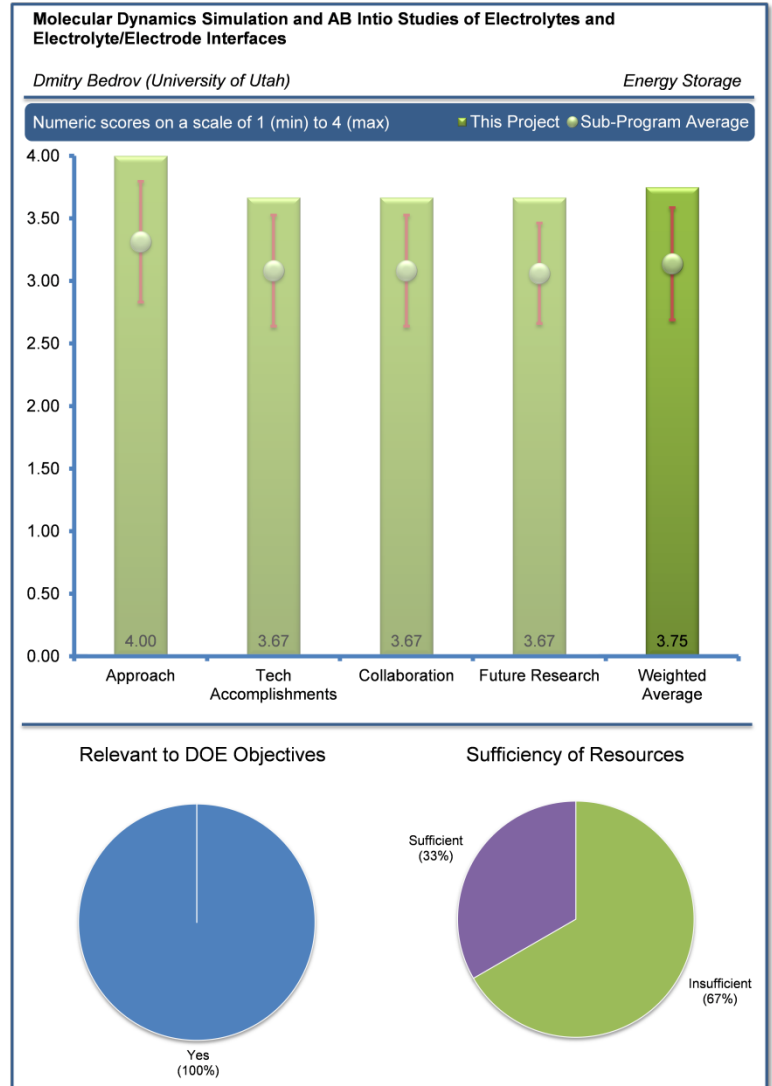
Molecular dynamics simulation and AB-Intio studies of electrolytes and Electrolyte/Electrode Interfaces: Dmitry Bedrov (University of Utah) – es058

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented that the electrolyte was an important contributor to performance, cost and safety, and that this program intended to improve the understanding at a fundamental level of the electrolyte and its interaction with surfaces. Another reviewer stated that molecular dynamic calculations were the best method to identify promising avenues and speed the development of new battery technology. This reviewer added that *ab initio* calculations provided insight into structure and properties essential for future progress. The same reviewer opined that the investigator was a valued resource and has shown the ability to assist others in their work while carrying out the investigator's own projects. The final reviewer noted that the project was looking at the chemistry and physics of high voltage electrolytes and electrode interfaces, using *ab initio* modeling techniques. Both aspects were critical if high energy that some of the new cathode materials promise to deliver is ever to be leveraged. This reviewer added that this work aimed at improving stability that could result in higher cycle life and a much longer calendar lifetime of high energy density batteries for EV applications.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer expressed that this was one of the most complex undertakings in the program and considerable work has gone into developing an approach which yielded results pertinent to the DOE program as well as suggestions for experiment to test the computed results and to lead to better electrolytes. The second reviewer stated that no one technique was capable of meeting all the requirements for identifying the most efficient direction for scientific investigations. This reviewer added that a combination of *ab initio* calculations, reactive molecular, dynamics simulations, as well as classical molecular dynamic simulations were employed. The third and final reviewer remarked that this work provided understanding on an atomic scale that experimentation simply could not provide. The final reviewer added that this group did excellent modeling studies and that the group also worked in close collaboration with experimentalists to deliver relevant insights. In this project, the project team was also looking at materials very relevant to new high energy density batteries, both from and electrolyte and electrode point of view. Often, one of the hardest things for such modelers to deal with was deciding exactly what to model. The final reviewer felt that this group remained very focused and relevant to the task at hand.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer explained that the oxidative stability of electrolytes was the key to high voltage operation. The results confirmed that many solvents may be oxidized through the solvated ions. This work should continue to develop as many examples of low energy pathways for oxidation as possible for as many solvents as possible to bring further understanding to the field. The first reviewer remarked that validation of the electrolyte simulations would be tested using Raman spectroscopic; results had given confidence to the simulations. This work should also be expanded to as many test cases as possible. The second reviewer noted several aspects of the project. The reviewer listed *ab initio* calculations on oxidative stability and decomposition pathways of electrolyte components: Molecular dynamic (MD) simulations of Li-ion transport through an SEI; MD calculations of bulk electrolyte and their interaction with electroactive surfaces; and *ab initio* calculations of nickel-manganese spinel particle surfaces. This reviewer also stated that much of the work had been in conjunction in support of other DOE projects. The final reviewer stated that the project's ability to show exactly how the presence of an anion such as BF_4^- could influence the stability of a solvent by acting as a bridge in oxidizing a solvent at much lower potentials than it would otherwise occur if a different, more stable salt were used. Thus, for the first time, the researchers are able to correctly predict the experimental oxidation potentials for a variety of solvent/salt combinations. Although there was some variability among experimental oxidation potentials (depending on the substrate, current density cut off and even the purity of the materials used), the project had presented a consistent approach that meshed experiment and theory very well. The reviewer added that more importantly, the project team explained exactly why some salts destabilized the solvent to oxidation. This was a very important issue to understand as there is a move towards higher voltage cathodes in order to improve battery energy density. The reviewer acknowledged that the team had shown which faces of the high voltage spinel $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_2$ are less or more stable and provided insight on the electrolyte/electrode reactions at the interface. The project models showed the actual structure of the electrolyte layers adjacent to the electrode surface, which could vary considerably from that of the bulk electrolyte. These effects were hard to determine experimentally or to predict theoretically without this kind of modeling work, but yet the effects are key to really understanding the surfaces.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the collaborations with W. Henderson on Raman spectroscopy used to compare results from simulations had been especially productive. This reviewer added that other collaborations were important to maintain. The second reviewer stated that the project provided significant services to ANL, Arizona State, NC State, ARL, Rhode Island and Pennsylvania State University. Additionally, this reviewer acknowledged evidence of a really productive researcher. The final reviewer observed clear evidence of a very close collaboration between the modeling folks and various experimental groups, which in the reviewer's view was an essential element of all successful modeling initiatives.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer listed: study electrolyte oxidative reactions of NMC surfaces with electrolytes; study the composition of the electrolyte-electrode interface as a function of voltage; Li-ion transport through the SEI and SEI composition; continue collaborations with ARL, URI, Pennsylvania State University, etc. This reviewer also suggested investigating the role of sacrificial additives for the SEI. These were common to Li-ion electrolytes but were closely held as proprietary to electrolyte suppliers. The second reviewer commented that understanding these interfaces was going to be crucial in developing solutions that provided the increase in energy that these and other new cathodes could deliver while still maintaining (or improving) high cycle and calendar life. The second reviewer added that indeed, the main value of this and other modeling work was not predicting reality but in explaining reality to a depth that could not usually be attained by experimental studies alone. Everything about stability and lifetime revolved around localized interactions in and between the material phases and this group was well-positioned to really explain these interactions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that that the funding was sufficient and did not provide further comment, while the other two reviewers affirmed the project funding as insufficient. The second reviewer asserted that while the investigator seemed to be overloaded with work,

the PI's level of productivity was amazing. The final reviewer expressed full support of this work and believed it was actually underfunded. In particular, the final reviewer stated more studies should be done on different types of cathode/electrolyte interface reactions, including work on cathodes coated with stabilizing layers.

Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Li-ion Anodes: Prashant Kumta (University of Pittsburgh) – es061

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

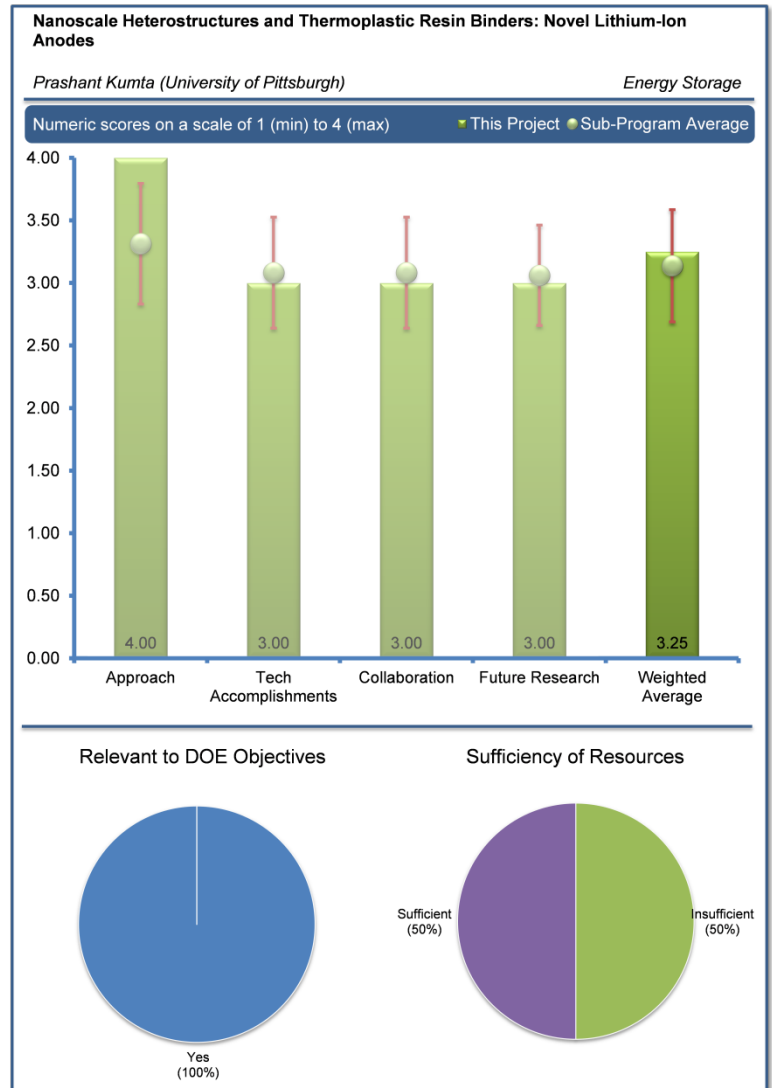
The first reviewer remarked that eventually a higher energy anode to replace graphite was essential. The anode material must have lower irreversibility (first cycle loss) than graphite, as well as a higher capacity, better efficiency, and longer cycle life. The second reviewer stated that silicon anodes were the most promising anodes for delivering a major boost in Li-ion energy density. This reviewer pointed out that the PI was trying to improve upon the researcher's previous excellent performance with silicon anodes for high energy density batteries. Some of this work also looked at low cost manufacturing and materials designs for S anodes. Thus, these designed materials had a decent chance of being manufacture-able.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the approach was to identify new nanostructured anode materials to replace graphite. It must have a lower first cycle loss, equal or better coulombic efficiency and a longer cycle life. A new thermoplastic binder with elasticity would likely be necessary as well. Initially, micro crystalline silicon would be studied as a possible candidate. The initial work would be directed at silicon in the micro and nano particle as well as amorphous forms. A new thermoplastic binder with elasticity would likely be necessary as well. The first reviewer remarked that initially microcrystalline silicon would be studied as a possible candidate. The second reviewer asserted that the PI had explored a diverse and very interesting set of approaches to attain high anode capacity, good cycle life while also reducing the initial irreversible capacity loss than was a major concern with Si anodes. In particular, the PI had focused on designing material structures with the functionality that was needed in a methodical way, rather than empirical studies that was often seen in this area. This reviewer indicated that the PI had built on past expertise and was designing and building up interfaces to minimize the irreversible capacity losses that could be associated with having too thick of an amorphous layer of carbon present on the Si anode material. The same reviewer further added that the PI was pursuing several approaches simultaneously and this increased the chances of success to make this a more robust program.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that initial work has identified a material with 800 mWh/g with 40 cycles demonstrated using surface control additives to control stability. The reviewer noted a Coulombic efficiency at 99.8% with an irreversible loss of 13.5% on the



first cycle using a surface control agent. Initial work on binders showed some improvement over PVDF materials. The second reviewer acknowledged that this work showed an excellent understanding of the surface chemistry and how the impacts on anode functionality, irreversible and reversible capacity, and cycle life occurred. This work showed two different approaches that had been very successful. One used a salt and polymer interface that led to a stable material with excellent cycle life although capacity was limited to 800-900 mAh/g (which is still far better than carbon, of course). One of the researchers' better results was an anode that delivered 1,200 mAh/g while being very efficient (high cycle life) and having an irreversible capacity loss of only 15%. While the latter figure was still somewhat high, it was less than half of that seen in previous work. Moreover, some of this could be balanced out by the irreversible capacity lost at the cathode and/or by adding lithium to the cell in other ways. One indication that the value of this work to the program was well recognized was that it was the first highlighted in the overview presentation given by Tien Duong (ES108, Slide 7). The second reviewer pointed out that the other approach used an ICA approach that could boost capacity to 2,000 mAh/g (about half of the theoretical value), but this material faded quite rapidly. It would be interesting to see the results of combining these approaches. The second reviewer felt that like many of the nanostructured approaches, manufacturing costs remained questionable. However, to address costs, the PI also had demonstrated good capacity with a low cost system based on using sugars as a binder. This reviewer stated that while cycle life was not yet there, this work was also worthwhile.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer observed collaboration with Ford, LBNL and the University of Pittsburgh. The second reviewer remarked that the presentation listed some important collaborators although it was not really clear how active the collaborators were in this program. The second reviewer also added that close collaboration would become more important as these materials migrated up the ladder and became candidates for full cell testing.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer suggested continued preparation of silicon anode materials with 1,200 mAh/g capacity; and identification of additives to control first cycle loss and new thermoplastic binders in coin and pouch cell configurations. The second reviewer remarked on two elements of a promising anode and stated that there was indeed a good chance that combining them would be successful in assuring good cycle life while enabling a reasonably high reversible capacity that would be a step improvement over conventional graphite anodes.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers were in disagreement. The first reviewer deemed the funding sufficient and provided no further discussion. The second reviewer felt funding was insufficient. The second reviewer expressed that the quality and the sheer amount of work done by this PI was very impressive and recommended an increase in funding for this PI.

Metal-Based, High-Capacity Li-ion Anodes: Stanley Whittingham (Binghamton University-SUNY) – es063

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the anode performance was a limiting factor in Li-ion cell performance and noted that improved performance was essential. The second reviewer observed that this program was aimed at developing a tin-based anode for high energy density batteries. The reviewer remarked that this was important because, while not quite so attractive as silicon from a capacity viewpoint, it still offered a chance to significantly boost cell energy density while avoiding or at least alleviating the stability and safety issues researchers were running up against in trying to get silicon to work. As such, it represented an important area of research for the EV program.

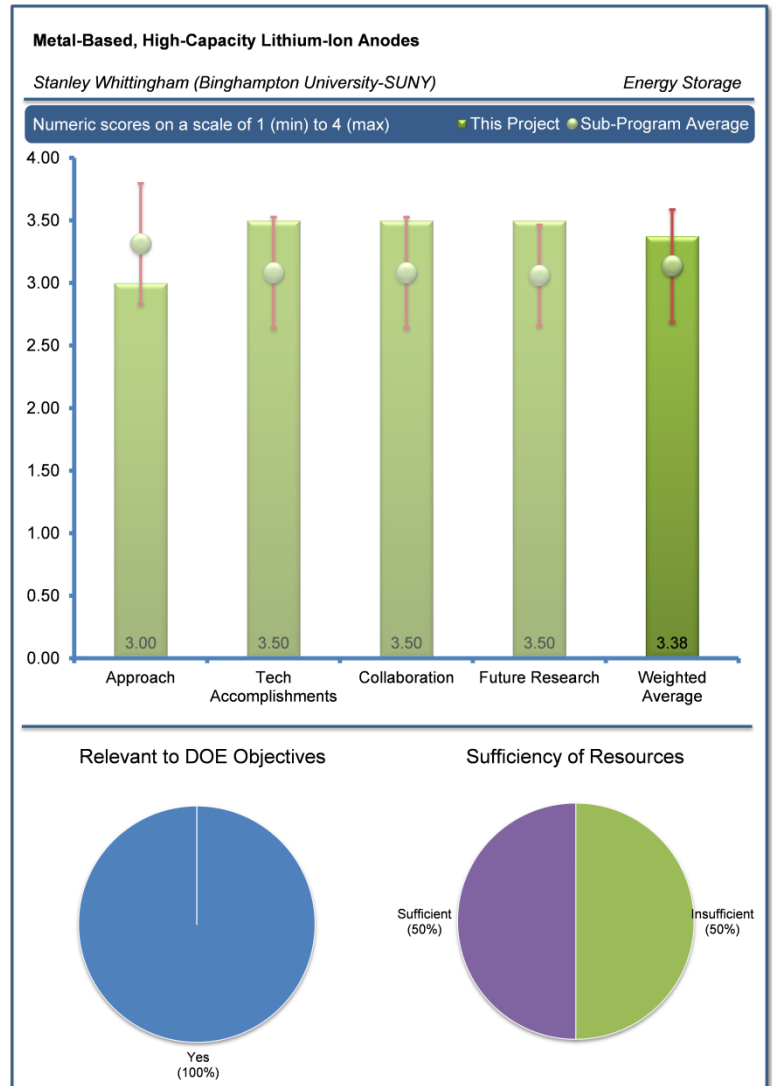
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer expressed that emphasis on low-cost tin and silicon materials should result on new high performance materials. This reviewer added that one or both may be successful. The second reviewer felt that the basic premise was good - going for tin which, while not as energetic as silicon, was still potentially far better than carbon anodes. Moreover, tin promised to be more stable, less reactive and maybe safer than silicon. As such it represented an important area of research, especially if silicon could not be made to work. The second reviewer pointed out that almost everyone else was looking at silicon, but silicon was a somewhat risky approach, especially for EV applications where long calendar and cycle life were required. It actually may be more practical for consumer goods where such demands were less stringent (although safety was still absolutely critical). The second reviewer expressed that in a way, the work on tin should be viewed as insurance in case silicon does not prove successful. The second reviewer did not think that starting with Sony's Sn/Co/C matrix was really well thought out. This reviewer remarked that this technology obviously never went anywhere, most likely because it had a poor cycle life. The approach seemed rather empirical and the reviewer hoped for a more designed approach to developing a Sn anode.

The second reviewer expressed that in a way, the work on tin should be viewed as insurance in case silicon does not prove successful. The second reviewer did not think that starting with Sony's Sn/Co/C matrix was really well thought out. This reviewer remarked that this technology obviously never went anywhere, most likely because it had a poor cycle life. The approach seemed rather empirical and the reviewer hoped for a more designed approach to developing a Sn anode.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer acknowledged that Dr. Whittingham had the knack to develop new technology that met or exceeded expectations once the program started. The second reviewer asserted that the group appeared to have identified a promising alloy for follow-up work. While capacity was about two times that of carbon, the higher potential of tin anodes (leading to a lower cell voltage) somewhat reduced the potential gain of these tin-based anodes in real cells. Nevertheless, these materials remained very interesting and should be followed up on.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted work with PRIMET, LBNL, BNL and NYBEST. The second reviewer observed that the project team seemed to be working well both with material companies to make these nanomaterials and also with the DOE labs for cell testing (LBNL) and fundamental studies (BNL).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that the new work continued the atomization of the nano-Sn-Fe and Sn materials. The second reviewer stated that despite some reservations about the approach (cobalt), the team had identified some promising approaches that should be followed up on. The second reviewer observed that the PI was well able to follow up on their initial findings in collaboration with the partner labs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that the project could use more funding given the productivity and creative ability. The second reviewer found the funding sufficient and pointed out that the annual funding for this project was not large, but continuance at the same or slightly higher level seemed warranted by the promising findings to date.

Electrolytes - Advanced Electrolyte and Electrolyte Additives: Khalil Amine (Argonne National Laboratory) – es066

Reviewer Sample Size

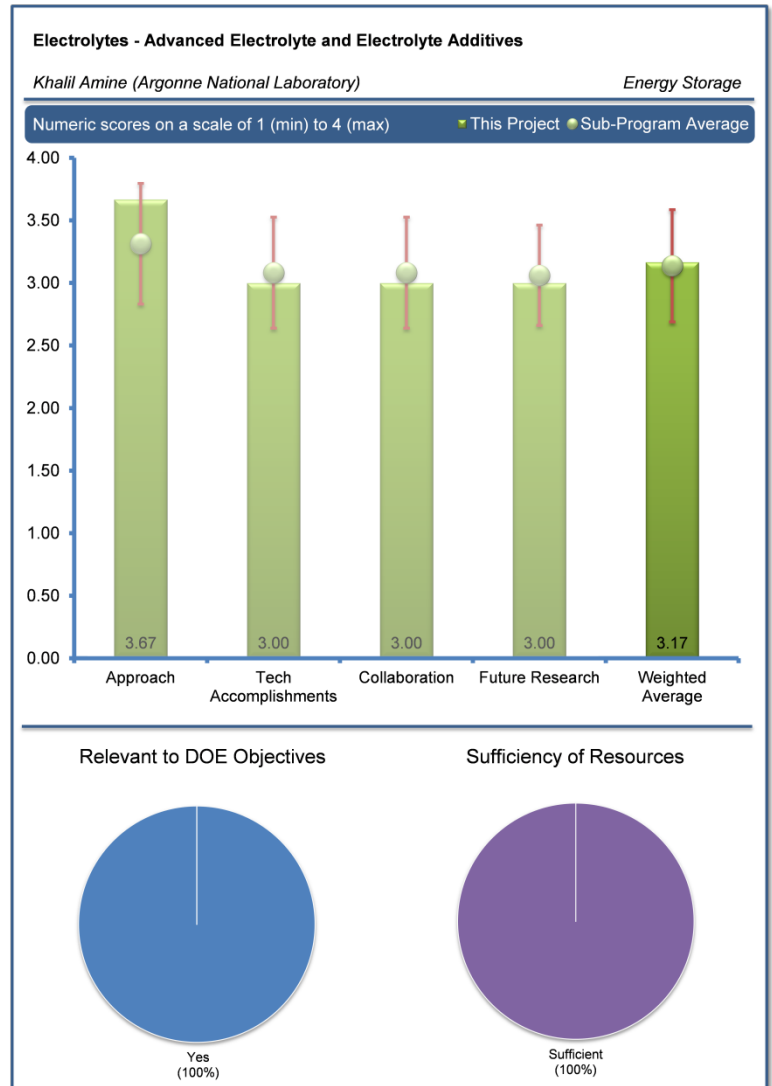
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the use of additives to improve cycle life was well established in battery chemistry. The search for them had been largely random until now. This program hoped to bring some scientific method into the search for new additives. The second reviewer observed that the approach was to couple calculations and experiment to develop additives leading to longer cycle life as well as a long calendar life. Quantum mechanical models of the materials directed at understanding and prediction of the functional additives for the SEI layer on active materials as well as shuttles for over charge protection by limiting maximum cathode potential. The second reviewer mentioned that the identified materials would be synthesized and evaluated in cycling and calendar life situations. The final reviewer commented that the concept was to modify the electrolyte to deliberately form a stable protective coating (the SEI) on the surface of high energy density cathodes being developed for high energy density batteries. An approach like this was needed to ensure the cycle life and lifetime of these improved materials. The final reviewer observed that this work was aimed at developing both new solvents and additives to fulfill this function.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer acknowledged that the authors were experts in the use of quantum chemistry to determine reduction potentials and reduction pathways. The approach was a good one, but it was not clear how each chemical additive would be characterized for inductive effect, steric effect, etc. of substituent groups. This reviewer stated that the experimental part would be enhanced by securing a certain level of statistical analysis for the evaluation of additives, repetition of experiments to lead to error bars, etc. This would give more confidence in results. The second reviewer commented that quantum mechanical models coupled with experiment were used to identify and develop additives to form a stable SEI layer on carbon and cathode materials as well as overcharge protection additives for longer, more reliable performance of Li-ion cells. The second reviewer commented on the project approach that it consisted of closely coupling theoretical and experimental results to better understand stability and decomposition pathways in order to guide the experimental program. The final reviewer observed that this project made extensive use of model calculations to predict material stability, oxidation potentials and degradation reactions at both the anode and the cathode. In particular, the work to better understand the electrode interface with the electrolyte and the reactions that could occur there could be very helpful in understanding this critical aspect of cell chemistry that governed cycle life and calendar life of the



cells. The project team was also using the calculations to determine the oxidation potential of possible overcharge shuttle compounds before doing the synthesis and lab work to evaluate such materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that the results for various chemical types were very good as far as it goes. The reviewer suggested that it would be helpful to try to establish some general rules as a result of the calculations, however. The second reviewer stated that the modeling work seemed to provide tremendous insight. However, the success in transforming this insight into solutions was not yet there. This reviewer felt that some of the additives, such as TTT, may work out but a dramatic improvement in capacity retention was not supported by the data shown. The second reviewer stated that most of the differences seen in Slide 15 were really in the initial capacity that then carried on over to the subsequent cycles. Thus, capacity maintenance with 0.2% TTT did not seem to be markedly better than control. Also, the meltdown in cycle life with one percent TTT suggested that either it was not very good at enhancing stability and/or there was another cause for the abysmal performance of this lot, which then called into question the reliability of the entire experiment. The final reviewer noted that *ab initio* calculations were used to predict reduction potential, decomposition pathway and protective film formation with close co-ordination of the experimental and theoretical activities. The project team started with an analysis of the present reactions of ethylene carbonate component of the electrolyte to better understand the formation of the SEI layer on graphite materials. The reviewer stated that the project team included DBBB additive limits cell voltage to 3.9 volts and added that the team mentioned that this did not hinder cycling at least up to 200 cycles.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that the more collaboration of quantum chemical researchers, the better. The second reviewer listed collaborations with O. Borodin (ARO), D. Bedrov (University of Utah) and K. Gering (INL). The final reviewer mentioned good collaboration between the modelers and ANL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer reported the following: improved modeling based on results to understand the electrolyte decomposition pathways leading to SEI layer formation; combined theoretical and experimental studies to identify new redox shuttles; and simultaneous identification of SEI additives with superior performance. The second reviewer stated that the plans seemed acceptable, but would like to see more lab evaluation of some of these materials once the modeling data showed the project had promise. The second reviewer recommended pairing up with LBNL to test some of these new materials that looked promising.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All the reviewers recorded sufficient resources for this project. The first reviewer stated that resources were adequate to carry out the planned program. The second reviewer noted that funding for this project seemed about right. Another reviewer made no comment.

Development of Electrolytes for Li-ion Batteries: Brett Lucht (University of Rhode Island) – es067

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that new electrolytes with better stability were required for the next generation Li-ion batteries. This work provided the basis for identifying new materials with long life potential, especially for high voltage (above 4.5 volts) cathode materials. The second reviewer observed that the concept was to modify the electrolyte to deliberately form a stable protective coating (the SEI) on the surface of high energy density cathodes being developed for high energy density batteries. Something like this was needed to ensure the cycle life and lifetime of these improved materials.

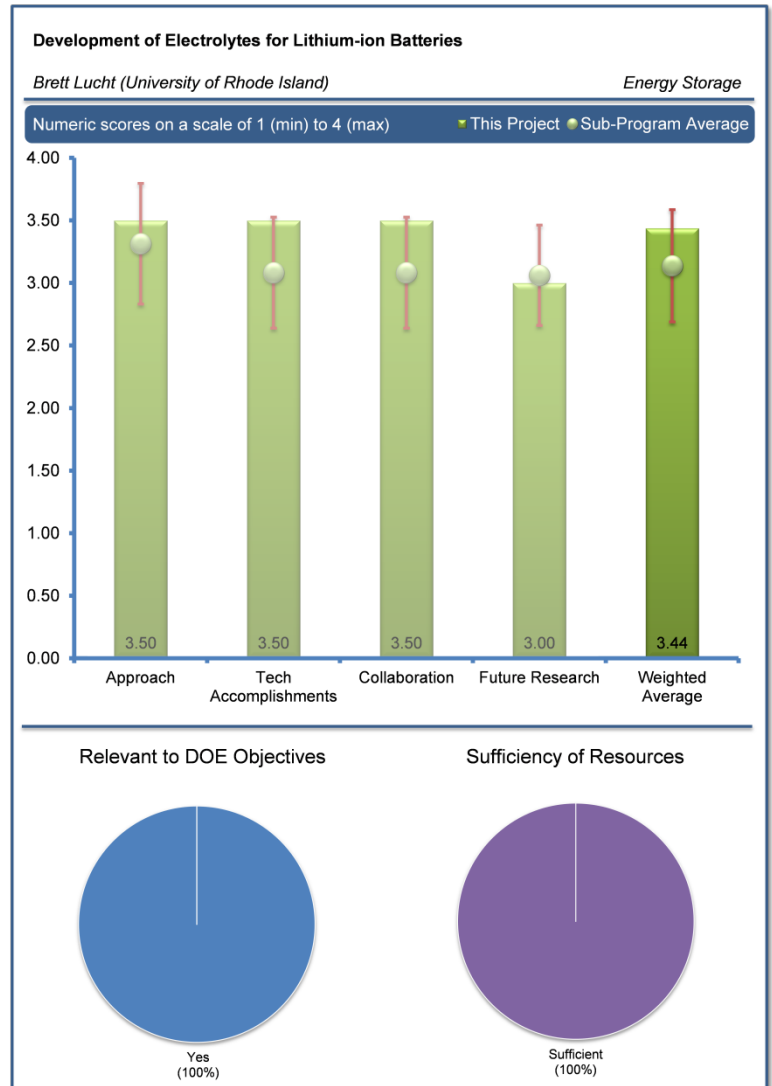
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer acknowledged that the focus of project was to investigate $\text{LiPF}_4(\text{C}_2\text{O}_4)$ solute in carbonate and ester electrolytes along with potential for additives that could form a protective film on 5 volt cathode materials, develop understanding of film

formation on cathode materials, also known as the SEI film formation on anode materials, and employ computational methods to screen and identify interesting additives. The second reviewer stated that the basic approach was to modify the PF_6^- anion structure by replacing two fluoride anions with an oxalate group for their LiFOP salt. This had the desired effect of essentially blocking the disproportionation reaction whereby the conventional PF_6^- salt forms F^- and PF_5 . PF_5 produced with the conventional salt was reactive and could cause further degradation within the cell. With LiFOP, the anion could not form PF_5 . The second reviewer also noticed that the project team was also looking at some other common additives (FEC, VC, LiBOB) and using ESCA to study their impact on the electrode surfaces. The LiFOP work therefore seemed well designed. However, the approach to the other additives did in general seem rather empirical and the reviewer hoped for a more designed approach to address solubility and reactivity.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer affirmed that the initial results showed good promise for phosphate, spinel and one-third cathode materials. Developed synthesis procedure for $\text{LiPF}_4(\text{C}_2\text{O}_4)$ solute, understanding of first cycle loss for $\text{LiPF}_4(\text{C}_2\text{O}_4)$ electrolytes. Good low temperature cycling, formation of stable SEI on graphite, good performance with silicon anodes with stable SEI formation. The second reviewer expressed that the project had shown some interesting results for a variety of anodes and cathodes. In addition, the project team had shown good performance in a PC-based electrolyte that, while it generally had better low temperature and rate properties, typically exfoliated graphite electrodes and/or generally led to poor cycle life. The project's PC/LiFOP electrolytes did



perform better at low temperature, but the conventional LiPF₆/EC blends did much better in terms of high temperature stability (55°C storage). Thus, the LiFOP was only a partial solution. The second reviewer also stated that the other main approach had been the incorporation of a base to try and suppress Mn dissolution. This seemed to be also partially successful in that it reduced the Mn concentration in the electrolyte by half. The researchers have done some good ESCA work to try and explain the results. However, overall the results to date were only fair. The reviewer did not believe that the project's conclusions about Mn dissolution or electrolyte oxidation causing fade to be novel.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer acknowledged good interaction with others including Abraham at ANL, Smart at JPL, Battaglia at LBL, as well as Garsuch at BASF and Puglia at Yardney Academics, Li in China, and Guduru at Brown. The second reviewer stated that the project had a lot of collaborators. This reviewer hoped to see input on which additives to develop in design based on modeling or mechanistic studies.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that future work built on the results of the work to date. Optimize LiPF₄(C₂O₄) electrolyte at high and low temperatures, develop understanding of film forming additives for high voltage cathode materials as well as novel/new electrolytes for high voltage cathode materials. The second reviewer commented that the plans seemed acceptable in that the project was working on addressing the right problems, but that it was far from clear how the researchers hoped to accomplish their goals. Therefore, the second reviewer was not very optimistic the project team would succeed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers agreed that funding resources were sufficient. The first reviewer stated that the resources were adequate for the present program. The second expressed that funding for this project had been rather meager, but mentioned that it was hard to recommend any increase without more evidence of a concrete design plan to come up with a better additive.

Bifunctional Electrolytes for Li-ion Batteries: Daniel Scherson (Case Western Reserve University) – es068

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer explained that the project was to develop the ability to include flame retardants in the flammable electrolytes used in Li-ion batteries. This reviewer expressed that this would remove a very serious problem of fires resulting from damage to the Li-ion battery (as happened in a recent Volt battery fire). The second reviewer emphasized that the concept was to make an electrolyte component do double duty, such as act as a fire retardant or overcharge protection. In this way, the electrolyte could provide functionality that otherwise would have to be done using a higher cost additive.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer described that the approach was to identify flame retardant ions for inclusion in the electrolyte of Li-ion cells used in electric vehicles as well as other electronic applications. Functionalized anions containing phosphorus and boron impart flame

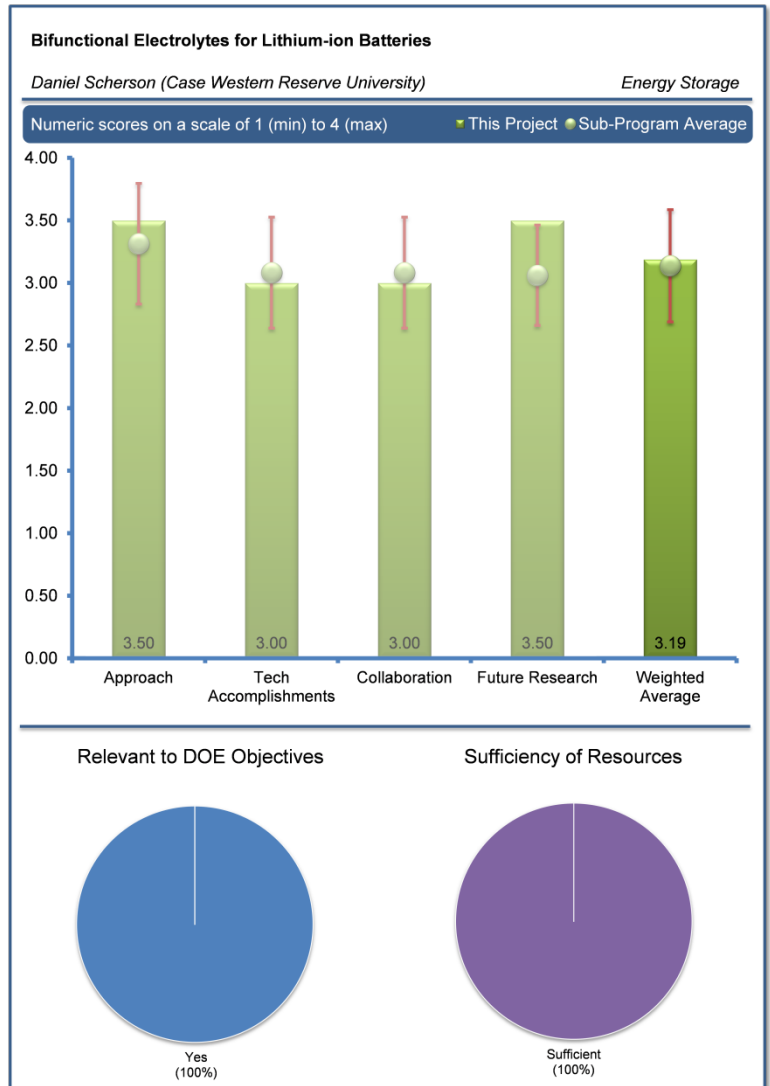
retardant characteristics to compounds fit the application would be studied using *in situ* spectroscopic means to develop guidelines for identifying functional relationship to guide the study. The second reviewer commented that the basic approach seemed fine, trying to get P, N, B into the solvent structure. The second reviewer expressed some concern that the amount of an additive or co-solvent required to confer non-flammability was often quite high with other additives reported (often 20%). The triol borates looked to be interesting; although this reviewer was not sure they would be inexpensive.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that FRION II had been identified as a good candidate for further study. Compounds such as the reaction product of $\text{Li}[\text{PHB}((\text{OCH}_2)_3\text{P})\text{O}]$ would be identified and produced in sufficient quantities to conform their activity. The second reviewer indicated that the project had shown some interesting results, but they were not very promising. This work involved a lot of synthesis work, which was typically quite slow. Having said that, the researchers really needed to pick up the pace of this work in the reviewer's opinion and get evaluation data that showed some sign of real progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted collaboration with Dayton University using their microscale combustion Calorimeter and Novolyte for coin cell evaluations of the new materials. Both were outside of the vehicle technologies program. The second reviewer described



that the synthesis work was by and large an independent project that had little need for a lot of collaboration. Now that the project had some materials, the researchers seemed to have lined up some collaborators to evaluate outside of the DOE program. It remained to be seen how responsive the project team could be without being funded. The second reviewer recommended that the researchers work with LBNL to evaluate some of their materials.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer described that the project would continue to fully characterize FRIONS, etc., to build a knowledge base for a new class of safety-enhancing materials and that the project would also synthesize LiPoBr materials and derivatives. The second reviewer explained that the plans to evaluate their materials seemed fine, although as discussed above this reviewer recommended that the researchers work with LBNL to evaluate some of their materials. The project team needed to focus and get more evaluation work done to move this project forward before the project's money ran out. Without good supporting data, this reviewer feared that this would be a dead end.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers agreed that the funding resources for this project were sufficient. The first reviewer indicated that when the project has successfully identified compounds, that additional funding should follow to develop a family of new flame-retardant materials. The second reviewer reported that the current funding level was modest, which was appropriate. The researchers did need to show that the project really had something useful to justify renewal after 2013.

Polymers For Advanced Lithium Batteries: Nitash Balsara (Lawrence Berkeley National Laboratory) – es088

Reviewer Sample Size

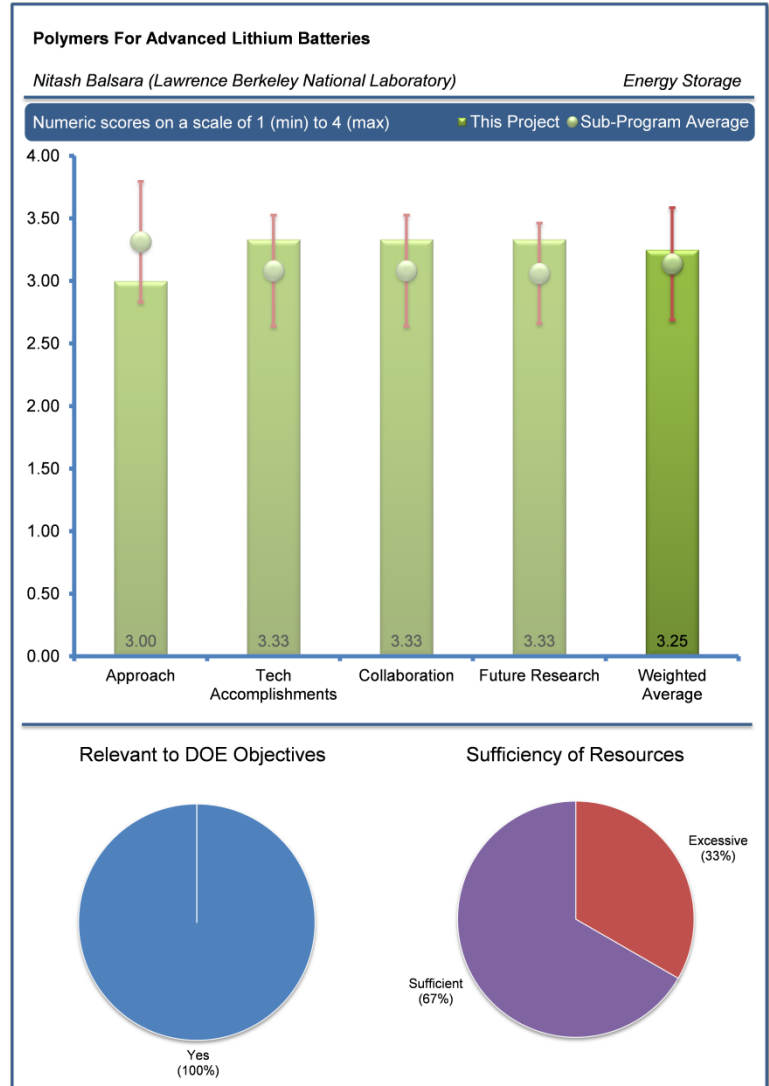
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer described the project as using a block copolymer with no liquid present to make possible a metallic lithium anode and a much higher energy density than with a graphite anode. The second reviewer stated that separators were a significant cost element of Li-ion batteries and new, higher performance, lower cost separators were essential for use in vehicle systems. The third and final reviewer explained that the researchers were exploring new polymers mainly to help prevent lithium dendrites in lithium metal cells, but also to assist in blocking the solubility of sulfur species in Li/S cells. Thus, this work was aimed at enabling lithium metal rechargeable cells which, in principle, could deliver even more energy than improved Li-ion cells and would be a boon to batteries for pure EV applications where range anxiety was an issue.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer suggested adding an alloy anode such as silicon to this work. The specific capacity could then be almost as good as lithium, but there was a little likelihood that dendrite formation would occur, which limited the present symmetrical and full cell work. Because the silicon would be encased in a block copolymer, the formation of an SEI would be minimized and the fade in capacity with cycling may also be much better than with a liquid electrolyte. The first reviewer added that the work on microporous separators should be continued with more emphasis than in 2012. The second reviewer suggested developing blends of SES triblock co-polymers and PS homopolymers to obtain nanoporous separator materials. The third reviewer reported that one of the project's approaches appeared to be to line the pores of a separator material with a copolymer that include styrene groups – these should add rigidity to the structure that could help prevent mix penetration of penetration by dendrites in lithium metal cells, for example. However, there was no way any of the polymers were going to compete with a liquid electrolyte as far as conductivity was concerned and in typical separators, the micropores were still large enough that the final reviewer did not believe conduction could be enhanced through a lining of the pore. This reviewer indicated that the researchers were looking at using the block copolymer as a stand-alone electrolyte imbibed with an electrolyte, which looked more promising. The reviewer admitted that the researchers were unclear as to what exactly some of the samples in the presentation were, especially in terms of the liquids present, and added that the slides did not make this very clear either.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that this program continued to develop new results which were cutting edge in battery research. The second reviewer stated that it developed SEO block co-polymer that resisted/prevented formation of lithium dendrites for use in rechargeable lithium metal cell systems. This reviewer felt SEO electrolytes had a significantly longer life than PEO electrolytes. The second reviewer added that Li/SEO/sulfur cells are constructed with good cycle life. The third and final reviewer highlighted that the results showed decent conductivity, but never better than uncoated separator. This reviewer did not agree that the results showed the polymers are helping conductivity. It seemed clear that the project team was simply blocking/constricting the pores and added tortuosity to the separator material. The research may have value for the strength properties, the reviewer added, but there was nothing to suggest that the project team was having anything than a physical effect of the physical and conductive properties of the separator. Unless the pores were almost completely blocked with a polymer, the reviewer saw little hope that the transport properties could even reflect the chemical nature of the polymers; it was just a question of strengthening the material while doing as little damage as possible to the materials' liquid electrolyte conductance. This reviewer suggested that the stronger separators did help delay but not fix lithium dendrite formation. This reviewer felt that there was some progress made, but asked whether this could not also be achieved with a stronger conventional separator such as a polyimide. Cycle life was still too low to be that interesting, but maybe acceptable in conjunction with other features. The final reviewer emphasized that the work with Li/S cells was much more interesting because this could be a much easier and potentially cheaper way to constrain the sulfur species in the cathode and realize both higher energy density and reduce the anode corrosion reactions in the cell caused by soluble polysulfides. This could enable low cost, high specific energy cells, although the energy density of the Li/S system was not that high (uses light materials for both anode and cathode).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted binder team leader interactions with Dr. Kumta (Pittsburgh University), Dr. Hickner (Pennsylvania State University), Dr. Liu (LBNL), Dr. Vaughey (ANL), and Dr. Hexemer (LBNL), among others. The other reviewer commented that the researchers listed a lot of collaborators, although it was not clear to the reviewer what the team was actually doing.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer suggested that the use of alloy anode could advance the progress substantially. One can refer to the comments under "approach" for more details. The second reviewer recommended quantifying the effect of SEO morphology on cycle life. This reviewer emphasized that a new separator materials was badly needed. The third and final reviewer indicated that the plans to look at full cells were good. This reviewer encouraged the researchers to give high priority to looking into the sulfur confinement issue as this could be an enabler for much higher capacity cells with better cycling efficiency.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two of the reviewers provided a response for sufficient resources, while only one provided comment. Another reviewer recorded excessive resources. The first reviewer stated that the resources were adequate for the present activity but should be increased for the development of a potential lithium metal-sulfur cell. The other reviewer indicated that candidly, \$700,000/year seemed a lot of money for this effort. Maybe focus a bit more and reduce the funding a little, suggested the reviewer.

Electrolytes - R&D for Advanced Lithium Batteries. Interfacial Behavior of Electrolytes: John Kerr (Lawrence Berkeley National Laboratory) – es089

Reviewer Sample Size

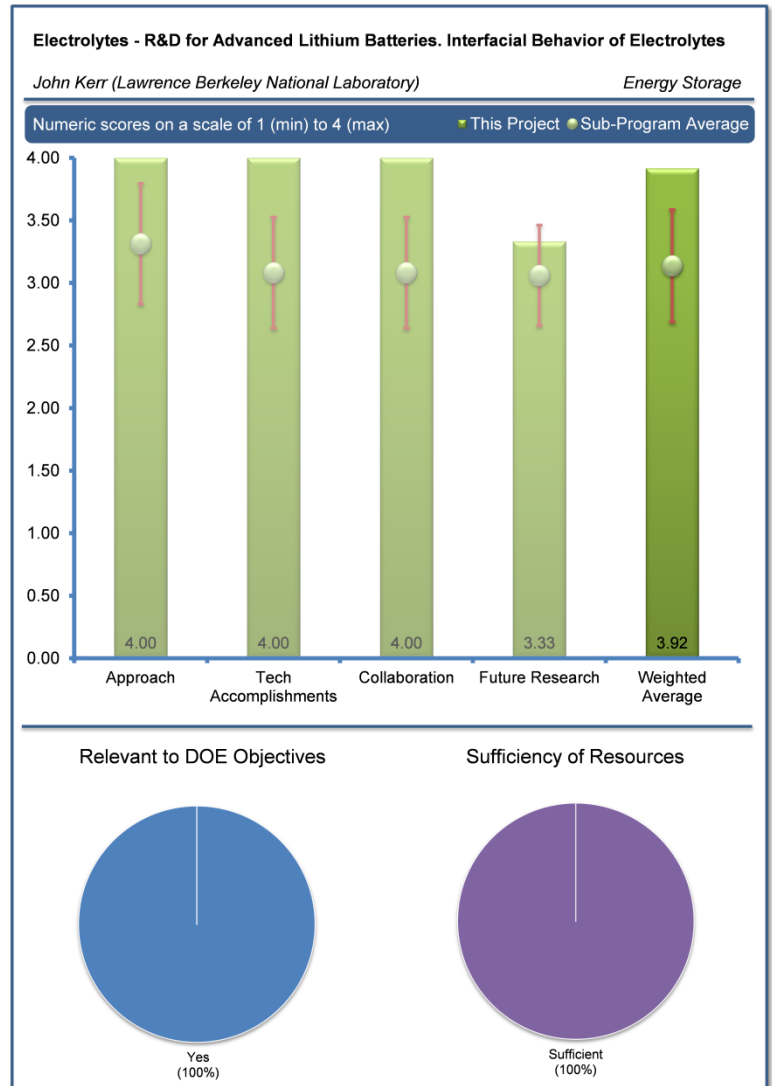
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the work was relevant to DOE objectives as the only real hope for a dendrite free lithium metal battery was through the use of single ion conductors, whether of the polymer type as studied here, or of the glassy or crystalline solid type as carried out in other studies. This approach may accomplish the use of thicker electrodes which the other types had great difficulty with. The second reviewer indicated that single ion conducting (SIC) electrolytes were being explored as alternates to the present liquid electrolyte-polymer separator construction. The reviewer added that single ion conductors eliminated concentration polarization and resulted in higher voltage cell systems, and that this represented a significant departure from present constructions. A flat discharge yielded a constant delivery of energy compared to energy curves where the current must increase as the voltage declined to deliver a constant power. The third reviewer mentioned that lithium true ionomers offered an extremely promising avenue to solid state batteries with excellent safety and performance characteristics. Lithium true ionomers also tended to be somewhat rigid which could help suppress lithium dendrites in lithium metal batteries that seemed to be the only type of battery that could deliver the kind of range the DOE desired for pure EV batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that the approach had developed some novel types of polymers which utilized polysulfone or polyether backbones with silicon-based side chains to carry the anion moiety. The conductivity of the polymers was adequate for the studies when enhanced by the use of solvents (no salt solutes) such as EC and EMC. It may be desirable to utilize other solvents such as PC or TMS (since sulfone groups are already incorporated) to enhance the polymer flow or solvents such as 2-methyl THF or Dioxolane which were found to be good for the figure of merit in rechargeable lithium. The first reviewer was concerned with the problem of making good contact with very fine crystallite materials such as LFP and that increasing the polymer fluidity may enhance this effect and lower the interfacial impedance within the cathode and possibly within the anode as well. The second reviewer stated that the study of the lithium interface was also called for since the interfacial impedance of this electrode (in a Li/Li cell) is observed to grow steadily with cycling using the SIC. The concern was that an SEI may be growing on the lithium surface which would increase the impedance steadily. The reviewer also recommended the use of determining the figure of merit for lithium deposition and stripping in order to determine the actual turnover of lithium. If this value was not high



enough, there would be serious problems in cycling an optimized system (with limited lithium present). The second reviewer mentioned that the Li/SIC-LiFePO₄ system was demonstrated and has charge-discharge curves that are flat as opposed to sloping in the normal liquid electrolyte systems. This essentially doubled the energy delivery by the battery system and would definitely be worth exploring in detail, suggested the reviewer. The third reviewer indicated that the downside of ionomers had always been relatively lower conductivity than liquid or polymer electrolytes and more especially very high interfacial impedance at the electrodes. The tremendous advantage of the ionomers was that the salt concentration did not change during charge and discharge. Thus, the research did not suffer from concentration polarization in the way that conventional electrolytes do. Moreover, polymer electrolytes that are not ionomers also fail during actual use because the concentration gradients that develop during charge and discharge also drastically changed, for the worse, the transport properties of the layers adjacent to one or both the electrodes. Previous developments had improved the transport properties of the ionomers to the point where this was no longer the limiting factor. This work was aimed squarely at the major problems with high interfacial impedance and interfacial instability. The third reviewer commented that the researchers had designed their materials and used fundamental measurements to characterize them and then followed up this work with actual cell cycling under high temperatures. This had involved some careful synthesis work and also meticulous materials characterization and cell testing.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer acknowledged that the project had made some major progress this year by showing high efficiency charging and discharging of a full Li/LFP cell utilizing SIC. The cycling was only carried out at 0.1C rates which are not sufficient for a practical cell. The data on capacity and impedance were not shown for this condition, so it was not clear what one might expect for higher rate cycling. The anodic stability of the electrolyte was good on platinum, but there were concerns about anode SEI formation on lithium metal. This reviewer highlighted that the tin oxide results were not very good for cycling, but this was not too surprising as a conversion reaction was needed to utilize the material and this may not be very reversible with the polymer electrolyte. Again, contact with the electrolyte was a potential problem for interfacial impedance. The second reviewer stated that the project has demonstrated a model system with SIC gel electrolyte of polysulfone TSFI-EC:EMC electrolyte. Cells have delivered several hundreds of charge-discharge cycles. The system was stable at 80°C and contained no Lewis acid salts such as PF₆⁻. Hydroxylated nanotubes gave improved performance. Cells with SnO₂ based anodes also performed well with constant efficiency output. The third reviewer stated that this group has shown tremendous progress and the reviewer expressed optimism that this approach could yield the kind of performance being looked for. The stability of these materials and their interfaces after extended cycling at very high temperatures (80°C) was exceptional. Their use of the imide anion, which seemed to have a general plasticizing benefit in polymer electrolytes, avoided the thermal instability experienced with electrolytes containing PF₆⁻ anions. The third reviewer added that the researchers have shown major advances in terms of avoiding dendrites for cycling Li/Li cells, attributed in part to the strength of the materials but also the transport properties of the ionomers. The same reviewer opined that the materials the researchers were developing may also prove useful as an electrode/binder matrix even if used with a liquid electrode as it may enable thicker electrodes while minimizing voltage drops due to concentration polarization in the electrode. The shape of the charge/discharge curves bore this out. Much of this work appeared to validate the theoretical predictions underpinning this project, added the reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted a very high level of collaboration with other institutions. It would be good to seek out any groups with background in rechargeable lithium metal work from pre-Li-ion days. The second reviewer indicated collaboration with Molecular Dynamics modeling with Grant Smith and Oleg Borodin at the University of Utah. This reviewer also acknowledged Marshal Smart at JPL. In addition, this reviewer mentioned that the DOE Fuel Cell Program and Applied Science program at LANL Polymer electrolytes had the potential to replace the present liquid electrolytes used in Li-ion batteries and fuel cells for new polymer electrolytes. The third reviewer indicated good collaboration, leveraging partners both within and outside this program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer reported that the future work was solidly based. The reviewer would like to have the PI consider adding a very small amount of a fluoride containing salt such as LiPF_6 in order to help build a passivating SEI. If it was thin enough it was possible that charging could occur mainly through the film rather than on the film. This could minimize the efficiency loss due to fresh lithium surface reaction with solvent. The second reviewer explained that the characterization of cell performance and evaluation of new polymer backbones should broaden the scope of this discovery. Attaching anions to the conducting carbon backbone and characterizing the new materials at Pennsylvania State University and NIST gave important information on the scope of the technology. The third and final reviewer agreed with their plans to look at the chemistry of the SEI layers. This reviewer suggested some baselining at low temperatures of their best-bet constructions, even at low rates, just to scope out the issues there. The reviewer added that also, the researchers may want to consider whether *ab initio* modeling of the interfaces could help them in their development work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated sufficient resources for the project. The first reviewer suggested that if progress continued that a doubling of the effort was in order. The second reviewer acknowledged that this group was making great progress and funding should continue. If the researchers saw value in adding modeling work, then increase funding for that.

Diagnostic Testing and Analysis Toward Understanding Aging Mechanisms and Related Path Dependence: Kevin Gering (Idaho National Laboratory) – es096

Reviewer Sample Size

This project was reviewed by five reviewers.

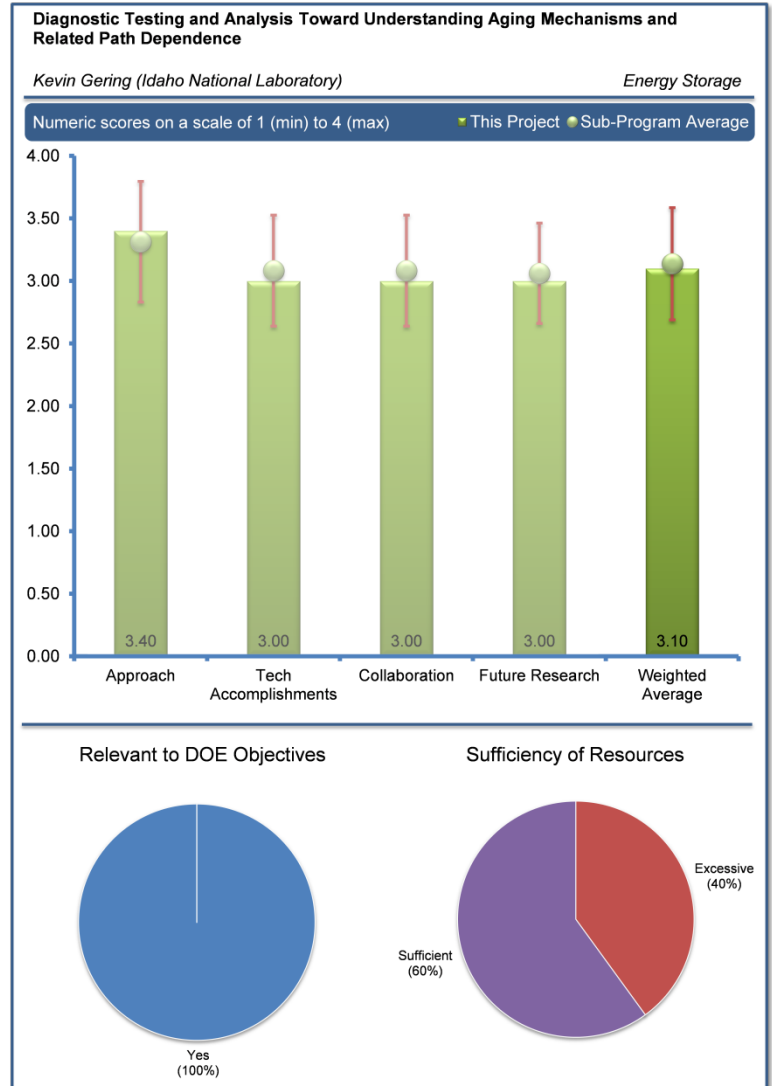
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that converting lab information into field data was valuable. In addition, the database management was valuable. The second reviewer stated that diagnostics facilitated the identification of mechanisms and challenges at the material, electrode, cell and battery pack level. Such studies were crucial and should be pursued in parallel with material, cell and pack development. In some instances, the diagnostics provided key information about widely recognized problems. In other instances, however, the diagnostics studies indicated potential problems/difficulties of which researchers may be unaware thus pointing to new research directions. The third reviewer indicated that the project should help educate DOE and BATT/ABR/etc. participants and inexperienced battery suppliers towards a greater understanding of real-world battery life challenges and requirements which may already be well-understood by significant electrified vehicle automotive OEMs and experienced automotive battery suppliers. This should

indirectly promote greater realism and efficiency in addressing DOE’s petroleum displacement objectives in DOE-funded activity and advance the capability of less experienced battery suppliers in the automotive world and in other markets. The fourth reviewer noted that there was a need for diagnostic to access the life of the battery to estimate battery warranty costs. The final reviewer explained that lifetime and cycle life remained key unknowns with new battery designs for electric vehicles that were critically important both from a view of assessing commercial viability and likely warranty costs but also in terms of reducing the uncertainty/risk associated with bringing on new products. Reducing this uncertainty could give auto makers the confidence that the researchers needed to bring new technologies to the market much faster.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer mentioned that path-dependent studies were good. In addition, pressure effects on aging addressed a real problem. This reviewer criticized that there were no obviously new approaches compared to what others had done previously. The second reviewer described that the project’s goal was to establish a Developmental & Applied Diagnostic Testing (DADT) platform. DADT would be used to support advanced prognostics modeling tools (described in presentation ES124), examine mechanisms for cell aging (both at the cell and pack levels), improve materials and create protocols to minimize aging processes. The work was intended to serve as a bridge between laboratory cell test conditions and PHEV field test conditions. The third reviewer stated that the focus on exploring and advancing capabilities to consider aging path dependence was excellent. The use of



wide variety of Li-ion cell sources was excellent. Inclusion of string-level studies was also excellent. The fourth reviewer remarked that the approach included all the stress factors and analysis of cells to determine the failure mechanism. The final reviewer believed that the researchers had taken a very sound approach to this work both in terms of rigor and looking at the right variables, while also using good judgment in constraining the battery testing to reasonable rather than extreme conditions. Testing to extremes was nice to do when one had the cell performance far exceeding needs and/or one really needed 100% reliability under all conditions. At a later stage, extreme testing may be warranted, but for now testing should be restricted to the challenging but real life test conditions the project had chosen. This reviewer agreed with the collaboration with Hawaii in part because Hawaii had done years of studies on driving patterns and actual battery performance in cars. This complemented the designed experiments that this program was seeking to carry out in the lab. This reviewer also liked the use of incremental capacity to help understand what was going on inside these cells.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that the modeling of lab results was critically important to take advantage of the experimental work. The reviewer detailed that the determining factors that control aging, and connecting thermal management with particle fracture were intriguing and that the simulation tool was nice. The second reviewer indicated that a large number of Sanyo Y' cells had been cycled under various conditions (i.e., temperature) and protocols (i.e., duty cycles). The data did not suggest that there was any evident path dependence to the capacity loss with different duty cycles. The effect of severe temperature variations on the capacity losses, however, was quite significant. The study related to pressure effects on pouch cells seemed inconclusive. The influence of thermal excursions on degradation was also examined using a simulation tool. A Battery Database Management System (BDMS) was also under development to facilitate the efficient and timely extraction of large and numerous datasets needed for diagnostics analysis. In addition to INL, perhaps this was of utility to OEMs and others. The work was interesting, but did not clearly point to any significant revelations that would suggest modifications to procedures or materials development for battery cells and packs. The third reviewer stated "good so far", and looked forward to further progress. The fourth reviewer indicated that the simplified models to include some of the stress factors e.g. temperature, SOC, charge and discharge power were not formalized. The fifth reviewer explained that this work obviously took some time to get results one could trust. The Sanyo Y cells had been cycling for just over a year and the results to date showed the strong impact of high and low temperature during actual cycling, less so during rest. Running the cells at high SOC was also undesirable, continued this reviewer. The same reviewer further noted that these findings were not particularly surprising, but acknowledged that this approach seemed to be working out. While the reviewer reported that the cells had generally lasted well (the reviewer believed they were intended for consumer goods, maybe power tools), the cells were not intended to cycle as long as needed for an EV program. Thus, opined this reviewer, the cells had already faded below 80% capacity in most cases. It was not yet clear to this reviewer how the predictions from these cells could be applied to a totally different chemistry and cell design using current or future batteries designed for EVs. This reviewer also noted that it did seem as though the researchers had enough degradation to mine and analyze the data more than what was presented in the talk. Presumably the analysis was ongoing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted collaboration with ANL and Hawaii. The second reviewer mentioned collaboration with the Hawaii Natural Energy Institute (HNEI) at the University of Hawaii and Argonne National Laboratory. The final reviewer acknowledged good collaboration between Hawaii and NREL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that all would be valuable in improving how lab tests were interpreted. The second reviewer explained that the project was essentially a continuation of existing work. It could be expected that useful information would be obtained, but whether or not it would be demonstratively useful for cell/pack development remains unclear. The third reviewer observed that the future research may not provide better aging models than what has already been followed. The final reviewer suggested to mine the existing data in more detail than shown in the presentation (which may have been already completed). This reviewer felt that it

would be good to set a goal for the amount of degradation one needed to see in the cells to make viable predictions. The better the cells were, the more testing one may need. This could be a guideline for setting how much data one would need to make an estimate of the actual lifetime. If all one cared about was performance after 10-15 years, maybe the project testing would not have to be increased as the cells got better; an estimate of how much extrapolation one was willing to accept from a single set of standard tests might then be a more apt guideline for testing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The majority of the reviewers indicated that resources were sufficient while the remaining indicated they were excessive. The first reviewer stated that sufficient funds were available. The funding may even be somewhat high relative to the insight obtained. The second reviewer liked the work, but noted that the amount of funding did seem excessive for this work.

Overview and Progress of United States Advanced Battery Research (USABC) Activity: Kent Snyder (Ford Motor Company) – es097

Reviewer Sample Size

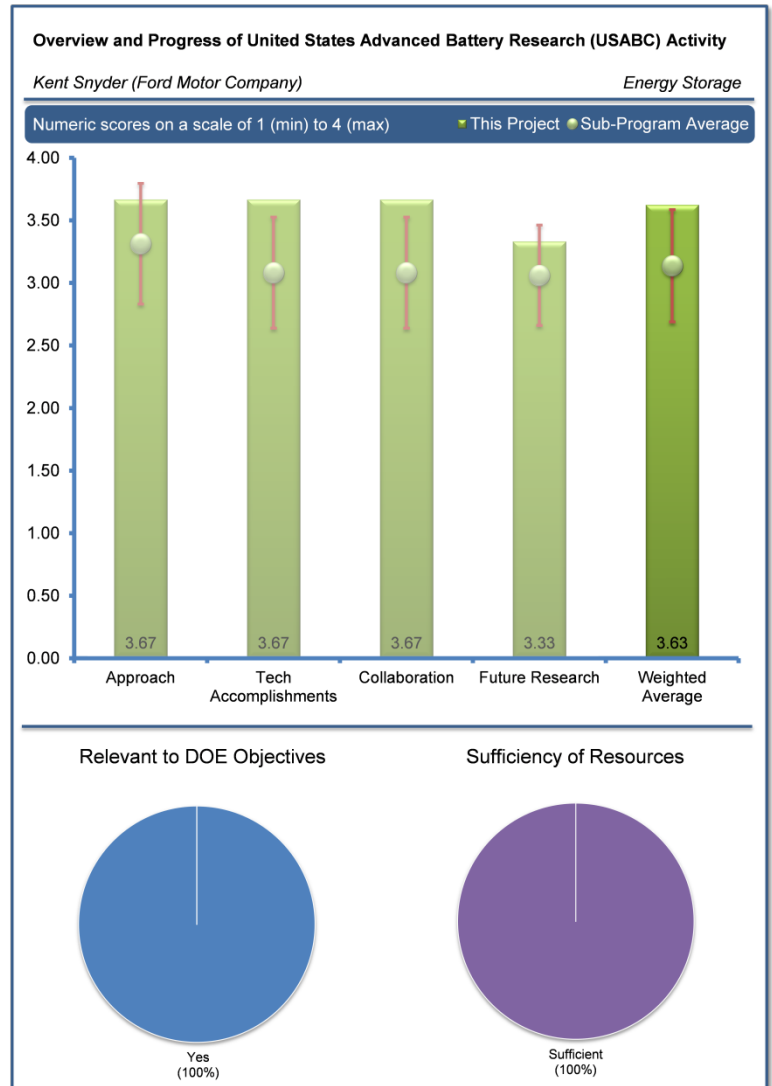
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the USABC served as an interface between the technical community and the U.S. car manufacturers. It funded research and development efforts to mutual benefit. The second reviewer mentioned that this project supported the overall DOE goal of partly replacing the conventional vehicles with hybrid (HEV or PHEV) or electric vehicles, both to minimize greenhouse gas emissions as well as the national dependence on petroleum resources. This ongoing project (USABC) was a collaborative effort among the U.S. auto manufacturers and various U.S. battery manufacturers and the national laboratories in jointly conducting advanced battery research and development with shared resources from DOE, OEM auto makers and developing partners. The objective of this consortium was to reduce the cost of the batteries via increased energy density in high-energy (PHEV and EV) systems, and reduced cost via lowering the total energy content in HEV systems. Successful implementation of this project would result in widespread infusion of battery technologies in vehicular applications, which would in turn reduce the petroleum consumption, and pave the way towards petroleum replacement. The third reviewer stated that this was the primary government cooperative effort with the U.S. automotive industry to work on advanced automotive battery systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer reported that the project allowed the car companies to share in non-competitive technology development that benefits all, manufacturers, national laboratories, universities and consumers, in developing new technology. The second reviewer felt that the approach adopted here was feasible and duly addressed the technical barriers of the HEV, PHEV and EV systems by identifying appropriate technologies and initiating programs for technology development as well as technology assessment. The objectives (since FY 2011) were thus to initiate and manage new and follow-on programs targeting reduced cost via increased energy density and life in high-energy (PHEV and EV) systems, and reduced cost via lower total energy content in HEV system. Other objectives included formulation of requirement sets for electrolytes and 12V stop-start applications, and to revise the existing EV goals. The approach here was viable with a variety of appropriate battery technologies being advanced, and was well-integrated with the material development efforts under DOE. The final reviewer said that the approach seemed to be more reactive to trends in the marketplace rather than innovating and trying to push the envelope.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that there was progress in co-operation in all aspects of the developing EV market area, workshops to address specific problem areas, and funding for RD&E where appropriate. The second reviewer observed that good progress had been achieved in initiating several technology development programs addressing the needs of lower cost and improved calendar life for batteries relevant to PHEVs and EVs, as well as high power batteries and capacitors for Low-Energy Energy Storage Systems (LEESS) for HEVs. Notable progress had been made in developing hardware, i.e., suitable prototype cells and modules from SAFT, A123 and LG Chemical, and the thermal management systems for the LG Chem. Some of these cells, packs and battery systems were being tested in the national laboratories for their life characteristics. Also, developmental work had been initiated on the advanced (shrink-resistant) separators, perceived as key component in improving the safety of Li-ion batteries. Finally, several new programs were going to be initiated in the next few months (of CY 2012) to fill the technology gaps for PHEVs and EVs. Furthermore, a few workshops were held to formulate the requirements of electrolyte, 12 V stop start requirements and revise EV goals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer pointed out that the researchers had an excellent balance in collaborations in all activities, work groups, and etc. The second reviewer stated that there were several useful collaborations with various national laboratories, e.g., in the testing of prototype cells, packs and battery modules. It would be more helpful, if through USABC, the battery manufacturers could assist the national laboratories in the development of next generation materials, for example in the infusion/demonstration of these materials in prototype cells and in the scale up of materials. Currently, there was only component development in DOE laboratories, but not a system level development effort, to which USABC contractors could significantly contribute.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted developing standards for 12 volt stop-start needed to meet CAFE requirements. The second reviewer remarked that the plans for future research were commensurate with the project, as shown here, i.e., to: continue initiating technology development programs with various battery manufacturers; finalize 12V stop-start requirements for potential program initiations in 2013; finalize electrolyte requirements for potential program initiations in 2013; and revise EV goals and requirements towards potential new future programs. These new programs were intended to address the needs of EVs more appropriately in the context of battery capabilities.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers responded that there was a sufficient allocation of resources. The first reviewer stated that the project seemed adequate and well-spent. The second reviewer noted that the resources were adequate for the planned effort.

Progress of DOE Materials, Manufacturing Process R&D, and ARRA Battery Manufacturing Grants: Chris Johnson (National Energy Technology Laboratory) – es098

Reviewer Sample Size

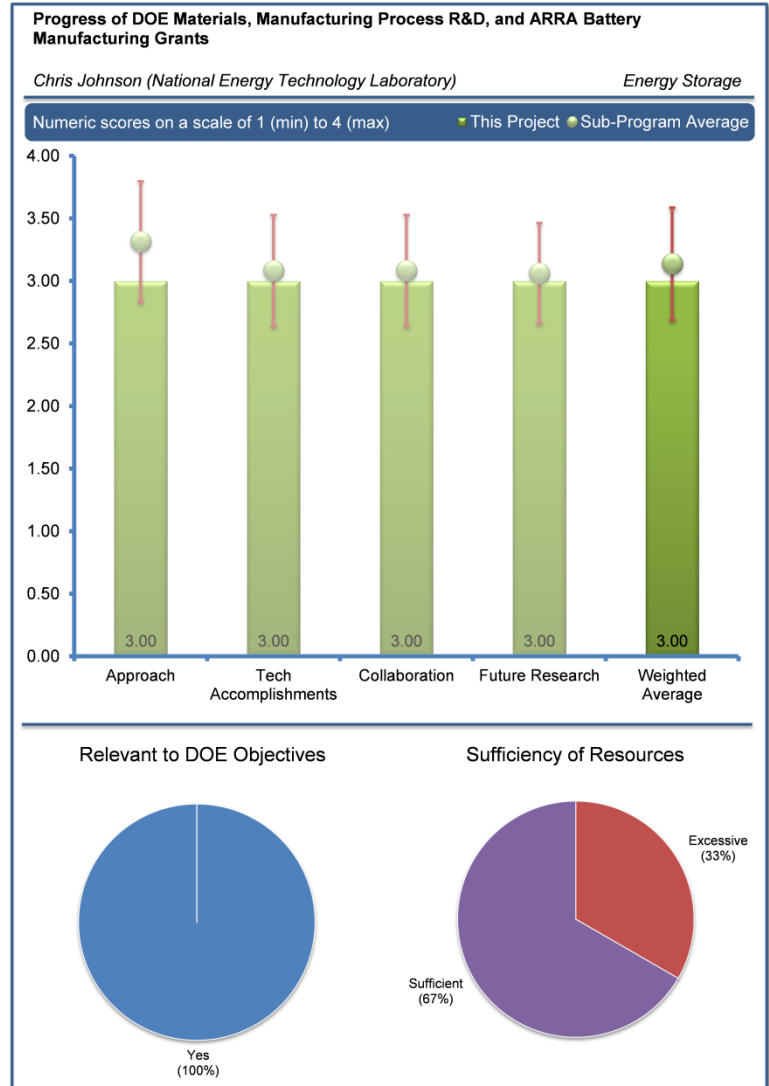
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer referred to an overview of the DOE program for Materials R&D and the ARRA manufacturing grants, over the period of 2008 to 2011 and the materials which resulted from the ANL programs. The second reviewer felt that this project was very relevant to the mission of the Vehicle Technology (VT) program to develop more energy-efficient and environmentally friendly vehicular technologies, which resulted in significantly less petroleum consumption and greenhouse gas (GHG) emissions. This project supported those goals by proving grants for various materials and manufacturing processes as well as ARRA funding for developing battery manufacturing facilities within U.S., with the objective of accelerating transition to the next generation of hybrid vehicle transportation. Under three different initiatives [i.e., Materials and Manufacturing Technologies for High Energy Li-ion Batteries (2008); Electric Drive Vehicle Battery and Component Manufacturing Initiative (2009); and Develop Advanced Cells And Design Technology For Electric Drive Vehicle Batteries (2011)], several developmental efforts were set up to accelerate the PHEV battery technology, which would result in widespread infusion of battery technologies in vehicular applications, and thus reduced the petroleum consumption. The third reviewer remarked that high energy, high power battery design and development of a manufacturing base in the U.S. for these types of energy storage systems were critical and necessary tasks to allow increased electrification of automotive drive systems and can result in improvements in energy efficiency and reductions in CO₂ emissions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the program has empowered companies to establish Li-ion battery manufacturing in the U.S. as well as help the supporting structure of cell components leading to battery pack production for electric vehicles. The second reviewer commented that the approach being adopted by NETL was two-fold, i.e., to institute several technology developmental projects, with approximately 50% cost share from the developers, on various components of Li-ion cells and assist in the setting up of manufacturing facilities within the U.S. for Li-ion batteries of various chemistries as well as capacitors, and the associated raw materials. Under the materials and manufacturing technologies initiative, four programs were started on topics ranging from anodes, internal shorts, overcharge-prevention additive and scalable manufacturing methods. Under the battery and component manufacturing initiative, programs were set up for developing advanced cell, battery packs and battery systems. Likewise, in the



manufacturing initiative under ARRA, several manufacturing and recycling plants had been set up in U.S. This reviewer acknowledged that the approach being adopted here was feasible and efficient, especially with the cost-share from the contractors, and addresses the key technical barriers (e.g., manufacturability and technology gaps).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that the industry had started to produce cells, batteries and battery packs for electric transportation needs. The second reviewer indicated that the progress achieved in initiating several technology development programs, based on cost-share related to the materials and manufacturing of Li-ion cells, on different materials was encouraging. Good progress had been accomplished in many of these individual programs. Some of the successful programs under the first initiative were the 3M project on nano-Si-C composite anode and the BASF project on the NMC cathode materials. In the recent set of awards, several new technologies: Pennsylvania State University's Li-S with carbon composite cathodes; Amprius project on Si nanowires; SEEO's PEO-block copolymer electrolyte; cell developing efforts at Dow-Kokam and Johnson Control; and Denso's thermal management scheme looked promising. Finally, under the ARRA battery manufacturing grants, several manufacturing plants were set up in U.S. on different technologies, even beyond Li-ion batteries, which bode well for the U.S. EV manufacturing. Some of them had already demonstrated production capability and it looked quite promising that tangible products would emerge from this effort that could benefit PHEVs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer observed a good selection of companies and co-operation between materials and cell producers. The second reviewer explained that there was not much of collaboration across these individual programs, understandably due to the fact there was substantial cost-share from the developing organizations, which needed to protect their IP.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted no new information on the ARRA Program. The second reviewer mentioned that future plans included supporting the research and development programs on materials and manufacturing processes as well as supporting the battery manufacturing facilities. The focus on multiple technologies, as was being done here, would mitigate the risk considerably.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer stated that in some cases duplication has resulted in the ability to produce more batteries, cells and materials than the present market could absorb. The second reviewer expressed that the resources were adequate for the overall project and most of individual projects.

Electrolytes and Separators for High Voltage Li Ion Cells: Austen Angell (Arizona State University) – es100

Reviewer Sample Size

This project was reviewed by three reviewers.

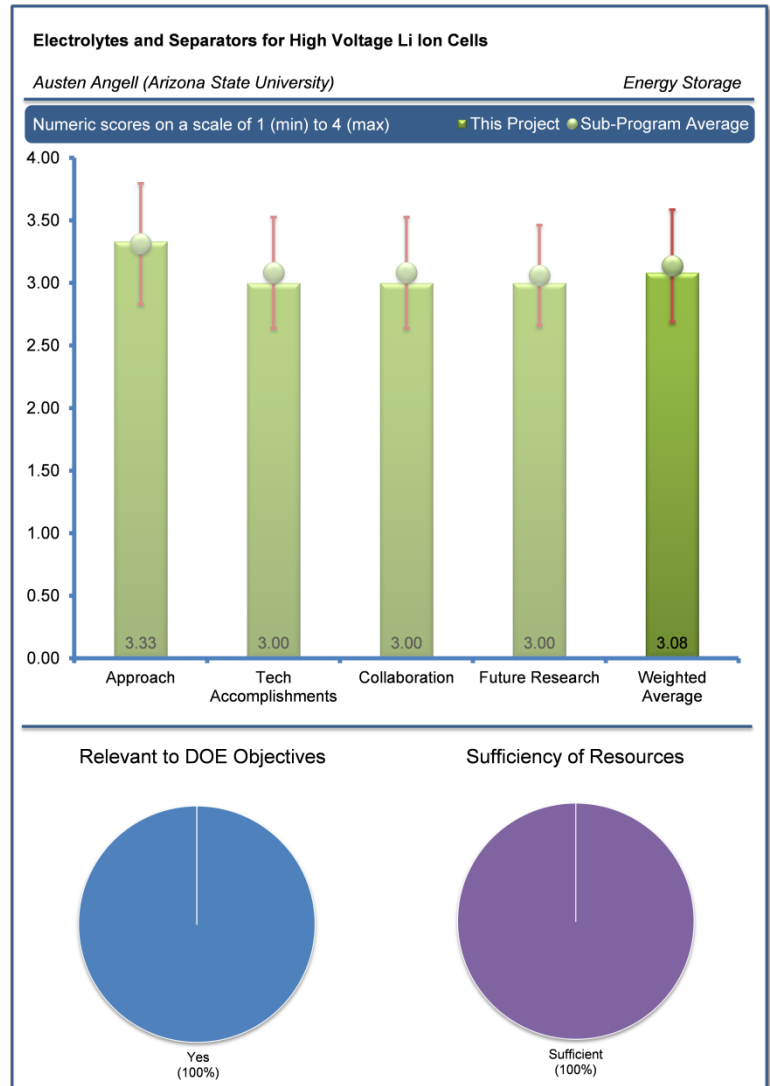
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that new electrolytes are the key to higher voltage systems. The second reviewer noted that new electrolytes and separators were needed for 5 V Li-ion cells. The final reviewer observed that this work aimed at developing improved electrolytes with better stability to high potential spinel cathodes (based on the sulfones) and thus could be an enabler for higher energy density Li-ion batteries. In addition, some of the materials had very low vapor pressures that might also offer some safety advantages.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
The first reviewer expressed that this was a difficult area for search, but that the approach had been productive in the past and likely to continue to be productive. The second reviewer mentioned that problems of liquid sulfone electrolytes had led to a diversion into solid electrolyte single ion study. This needed to be continued at a greater level of effort. The third reviewer explained that the approach was to look at modified sulfones to overcome or alleviate their high viscosities while still retaining good stability. The researchers had encountered issues with stability of the materials and had changed direction to look at single ion conductors.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer found that the most interesting materials were the semisolids and single ion conductors. The second reviewer noted that a new inorganic ionic liquid had been identified with pure Li⁺ conductor. The liquid range was 100-350°C with stability to over 6 V. This was very remarkable and needed to be pursued with vigor. The final reviewer acknowledged that their work with sulfones was progressing well from a materials viewpoint, but they ran into stability issues with the high voltage spinel cathode. The stability issues were not well understood in the reviewer's view – and asked what the reactions were and if it could be a solvent impurity effect. The reviewer continued to ask if the modelers listed (Borodin) could not assist in explaining this. Also, maybe the problem could be addressed though surface modification of the cathode. This reviewer expressed concern that the sulfones were abandoned prematurely. The new work looked interesting and should be pursued, although the high activation energy of the new membranes meant that its conductivity was only greater than that of a conventional solvent-based electrolyte at 60°C and above. At room temperature and below, the conductivity was worse than that of the liquid electrolytes, but still reasonable.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer suggested collaboration with John Kerr of LBNL, especially in the area of single ion conductors. The second reviewer mentioned Borodin (Utah), Chen (LBNL), Lucht (Rhode Island) and Zhang (PNNL). The third reviewer did not see much insight that could be provided by the modelers. Also, discussions/working with John Kerr at Berkeley was encouraged as he also had made some very nice progress on single ion conductors. The reviewer suggested that maybe ANL or LBNL could help better diagnose the instability issues with the sulfones.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer mentioned that a solid single ion conductor had been identified with good conductivity. Further characterization may result in a new electrolyte system for Li-ion batteries. The second reviewer expressed that it was not quite clear where this work was going, but that this could end up being an enabler for either high voltage systems or even a solid state battery with all the advantages that would bring. Also the reviewer was not yet ready to give up on the sulfones; the basic problem with these materials needed to be nailed down more, maybe by ANL or LBNL.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All the reviewers agreed that the resources were sufficient. The first reviewer emphasized the project may need increased funding to fully develop the new electrolyte. The second reviewer stated that this PI had an exquisite understanding of such conventional and concentrated electrolytes and ionic liquids and that these were important areas of research for future high energy density batteries. As such, continuing this work was supported.

PHEV Battery Cost Assessment: Kevin Gallagher (Argonne National Laboratory) – es111

Reviewer Sample Size

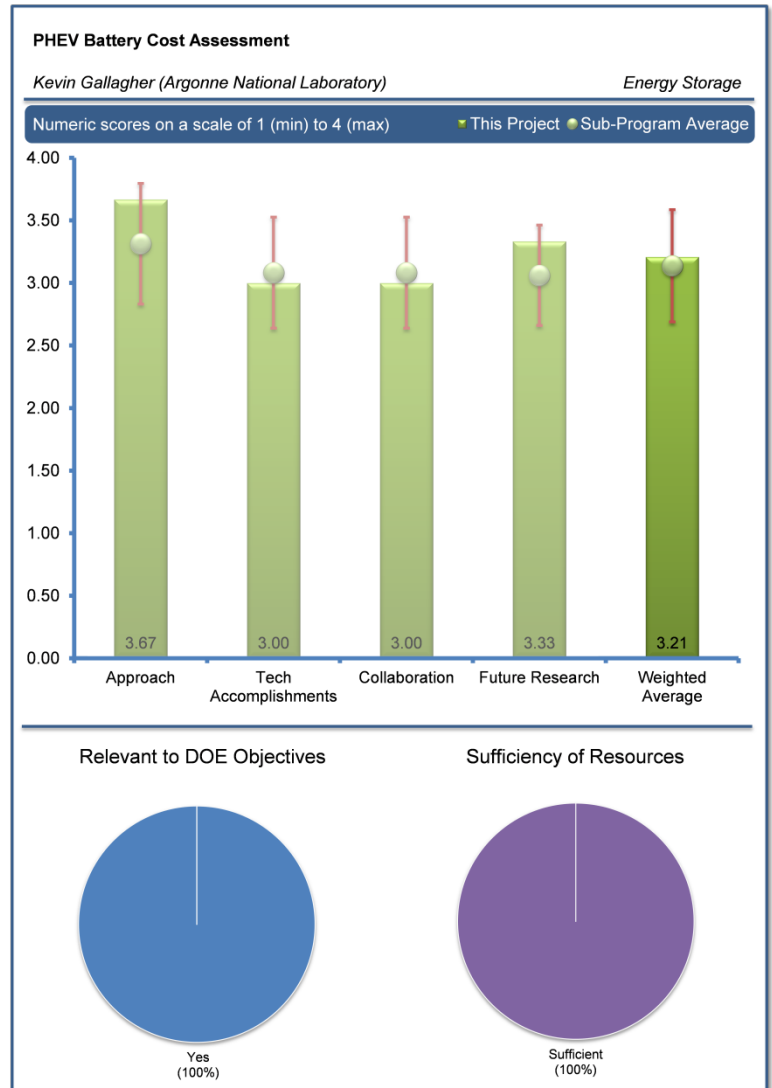
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that costs were critical for the success of the shift away from gasoline to electric propulsion. The availability of a model to predict the costs of various battery compositions was essential in developing viable research and development programs. It is also essential when decisions are made to continue a given technology into commercialization. The second reviewer mentioned that this project was quite relevant to the overall DOE goal of partly replacing the conventional vehicles with hybrid or electric vehicles to minimize the national dependence on petroleum resources. The (high) cost of batteries for PHEVs is a serious issue and is determined by the characteristics of electrode materials, among other things. The overall objective was to develop cost assessments based on appropriate models, for predicting cost and performance characteristics for battery pack values from bench-scale results and for predicting methods and materials that enable the manufacturers to reach the cost goals. The objective was in support of overall goal of developing a PHEV40 with a price less than \$3,400, weight not exceeding 120 kg, and volume within 80 liters. These studies would guide the manufacturer in addressing the cost barrier for Li-ion batteries. The third reviewer stated that ANL had developed critically needed analytical tools for battery storage system design and cost.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer mentioned that a cell/battery was designed based on power and energy requirements, specific chemistries with accompanying costs. A report had been issued that detailed the model and its utility. The cost of the BMS seemed low. The second reviewer described that the approach adopted here was based on designing a suitable battery based on power and energy requirements for PHEVs and the performance characteristics of a specific cell chemistry and the required manufacturing facility and thus obtained cost calculations for advanced Li-ion electrochemical couples (LMR-NMC, LNMO, Gr-Si composite), and to predict the required materials and processes to reach the cost goals. The approach was based on similar models developed at ANL in the past and utilized the likely production costs for the OEM manufacturers in 2020, with due consideration for the materials improvements and high volume production of modules based on pouch cells. Since both the design and cost were coupled here, this model quantitatively correlated the impact of underlying properties, such as cell chemistry, parallel cells, electrode thickness limits, power to energy ratio and etc., on the total battery pack cost. The approach appeared sound, but there were a couple of deficiencies here: there was no consideration for low temperature performance (as well as high temperature life), which varied considerably depending on chemistry, and all the chemistries were assumed to have similar life characteristics, which was a huge



challenge for some of the new chemistries (e.g., Li excess LLC and Si anode). The second reviewer stated that the project was well designed and integrated with other developments in materials, processes and cell designs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer indicated that these model calculations were essential to guide tech research and development efforts effectively. Assistance to the EPA in their efforts to set rules for Li-ion batteries was critical in arriving at a realistic rule setting. The second reviewer acknowledged that reasonably good progress had been achieved in carrying out the cost analysis for the batteries for PHEV applications and the results were not unexpected. Specific accomplishments included: completed and published BatPaC v1.0 with documentation model and a detailed report, and the BatPaC v2.0 and documentation was in progress; implemented both liquid (v1.0) and air thermal management (v2.0) in the model as well as pack integration components; and performed cost uncertainty calculation (v2.0). Some of the useful, but expected, trends were estimated cost reductions from high voltage and high-energy systems, increased electrode thicknesses and large-format pouch cells. Though these numbers were generated based on the information from an unspecified battery manufacturer, further validation of these cost projections was required by comparing with similar cost models or real data. Surprisingly, the costs appeared low both the battery management and thermal management. One difficulty associated with this model was that it was largely based on ASI data. Instead, it would be a robust model, if it was based on the real-time performance data over range of temperatures and discharge rates and lifetimes from the manufacturer's prototype cells. The reviewer noted that a more direct collaboration with the manufacturers of one or two representative chemistries in terms of using their electrodes/cells data would add credibility to these analyses and to the conclusions from this study.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that a good cross-section of people was essential in developing models of this kind. The second reviewer stated that there were no external collaborations here, and it was entirely ANL in-house effort. A more direct collaboration with the battery manufacturers would be greatly beneficial.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer mentioned that the project would release/distribute into the ABR format for public use. The second reviewer observed that the proposed future research was to complete and distribute BatPaC v2.0 to the public, which included an evaluation of new evaluating new electrochemical couples and a further refinement of model calculations & parameters. Further, this project would transition to the new ABR format to support its other projects, e.g., voltage fade project, development of electrochemical couples and ABR facilities (CFF, MERF, Post-Test).

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers indicated that there were sufficient resources for the project. The first reviewer noted that the release of the second edition of BATPAC supported EPA rule making. The second reviewer stated that the resources were adequate for the planned effort.

High Voltage Electrolyte for Lithium Batteries: Zhengcheng Zhang (Argonne National Laboratory) – es113

Reviewer Sample Size

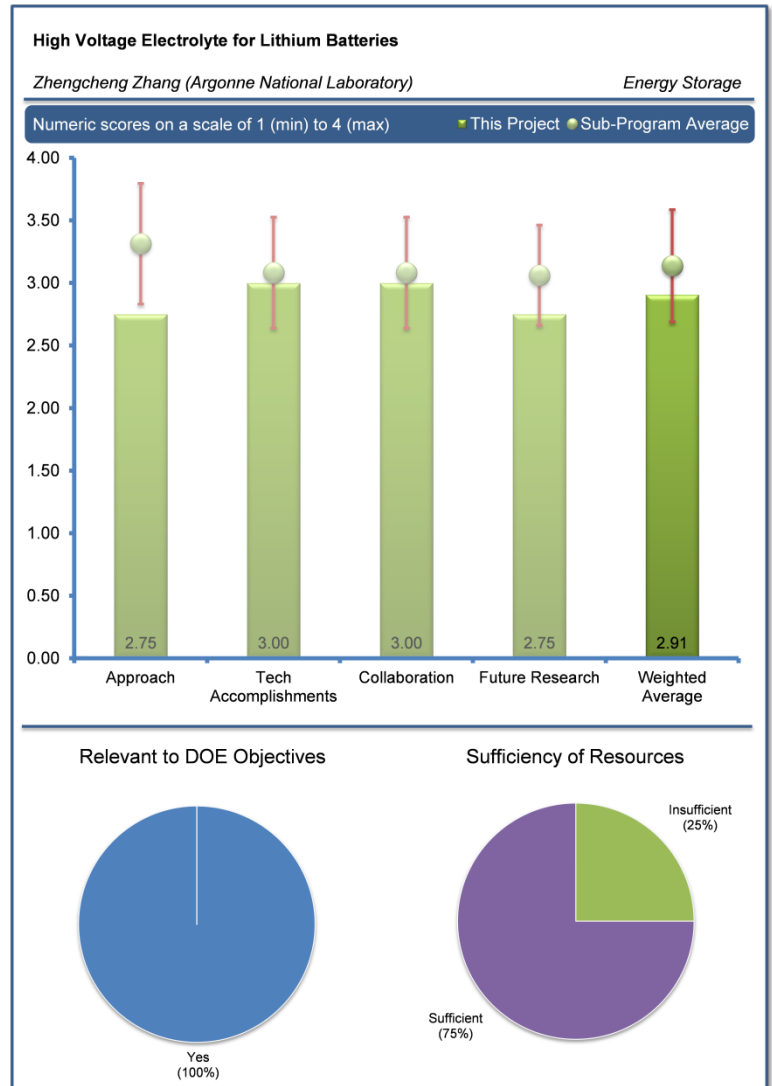
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that using high voltage cathode was one of many methods to improve energy density of batteries used for electrified vehicles. However, conventional electrolytes easily decompose at high voltage and cause a degradation of the cell life and performance. Development of new high voltage electrolytes was one of the key areas to be investigated for viable cell technology with higher energy density. The second reviewer commented that new high voltage electrolytes were required for higher voltage, higher energy, and longer life Li-ion batteries that would be required for the successful commercialization of electric vehicles. Synthesis of fluorinated carbonates, ethers, sulfones is needed to identify stable solvents, and conduct DFT calculations to guide the work. The third reviewer stated that high voltage electrolytes were critical to the development of high voltage cathodes leading to the next generation of electrolyte and are perhaps one of the more significant barriers to improved performance. The fourth reviewer indicated that as explained in the presentation, higher voltage combined with high capacity provided for both higher energy and higher power which are desirable for transportation applications. However, it was not clear whether this was a sensible thing to do since electrolyte stability at 4V was still a problem. In fact the presentation illustrated the problem by using LTO anodes to avoid the reactivity of the solvents at the anodes. Obtaining a voltage window of more than 4V may not be a sensible objective.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer explained the approach as finding the best candidates through theoretical calculations, electrochemical analyses and evaluation of their effect with full cells having high voltage cathodes. The second reviewer described that the project was directed at identifying and developing new electrolytes for Li-ion batteries, experimental screening of organic compounds for greater than 5V stability, current-voltage curves with lithium metal and lithium titanium oxide materials, that fluorinated sulfone, ethers, ethylene carbonates were explored as electrolyte solvents for a start, and that DFT calculations were used to predict stability. The third reviewer mentioned that the approach seemed reasonably well thought out and that the screening data seemed clear and logical. This reviewer stated that a good job was done of explaining the relevance of all of the characterization data and the techniques were chosen appropriately for the task. The fourth reviewer stated that the approach was okay as far as it goes. The use of fluorinated materials had obvious problems at the anode but those might be solved by using an appropriate SEI formation. The presenter gave no rationale for why the electrolytes oxidized so easily when the theory said that the potential stability was much higher. This implied that some other chemistry must be going on. There was no approach to this, stated the reviewer.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted the decent effect of fluorinated solvent for obtaining better life with high voltage cathode compared to the conventional solvents. However, it was recommended to run some more studies on its trade-off by carrying out a full evaluation including power and low temperature performance tests. Also, the reviewer added that the development of its cost model would be a good addition. The second reviewer observed that the fluorinated ethylene carbonate had excellent cycling, capacity retention compared 5V spinel. Fluorinated heterocyclics showed promise and could be cycled at comparatively higher temperatures (55°C). Improved cell capacity faded for graphite anodes. The third reviewer asked if the DFT differences were significant. The third reviewer noted that the connection between performance and an anode interaction was implied but not made completely clear. The reviewer added that more time could have been spent on this. Ultimately this work needed more fleshing out to understand its true potential. The fourth reviewer indicated that much data had been obtained that would be useful and these had been worthy accomplishments. However, the theoretical basis for the work was not deep and the premise of the project appeared to be shaky. Lastly, the reviewer concluded that an answer to the divergence between theory and experiment was needed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted decent collaboration with modeling experts and electrolyte experts at the United States Army Research Laboratory. The reviewer added that the project was nicely partnered with a national laboratory, universities, and an electrolyte manufacturer. The second reviewer reported collaboration mainly with ANL for calculation of redox potentials of the new materials. Daikin Industries prepared new electrolyte materials. Collaboration was with ARL and Conoco Phillips, Saft and EnerDel in industry. The final reviewer expressed that more collaboration with other DOE-funded groups appeared to be in order. The project did not have enough funds to do everything but the collaborations, particularly on the fundamental side, needed to be improved.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer observed clear plans for the next steps, including further characterization of cells with the proposed chemistries. The second reviewer noted the continuing search for fluorinated electrolytes with superior stability and defining the performance of promising candidates. This reviewer also noticed that the project would address reducing first cycle loss using additives. The third reviewer mentioned that some more materials-focused studies on the basic electrolyte thermal stability could be employed to help understand fundamental stability of the materials before entering the complicated world of full cells interpretation. The final reviewer cautioned that future research was very vague. Collaboration with a BATT project, for example, might provide better foundations for the work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The majority of the reviewers found the resources sufficient. The first reviewer stated that resources were of the correct magnitude. Another reviewer mentioned that the project was seriously underfunded to achieve what was desired, but that the objectives were best served through more extensive collaboration.

Spherical Carbon Anodes Fabricated by Autogenic Reactions: Michael Thackeray (Argonne National Laboratory) – es114

Reviewer Sample Size

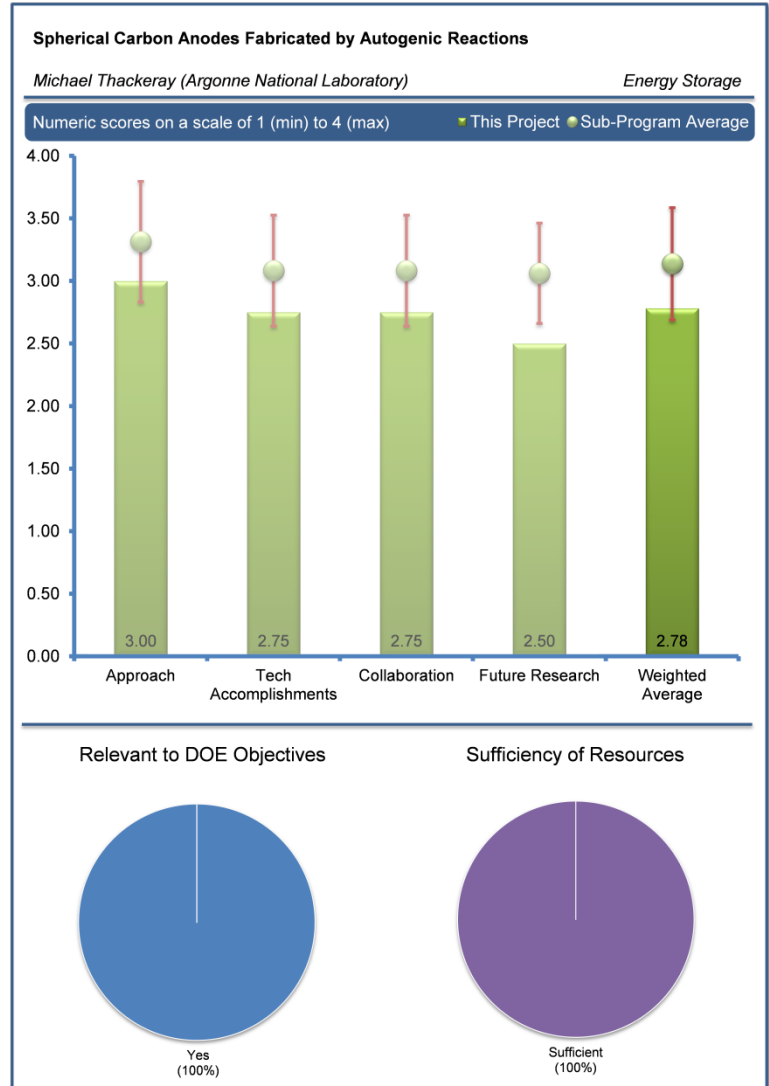
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project may provide an opportunity for energy density increase via improved/new anode materials. The second reviewer indicated that the electrification was expected to reduce petroleum imports significantly. This project was aimed at improving electrodes used in Li-ion batteries. The third reviewer mentioned that the aim of this work was to further expand upon Argonne’s spherical carbon particles (SCP) used for Li-ion anodes. The researchers were trying to retain the good cycle life characteristics of their SCP anodes while boosting the capacity up to match that of conventional graphitic anodes – currently the SCP had about two-thirds of graphite’s capacity. As such, this program could lead to a Li-ion cell with good, although not necessarily better, energy density that also had improved cycle life and maybe calendar life. Applying those concepts to some other materials or using different coatings could also lead to a modest increase in capacity.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer noted that spherical carbon particles were clearly of great interest and this work was a very significant contribution in that respect. The second reviewer asked what the yield of autogenic synthesis was. There were several steps that were needed to make the final product. This reviewer then asked if this process was commercially viable. Graphite and other carbons currently used in LIB have a cost in the \$20/kg range. The reviewer continued to ask if this process could achieve that target. Similarly, was the additional step of depositing SnO₂ onto small carbon particles was commercially viable? The final performance was similar to graphite. The reviewer questioned if the additional cost was acceptable. The second reviewer indicated that the approach in terms of conversion of carboneous materials into spherical carbon particles was sound. However, the entire motivation for their application to anodes was somewhat not clear – was it to get improved safety through spherical shapes. The final reviewer remarked that the materials the researchers were working with were certainly elegant and the synthesis seemed fairly simple and scalable. The premise is that the anodes would improve cycle life and, and when combined with a SnO₂ coating, would still deliver good capacity. The reviewer opined that this seemed somewhat empirical in that it was not clear how these coatings improved reversible capacity, but maybe that was just a reflection of the time constraints of these presentations.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the overall progress was excellent, but noted that the understanding and demonstration of abuse tolerance improvement seemed limited and unclear. Another reviewer asked a series of questions such as: whether there was a plan to study packing properties on small carbon particles; whether packing density was affected by the small size of carbon particles; whether graphite particles used today were typically much larger than small particles developed in this work, and whether or not there would be an effect on the energy density of LIB cells using this new material. This reviewer reported that it would also be useful to understand how SEI layer formation was impacted by the choice of anode particles. Would there be a need to re-optimize SEI layer formation for small particles developed in this work, asked the reviewer. This may be challenging for cell makers who have had experience with graphite. This reviewer criticized that the cycling results for MCMB shown on Slide 15 were strange. Typically, it was possible to get much better cycle-ability with MCMB anodes. The third reviewer reported that the spherical carbon materials had been produced using a simple autogenic combustion type reactor. However, the main motivation was to produce smooth spherical shapes for materials that could be used to smoothen the current distribution, thereby removing possibly lithium whiskers and the corresponding safety issues, and etc. Also, there was another major motivation to produce these spherical shaped carbon particles with Sn and Sb to produce composite anodes. The reviewer opined that both the method of making spherical carbon particles and the post-synthesis high temperature treatment for improving crystallinity were fine, but, the project was not clear on the advantage of using spherical shaped carbons for producing composite anodes, added the reviewer. The reviewer suggested looking at the reasons for preparing these spherical carbons. The fourth reviewer indicated that the uncoated SCP materials had rather low capacity compared to the standard graphite, but that the materials had very good cycle life. The reviewer added that heat treating the material to make it more graphitic reduced the first cycle capacity loss, but did not significantly boost capacity. The researchers obtained a significant increase in capacity by applying a very thin SnO₂ coating that boosted the capacity up to that of graphite. However, fading of this material was higher than that for the uncoated SCPs and even higher than that of conventional graphite anodes. The reviewer noted that the capacity after 15 cycles was actually deficient compared to the control graphite. Thus, at this stage the material was not very promising. The fourth reviewer acknowledged that the concept of applying the coatings to other materials and/or using different coatings could prove valuable. Because the coatings were typically thin, this reviewer did not expect that the coatings in themselves could greatly boost capacity above that of the native material. The reviewer added that it would have been nice to have seen a better understanding of how these coatings worked.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the collaboration with an industrial partner for high temperature post treatment was good. The second respondent was not sure that this project needed much collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer asked what the reasons were for making particles even smaller. The second reviewer mentioned that planned future work seemed excellent overall, but any plan for further abuse tolerance characterization was either not mentioned or was absent. The third reviewer felt that future work was not very motivating. It was not clear on why and how sub-micron sized carbon spheres could help in producing composite anodes. Also, it was not focused on how the researchers would obtain such sub-micron spheres. The fourth reviewer indicated that the project plans seemed good, although the reviewer called into question the desirability of going to even smaller particles from a packing and electrode fabrication point of view. The reviewer noted that it could provide useful for fundamental understanding, though. This reviewer agreed with the concept of applying the coatings to more conventional anodes that already have a high capacity. A better fundamental understanding on how the coatings work would seem to be in order as well. Issues with hard carbons not addressed in the presentation were the typically lower density of such materials (reducing energy density). If this was the case with these materials, it would be something that should be at least acknowledged, if not addressed. The reviewer suggested that, at some point, studies to explore low temperature, high rate and sensitivity to Mn from cathodes would be valuable.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated sufficient resources for the project to achieve milestones. One reviewer mentioned that the resources and funding were fine and the project team was making decent progress.

Novel Composite Cathode Structures: Christopher Johnson (Argonne National Laboratory) – es115

Reviewer Sample Size

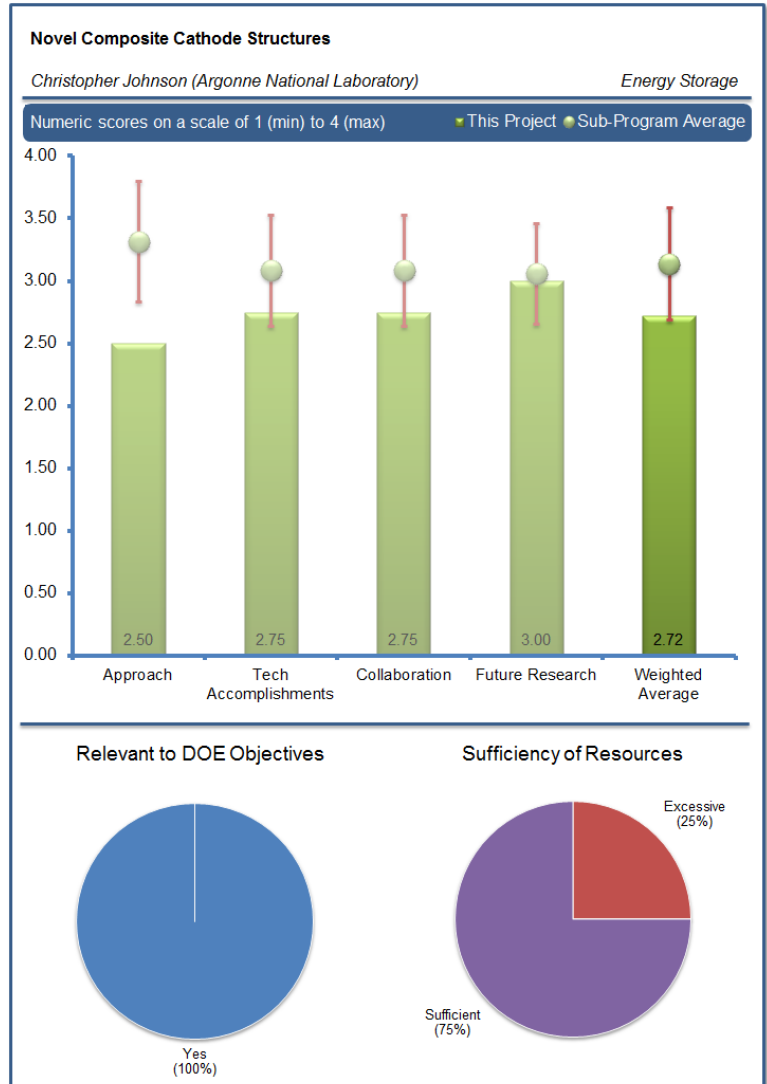
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that, in general, the development of new positive electrode materials was nicely aligned with the national policy to reduce petroleum dependence in energy. This reviewer acknowledged that seeking different synthetic routes for battery materials better suited for PHEV was believed to be a correct approach. The second reviewer noted that this project addressed the improvement of a key material for increasing Wh/L, which may decrease cost, and reduce dependence on petroleum. The third reviewer asserted that the project supported the overall objective. The cathode powders being investigated were critical to the overall objective of petroleum displacement. The fourth reviewer indicated that this project was okay for proof of concept only. It was not a low-cost process as listed and required in objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer noted that an ion exchange was a powerful approach to treat an electrochemical material in contact with electrolytes. In addition, the rate capability of such a material should be better due to the open structure obtained by exchanging larger ions with smaller ones. However, regardless of the bulk properties, its electrochemistry was often limited by the surface layers of particles that may form later with cycles. The cycle performance was yet to be tested. This reviewer added that ion exchange methods were hardly new and were routinely used by others including the MIT group as listed in the literature. The second reviewer expressed concern about the process cost for this route. This reviewer questioned as to how much cost it added, and whether the process could be changed to reduce this cost. This reviewer was also concerned about the density and average discharge voltage. Mn dissolution should be measured and optimized too, added the reviewer. The voltage stabilization looked good, and the concept of putting Na in the structure was clever, stated the expert. The third reviewer stated that the ion-exchange synthesis was interesting and could provide well-defined materials. At some point, if something interesting and important was found, probably another or a simplified synthetic method should be implemented for practical purposes, suggested the reviewer. At the moment it was hard to know how easy it would be to scale this process. The fourth reviewer remarked that the use of LiBr for ion exchange made the process cumbersome from an industrial scale point of view.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer mentioned that when the material was discharged to 2.0 V, it was speculated that a significant amount of Mn(III) was produced, unlike in the pristine material. Thus, an extra amount of Li-ion may be needed, since there was no clear evidence of Li-ion site changes during discharges. It was questionable if the same capacity could be obtained in a full-cell configuration. This reviewer felt that this had to be demonstrated. In addition to the extra cost and slow processing, treating with a calcined material with a solution involving ion exchanges, e.g., acid-washing or the current method by PI generally resulted in a low density material. PI perhaps wanted to examine the tap density in consideration of electrode processing later. The PI mentioned characterization of the material by XANES. This reviewer questioned if the team had a plan to conduct or already carried out *in situ* XAS and/or XRD at APS. No data was presented. It was expected that critical scientific information was contained in the first two cycles. The second reviewer indicated a good rate of progress. This reviewer wanted to see full cell data at different temperatures, and some insight into how the process could be controlled to make consistent materials. The third reviewer acknowledged that excellent capacities were reported with some of the cathode powders. It could be of interest if in future presentations the authors mentioned the tap density obtained with some of these powders. The stacking fault and edge defects observed with some of the powders were a nice accomplishment. The fourth reviewer noted some good TEM and cycling data. This reviewer would have liked to have seen high temperature discharge at high rates, and full cell data. This reviewer asked how the surface area and tap density compared to the traditional synthesis.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the project collaboration and coordination was well-organized for basic studies and asked if there were any industrial partners or scale-up plans. No expertise in synchrotron x-ray based characterization team was seen. The second reviewer found it unclear how the collaborators contributed. The third reviewer emphasized important partners in national laboratories and academia and an industrial partner in the latter stages would be important. The fourth reviewer expressed the need to collaborate with others rather than only internally at ANL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that the ANL internal team was not known for *in situ* APS-based characterization. Unlike BES programs, a cost aspect may be checked, particularly on material processing (ion exchanges, cobalt incorporation, etc.). The second reviewer indicated that good directions were planned, but that perhaps too many directions were given at once. This reviewer suggested focusing on small amounts of Co addition, and optimizing the process for cost and performance. The third reviewer stated that full cell testing should be important. At some point discussions about tap density should be incorporated; since that was an important variable with strong practical implications, added the reviewer. Electrode fabrication should be discussed at some point too. These powders may require a slightly different electrode preparation. DSC seemed to be important too, added the reviewer.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The majority of the reviewers indicated that resources were sufficient, while one reviewer noted excessive resources. The first reviewer stated that the ANL resources were the best in the world. The second reviewer remarked that at the moment, the resources seemed sufficient. However, if a new development came along that required special attention, additional resources may be required. High energy cathodes were a key driver for batteries designed for propulsion applications, added one of the reviewers.

Overview of Computer-Aided Engineering of Batteries (CAEBAT) and Introduction to Multi-Scale, Multi-Dimensional (MSMD) Modeling of Li-ion Batteries: Ahmad Pesaran (National Renewable Energy Laboratory) – es117

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

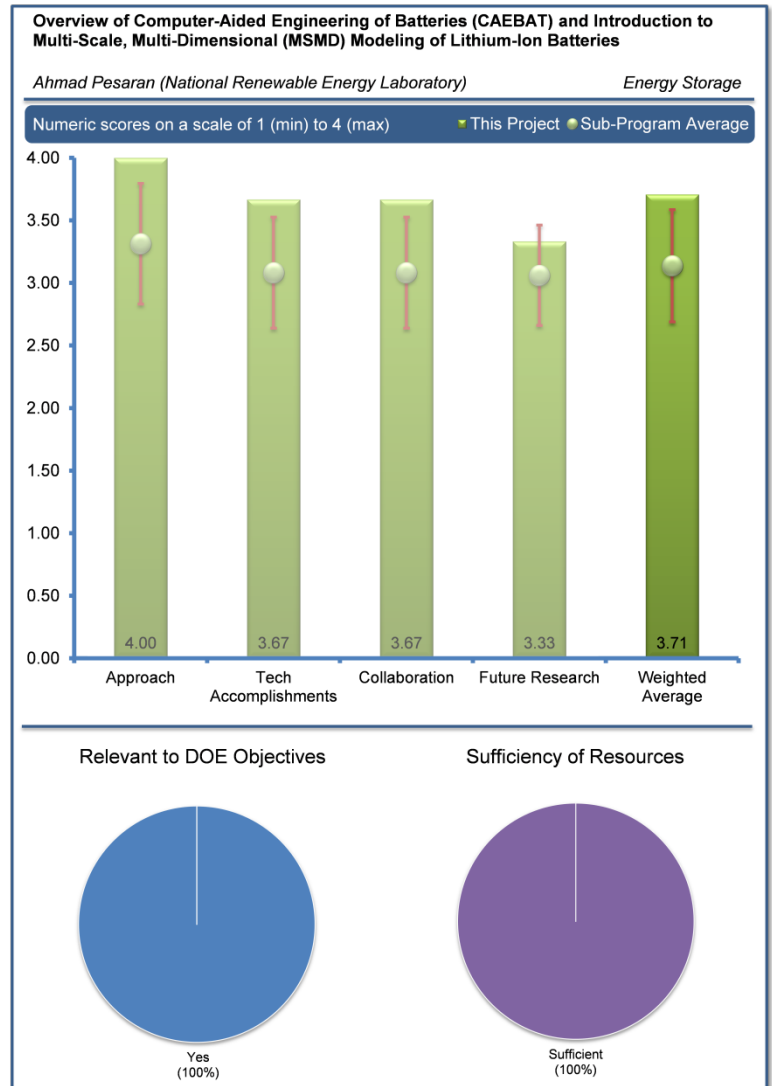
The first reviewer stated that yes, this main Computer-Aided Engineering of Batteries (CAEBAT) project was a central component of the computer-aided modeling program launched by VTP in 2010. Its main aim was to speed up the process of designing batteries for plug-in electric vehicles, which aimed to use electricity instead of petroleum as the fuel source, so this would support the objective of petroleum displacement. The second reviewer felt that if successful, it could really aid in the faster development of advanced propulsion batteries. The final reviewer observed that this project provided a set of quantitative tools to evaluate automotive battery designs and predict battery cell, module and pack performances.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer mentioned that the project appeared to have gotten off to a strong start, with portions of work delegated to subcontractors who were focused on modeling phenomena that occurred at different scales within batteries. The open architecture of the CAEBAT program enabled various modules to be added readily, and it should be easy for all parties to continue to refine their tools as the understanding of battery behavior grows. The relevant parameters were passed between modules that handled the physics occurring at different scales. Both prismatic and wound battery geometries were handled. It looked like the modules would add up to a very thorough approach. The second reviewer expressed that on paper, the project looked very well-organized, involving parties who brought in considerable expertise in their own fields, but the success of these activities would depend on the ease and relevance these packages brought to the battery developers. This reviewer was reminded of the TLVT work performed within the DOE program and was not sure if any battery developer actually used it. This reviewer felt that attention needed to be paid to the fact that these packages needed to be innovative, elegant, tractable and as user-friendly as the researchers could be so that the project could bring real benefit to the users.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer indicated that there were some resulting simulations that modeled the current density and temperature distribution in these batteries. The results appeared highly plausible, capturing subtleties that were specific to the cell geometries.



The second reviewer stated that the progress appeared to be quite impressive. This reviewer inquired about the following: whether there was any modeling work on tab locations (prismatic) on the long side; whether there were now designs out there which considered such locations especially for EVs; and whether the temperature data matched those in real cells.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the NREL team was collaborating with industry and universities through its three subcontracts. Through the Open Source Architecture that CAEBAT uses, NREL was also collaborating with ORNL, another national laboratory. This reviewer felt that the amount of partnering was great. The second reviewer expressed real concern for this area. The reviewer observed that over the years, with respect to programs involving many participants, it had been a challenge to track and coordinate and often one runs the risk of losing momentum and focus. This reviewer felt that having separate PMs for the separate programs was a good idea.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the chances of overcoming barriers were actually outstanding, but was not sure what the barriers were. The project seemed to be thought out well, with the open architecture for the system, so it seemed to be mostly a question of the contractor and subcontractors executing their respective portions of the CAEBAT model. Much of this appeared to be reuse of the computational techniques that had already been developed for battery behavior at different scales and converting it to fit within the CAEBAT modular architecture, so there was no major conceptual hurdle. Rather, it was a question of the researchers doing the necessary coding to make this conversion. The third reviewer asked how the final judgments would be made among the “three horses”. The reviewer also asked: what criteria would be used to determine which consortium was successful; when the end of the program would be; who was going to market the software; whether it was open source; how the cost modeling got incorporated in the program; who the vendors are; and whether there were any plans to develop abuse-tolerance models.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers all agreed that the resources were sufficient. One reviewer stated that the resources looked to be sufficient to pull together this large project.

Development of Computer-Aided Design Tools for Automotive Batteries: Steven Hartridge (CD-Adapco) – es118

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that there was relevance to the overall objective of petroleum replacement. The second reviewer stated that the advancement of CAE capability or speed for cell and/or pack modeling and simulation could support overall DOE objectives of petroleum displacement. Any significant focus on standardized battery CAE software did not support overall DOE objectives as monopolization of this industry could stifle both innovation and further advancement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? One reviewer indicated that the program looks very focused.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer was quite impressed with the progress already made. The other reviewer felt that understandably, it may be too early in the project to elaborate on any significant technical accomplishments or progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

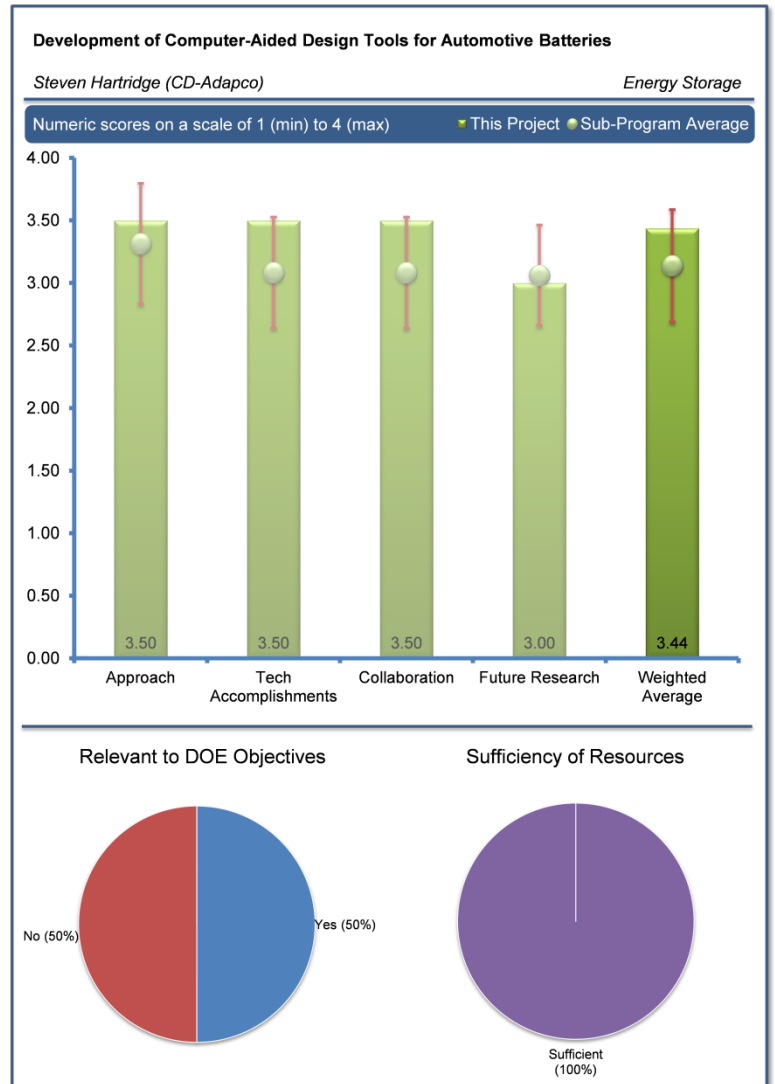
The first reviewer acknowledged that the data sharing among the participants seemed very encouraging. This had always been a big issue among the participants. The second reviewer observed that collaboration with JCS and A123 was good, but additional collaboration with other, more diverse battery developers would be even better.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer questioned whether abuse/cost life prediction and would be part of the package. The second reviewer noted that it generally looked good. This reviewer felt uncertain of the background on potential particular focus on electrolyte properties for future work. The same reviewer inquired about binder properties, separator properties, etc.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers felt that the resources were sufficient. One reviewer stated that it could be more, though.



Development of Computer-Aided Design Tools for Automotive Batteries: Taeyoung Han (General Motors) – es119

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

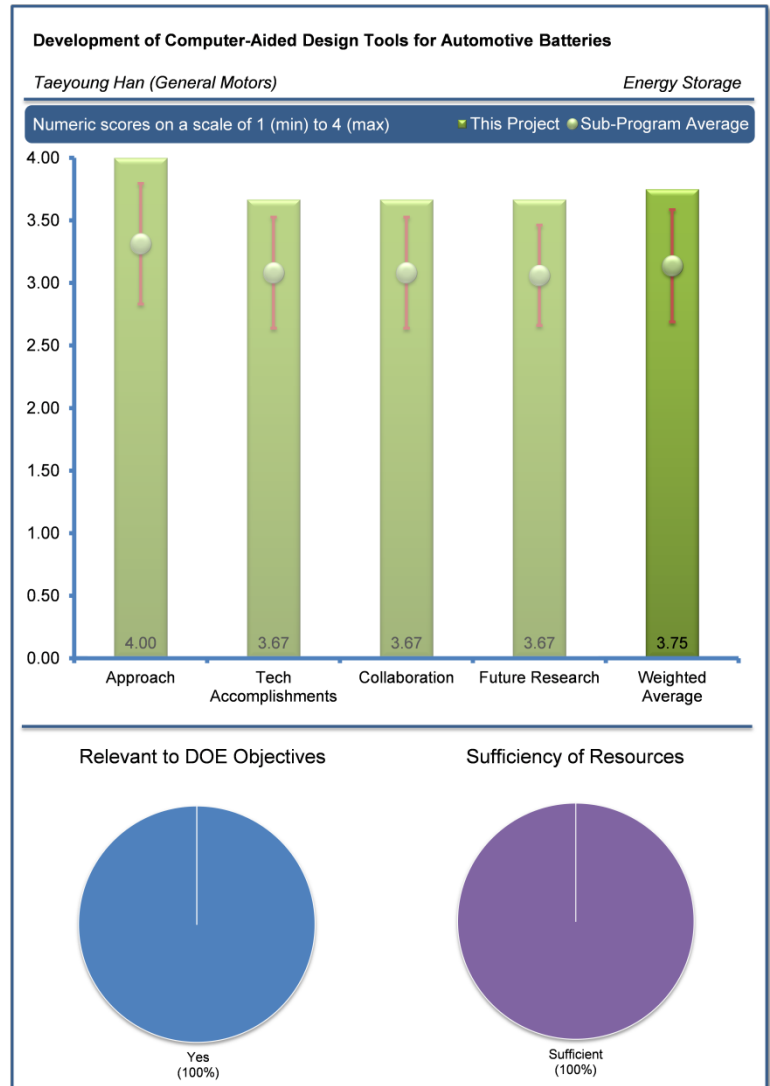
The first reviewer indicated that this project was a subcontracted portion of the CAEBAT program run by NREL, which indeed supported the DOE objectives of petroleum displacement through using computer modeling to accelerate the process of designing improved batteries for plug-in electric vehicles, which aimed to replace petroleum with electricity as fuel. The second reviewer mentioned that the battery cell design model was a useful tool to predict cell performance with many different battery material and design changes. With a robust cell design model, fewer experiments would be carried out and hence can save on time, effort, and cost by improving work efficiency with modeling tools. The third reviewer stated that the design and construction of the battery system, cells, BMS, temperature control, etc., were essential for the commercial success of electric vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer expressed that GM was focusing on cell- and pack-level simulations for batteries, which made sense in light of its recent work designing the battery for the Chevrolet Volt. The group was applying known physics models to perform numerical calculations. The second reviewer pointed out that the models that were currently available and those that would be developed through this project were well defined and it clearly provided information on cell and pack level model strategies including details on cell level sub models. The third reviewer indicated that this presentation/discussion was a report on the design of the GM battery pack. The reviewer felt that it did not include detailed information, but was a good discussion of the design principles. Further, this reviewer expressed that GM's needs and LG Chemical's cell parameters served to start the technical design.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer criticized that this piece of the overall CAEBAT project seemed a little behind, but guessed that perhaps the researchers got a later start because choosing subcontractors was part of CAEBAT's work for the past year. Right now the status was that cell user requirements had been defined and completed, and a cell-level validation test was in progress. Pack-level simulation requirements had also been defined and completed, but much of that work remained to be done. The second reviewer explained that the input parameters from battery manufacturers were obtained for model development. Basic ECM and thermal models had been implemented, and cell level validation results were available from GM. Pack evaluation data was currently available for model development. The third reviewer pointed out that it was not possible to give a realistic opinion because of a



lack of details on cell parameters, electronic control algorithms for control, and cell construction. The cell design showed some end termination, which usually resulted in non-uniform current distribution in the same cell with resulting voltage loss appearing as heat inside the cell.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the GM team appeared to be collaborating well with the NREL lead team. The second reviewer acknowledged that it was not easy to get all kinds of physical properties of materials and design parameters from a cell manufacturer for accurate model development, but this team managed to get input parameters from the cell manufacturer. Lots of cell and pack data were available from GM and the modeling expertise including thermal analysis were provided by NREL, added the reviewer. The third reviewer noted monthly reviews but no details on the results of monthly discussions, implementation, change orders, etc.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer indicated that the GM team's plans for future research appeared to be heading in a very logical direction based on the overall scope of the proposed work. The second reviewer felt that the methods used for this project were clearly defined. This reviewer noted plans of validations for additional information for the model development. The third reviewer emphasized the typical engineering activities in generating a new cell/pack design. This reviewer felt that data was needed on reliability of the operations to make a good judgment.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All the reviewers indicated sufficient resources. The first reviewer observed that the resources to complete the work should be sufficient. Only about 11% of the funding from DOE had been spent so far, and the work achieved thus far seemed congruent to the expenditures. This piece of the CAEBAT project should be completed with the remaining money. The other reviewer noted there were adequate resources for a preliminary design but there was a need for validation to reach ISO requirements for automobiles.

Development of Cell/Pack Level Models for Automotive Li-ion Batteries with Experimental Validation: Christian Shaffer (EC-Power) – es120

Reviewer Sample Size

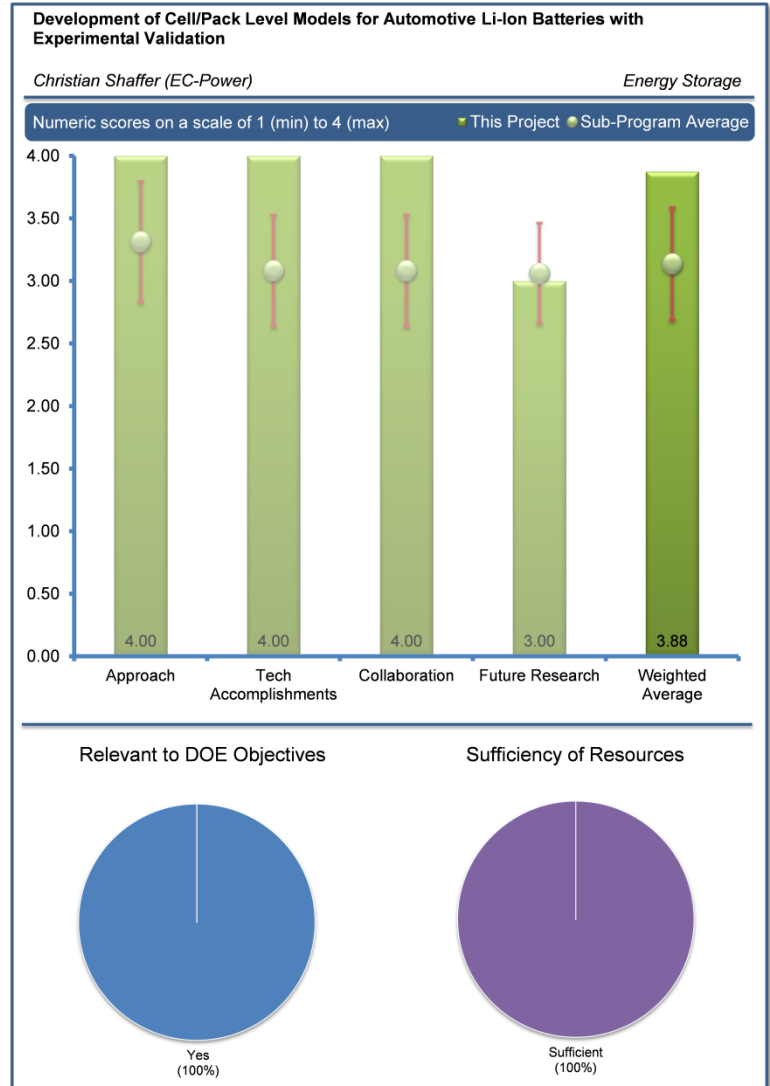
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated that this project actually was a subcontracted portion of the overall CAEBAT project being done by NREL, which certainly had the aim of making the process of designing batteries for plug-in electric vehicles easier. Both projects were certainly targeting the displacement of petroleum. The second reviewer explained that the key issues associated with reducing the dependency on oil for transportation using batteries were the battery cost, life, and safety. Identifying and optimizing these attributes usually took years and was very expensive. The development of models that could fairly accurately predict how battery designs and materials used to develop these batteries could reduce both the development time and expense. This project went a long way toward developing and then providing an easy to use system that provided tools for both the battery developer and the end user (automotive companies) that would help identify systems to meet the goals of the user. This reviewer felt that the goals of this program to reduce cost, improve safety, and improve performance of battery systems using modeling should be realized. The final reviewer commented that the project's goal was to develop an electrochemical/thermal (ECT) coupled model for large-format Li-ion batteries (cells and packs), as well as a materials database. This would then aid OEMs and cell/pack developers in accelerating the adoption of batteries for vehicle applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer observed that the EC Power model incorporated many known parameters from materials used in Li-ion batteries, and was modeling both performance and safety. EC Power was one of the subcontractors working with NREL on the CAEBAT project, so its contribution could be added to the overall project in a modular fashion like the others. The second reviewer asserted that the approach was excellent because of the early involvement of key partners such as a major U.S. based automobile manufacturer and a large U.S. based battery developer. Their early involvement allowed the program to go in a direction that would be most beneficial and useful and allowed for the validation of the model in real world conditions, by real world users and developers. This reviewer noted that the key concerns of both the battery supplier and the automotive industry could then be addressed in the model and consequently made it not only a useful tool, but a user friendly tool as well. The second reviewer pointed out that the technical approach also addressed the key elements associated with both life and safety – the overall addressing of the relationship of temperature and its impact on the system. The third reviewer reported that the ECT model would



be developed for materials characterization, physicochemical models, advanced algorithms and experimental validation. This would be fused together by EC Power into the ECT3D model which would then predict performance, cycle life and safety. These predictions would be validated by the industrial partners (Ford, JCI). If successful, this would certainly be exceptionally useful, but the complexity of such a model casted doubt on the ability to do what had been suggested. Still, without the effort, it would not be known how close one could get to predictive capabilities for critical battery performance criteria.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer asserted that the project seemed to be making good progress in modeling the behavior at the scale it worked at. It was showing plausible results for the thermal, electric, and safety performance thus far. The second reviewer acknowledged that the program was only recently started and had made significant progress toward the stated goals. This reviewer described that initial reports included increases in the materials data base; delivery of ECT3D to NREL for simulations; and the start of safety modeling work, with work on the nail penetration safety test. Good correlation between the modeled data and experimental performance data had been observed. The third reviewer reported that the materials database was established. Material, thermodynamic and kinetic properties for common Li-ion battery materials were compiled for variable temperatures, compositions, and SOC. The reviewer asked how this was done and where this information originated from. The ECT model was created and safety simulations (nail penetration and shorting with metal particles) had been performed. This reviewer stated that preliminary validation was underway. Although the results were interesting, it was unclear what new insights they offered thus far. The reviewer continued to say that if the results helped up the validation, the model may be very useful, given the complexity of understanding safety challenges. The prediction of life and degradation mechanisms, however, was expected to be quite difficult.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer indicated that even within its subcontract, EC Power was collaborating closely with Ford, Johnson Controls, and Pennsylvania State University. The second reviewer described that the key strength of this program was related to the collaboration with other partners. These partners included both key representatives from industry and capable representatives from a university. This reviewer affirmed that the way the program assigned the tasks to the partners allowed each partner to concentrate on their strengths, while using input from the other partners. Additionally, the established real time feedback loop to the partners allowed for dynamic and rapid improvements in the model. A good deal of progress appeared to have been made in a relatively short period of time, and for minimal funds. The third reviewer observed that the project involved numerous partners from industry, academia and national laboratories.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer suggested that the projected future plans appeared to be an extension of the work conducted thus far, with pack behavior to be added to the cell behavior currently modeled. It was not clear how this would be approached or how it would synch up with the pack-level work to be done by the GM team (another subcontractor for the CAEBAT project). This reviewer would like to see more details about this, but generally the progress thus far seemed to be good, so building on the work thus far should not be a problem. The second reviewer indicated that safety was a key enabler for this technology and that the future plans included increased simulations related to safety concerns. The stated major involvement of the automotive manufacturer and the battery developer in determining what safety issues would be simulated was excellent as they were the primary players and end-users. Continued validation of the model was the key to making this a usable tool and that was a major future effort. This reviewer felt it would be good to get more definition on what the extensive cell and pack validation methods would be; and, what the refined user interfaces would be. The third reviewer discussed the continuation of current work with safety simulations. This reviewer observed plans to extend work to packs (from cells) and continued with validations. The reviewer added that the project began work linked to life-degradation modeling and the optimization of battery usage.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers felt that the resources were sufficient to achieve milestones. The first reviewer said that if the project was already 33% done on about 13% of the funding, the project was being run very well and questioned that maybe the portion reported done already was just based on the timeline. The reviewer pointed out that EC Power should not run out of money based on the project's current rate of spending. The project would have the wherewithal to add additional features. The second reviewer stated that the funds appeared to be sufficient for this program as it as a 50/50 cost-share program and the commercial partners were providing their shares. The work seemed to be progressing at a faster rate than anticipated, and additional work may be the result. The third reviewer said that the project seemed to have suitable resources.

Open Architecture Structure for CAEBAT: Sreekanth Pannala (Oak Ridge National Laboratory) – es121

Reviewer Sample Size

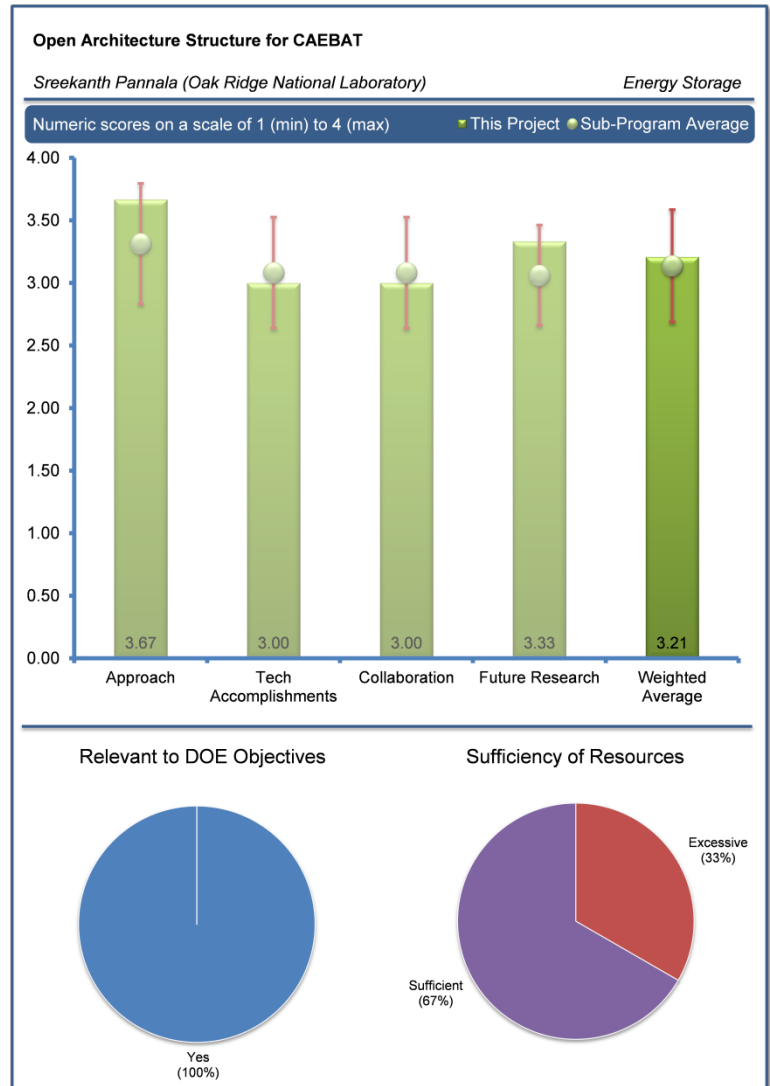
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project was very relevant and interesting. The second reviewer asserted that the project was very much related to petroleum displacement. In particular, the thermal management of a battery was critical for practical applications. The understanding of heat transfer within batteries was a practical and very important area of research and development. It had important safety implications. The final reviewer stated that this program was aimed at the standardization of models and bringing them together into a useful, consistent package. This would help bridge the gap between cell developers and systems engineers. Equally important, by bringing some discipline, clarity and consistency to the modeling efforts, the individual modeling efforts would work together much more easily. Thus, this work should improve the efficiency and utility of the other modeling teams.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer observed there were solid thoughts behind the approaches. Of course, the goals were rather grand and it would be interesting to see how the three programs were incorporated into this architecture. This reviewer expressed that the success of this project would depend on how well the various programs could be built into this architecture and how well the final package could model the entire sequence of battery development. The second reviewer suggested that it could be of great interest if, at a later stage, this program developed some useful hints about the chemical or electrochemical behavior of the different cathode materials, its combination with anodes, etc. This was such a complex area that if the program could discover or put together a model that could simplify and explain certain battery issues -to battery people with limited theoretical knowledge- could end up being very useful. The third reviewer applauded the overarching approach taken to get a handle on and to coordinate the various modeling efforts. The reviewer continued to suggest that this project should bring the necessary level of discipline to the modeling work so that the individual modules could work together. Without this, one would end up with just a bunch of pieces and parts that do not connect to each other, rendering them virtually useless in predicting and understanding the overall system design. This reviewer appreciated the agnostic approach taken to enable them to incorporate modeling work from any of the three teams into this master model. This reviewer discouraged the reliance upon proprietary modules for two reasons: such a black-box could not be properly peer reviewed by other modeling experts in the program and without knowing the details of the module it may also not provide the desired degree of fundamental insight needed in such a model; and the master model was then held to be enslaved by the proprietary module – the provider could make changes without explaining them and/or could withdraw support completely



leaving the overall module orphaned and frozen in place. The third reviewer felt that the open architecture approach was interesting and would seem to provide a completely open system that was much preferred, especially vis-a-vis any systems relying on proprietary programs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer considered the presentation by the author as excellent. The progress was quite impressive in all facets of the work the team proposed. The reviewer was curious how customizable the package would be. The second reviewer stated that the program could end up being of great value if it managed to develop some trends among the different cathode materials, for example. This reviewer added that the program may be off a little in terms of absolute values, but at least the provided trends could be very useful. The same reviewer questioned whether the thermo-electrochemical-electrical model, for example, could be expanded to other cathode materials. The final reviewer observed that the project team had delivered a prototype open architecture program. Progress seemed good on the basic architecture, added the reviewer. It was hard to say from such a short review how the researchers were doing in incorporating the individual modules, which were still being developed, into the program.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer observed good collaboration among the team members. The second reviewer noticed that there were strong interactions with other institutions. This reviewer highlighted the hope that at some point industrial battery companies would decide to engage a little more in this area of research and development. The reviewer indicated that it was nice to see three industrial partners already. The third reviewer noted that collaboration was absolutely critical here and the researchers need to excel here as this is what this project is all about. The researchers seemed to have the right linkages in place. This reviewer encouraged monthly meetings with each and every one of the modeling teams/PIs feeding into this program, not just NREL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer questioned how ORNL planned to incorporate proprietary information into its model architecture. The second reviewer indicated that increased portability to Windows could be of great value. Similarly, the incorporation of a cost model could have important practical implications. The third reviewer affirmed that the project team's plans going forward seemed very good and that this effort was supported.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers had mixed responses as to the resources. The first reviewer stated that it was hard to judge at this point if the resources were sufficient or not, but opined that resources probably were not if further interactions with additional institutions are not implemented. The second reviewer supported this effort, but found \$500,000/year to be a bit excessive for this activity. The overall work is important, but this reviewer did not believe it to be that hard or to require so much in the way of resources. It seemed to be mostly a coordination and computer/modeler interface design development and study.

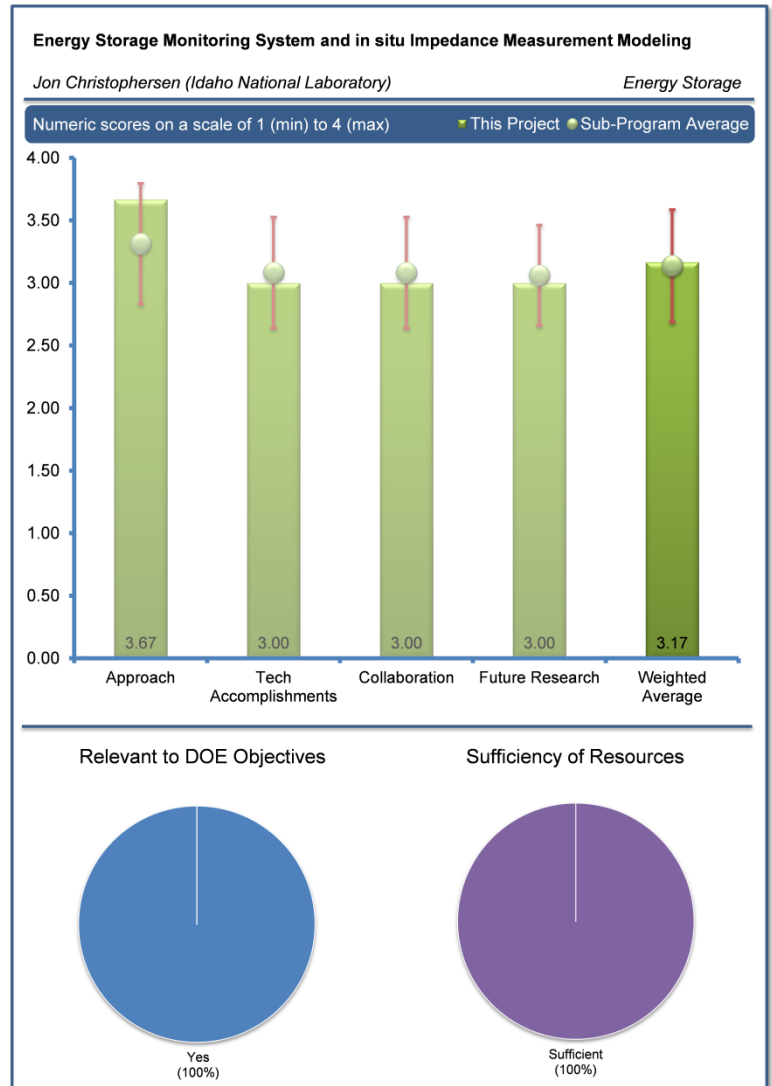
Energy Storage Monitoring System and *in situ* Impedance Measurement Modeling: Jon Christophersen (Idaho National Laboratory) – es122

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback was positive in this section. One reviewer stated that battery life estimation was related to the electrified vehicle warranty cost (for battery pack) and hence, an improved system for monitoring the battery state of health and predicting the battery life based on that could be a key tool for an electrified vehicle. A second reviewer offered that some of the concerns with an electric powered vehicle included the uncertainty of battery life and the predictability of battery performance during the life of the battery. Additionally, this reviewer opined that this program was intended to identify an *in situ* diagnostic and prognostic system that allows automotive OEMs to significantly reduce the anxiety that customers may have about these areas by establishing and setting meaningful warranty and replacement time periods, as well as the costs for the vehicle batteries. Furthermore, including a system that could accurately perform the stated diagnostic objectives would increase the confidence of both OEMs and customers in battery electric powertrains and allowed for their increased acceptance. Finally, this reviewer stated that increased acceptance would reduce the use of and need for petroleum for vehicle transportation.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments received in this section were generally positive. The first reviewer indicated that the project identified the objectives and applications of the techniques for measuring AC impedance at a significantly lower cost than normal EIS equipment. Furthermore, the ESMS concept for this project was clearly defined. The second reviewer observed that much of the work done to establish battery SOH was based on no-load conditions, as it allowed for more controlled data selection. However, continued this reviewer, the most useful data was captured during real time usage. Additionally, the collection of the data during vehicle usage provided the opportunity for real time feedback to the vehicle system controller, and was less visible to the customer. This real time feedback could also be used to make real time vehicle system performance adjustments to provide for optimum vehicle performance, fuel economy, and battery life. This reviewer continued, saying that the program attempted to correlate battery SOH during real time usage to a no-load condition, using several systematic and logical steps. The approach first established the key metric that would be measured, how it would be measured, the conditions under which it would be measured, and then related the results. These results were then used to develop the hardware and software system that could become the basis for a system that could be incorporated into a vehicle or battery system for use in establishing the battery SOH.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive in this section. The first reviewer remarked that the project had proven there was little difference between this cheaper technique and the expensive EIS technique. Also, the growth of impedance measured through this technique was shown to be correlated to the corresponding cycle life pulse resistance. A second reviewer expressed that the approach as mentioned was excellent and progress had been steady since the program began. Novel techniques to capture the key desired metric of wideband impedance were identified and a technique was downselected that met the most obvious need of short test duration. This reviewer observed that the decision was made to proceed with the HCSD method and that the prototype hardware and upgraded software had been completed. However, it was unclear whether this system would be able to test a full battery pack or if it was intended to check individual battery modules. It was also unclear why the FST system was not chosen instead of the HCSD system, as the FST (as stated) had the same test time and resolution, but required less computational capability. This reviewer concluded that these items should be made a bit clearer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The comments received in this section were generally positive. The first reviewer observed good outcome through the collaboration with both hardware and software companies for the equipment, while a second reviewer stated that the collaborators selected for the start of the program were excellent. The second reviewer also opined that a battery industry partner, and later an automotive OEM, should have been included further along in the program. These additional collaborators could contribute to faster implementation and development. Finally, the reviewer added, this had the potential of becoming a valuable tool and was needed as more EVs and other electrified powertrains became available.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback was generally positive in this section. One reviewer observed a clear plan for future work such as enhanced model development for better equipment accuracy and the investigation of bias voltage or transient effect for under-load measurement. A second reviewer offered that addressing the IMB limitations were key, especially when considering the cost of another system being added to the vehicle. Ideally, the system would be either implemented as part of the vehicle system controls or the battery control module. This was the reason, continued this reviewer, for the suggestion for a battery supplier partner and/or a vehicle manufacturer partner. The need for additional collaborative opportunities was expressed in the future work and the project should include a battery developer and automotive OEM.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that the project resources were sufficient. One reviewer added that the current list of collaborators appeared to support this level of funding, and if the work was to be moved forward in a timely manner, it required more involvement from industry partners who may be willing to provide matching funds. This reviewer emphasized that this may increase the resources needed.

Battery Ownership Modeling: Jeremy Neubauer (National Renewable Energy Laboratory) – es123

Reviewer Sample Size

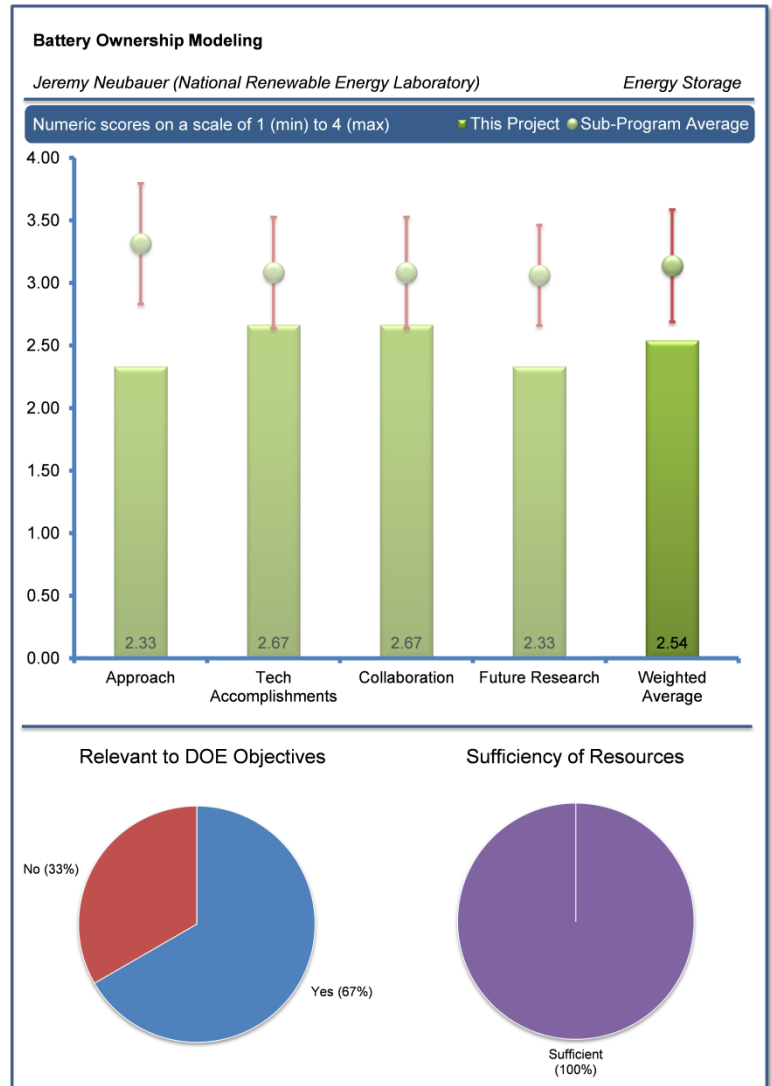
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback from reviewers in this section was generally positive. The first reviewer stated that the project provided useful perspectives on battery-electrified vehicle usage over life and relative ownership costs. A second reviewer remarked that the project was trying to provide models and predictions showing where BEV, etc., actually made economic sense for the end user. As such, it had the potential of providing insight on potential usage patterns and of becoming an important element guiding DOE programs and funding initiatives, incentive programs in various countries in the world, as well as being very useful to the auto companies. The third reviewer opined that the battery usage strategy by the OEMs for their customers may not be widely used because each customer may have their usage profile irrespective of what OEMs may recommend. The strategy may have some value if it was used to educate customers on the benefits available to them if they find it acceptable. This reviewer cautioned that new EV customers may interpret this strategy too difficult to follow to reduce TCO and may be discouraged to buy this type of new technology. Finally, a simpler approach that told EV customers about the battery temperature, frequency of charging, aggressive driving may be good enough for the maximum life and TCO.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments in this section were somewhat positive. One reviewer acknowledged that the project was tackling an inherently difficult and complex area of predicting how various technologies were likely to affect real users without having good supporting models for battery degradation. This reviewer accepted being fine with doing the best one could do with what one had to work with, especially as the results could presumably be rerun when better source data and models became available. However, concern was expressed regarding known deficiencies in the source model and about the fact that some factors had not yet been included merely because good data did not exist. This reviewer suggested it better to guess or include what one felt was the best data, although this raised the perception of gaming the system. More importantly, this reviewer added, there were many assumptions built into the results shown (i.e., Slide 13 footnotes), which in and of itself were fine. The same reviewer acknowledged that the project team was trying to do a very complex task. However, this would seem to call out for a lot of sensitivity analyses to better define truly critical unknowns. Knowing the critical unknowns could give a much better appreciation of the validity and limitations of the modeling works and lead to a more useful package. Equally important was that the sensitivity analysis could then be used to target support work in the labs to improve the model's basis in those few critical areas. Thus, the reviewer concluded, leveraging this



work to actually direct some of the other lab work would be desirable, but that did not appear to be happening. A second reviewer stated that the total scope of assumptions included in many parts of the analysis was unclear, but at the same time it was understandable that it would probably be impossible to illustrate all of those in a twenty minute presentation. However, for example, some key assumption points which were unknown would include whether battery warranty costs were included in estimations; whether capital amortization costs were included in estimations; and whether variations in local fuel costs and/or electricity costs were included. The final reviewer recommended including battery swapping, fast charge, etc., which would determine TCO for the customers and businesses owning the batteries.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was somewhat positive in this section. The first reviewer stated that findings and definitive statements regarding financial justification of electrified vehicle battery replacements, whether positive or negative, were helpful and could help direct focus of related DOE research and/or encourage further exploration of related DOE research. This reviewer added that the assumption of 100% state of charge (SOC) charging may be unrealistic from an actual OEM implementation perspective. A second reviewer acknowledged that the models incorporated a lot of key variables and that it was good that the project team looked at the distribution of driving patterns rather than just the average. The quality of the estimates seemed good, continued this reviewer, but it was only going to be as good as the assumptions made and cell models used. Thus, the reviewer stated, the conclusions had so many caveats that it was difficult to see how the project could be considered very solid at this stage. Hopefully, as things get narrowed, the confidence in the conclusions could improve to the point where this work becomes more valuable. This reviewer further clarified that a good rating was given not for the value of the conclusions, which was considered suspect, but because the project team seemed to have created a good model for answering some very difficult and important questions that just needed better inputs and a clearer assessment of sensitivity to the various assumptions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The comments received in this section were generally positive. One reviewer acknowledged that the level of collaboration was useful and that, while greater collaboration with industry OEMs may be challenging, this would be of great benefit to this project's relevance. A second reviewer recommended that sensitivity work and the importance of the cell degradation model already identified by this work could really guide some of the other research activities in DOE's various programs, although that did not currently appear to be happening. Furthermore, collaboration and communication between this group and the rest of the program would be especially critical for this program to start delivering trustworthy conclusions. This reviewer offered that it would be preferable to use the modeling to direct the lab work, rather than the other way around.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments were generally positive in this section. The first reviewer affirmed that this was actually a noble effort, but needed more work to become truly useful and trustworthy. Further, that reviewer would like this work to at least identify the key unknowns, assumptions, and models needed to improve the model's reliability. Patience may be needed as some of the improvements in the key inputs may take some time to be developed by others. In the meantime, this reviewer would rather see this model used to identify those assumptions and areas that needed more resolution rather than presenting one model result. The reviewer also offered that, at this stage, this program might be best viewed as a source of guidance rather than providing absolute answers. A second reviewer recommended that future research combined the battery degradation model with the work of Dr. Kevin Gering (presented in ES124) because both needed the same model for future work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One of the reviewers noted that while what the project team was getting seemed fine in terms of funding, funding to other groups may need to be boosted to fill in some of the key gaps in the knowledge needed to make this model as something one could trust and really start to leverage.

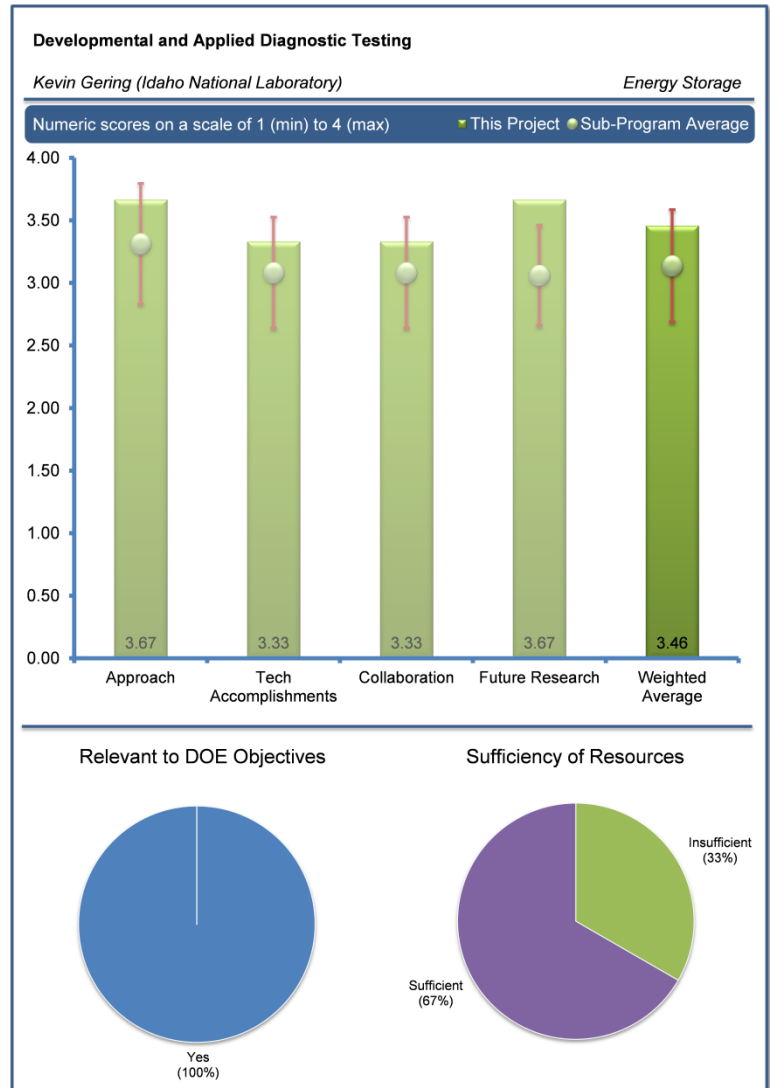
Developmental and Applied Diagnostic Testing: Kevin Gering (Idaho National Laboratory) – es124

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall feedback in this section was positive. One reviewer offered that warranty issues were a significant commitment without a firm basis for justification and decision making. Further, a framework for establishing the aging issues and life-modeling tools was badly needed and was being developed on this project. This reviewer indicated that there was very little published data on aging and concluded that reliable data and experimentation were essential to provide accurate information on the life expectancy of a battery system. The second reviewer stated that there was a need for diagnostics to assess battery life and estimate battery warrantee costs. A final reviewer acknowledged that the project should help educate DOE, inexperienced battery suppliers, as well as BATT, ABR, and related participants, towards a greater understanding of real-world battery life challenges and requirements, which may already be well-understood by significant electrified vehicle automotive OEMs and experienced automotive battery suppliers. This should indirectly promote greater realism and efficiency in addressing DOE's petroleum displacement objectives in a DOE-funded activity and advance the capability of less experienced battery suppliers in the automotive world and in other markets.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments in this section were generally positive. The first reviewer observed that a model was constructed consisting of the thermodynamic, transport phenomena, as well as chemical and physical interactions, especially of the electrolyte with battery components, to serve as a standardized evaluation model for predicting battery life. This reviewer further noted that the mechanical aspects of loss of contact of the active materials and the mechanical stability of the electrode materials were elements of the model. A second reviewer identified the project's modeling approach as one built on evaluating the life based on the path dependence, including the seasonal temperature, duty cycle, SOC target and SOC window. Also, this reviewer pointed out that the drive profile and the rest variations were included. A third reviewer suggested that while the focus on exploring and advancing capabilities to consider aging path dependence was excellent, the focus on embedding capability in onboard device monitoring and control systems for automotive applications may not be realistic or appropriate.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments from reviewers were generally positive in this section. One reviewer opined that significant progress had been made in predicting battery life, causes for aging, and developing metrics for understanding aging processes. This reviewer added that these were chemistry specific and could be used to identify the best battery system for the application. Further, the changes in kinetic parameters and the thermodynamic framework of the reactions made it possible to quantify the behavior of electrochemical reactions in the battery and estimate the effect on capacity loss. A second reviewer observed that the results showed the capacity fade at various temperatures and SOC, but noted that the internal resistance change was not monitored. This reviewer suggested that the aging should include the capacity as well as power characteristics for estimation of life.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were generally positive. The first reviewer observed collaboration with the Hawaii Natural Energy Institute, ANL, and Dow Chemical that was directed at the path dependence and aging, testing and battery aging, and modeling of performance as well as some electrolyte development. This reviewer further offered the need for greater funding here. The second reviewer expressed that collaboration with a viable battery supplier having a significant global presence could be helpful and more useful in guiding some aspects of the aging path dependence studies.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall feedback in this section was positive. One reviewer stated that future work was directed at the temperature profiles for selected cities, variations in upper and lower boundaries, to assist in projecting battery life as a function of location. Furthermore, this project should be a good source for lifetime estimations. A second reviewer recommended that future work should include the life estimation of additional factors (e.g., target SOC and SOC window for cycling and calendar life). The final reviewer remarked that the plan for future work was generally excellent. This reviewer also cautioned that the plan for integration of Cell-Sage into actual ES monitoring and control systems may not be practical or of commercial interest to the automotive industry or other industries and therefore may be a poor use of the funds.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. While two reviewers indicated that the resources were sufficient, another reviewer reported that the resources were insufficient. One of the reviewers noted it was useful work given the funding level and also offered support for greater funding and activity for this or generally similar efforts. Another reviewer expressed that the present level of funding was low for the nature of the work and the end payoff for the results. This reviewer affirmed that funding was incorrect for this project, and suggested that the USABC could also be included if not already involved.

Electric-Vehicle Battery Development: Herman Lopez (Envia) – es137

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

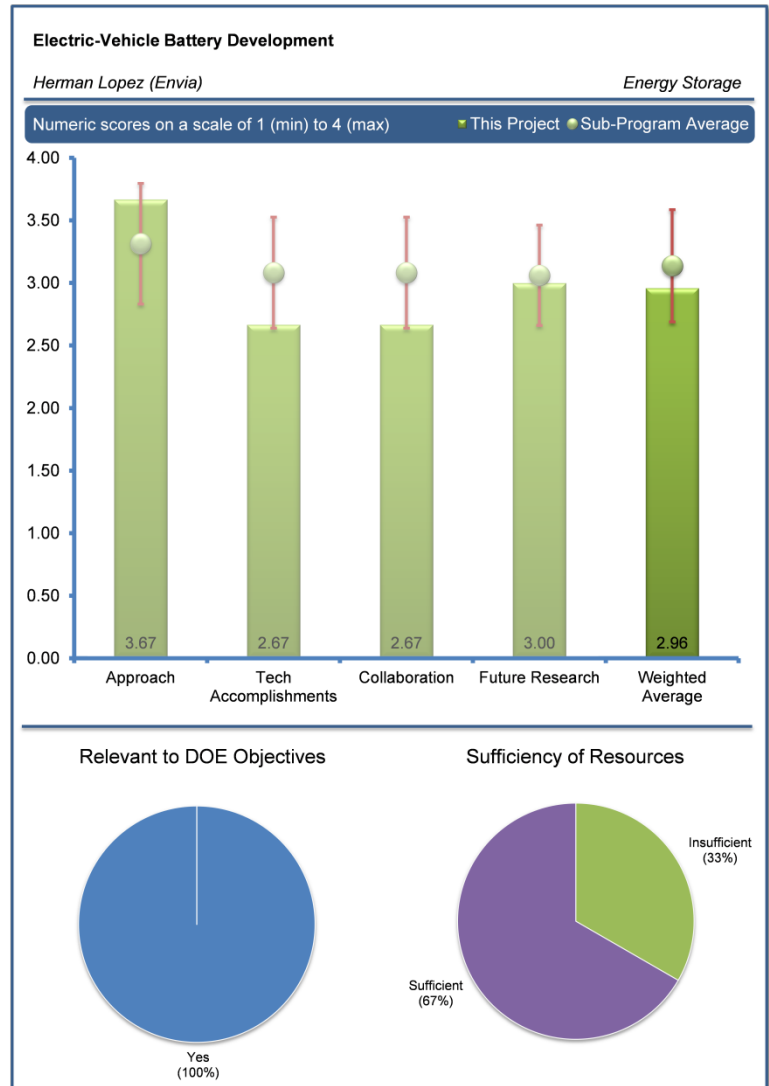
Feedback in this section was positive. The first reviewer asserted that high capacity cathodes were important to DOE goals. A second reviewer agreed that higher energy cathode materials were a key element in providing high energy rechargeable batteries for transportation applications. A third reviewer observed that this work was aimed at screening and developing high energy cells as well as integrating these materials into large pouch cells suitable for vehicle applications. Furthermore, this reviewer indicated that an important element of this work was aimed at fixing ANL’s manganese-based high capacity cathode for high energy cells. This reviewer concluded that it also meshed well with the ARPA-E funded work on silicon anodes for even higher energy cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were generally positive in this section. One reviewer observed that the project team had looked at not only the individual components but also their interaction all the way from single electrode to full, commercial-sized pouch cells. This reviewer noted a holistic approach that had led to fantastic results. A second reviewer reported that cells with manganese rich cathodes, silicon-carbon anodes and proprietary electrolyte were produced with 1 Ah and 20 Ah capacity, but stated that no details were provided on the composition of the anode, cathode, and electrolyte or on the cycle life. This reviewer cautioned that the long sloping voltage (4.5 volts - 2.0) of the cathode may present problems for the BMS control. The reviewer further added that the chemistry was said to be tunable for the application. The final reviewer commented that the approach was valid as far as the description goes. However, there was no mention of one of the important problems of the high manganese composite materials, which is the fade in voltage during cycling. The reviewer added that this did not show up in the capacity as much as attrition in the energy and impedance growth, and further recommended that these problems be addressed by the authors.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback was generally positive in this section. The first reviewer commented that the worked presented here on the carbon anode/modified ANL cathode was outstanding, similar to the project team’s outstanding work under an ARPA-E Grant on Si anodes. The project team had demonstrated an almost complete suppression of the voltage drop phenomenon, which was one of the key barriers to getting this material out of the lab and into actual products. Although this reviewer acknowledged that rate performance remained a barrier, the reviewer had not seen that anyone else even knew what the problem was, let alone had a clue



on how to fix it. Using a sports analogy, this reviewer described that Envia seemed to have hit a home run while everyone else was in the batting cage warming up. The reviewer also pointed out that this design should be very interesting for consumer electronics batteries where the rate and power requirements were not so high. Equally impressive was the project team's ability to combine its advances into a finished package and its implementation with a Si-based anode under the ARPA-E program. The reviewer recognized that the project team had even developed a low temperature electrolyte for this cell system. The reviewer was emphatically impressed with the small outfit, and described it as innovative, focused and delivering the goods. This outfit was characterized as far and away the most impressive this reviewer had seen in this arena. The second reviewer reported construction of 20.5 Ah cells with 3.56 OCV that yielded 218 Wh/kg, with 1100 W/l. This reviewer further observed that no Wh/l was specified, but that a new electrolyte was developed with good performance down to -30°C. The reviewer added that cycling of the 20 Ah cell gave 600 cycles to 80% of original capacity, while 1 Ah cells gave 1000 cycles to 70% of original capacity somewhat dependent on electrolyte composition. This reviewer concluded that long term goals for cost were \$100/kWh. The final reviewer was somewhat puzzled by the poor cycle life of the cell as tested at 30°C. The rate was only C/3 and the upper voltage limit was only 4.35 volts. While the new electrolytes seemed to improve the cycling, the tests were now run at 45°C and the rate was C/1. This reviewer noted that upper and lower voltage limits were not given and the cell seemed to have an entirely different capacity. The reviewer expressed difficulty in knowing how to evaluate results under such different conditions with different cell types.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were positive. The first reviewer described this as a corporate effort by a start-up, and by its very nature, one could not expect the project team to be very open. The reviewer offered that the project team has really worked well with ANL in extracting the knowledge, having not just acquired a license. Thus, within the framework of a for-profit organization, the collaboration has been excellent. The project team was also observed by this reviewer to be using outside labs to validate some of their results. A second reviewer reported that while no date was specified, cells would be delivered for testing to INL, SNL, and NREL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback was generally negative in this section. One reviewer observed little description of the proposed work and indicated that there was very general discussion of work on scale-up, cell testing, and material screening. The second reviewer suggested working on rate performance and checking out high temperature stability, then combining with Si anode work, but still keeping the carbon anode cell design going as a backup. A third reviewer commented that future work was not presented.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed on the adequacy of project resources. Two reviewers indicated that the resources were sufficient, while another reviewer stated that they were insufficient. The first reviewer opined that the project team should be given all the money it wanted so it could run with its inventions then license to everyone else. This reviewer added that the project team seemed able to make major advances in all areas of cell chemistry, all at the same time. A second reviewer offered that resources were adequate for the described work.

EV Battery Development: Nick Karditsas (Cobasys) – es138

Reviewer Sample Size

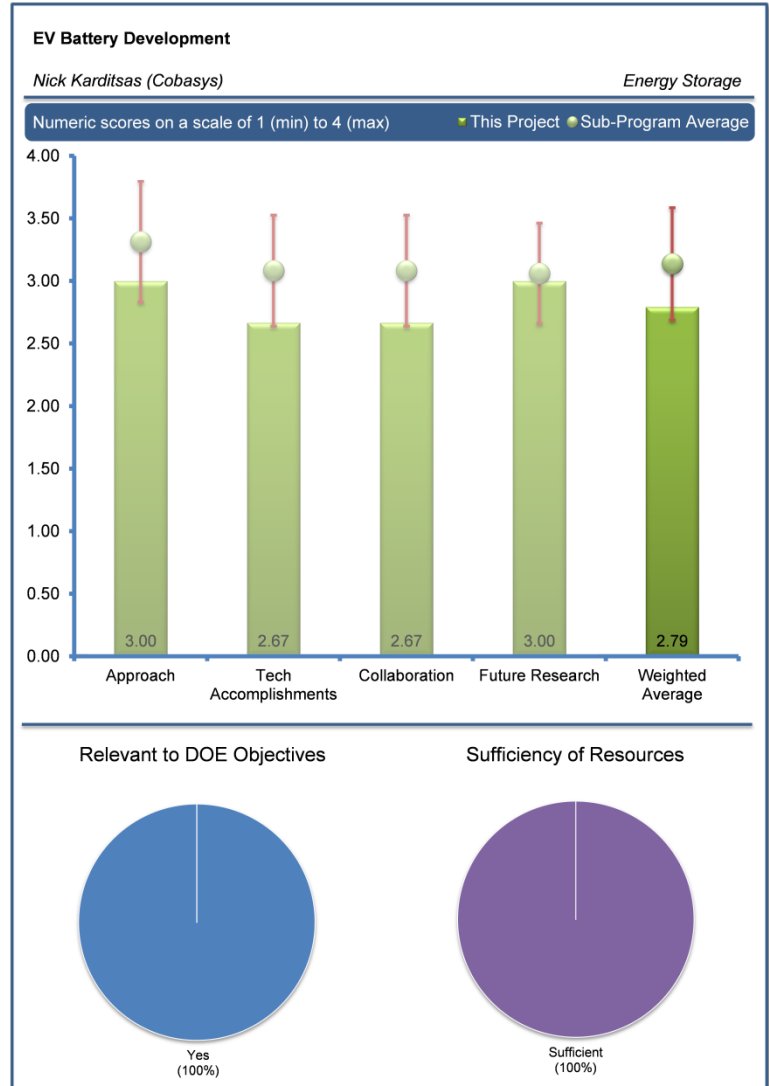
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. One reviewer explained that advanced lithium-ion chemistries with high energy densities were the horizon for PHEVs and EVs, aided by the rapid emergence of new cathode, anode, electrolyte, and electrolyte additive materials for interfacial stability or over charge protection, both within the DOE laboratories and elsewhere. In addition to the performance improvements with these materials, this reviewer opined that cost purity and manufacturability were also important factors in the overall cost, life, and feasibility of PHEV batteries. This reviewer stated that the objectives of this project were to develop scalable processes for manufacturing electrolyte materials, synthesize kilogram quantities of each material, and make them available for industrial evaluation in large-format cells. This reviewer offered that this program was a key missing link between the discovery of advanced battery materials, market evaluation of these materials, and high-volume manufacturing. This program would also reduce the risk associated with developing and maintaining a domestic, commercially viable, battery manufacturing capability. A second reviewer pointed out that the goals of this work were to implement higher energy materials for improved Li-ion batteries (greater range) and also to lower costs, which was one of the main barriers to acceptance of this technology. The same reviewer reported that this work was focused on the battery pack design, thermal management issues, and on devising a complete product, and would form a framework for commercialization of new advances in materials and design.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback was positive in this section. The first reviewer explained that the use of high energy cathode materials was key to low cost, high energy systems, and that the project team seemed to have a step-by-step approach to the work, which was good. The second reviewer remarked that the approach involved development of advanced cells, packs, and a thermally efficient pack module. This same reviewer reported that the cell development involved the study of two cathode materials (i.e., convectonal NCM cathode and NCM with Li-rich layered-layered structure in coin cells, 18650 cells and full cells) while optimizing several design parameters such as particle size, porosity, composition of composite cathode, and surface coating for thermal stability, and optimization of cells design relative to safety devices and separator. The pack design involved the following, as described by the second reviewer: optimization of pack layout; use of advanced materials; simplifying, reducing or eliminating the cooling system; ease in assembly; and mass production. The reviewer stated that the approach looked comprehensive, well-designed, feasible, and was well aligned with the material development strategizes in ABR. A third reviewer opined that the approach seemed rather



timid. The reviewer continued that NCM with 40% nickel content in particular was, by some measurements, a lower Ni content than that already in use in some power tool cells that had been torn down and analyzed. Other than that, the basic approach seemed very thorough and well thought out.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Positive comments were generally received in this section. One reviewer observed excellent progress achieved thus far in all categories (i.e., materials for advanced cell designs, cell designs, and pack designs). Further, this reviewer listed significant accomplishments that included the following: demonstration of high specific energy of 165Wh/kg in large format cells with the conventional NCM cathode (150 mAh/g), satisfactory safety performance of cells with thermally stable electrolyte and separators, and enhanced life performance via surface treatment of cathode and anode materials; completion of the initial assessment of Li-excess LLC cathode, and demonstrated good cycle life with an improved electrolyte system and initiation of the development of large format cells (32Ah cell); evaluation of different separators and effects of different surface coatings/dopants on cathode; and verification of the benefits from new pack materials and component integration as well as assembly process improvement toward target attainment. A second reviewer noted that although results have shown a continually increasing power density with each change, the energy density had not increased significantly and was still far short of the goal. This same reviewer cautioned that while this may be acceptable for HEV, it was not so for PHEV, and recommended that the authors rethink the approach to improved energy density. The third reviewer recognized that the project team had tackled a whole range of cell material issues, looking to cathode surface treatments, electrolytes, and separators in a screening mode. The team had also made good use of computer aided design work and the final specific energy of the package was quite good. The same reviewer indicated that many of the goals had been met and that the project team was only a third of the way through this contract, the energy of the system should be increased to meet the specific energy and energy density goals. The reviewer pointed out that the project team had demonstrated good power ratios and improved cycle life, but low cost lightweight materials for pack construction were also important in bringing down the \$/kW and \$/kWh figures. The project team had devised the pack to minimize the effect of cold and hot ambient temperatures on performance and lifetime, although these remained challenges. The reviewer noted that this program was well positioned to take advantage of improvements made by other material suppliers. Furthermore, the same reviewer shared that costing information from this program on actual packs should also be valuable, although actual costs were not disclosed for obvious reasons.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback in this section was positive. The first reviewer stated that there were several useful collaborations on-going and planning to be continued, as the material development and demonstration in improved cells and packs would continue. This reviewer added that there was little interaction with the DOE laboratories, which could be used to verify these promising results from Li-rich LLC cathode. Another reviewer acknowledged that this was a commercial company, so collaboration was typically never going to be as open as with an academic institution or a national lab. This reviewer observed that the project team had good relationships with its suppliers, such as BASF. This reviewer expressed the hope to see some validation work and safety studies in cooperation with Sandia as this work progressed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was generally positive. The first reviewer reported that future plans included the following: development of cell with 180 Wh/kg with NCM materials; optimization of cell design for mechanical and thermal configurations of module and pack; further improvement of Li-rich LLC by surface coating and doping for a better rate performance and with an advanced high voltage electrolyte; elimination or further reduction of the cooling system; and additional optimization and integration of components with low cost and less complexity. The same reviewer remarked that these plans were well integrated with the project objectives and addressed and mitigated the risks associated with the Li-rich LLC cathodes. The second reviewer stated that the project team's plans seemed acceptable, but indicated a desire to see that new anode materials such as those developed by Envia Systems were incorporated, if possible.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that the project resources were sufficient. One of the reviewers noted that the budget of \$1.5 million, including 51% of cost-share from the contractor, looked adequate and well justified, based on the progress accomplished and its significance. Another reviewer expressed that while this was a substantial award, Samsung should at least match this, presumably with in-kind staffing. This reviewer shared that pack design work was significantly more expensive than cell design as one needed at least prototype molding and/or tooling for many components to provide actual samples. Thus, the same reviewer commented that the funding level did not seem too bad, although this was basically subsidizing product development work that normally could be funded internally by such large corporations. However, the project team was at least returning results.

LEESS Battery Development: Kimberly McGrath (Maxwell) – es139

Reviewer Sample Size

This project was reviewed by three reviewers.

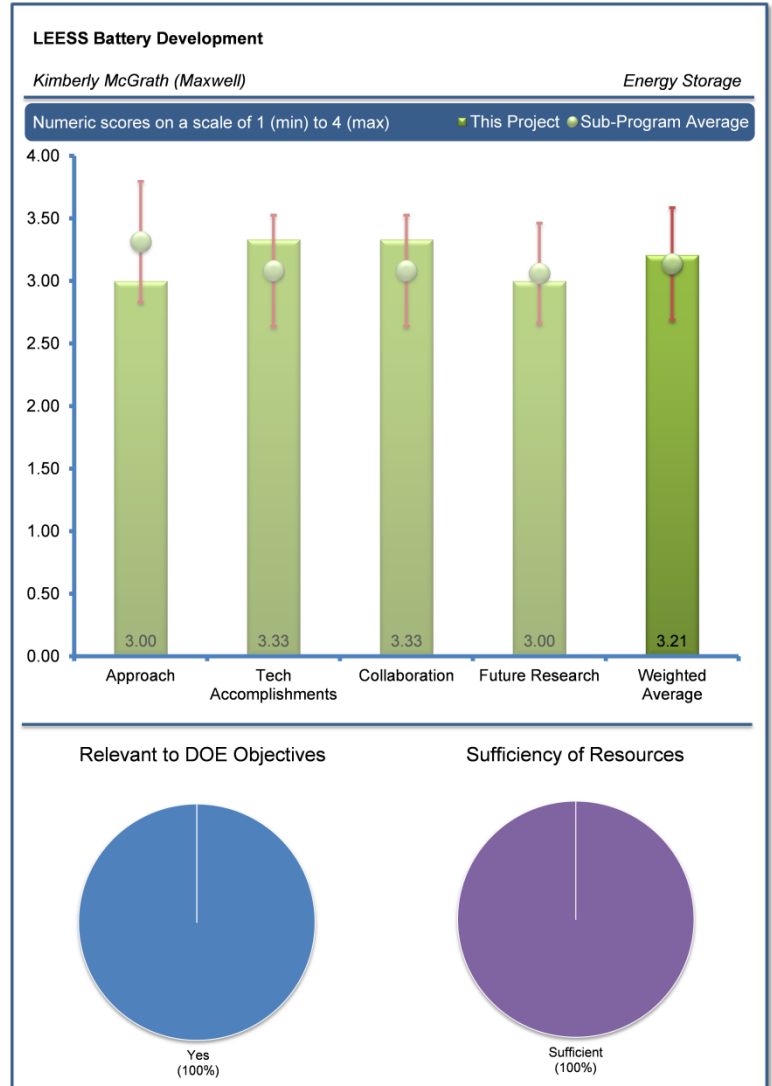
Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback in this section was positive. The first reviewer observed good relevance. A second reviewer explained that one of the deterrent factors for the use of the current Li-ion batteries for HEVs was the cost, particularly if the high power batteries would have to be met by the battery. The same reviewer added that an alternate approach for this was to augment the Li-ion battery with a Low Energy Energy Storage System (LEESS), which would be an advanced electrochemical capacitor. The second reviewer remarked that the objectives of this project were to meet LEESS EOL power and energy requirements through the development of capacitor cells and develop a system that represented a significant advancement over commercially available capacitor technology, with enhanced low-temperature performance and amenability for low-cost manufacturing. Such an advanced capacitor-based energy storage system would accelerate the infusion of Li-ion batteries in HEVs and may also benefit PHEVs. The third reviewer pointed out that the program aimed to improve the performance and reduce the cost of capacitors, which aligned well with the DOE goal of reducing petroleum consumption. Low cost capacitors

could be married with a battery pack to create a hybrid energy storage system for vehicles. The hybrid energy storage system would allow the capacitor to respond to the vehicle's power demands and the battery to provide the energy. This could allow manufactured batteries to be optimized for energy storage since it would not need to respond to the instantaneous power demand. This could also potentially reduce the size of batteries installed in vehicles if the current buffer provided by the capacitor was able to increase the battery's life for a given use-profile. This reviewer noted that current battery discharge paradigms limited the depth of discharge to preserve battery life. If capacitors were able to increase battery life by minimizing the instantaneous power draw, then the battery's depth of discharge could be increased without reducing the overall life of the battery. This would allow for a smaller pack to be installed, which would be lighter and cheaper. Further, as expressed by the third reviewer, the higher power potential of a capacitor could enable a greater amount of braking energy to be harvested and used for tractive power, which would increase the HEV's overall system efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, reviewer comments were positive in this section. One reviewer offered that the program seemed to be taking a holistic approach to developing a low energy, high power capacitive system focused on materials and system design to meet the performance, price and packaging targets. A second reviewer observed that the capacitor development involved identification of new cathode, anode, electrolyte, separator and suitable cell design architecture. Specifically, as indicated by this reviewer, the



approach included development of the following: electrolytes with a wide electrochemical window, good low-temperature conductivity and lifetime; improved cell via selection of anode and cathode electrode materials based on discrete structure-property relationships and combinational screening; low-cost separator; and leveraging economical cell design to produce the lowest cost and smallest and/or lightest system. This reviewer further noted that the approach looked feasible, it addressed the technical barriers of power, life, and cost, and was well integrated with the ABR program objectives. The third reviewer recognized that it was a novel idea, although handling a lithiated anode did pose its own challenges. This reviewer inquired about the impact on manufacturing steps.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback in this section was generally positive. The first reviewer asserted that progress accomplished thus far was quite encouraging and went on to list the following, significant accomplishments: identification of two best anodes with low ESR and superior cycle life, from the screening of 20 anode materials; initiation of combinatorial screening of multiple cathodes; optimization of electrode thickness, resulting in 10% reduction in cell weight; electrolytes with superior low temperature performance than baseline; identification of electrolyte additives for improved cycle life; low-cost separator from Porous Power Technologies; and development of system with thermal design. Additionally, this reviewer remarked that these results indicated that the progress demonstrated thus far was consistent with the project objectives and that all the scheduled milestones were met. The second reviewer observed that the program appeared to be progressing in a methodical manner. This reviewer added that Maxwell had identified the necessary development steps that needed to be taken with regard to the energy storage system components and was working through the development in terms of material vetting and selection. A final reviewer acknowledged that progress had been made on several fronts, but cautioned that key challenges remained, including weight, and above all, cost and volume gaps.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Positive comments were received in this section. One of the reviewers noted good collaboration among the competent organizations, and a second reviewer further specified that there were useful ongoing collaboration with URI and Porous Power Technologies, and new collaborations with the DOE laboratories, INL, NREL and SNL were being planned for life testing, thermal modeling and abuse testing, respectively. A final reviewer observed a strong collaborative relationship with the national laboratories, but suggested that the project team could potentially benefit from an OEM that could provide additional insight on the performance and cost targets that needed to be met for commercial adoption of the technology.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was somewhat mixed. The first reviewer reported that future plans were aimed at the following: finalizing the anode and cathode electrode materials, electrolyte, and separator based on previous down-selection results; fabricating cells from a pilot line; fabricating and testing hybrid ultracapacitor cells in final system architecture; and completing a full manufacturing cost model for both the cell and the system. The same reviewer added that the planned work was effective in removing the barriers to the realization of capacitor technology for LEES without any obvious risks. Another reviewer explained that the project team had attempted to mitigate risks by identifying multiple sources to supply key components so that the program's success did not hinge on a single supplier. This reviewer indicated that the remaining steps forward seemed like a methodical approach to achieving the program goals and further described that the project team was moving forward systematically to achieve the following: selecting the component materials from the identified pool of candidates meeting specified performance and cost criteria; constructing and testing cells from the identified materials; constructing and testing capacitor systems from the prototype cells; developing a cost model for systems and cells; and constructing and testing production cells and systems. This second reviewer noted that while the project team's overall approach was consistent with production releasing an automotive grade component, the presentation did not provide a discussion on the level of validation work that would be undertaken on qualifying the cell and system design before initiating the production phase. This would be key to ensuring that the product was robust prior to its being released for production. The final reviewer acknowledged that a good amount of progress

had been made on multiple fronts, but questioned whether a roadmap existed to close the large gap in volume requirement and cost.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer explained that the budget, with 50% cost share from Maxwell, looked reasonable for the hardware development being planned. Another reviewer indicated that the financial resources dedicated to the program seemed adequate for the development activities, but could be light for full production qualifying a component for high volume manufacture. However, the reviewer qualified this statement with the caveat that the reviewer had not been involved with a battery or capacitor development program in the past.

Novel High Performance Li-ion Cells: Keith Kepler (Farasis) – es140

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

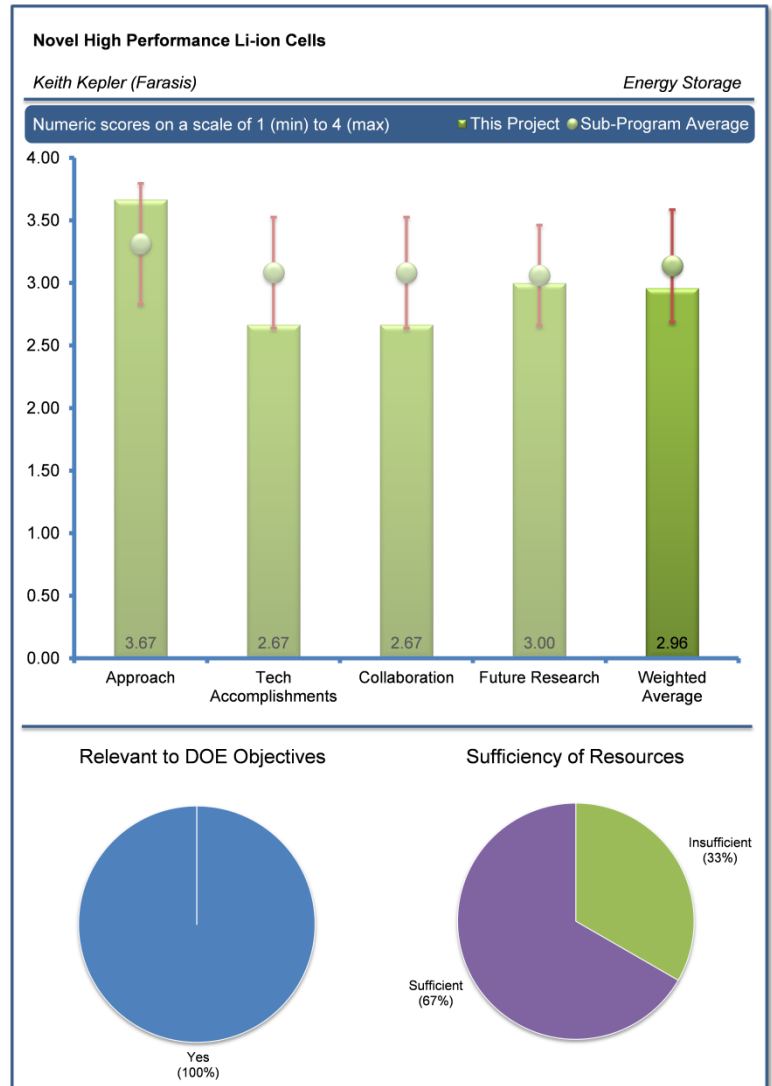
Feedback in this section was positive. The first reviewer described that increasing the capacity of electrodes and employment of abundant transition metals for electrode were ways of reducing the cost of batteries. In addition, this reviewer noted that the project's approach was to bring a new cathode chemistry to increase battery energy density and reduce cost, which was a key parameter for formation of the electrified vehicle market. The second reviewer also observed that the project goal was to develop a cathode additive that could enhance practical, usable energy density for the cathode. Further, this reviewer stated, the precursors and process were intended to be low cost, thereby enhancing battery performance with a minimal cost impact. A third reviewer remarked that the project dealt with improving energy density, cost, and safety of energy storage systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were generally positive in this section. One reviewer expressed that the project was well thought out, and well executed. Further, opportunities arising from the execution of the program were identified, evaluated and accounted for, as part of future work. Another reviewer opined that the LFO/LVO cathode seemed interesting with higher energy density as compared to the LFP chemistry. However, this reviewer cautioned, it had low voltage (i.e., lower than LFP), which may be issue for electrified vehicles that did not employ an expensive voltage booster. It was suggested that additional cells with LFO/LVO cathode may be required to meet the vehicle-level voltage requirement. This same reviewer commented that while the general concept of employing LFO/LVO cathode material to boost energy density was very interesting, it would be better to compare its energy (i.e., specific energy) densities to those of NCMs or Ni-rich NCMs widely used for high energy cells for automotive applications. This reviewer reported that the approach included the recycled LFO electrodes and synthesis process, study of the reliability of the electrodes, and building cells with Vanadium oxide cathodes for testing and validation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, positive feedback in this section was received. The first reviewer observed significant progress in terms of modifying LFO materials for its stabilization and evaluation of its effect on the active cathode materials. This reviewer also reported that the evaluation of life and performance of cells with LFO was ongoing. The second reviewer noted that increasing the specific capacity was accomplished, the cathode was developed, and building cells had been started. The third reviewer asserted that the cathode



work was well done, but identified a missing project element, which was the comprehensive characterization of a test cathode formulation, in a baseline cell configuration, so that a broader performance assessment could be done.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Remarks in this section were mixed. One of the reviewers pointed out that collaboration was not made as clear in the slides as it should have been, whereas the collaborations were made clear in discussions during the poster presentation. Another reviewer recognized ANL as a good collaborator for this project, but recommended additional collaboration with other national laboratories to fully evaluate cell performance such as abuse tolerance evaluation with new chemistries.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer statements were mixed, overall, in this section. The first reviewer stated that future research solved the problem of electrode stability and anode to cathode capacity ratio. A second reviewer observed that the project had effectively reached completion although the presenter indicated a 90% completion point. The final reviewer recommended a more detailed plan for future work to include clarifying the tests (e.g., low temperature performance and life tests under accelerated test conditions) that would be included for full evaluation of cells with new cathode material.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of the project resources. Two reviewers indicated that resources were sufficient, while another reported that resources were insufficient. One of the reviewers observed no issues, while another opined that support from ANL may be enough for material development, but collaboration with other national laboratories was recommended for full evaluation of cells with new chemistries.

3-D Nanofilm Asymmetric Ultracapacitor: Fraser Seymour (Ionova) – es141

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

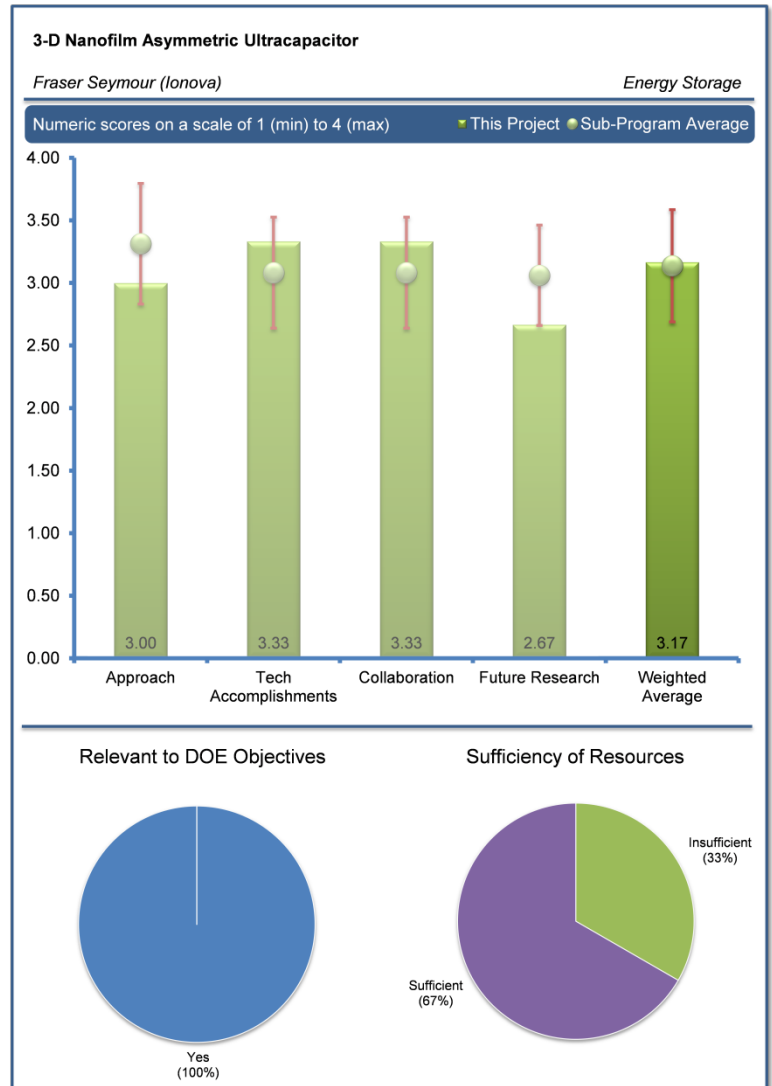
Reviewer feedback in this section was positive. One of the reviewers indicated that the technology was targeted for use in mild hybrid or LEES applications, as defined by USABC. This reviewer further noted that these had the potential for large-scale market penetration into automotive applications and similar applications exist in grid storage. The challenges facing ultracapacitive energy storage were correctly identified. Another reviewer observed that this program demonstrated the cost savings, improved performance, and life with a water-based, asymmetric ultracapacitor, which had a higher energy density compared to conventional symmetric ultracapacitors. Key features of the technology developed by this project were employment of 3D nano metal oxide film for positive electrode and bi-polar electrode design to increase energy density and reduce costs. A third reviewer relayed the need for low-cost supercapacitors with the performance and life capabilities in order to meet USABC goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments in this section were generally positive. The first reviewer acknowledged the correct alignment of project goals with the reported barriers, which were correctly defined with respect to USABC goals. A second reviewer observed that IONOVA seemed to pre-define the issues with the conventional ultracapacitors (both symmetric and asymmetric) and addressed the issues by using a novel electrode, less corrosive electrolyte, and efficient cell design. The final reviewer explained that using the aqueous electrolyte would increase the self-discharge and may limit the application for HEVs when there was a long storage (e.g. 30 days at the airport). This reviewer further stated that the bipolar electrode designs were very difficult to implement and the battery industry had tried the concept using Pb-Acid and NiMH batteries without significant success.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, feedback in this section was generally negative. One reviewer indicated that developing high porosity, high surface area carbon was beneficial to supercapacitor development. Another reviewer noted energy density improvements but highlighted that the power density was not as well defined. This reviewer also pointed out that both cyclability and self-discharge performance results were concerning at this stage of the project. The same reviewer recognized that the presenter somewhat addressed these concerns, and further stated they were part of the future work. The final reviewer stated that highlights of technical accomplishments for each cell component were described in the poster presentation materials. However, initial performance of the



cell was mostly highlighted and no life related data was informed. Also, this reviewer reported that key performance for xEVs (e.g., low temperature power capability) was missing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments received in this section were somewhat negative. The first reviewer observed decent coordination with electrolyte experts, bi-polar cell and full cell design companies to address the main issues, while another reviewer explained that key collaborators had not engaged significantly in this project, at this phase. It was clear to the second reviewer that the collaborators would provide valuable support once their phases of the project became active.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback was generally negative in this section. One reviewer remarked that less work seemed to be done for cell design optimization and suggested a more detailed plan for cell design and evaluation of bi-polar electrode stacks. A second reviewer explained that future research should be represented in terms of work yet to be done, and gaps to project goals. Additionally, the description of future work was overly qualitative.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. Two reviewers indicated that resources were sufficient, while another reported that resources were insufficient. One of the reviewers summarized that the program was over two years in duration, with less than five months left, and reported at 75% complete. Further, the perceived gaps between current status and goals appeared to be potentially greater than indicated. This reviewer also cautioned that extensive risk was associated with the systems integration aspect of the project.

Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells: Suresh Sriramulu (TIAX) – es142

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

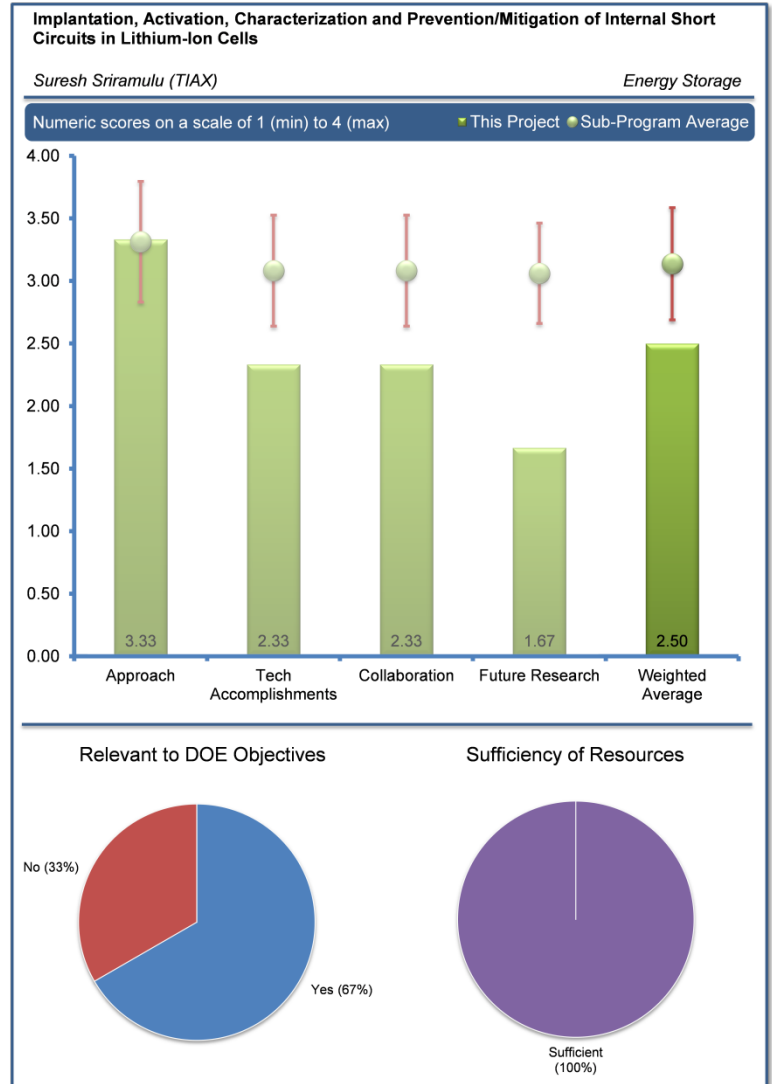
Reviewer feedback was generally positive in this section. The first reviewer asserted the need for predicting and preventing the potential for thermal runaway in Li-ion batteries, and a second reviewer offered that understanding the internal short circuit mechanisms and finding test method representing the internal short was very critical for battery safety. This second reviewer further added that, without understanding the safety failure mechanisms, no safe device could be correctly designed to prevent severe safety issues. The same reviewer remarked that this type of investigation needed to be carried out for better understanding of internal short circuit mechanisms to enable the use of reliable and safe batteries in electrified vehicles. A final reviewer pointed out that it would have met the overall DOE objectives if a mechanism for mitigation and detection was included, and that this was described qualitatively in the poster discussion.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments received in this section were generally positive. One of the reviewers offered that the implantation of precursor of metal dendrite and monitoring from outside the cell had a lot of value for the automotive OEMs. Another reviewer observed that the approach was very logical, involving screening various metals causing internal shorts with time or number of cycles and finding the best candidate for this project. Further, this reviewer noted that validation tests with coin cells and commercially available larger cells (18650 cells) supported the mechanisms for the internal short circuit. A final reviewer explained that the test described herein was an extension of that developed by the Japan Battery Association. The specific objectives behind this particular study were not clear in the poster presentation. Finally, this reviewer offered that while the study demonstrated that the test was effective when contaminating the cathode, it did not clearly explain what form of cycling induced the short circuit, as opposed to standard formation and cycling.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer statements in this section were mixed. One reviewer reported good findings and progress towards the project objectives. During discussion with the presenter, this reviewer learned of some information on a sensor that could detect the internal short circuit before an extreme thermal event occurred. More information on that sensor may be communicated in greater detail in the



future. A second reviewer remarked that progress was difficult to judge, as goals were not clearly defined. Although the project alluded to a method for the detection of soft shorts, this reviewer noted a lack of any science to support the claims. The third reviewer observed that the poster presentation did not disclose information regarding the mechanism of formation of internal short, monitoring for significant characteristics during the life of the cell, and thermal run-away. Thus, it was very difficult to assess the significance of monitoring to find the potential of internal thermal run-away.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback from reviewers was generally negative in this section. The first reviewer noted that Tiax was working with their customers, while the second reviewer remarked that no information regarding project partners was available in the presentation slides. This second reviewer recommended that it would be good to team with a large cell manufacturer and apply the same test method to large format cells (at least 5 Ah cells), which would further validate the test method to find similar responses to smaller cells. The final reviewer observed that no appreciable collaboration was indicated apart from prior work.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were negative. One of the reviewers observed that future work was qualitatively described. Additionally, though detection methods were discussed, mitigation was beyond the scope of the proposed future work. A second reviewer remarked that no future work was clearly mentioned in the presentation slides, while a third reviewer asserted that there was no future research plan.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer clarified that because milestones were not clearly defined, it was assumed that resources are sufficient.

Novel Anode Materials: Jack Vaughey (ANL) – es143

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

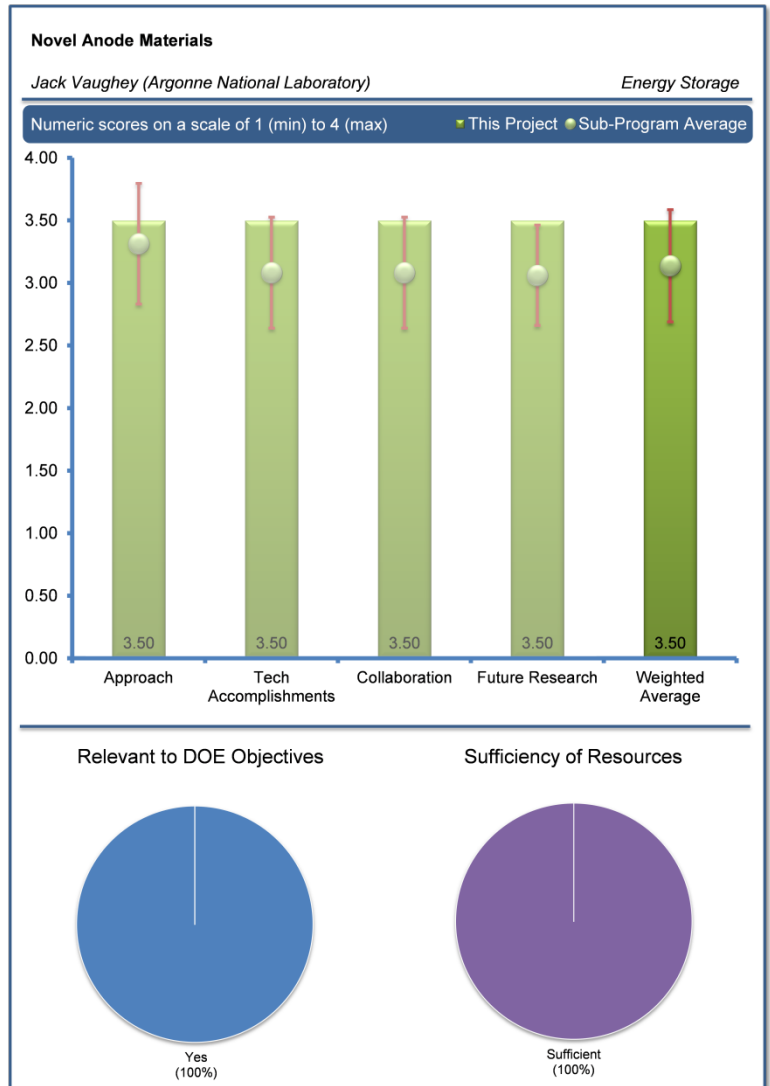
Feedback in this section was positive. The first reviewer explained that this work was aimed at developing new ways to study electrode structures using NMR and tomography to better understand how some of the new high energy anode materials actually change inside the battery during cycling. As such, it should bring a useful capability to the DOE's infrastructure in this area. Another reviewer observed that this study was arriving at a better understanding of how lithiated silicon interacted with its surroundings. Further, continued this reviewer, silicon materials are viewed as a potential replacement for graphite.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, remarks in this section were positive. One of the reviewers stated that the approach seemed very good, and praised the use of NMR as it was not dependent on having an organized structure in the same way that diffraction studies are. This reviewer believed this to be especially important as the field goes more and more into nanoparticles or particles with nanostructures where the materials are often found to be amorphous, which limited the amount of information that diffractions studies could provide. Another reviewer expressed that the ANL synchrotron would be used to better understand how silicon interacted with its surroundings in a battery environment, while nano- and micro-tomography synchrotron would be used to better understand the synthesis procedures and effects of cycling. This reviewer noted that studies included the interaction of silicon with the surroundings varying the loading, morphology, and thickness in the electrode-electrolyte environment. The reviewer added that it should also be possible to study the electrode position of silicon, antimony, and tin in a similar manner. The same reviewer suggested identifying and assessing the role of electrolytes and irreversibility as well as SEI composition.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was positive in this section. The first reviewer reported the following: silicon metal was deposited on copper foam with a 50 micron pore size; electrodes were cycled and gave over 250 cycles without significant fade; CuSix alloys were prepared and also cycled; tomography gave evidence of the effect of volume changes on cycling, as well as the depth of discharge; and *in situ* experiments were underway to provide information on Li⁺ diffusion in the electrode structure. The second reviewer described the project team as having devised and made some interesting structures, although their utility remained to be seen as it was still in the early days. Additionally, the project team had developed techniques and demonstrated some very good images of



certain key materials. In terms of capability, this reviewer found that the project team had made good progress on the tomography and was getting its NMR system up and running.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were generally positive. One of the reviewers commented that interactions included Cui at Stanford, Liu at LBNL, Whittingham at SUNY-Binghamton, and Thackeray at ANL, and a second reviewer observed that overall collaboration seemed good. The second reviewer had hoped that the project team could have worked with Clare Grey or her group at Stony Brook University for the NMR. The same reviewer suggested that Rex Gerald may also be worth consulting as he did some early work on *in situ* NMR of batteries at ANL and was still located there, though in a different division.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback in this section was positive. The first reviewer reported that NMR would be employed to improve the understanding of the macrostructure of silicon electrodes and x-ray tomography for studying the internal structure and morphology relating to capacity fade. A second reviewer asserted that the plans seemed fine.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer indicated that the present funding level was adequate for the present program needs, but cautioned that additional funds may be needed in the future to speed development of commercial electrodes. Another reviewer opined that while the work was worth continuing, \$400,000 for 2012 was a little pricey.

Development of Si-based High Capacity Anodes: Ji-Guang (Jason) Zhang (Pacific Northwest National Laboratory) – es144

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

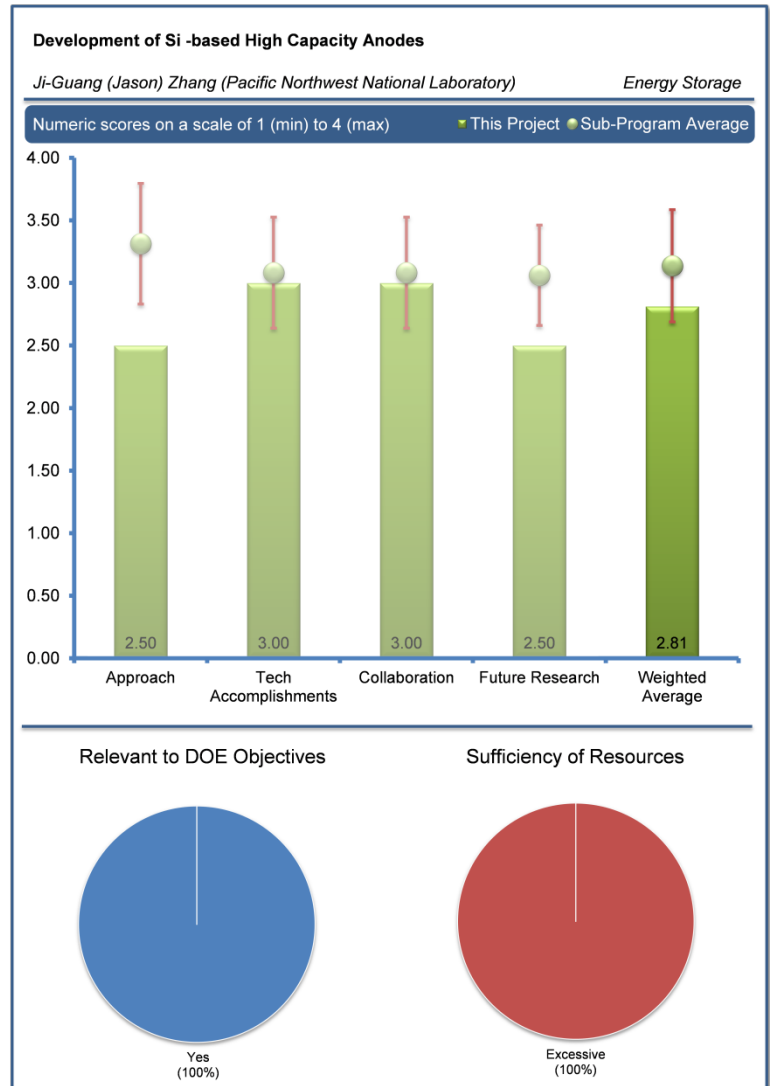
Reviewer feedback was positive in this section. One reviewer explained that new anode materials for higher performance Li-ion batteries would significantly increase energy storage capability, while another remarked that this work was aimed at new ways to make high capacity silicon anodes for Li-ion batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, comments in this section were mixed. The first reviewer stated that the problems and potential solutions for the following were identified: mechanical instability of Si particles - nanostructured Si; electrical instability, loss of contact to active mass - conductive additives and coating; and electrochemical instability - new electrolyte and additives. Another reviewer indicated that two approaches were mainly used. This reviewer reported that the first was the core-shell approach with silicon inside a carbon shell, which seemed satisfactory, but was not especially novel. The other approach, continued this reviewer, was based on using a very hard B_4C core and then coating Si on the outside. The reviewer did not see how this could help contain or handle the effect of Si expansion because the Si was fully exposed to the electrolyte. This reviewer opined that, in a sense, the B_4C seemed to act as voluminous, wasteful current collector. Additionally, because the B_4C comprised about half of the anode coating, adding this inert material cut capacity in half, with no real advantage observed from the second reviewer. The same reviewer expressed difficulty in seeing why one would expect this to work and concluded that some of the work seemed rather empirical (e.g., slides purporting to understand the additive effect described work that just evaluated the materials and did little or nothing to understand how it worked or did not work).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback from reviewers in this section was mixed. One of the reviewers reported the ratio of Si/Core/Graphite for optimum performance had been established. This reviewer also observed an electrode with 822 mAh/g capacity retention of 94% after 100 cycles with reasonable rate dependency had been achieved. Further, addition of FEC additive improved cycle life. The second reviewer acknowledged that the work on Si with large pores showed an advantage, but cycle life was still far too poor to be of interest. In addition, this reviewer noted that the Si in carbon framework studies showed decent stability and capacity, although not any more than many other approaches by other groups. The same reviewer also described the manufacture method as reasonable, and that even the data for the B_4C electrodes looked decent. However, the reviewer was unconvinced of the project team



explanation regarding why this worked at all. The PI indicated that the hardness of the balls compressed the Si and retained it in place, but the electrode structure was essentially open on one face, which led this reviewer to query why the Si could not just expand and squeeze out material in that direction.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were mixed. The first reviewer recognized Princeton and Vorbeck for grapheme, Rhode Island for electrolyte additive, Vesta for porous Si, and North Dakota State for Si nanowires. Another reviewer did not get a feel for this in the time available, and though many partners were listed, this reviewer was unsure whether this work needed a lot of collaboration in the early stages.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks in this section were mixed. One reviewer acknowledged an acceptable, proposed work plan. The plan, as reported by this reviewer, involved improving cycling performance of rigid skeleton concept, carbon layer, and porosity, etc., as well as characterizing full cell performance. This reviewer also noted the inclusion of a SEI layer study and additives. The second reviewer saw no evidence that the PI had a plan to really understand the project team's electrode materials, especially those with the B₄C core particles. The entire project seemed very empirical. This reviewer questioned that such work would lead to a significant advancement in the understanding of these materials, and without such understanding, progress or value returned to the program was doubtful. In another area, shared this reviewer, other PIs in the program were already working on additives and electrolytes to improve Si cycling stability. The reviewer inquired whether the project team could tap into them rather than trying to do this on its own.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer opined that resources seemed reasonable for the work plan, while another saw little reason to expect the project team to significantly advance the state of the art in this area.

Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes: Anne Dillon (National Renewable Energy Laboratory) – es145

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

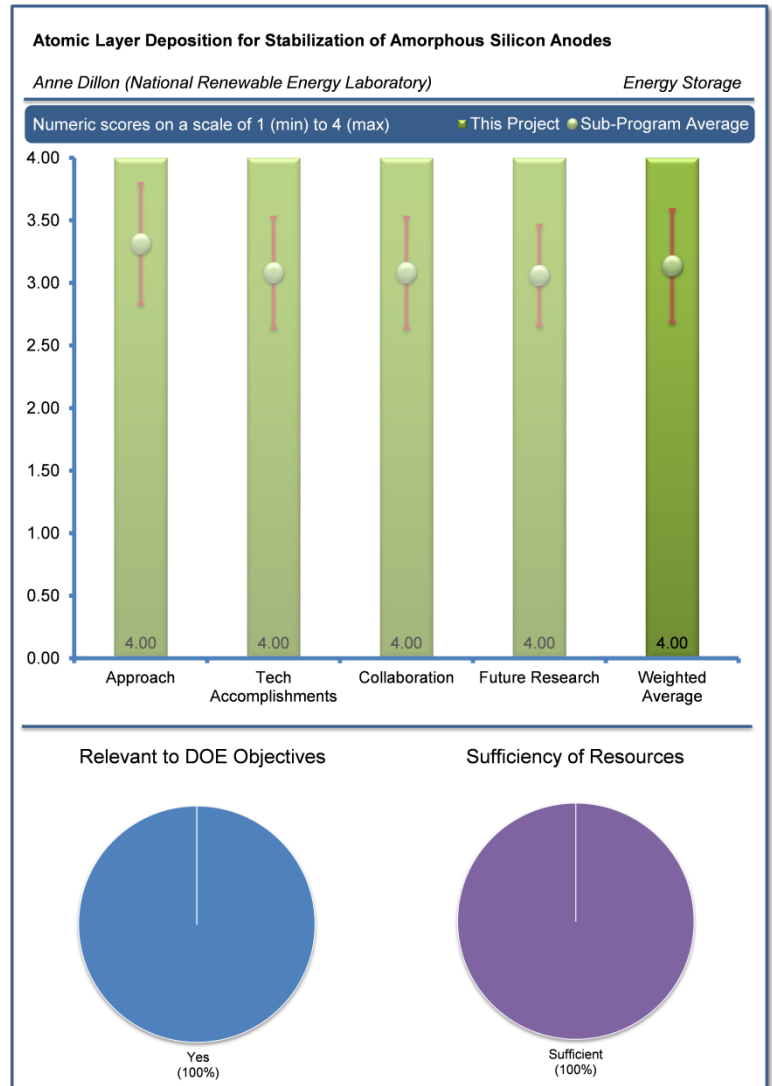
Reviewer comments in this section were positive. The first reviewer explained that the focus of this project was on using atomic layer deposition (ALD) to make very thin stabilizing coatings on both anodes (i.e., Si, Natural Graphite – NG) and cathodes (i.e., LiCoO₂ – LCO) to improve cycle life and reduce the irreversible capacity loss. As such, this reviewer further added that these approaches promised to significantly enhance the useful capacity and especially the cycle life and calendar life of new high energy density batteries. Another reviewer reported that the project was directed at developing inexpensive processes for silicon-based electrodes, including HWCVD and ALD, as well as developing a better understanding of the process parameters.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was generally positive. The project team, as indicated by the first reviewer, had shown a novel and excellent series of approaches to stabilizing the Si surface. The ALD coatings were thin so that it should minimize any adverse impact of the coatings on the rate performance of the materials. The reviewer stated that the project team was making full use of a variety of spectroscopic methods to really study and understand the materials interface and combining that with some good cell builds, electrochemistry, and impedance studies of symmetric cells to help clarify which electrode was responsible for what phenomenon. This reviewer also praised the fact that the project team was looking at non-vacuum methods that would be necessary to scale up such an approach. A second reviewer observed that the major problems of volume change, mechanical degradation on cycling, as well as developing a simple solution using ALD coatings on a nanoscale Si particle, were all addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer statements in this section were positive, overall. The first reviewer explained that scale -up of HWCVD revealed that the substrate temperature played an important role in preparing suitable electrode materials. This reviewer further offered that the formation of crystalline silicon was identified with Raman study and must be avoided for long cycle life. The same reviewer observed that Si/Cu electrodes stabilized by ALD of Al₂O₃ with excellent coulombic capacity. The particles became amorphous after the first cycle and gave stable cycling capacity. The reviewer also remarked that the coating seemed to improve the mechanical stability of the anodes. The second reviewer was very favorably impressed by the amount of work and progress shown



by this team, which had made the materials and structures it was targeting and shown that the ALD coatings did indeed offer significant advantages in terms of boosting the cycle life. Moreover, this was true on all three electrodes studied. This had shown that the method had a very wide range of applicability and the project team had basically proven the premise upon which this proposal was based. The project team, continued this reviewer, had made a Si/C anode that needed no binder and had a high Si content (70:30 Si:C). The uncoated thick core shell Si electrode did have a high fade rate, but it started with a very high capacity (2,600 mAh/g). Applying the 3ALD coatings maintained the high capacity while yielding a dramatic increase in cycle life. While still fading, this was one of the most promising results this reviewer had seen with Si. The thick core shell Si electrode did have a high fade rate, but it started with a very high capacity (2,600 mAh/g). The reviewer expressed interest in seeing how this material benefited from ALD protection, and further noted the possibility that the project team could deliver extremely high capacity and good cycle life. This second reviewer also observed that the project team's work was also getting at some of the anode/cathode interactions in real cells that were often overlooked by groups doing fundamental studies such as these. This reviewer emphasized that the project team was using a good combination of electrochemical characterization paired with detailed surface studies. The rate studies showed that ALD coatings were thin enough to at least handle moderate discharge rates. While this may yet be an issue for EV/HEV applications, it seemed to be fine for more modest discharge rates, such as those used in consumer devices or envisioned for some grid applications. The same reviewer opined that ALD was too slow to be commercially viable, with the possible exception of high end batteries (e.g., microbatteries, where the cost and scale are less of an issue). Thus, the separate work by Tenant (in presentation ES162) under a new ABR award was very important to build on the excellent work that this group had done. The reviewer concluded that while the carbon nanotubes (CNT) work with NMC cathodes was also interesting, the commercial feasibility of CNT remained a concern.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments presented in this section were positive. One of the reviewers listed collaborations, which include SUNY Binghamton, General Motors, LBNL, University of Texas, and SSRL. Another indicated that the project team was very well connected to other laboratories, industry, and SUNY. Moreover, continued this reviewer, the project team was actually using these connections to move the project forward.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback was positive in this section. The first reviewer opined that the volume expansion problem may be easier to solve than the first cycle loss in preparation of Si electrode structures. In addition, this reviewer reported that work on the core shell process and alternates would be undertaken to lower the costs. A second reviewer observed good plans and offered no further suggestions since per that reviewer, this group is doing excellent work already and beating its deadlines. This reviewer expressed enthusiasm in watching the project team continue its progress, and appreciated the emphasis on moving from a vacuum-based ALD process to an e-beam method that could be used at atmospheric pressure.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One of the reviewers offered that resources appeared adequate and the researchers had demonstrated a high level of creativity and ingenuity in developing the Si-Cu processing. Another noted that funding for this project is quite high, but reflected the varied work involved. This reviewer added that it was really too much to take in on a single poster. The level of effort observed by this reviewer was impressive and fully justified the funding level. The same reviewer concluded that the team was working very well on multiple fronts to deliver value back to the program.

New Layered Nanolaminates for Use in Lithium Battery Anodes: Yury Gogotsi (Drexel University) – es146

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

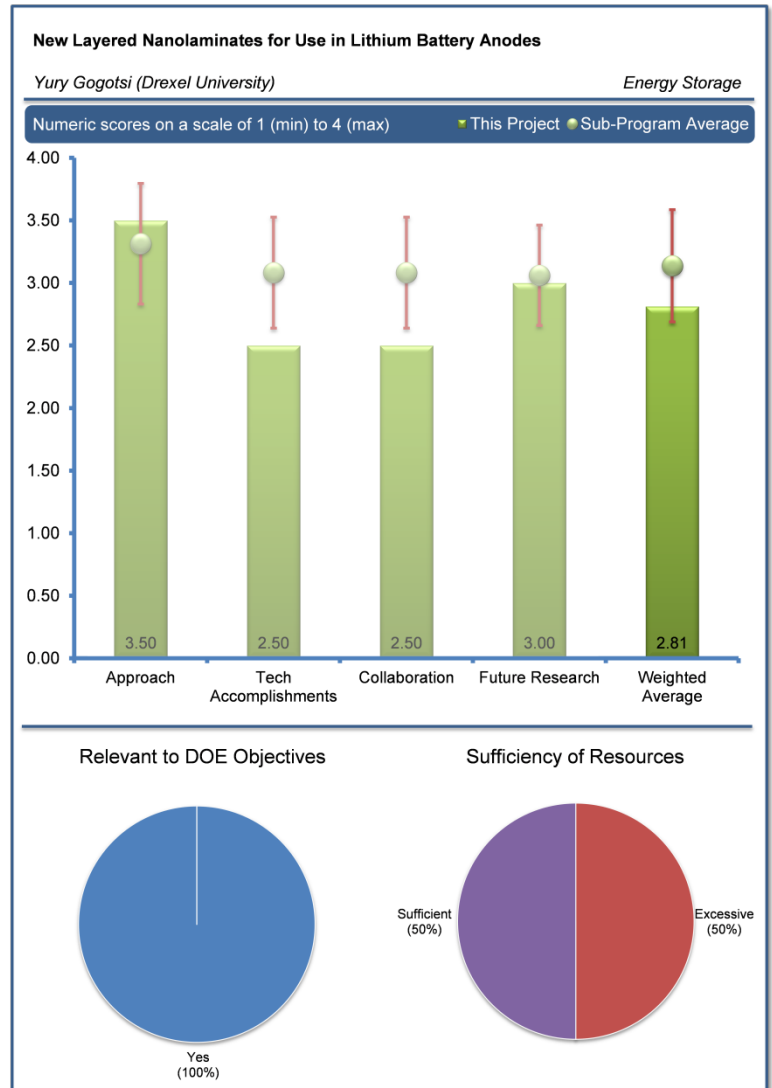
Reviewer feedback in this section was positive. One reviewer communicated that there was a strong need to develop anodes with higher capacity than graphite, and suggested that layered ternary carbides and nitrides may prove to be the best replacement for graphite anodes because they have a higher capacity, less expansion, longer cycle life, and lower cost than silicon materials. This reviewer further stated that layered ternary carbides and nitrides known as MAX phases offered higher capacity than graphite and lower expansion, longer cycle life, and lower cost than silicon nanoparticles. Another reviewer reported that this work was aimed at exploring new, high capacity anodes based on MAX materials such as Ti_3AlC_2 .

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Comments were somewhat positive in this section. The first reviewer reported the following: *ab initio* calculations to guide the selection of MAX materials and

to reduce particle size for long cycle life; modify surface structure (e.g., exfoliation) to increase lithium uptake; establish a family of MAX phase materials with superior performance; and develop an exfoliation process to increase surface area. The second reviewer explained that the project team evaluated a number of MAX materials and found that the materials did not work well, but then redirected the team's work upon discovering that exquisite exfoliated layers could be formed. The project team stated that it used modeling to guide this work, although the reviewer found there was little in the poster showing this.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, reviewer statements were positive in this section. One of the reviewers observed the identification of MAX materials and process development for HF treatment and sonification to separate sheets of active materials. This person further stated that resistivity of sheets was comparable to graphite and it was hydrophilic in nature. The same reviewer concluded that materials had essentially constant capacity for 100 cycles or more and capacities ranging from approximately 100 mAh/g to 250 mAh/g. A second reviewer remarked that the MAX materials, by and large, did not work out. However, the removal of Al by HF etching of the MAX layers produced well-characterized MXenes layers that could be separated out through sonification and had interesting properties. The lithiation/delithiation peaks were quite high, similar to that for lithium titanate spinel (LTO). However, this meant a substantially lower cell voltage and associated loss in energy and power unless compensated for in other ways. The reviewer explained that LTO actually had high power despite the lower cell voltage, but the energy loss remained a big problem. The



second reviewer opined that Ti_2C and similar materials looked to be an interesting class of anodes from a scientific point of view. The project team had done good work and answered the question as to what these materials could do. Unfortunately, the materials seemed to have three basic problems that the reviewer identified as unattractive for future development: high potential that led to a low cell operating voltage; low capacity; and high aspect ratio particles (e.g., exfoliated materials) typically do not pack well and are, therefore, volumetrically inefficient. The first two characteristics in particular would seem especially hard to overcome, although the PI felt that the capacity could be increased with additional work. In closing, this reviewer pointed out that the synthesis of these materials with HF etching did not look cheap.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were mixed. One reviewer acknowledged P. Simon at Paul Savatier University in France and L. Hultman at Linköping University in Sweden, while the second reviewer had not developed a feel for this the level of collaboration in the limited time available. The second reviewer observed that the modeling work was not highlighted in the presentation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Statements from reviewers were mixed in this section. The first reviewer stated the following: evaluate different Xenes as anodes in cells; develop processes to reduce first cycle loss; and study effect of carbon additives for conductivity. Another reviewer stated that the materials seemed to have three basic problems that made them unattractive for future development: high potential that led to a low cell operating voltage; high aspect ratio particles (e.g., exfoliated materials) typically do not pack well and were, therefore, volumetrically inefficient; and low capacity. This reviewer suggested to first focus on materials that have, or at least might have, a lower potential so that cell voltage would be higher. Otherwise, the reviewer observed, no chance that this would compete with graphite. It would even have a problem versus LTO because the commenter believed it was more expensive to make. Thus, this same commenter recommended voltammetry or modeling work to identify a promising candidate before any additional work as done.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. One reviewer indicated resources were sufficient, while another reported that resources were excessive. The first reviewer observed that the present funding was adequate, but should be increased when a suitable MAX candidate as identified for increased evaluation. The second reviewer acknowledged that while the project team did well with their funding to date, the likelihood of ending up with an energetic cell using these materials as anodes seemed very low. This reviewer expressed that it seemed a dead-end from a battery development point of view, and saw little reason to expect these materials to become viable as high energy or cost effective anode materials. Although these materials were interesting, this reviewer noted that funding this project could not be justified unless modeling data could indicate that the voltage penalty could be overcome or seriously mitigated.

Synthesis and Characterization of Polymer-Coated Layered SiO_x-Graphene Nanocomposite Anodes: Donghai Wang (Pennsylvania State University) – es147

Reviewer Sample Size

This project was reviewed by two reviewers.

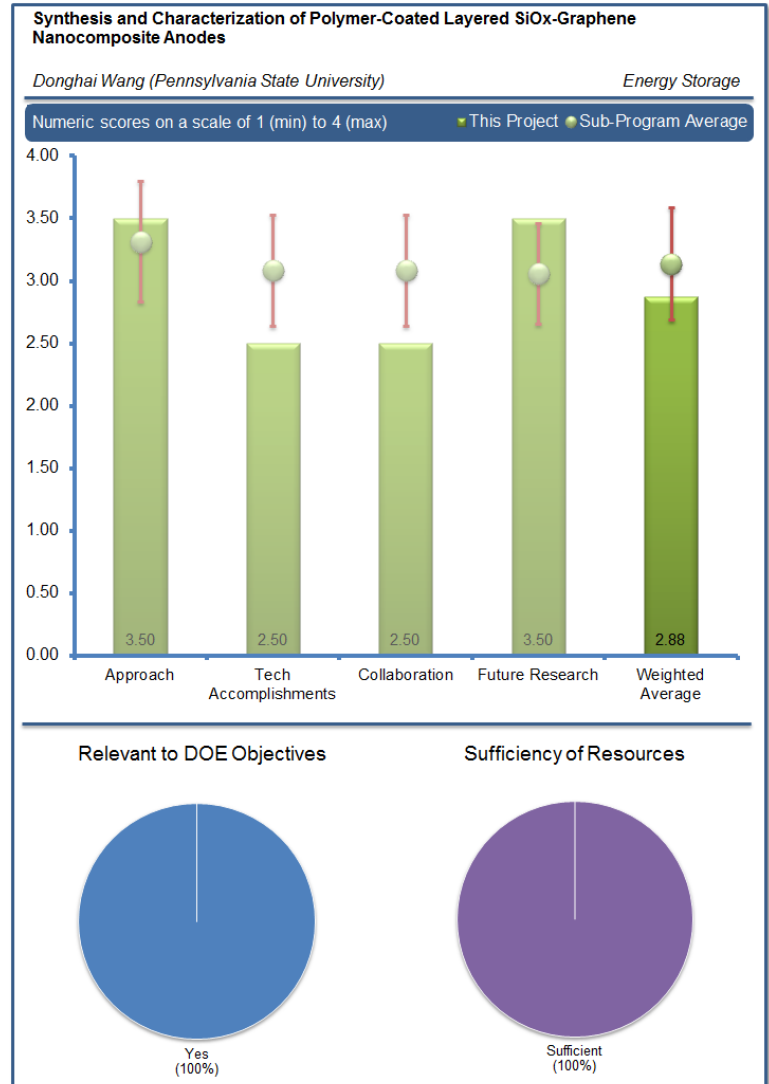
Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were generally positive. One reviewer stated that this program aimed at making core shell Si/C particles for the next generation of high energy batteries. Further, noted this reviewer, the approach was aimed at improving the cycle life and calendar life of such batteries. The second reviewer stated that Silicon anode materials offered promise for higher performance Li-ion batteries. The same person observed a very exploratory approach and acknowledged that the best technology had not been established.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Reviewer feedback, overall, was positive in this section. The first reviewer observed the following: design Si-based anode composite with fast kinetics, low irreversible losses, and tolerance for volume changes on charge and discharge; develop binders to improve cycling stability, realized 200 cycles; and develop Si-based anodes with 40% first cycle loss and 90% efficiency. A second reviewer described the project team's approach, which included forming SiO₂ on the surface of Si, coating with C, and then dissolving out the SiO₂. The reviewer added that this left a slug of Si within a hollow carbon shell to allow room for Si expansion while protecting the Si from the electrolyte that could otherwise lead to capacity loss from SEI layer formation and reformation. The second reviewer concluded that the only concern with this approach was that many other people have done, or were in the process of doing this.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Statements in this section were generally positive. One of the reviewers observed that the Si nanoparticles with controlled size and Si-graphene composites were prepared and characterized, new polymer binders were synthesized, and experimental electrodes were characterized. Another reviewer remarked that this project was quite new, but good progress was being shown after just a few months of work. The TEM imaging work done showed that the project team was making the core-shell structures it set out to make. This reviewer highlighted that the project team was already getting good capacity and decent cycle life (i.e., 2,500 mAh/g matrix for 80 cycles). The same reviewer opined that although this project had just started, more extended cycling work was needed.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, comments in this section were mixed. The first reviewer pointed out cooperation with PNNL (i.e., Zhang and Liu) and the Pennsylvania NanoMaterials Commercialization Center. The second reviewer stated this was unclear, but was unsure that much collaboration was needed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback was generally positive in this section. One reviewer listed the following: study SEI layer on Si-graphene and SiHC nanocomposites; synthesize and characterize amorphous Si-carbon nanocomposites; and identify causes of binder failure and designs of new low-swelling binders. A second reviewer explained that the plans seemed fine and expressed interest in seeing how the binder studies turn out. This reviewer concluded that more cycling work was needed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. The first reviewer observed these were adequate resources for the present study and suggested that the effort level should be increased if a breakthrough is realized. Another reviewer stated that the costs were modest.

Wiring up Silicon Nanoparticles for High-Performance Lithium-Ion Battery Anodes: Yi Cui (Stanford University) – es148

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

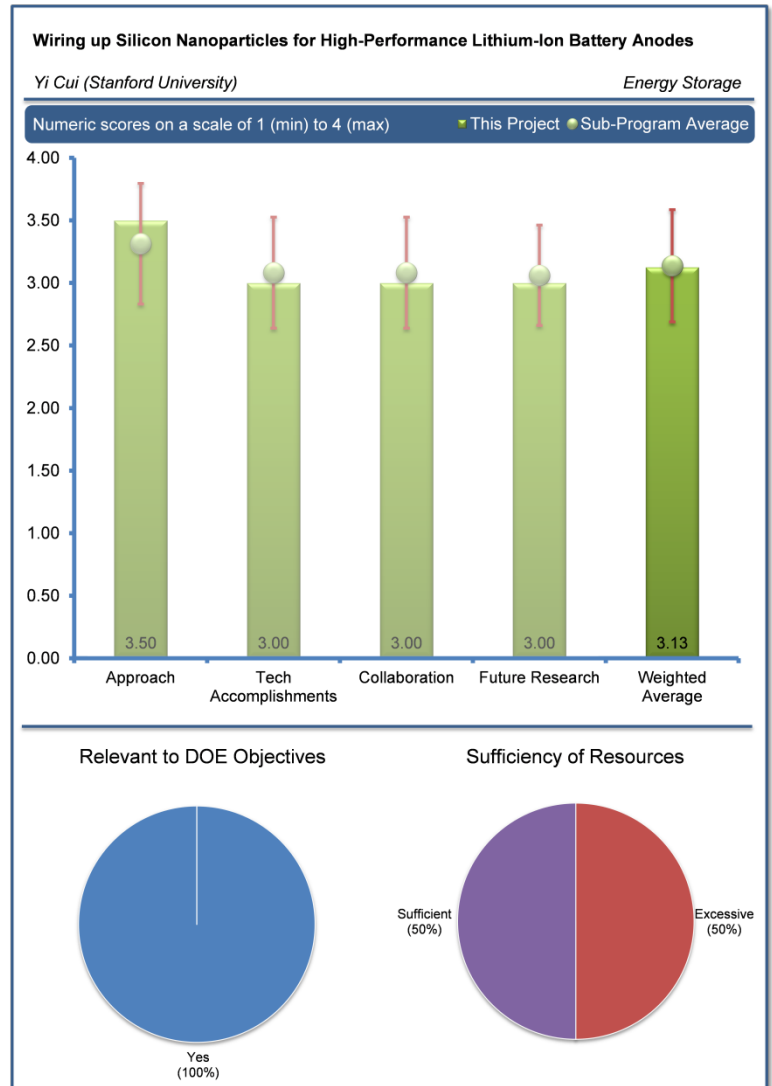
Reviewer feedback in this section was positive. One of the reviewers remarked that this work was aimed at understanding the strength of Si nanowires and also ways to improve their cycle life. This reviewer continued that Si anodes were the most promising approach for the next generation of high energy density batteries. Another reviewer opined that Silicon anodes appeared to be the best choice for replacing graphite for higher energy storage capability.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Comments were mixed in this section. The first reviewer stated that the major problem with Si anodes was the volume change on charge-discharge. This reviewer observed the following actions: it has concentrated on designing and constructing carbon nanotube anodes to produce a nano Si anode; it has developed a basic understanding of Si expansion and fracture during charge-discharge reactions of lithium; and it identified hollow structures as a promising avenue for future work.

Another reviewer acknowledged that the project team had taken a very nice, designed approach to try and accommodate the Si expansion by developing hollow nanowires of Si attached to a substrate. The Si could then expand inwards rather than outwards, which would expose less new Si surface to the electrolyte and minimize side reactions. The project team also had diffraction to study the reactive faces of the structures and had explored the impact of length and discharge rate on the fracture strength of these materials. This second reviewer, expressed uncertainty that nanowires, while exquisite and elegant, were ever going to be commercially viable, both from a manufacturing cost point of view and the space lost by relatively poor packing of the nanowire forests. The PI stated that the project team was going to start on more practical particles of Si, but nothing specific was outlined and it was unclear how relevant the work done would be to more practical materials. These materials may be useful to this program only for fundamentals studies; they are certainly very interesting, but this reviewer offered no chance of this type of work being relevant to anything but high cost batteries (e.g., microbatteries for electronics). This reviewer concluded that bulk materials were needed for large batteries, which could have nanofeatures.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The statements in this section were positive. One of the reviewers observed potential for ten times the improvement over graphite anode materials. This reviewer continued that the PI had a history of taking the best course of action to solve problems, and



applauded the very prolific, cutting edge, research program. The reviewer also stated that double-walled nanotubes showed good promise and had given a long cycle life (6,000 cycles at 12°C Rate) and very high rate up to 20°C. Technically, asserted the second reviewer, this work had been very impressive. The SEM and TEM images had clearly shown that the project team has been successful in making the exquisite structures that were targeted and that the Si did indeed shrink inwards and partially fill the cores of the tubes. The double-walled hollow nanotubes worked very well, the pores were so narrow, and the aspect ratio so high that minimal Si/electrolyte reaction occurred inside these columns. This may have reflected either minimal electrolyte penetration into or maybe just minimal replenishment of the electrolyte inside the columns. Like others, the relatively low utilization of Si was actually a reasonable approach. This second reviewer further explained that while the 4,000 mAh/g was often used as the carrot, expansion and reactivity of a fully lithiated silicon anode would be very daunting to handle, especially for such long lifetime applications as electric vehicles. Thus, by backing off on the Si discharge, very high capacity could still be demonstrated while having a greater chance of assuring sufficient stability. With this method, concluded the same reviewer, the project team had attained very good cycle life (6,000 cycles and more) at a 1,000 mAh/g capacity.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, feedback from reviewers in this section was mixed. The first reviewer recognized collaboration with many of the DOE BATT PIs as well as involvement with a number of universities and national laboratories. The second reviewer had not seen much evidence of collaboration, but noted uncertainty regarding the need for this if the project was only concerned with nanowires. This reviewer further explained that if the project team took its expertise and applied this to other, more practical Si materials, it would likely need to collaborate with other PIs, though many may view each other as competition.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were generally mixed. One of the reviewers listed the following: conduct transmission microscopy to watch Li-Si structure and volume change in real time in order to identify the best process for handling volume changes; take advantage of nanoscale designs to optimize Si anode structure; develop methods to produce designed experimental structure; and best experimental plan. The second reviewer emphasized that this work needed to be directed away from nanowires into more practical materials to satisfy program needs, and noted that it was unclear that this was going to happen, let alone how. The reviewer added that if the project team could not demonstrate a practical technical approach to truly viable materials, this reviewer asserted that funding additional work though the EERE program could not be recommended. Although the work on nanowires was really nice and elegant, this reviewer concluded that it was on the wrong material for this program.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. One reviewer indicated that resources were sufficient, while another reported that resources were excessive. The first reviewer described the investigator as very prolific and having a knack for taking the best experimental approach to solve problems. Another reviewer observed an appropriate funding level. The same reviewer recognized that these were very hard studies to carry out and indicated the project team had been very successful on a technical level. However, unless the project team could demonstrate a clearer path to working on more practical materials, the second reviewer expressed fear that this work was of little practical benefit to the program. Until this could be done, the reviewer expressed inability to justify continuing program funds for this work. Perhaps, concluded this reviewer, the PI and project group were better focused on doing only fundamental studies. If so, this may be more appropriately funded out of the BES program.

Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries: Kwai Chan (Southwest Research Institute) – es149

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

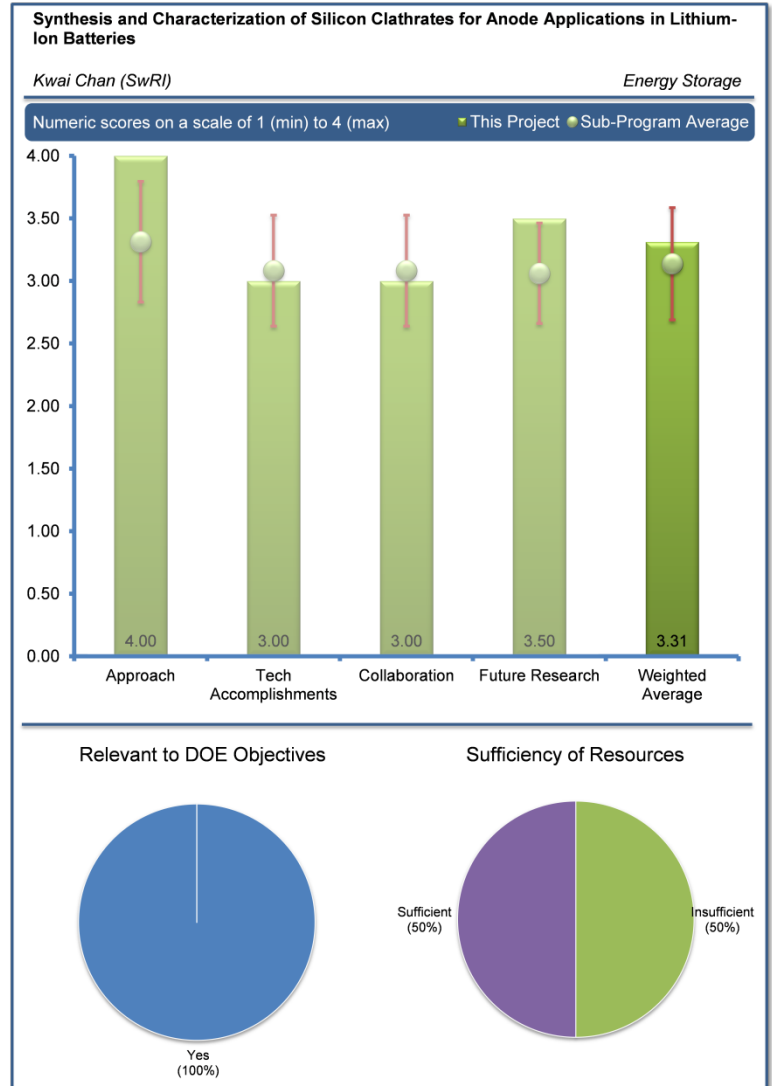
Overall, statements from reviewers were positive in this section. The first reviewer indicated that batteries with significantly improved energy storage capability were essential to meet the demand for battery powered vehicles with ranges exceeding 200 miles. This reviewer continued that silicon anodes showed the best promise for increasing the energy storage capability of Li-ion cells, and that emphasis on silicon clathrates appeared to be a promising approach. Another reviewer expressed that this work was aimed at devising a clathrate structure of silicon that could form the basis of an anode material for the next generation of high energy density batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback in this section was positive. One of the reviewers opined that silicon appeared to be the best of many approaches. The second reviewer observed an excellent balance of both innovative and scalable methods to make silicon clathrates and also pointed out that parallel synthetic pathways had been evaluated by the project team. Moreover, this reviewer highlighted that the project team was very well aware of issues in devising a practical synthetic method and as not just developing a lab curiosity. The second reviewer also acknowledged the project team’s firm theoretical understanding of the materials and processes.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive in this section. The first reviewer observed that additive elements to stabilize Si clathrate structures had been identified. The same reviewer also stated that theoretical calculations and experiments gave consistent results. Another reviewer recognized excellent progress in making these new materials, and encouraged the project team to just do more in terms of characterization of the materials in cells. The project team showed good cycle life, but only at about 10% DoD (400 mAg/Si) and good capacity at one cycle. The same reviewer expressed that evaluating the wider range of performance and seeing how cycle life was affected by DoD is needed. This reviewer also described the sheer amount of work done in synthesis, characterization, and theoretical studies as very impressive, particularly in light of the modest funding level of this project.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback from reviewers was generally positive in this section. One reviewer reported that Dr. C. Chan provided services for arc-melt synthesis of metal substituted clathrates, while Dr. J. Chen provided services and expertise on multi-anvil synthesis. The second reviewer observed that only a couple of PIs were working together, albeit very well. This reviewer opined that the project team could benefit from working with and deserve assistance from the national laboratories to help characterize the materials it was making.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were mixed. The first reviewer stated that the project team could carry out first principal calculations to identify the path for formation of empty clathrates of silicon, lithium-silicon, and lithium-silicon-X materials, while the second reviewer stated that the project team disclosed a very good plan going forward. This second reviewer underscored the need for the project team to evaluate the capacity/cycle life performance of its materials.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. One reviewer indicated that the resources were sufficient and adequate. Another reported that the resources were insufficient, and that this was a very modest award. Additionally, this reviewer asserted that this project, both in light of the approach and results, should definitely continue or be expanded with both additional funding and direct support from the national laboratories in characterizing those materials in electrochemical cells.

Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials: Anthony Burrell (Argonne National Laboratory) – es161

Reviewer Sample Size

This project was reviewed by five reviewers.

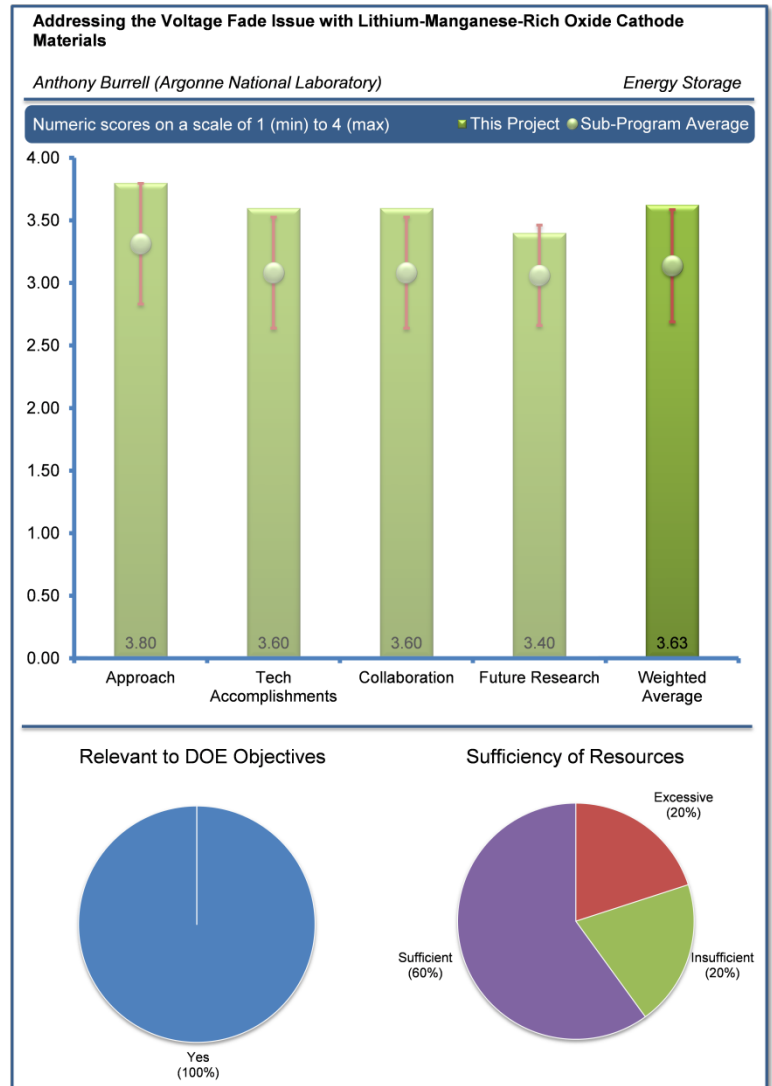
Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer statements in this section were positive. One reviewer strongly emphasized the relevance to DOE objectives, and another acknowledged that resolving this issue was critical to using these types of High energy materials. The third reviewer explained that for a successful utilization of Li-ion batteries in PHEVs and EVs, it was essential to enhance their gravimetric and volumetric energy densities, which, in turn, warranted new advanced electrode materials. High voltage, high capacity cathodes in the class of lithium and manganese rich NMC (LMR-NMR) cathode materials, $x\text{Li}_2\text{MnO}_3:(1-x)\text{LiMO}_2$ ($M = \text{Ni, Mn, Co}$), were quite promising. However, these materials underwent some structural transformation during the early stages of cycling that manifested as a voltage slump. As described by this third reviewer, the objective of this project are to mitigate such voltage slump by stabilizing open circuit voltage discharge profile during aging (i.e., voltage fade phenomenon) without sacrificing power, life, capacity, and abuse tolerance. Furthermore, offered the same

reviewer, this would require a good understanding of and the mitigating of complex electrochemical–structural relationships of these materials, essential to successfully adopting this material in PHEV or EV batteries. The fourth reviewer commented that the goal of eliminating the change in the voltage curve for high-energy cathode materials was critical to getting this material to work. Such oxygen-loss materials were the only ones that could potentially provide higher volumetric energy cells (i.e., higher than high voltage LCO). Accomplishing this goal would help to provide a higher volumetric capacity, which would decrease cost, and decrease dependence on petroleum. The final reviewer answered yes, and added that the interdisciplinary team being assembled gave great hope for future developments.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback was mixed in this section. The first reviewer observed that technical barriers were clear and well known, and highlighted that the reaction taking place during the first charge of the Li- and Mn-rich NMC cathode material had to be thoroughly investigated. Further, the capacity fade issue seemed to be the other important issue to be resolved. Another reviewer asserted that this could be the template for resolving other challenging problems, while a third reviewer remarked that a combinatorial approach to understand the phase diagram was an outstanding approach to sample the whole space and better understand it. Doing this right was difficult and would take a lot of focus, continued the reviewer. It was unclear whether modeling would help, but this reviewer pointed out that deep characterization would be very beneficial. Finally, the third reviewer reported uncertainty that a synthesis



approach would solve this problem. The fourth reviewer described the plan as solid and asserted the need for this program to sharply focus because of its significance to many material, battery, and vehicle manufacturers who were counting on this material to develop the next generation, low-cost battery. With the intention of not minimizing the significance of voltage drop, this reviewer relayed that discussion within the community pointed to life of this material as a more serious concern. Hopefully, concluded this reviewer, they were related intimately and the proposed work would resolve both the issues. The fifth reviewer recognized that the approach adopted here was quite broad and comprehensive starting with the following: definition of the problem and quantifying the limitations of the composite cathode materials; synthesis of a broad range of compositions of both lithium and transitional metals in combinatorial fashion through robotic means; fundamental characterization of these materials before and after aging using a suite of spectroscopic techniques; effects of surface coating and/or other treatments for a fix; detailed electrochemical performance assessment and its correlation to structural aspects; and augmenting the experimental findings with modeling and theory. The same reviewer noted that because this voltage fade was deemed the most important deterrent factor for using these materials, considerable emphasis had been placed on this project, with support from several individuals at ANL that contributed in the past to the development/understanding of these materials. Thus, explained the reviewer, all of the expertise at ANL was being brought into this project. The fifth reviewer described that one of the obvious problems with this comprehensive approach and broad trade space (in composition) was that too much variability in the results may be encountered without any clear correlations. Also, this reviewer added, the problem looked fairly daunting to be solved in a year. Lastly, this reviewer pointed out that the electrolyte, which was a key component in defining and determining the interfacial properties, was not part of those variables.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were mixed. Acknowledging that this was a new project, the first reviewer observed that there were not many accomplishments, except for the following: the problem had been defined; test protocols were established; and the team was formulated and the facilities identified for the synthesis, characterization, performance assessment, and post-performance characterization tests. In addition, this reviewer expressed interest that a more complete and comprehensive picture on these otherwise promising materials would emerge from these studies. The second reviewer also asserted that the project was just starting and noted difficulty in judging the technical accomplishments. Another reviewer agreed that it was difficult to judge the progress that has been made because the program was in its infancy. The fourth reviewer indicated this was not really applicable at this stage, though there may be difficulties with only using the combinatorial approach. This reviewer suggested giving thought to a secondary synthesis approach, and at least check on promising results. The final reviewer reported no progress shown beyond scoping the team and problem.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer statements were generally positive in this section. One of the reviewers described the team as strong and of great quality, and another observed a good collaborative team. The third reviewer noted multiple team members and collaborators from ANL, which was expected because of the nature of the project. However, considering the complexity of the problem, this reviewer suggested that it would be prudent to go beyond ABR to address these issues. The fourth reviewer explained that while it probably was already in the plan, involving actual material manufacturers (e.g., battery makers at least) would be desirable. The fifth reviewer agreed that progress would be faster if the project team could find a way to work with a major material supplier. This reviewer also asserted that the model of this approach was collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments received in this section were generally mixed. The first reviewer noted great direction and suggested focusing on the phase diagram. Understandably, remarked the second reviewer, future plans were aimed at understanding the cause of voltage fade and constituted the following: selecting the most promising compositions/chemistries for exhaustive electrochemical evaluation; characterizing their chemical, physical and thermal properties; correlating with electrochemical properties; and evaluating the electrodes in a full lithium-ion cell configuration, hopefully with reduced voltage fade. Another reviewer reiterated that the work

plan looked solid, but cautioned that while using materials synthesized by various processes was understandable, the authors should eventually focus on a synthetic procedure that emphasized low cost. Otherwise, continued this reviewer, it would be back to the drawing board. The fourth reviewer asserted that communication between the different team members was going to be critical. This reviewer opined that, in terms of modeling and theory that the authors have proposed, it could be of great interest if the project team managed to provide trends and useful hints to the experimentalist. Although the absolute values may be off slightly, the reviewer observed that trends could provide very useful information. Finally, this reviewer observed that the synthetic work seemed to become very important. The fifth reviewer recognized that these materials also had an initial gassing issue, and that the project team should probably address this simultaneously.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. Three reviewers indicated resources were sufficient. One of these reviewers further stated that the institutions involved seemed to be well-equipped, while another remarked that ANL had the best lab in the world for Li-ion materials development. The third reviewer pointed out that additional funding may be necessary if results looked promising and if there was a need to resolve this issue more quickly. The fourth reviewer reported that the resources were insufficient and recommended adding more funds to this project because of its high importance. The final reviewer observed that the budget looked a little excessive, but the complexity of the project probably justified it.

Development of Industrially Viable Battery Electrode Coatings: Robert Tenent (National Renewable Energy Laboratory) – es162

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

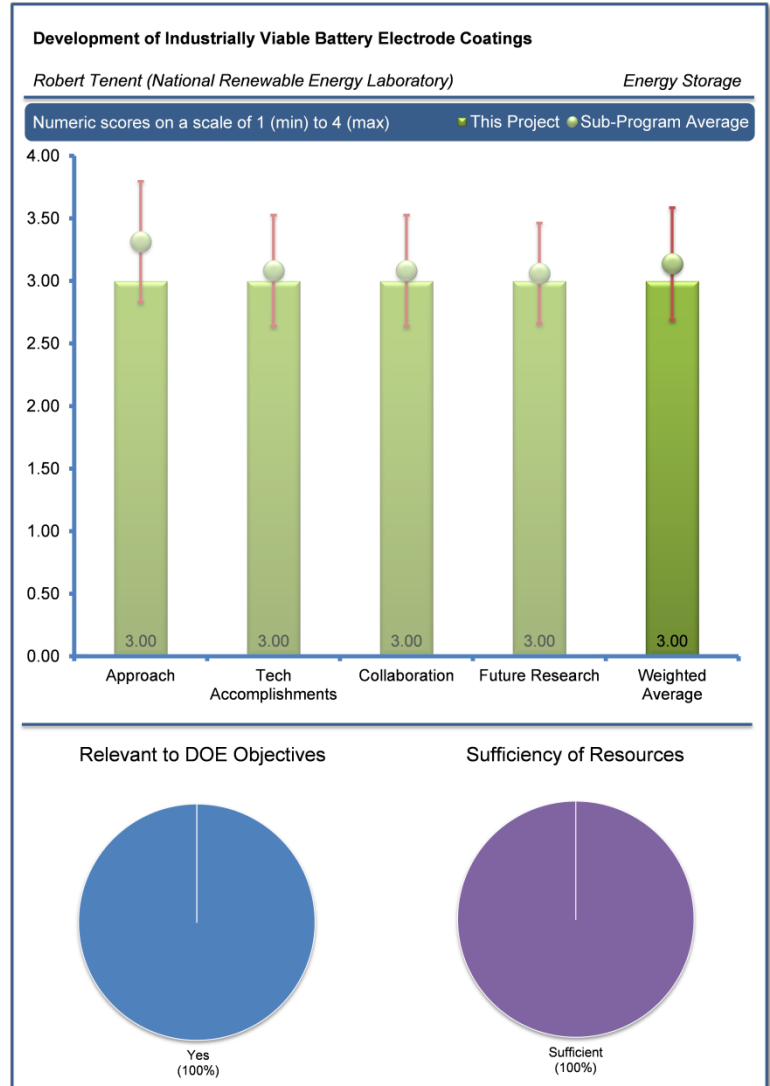
Mixed remarks were received in this section. One of the reviewers described energy storage as an important issue in the electrification of transportation necessary to reduce petroleum imports. Another reviewer indicated that the relevance depended on the success of the program, and that while it has not yet been shown that continuously applied coatings would result in improved performance, this program may provide that information.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Overall, reviewer feedback in this section was positive. The first reviewer observed an interesting project with great potential for significant advances, and a second reviewer asserted that integrating ALD into an electrode manufacturing process was attractive both from the cost and performance aspects. The final reviewer indicated that the program was setting up to do an automated line without doing many preliminary experiments, and

continued that the problem was reflected in the results of 18650 cells made at Sandia that demonstrated a number of cell failures. This third reviewer also highlighted that the heat of reaction of charged cathodes was worse for the coated electrode than for the uncoated, although the onset temperature of reaction was slightly lower for the uncoated. The reviewer expressed the belief that it would be cost-effective to demonstrate good results with a single coating head before going on to design and implement a multiple head continuous process.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were generally positive. One reviewer reported significant progress shown in technical advances to date, while a second reviewer offered that the results on Si carbon seemed to be better than those on LiCoO₂ and other high voltage materials. Although this project started only recently, the third reviewer observed good technical progress. Basic feasibility was demonstrated and prototyping was under way to improve original design. This reviewer further noted that the quality of the figure shown on Slide 7 was poor and it was hard to distinguish between items. Regarding the ALD coating applied onto an electrode slurry coated foil, this final reviewer inquired about the uniformity of this coating – whether its location was restricted to the top surface of the electrode power layer, or whether the coating was uniform throughout. The reviewer explained that it would be useful to understand this as this may help optimize the process to maximize benefit. In conclusion, this reviewer suggested that



cross-sectional analysis may help understand this, and that one would think applying ALD on powder in some sort of fluidized bed would result in a more uniform coating than coating on the electrode.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Statements from reviewers in this section were mixed. The first reviewer stated the collaborations were very appropriate to the goals of the project, while the second reviewer strongly recommended partnerships with other academic institutions that made single crystalline, nanoscale materials for electrodes. This reviewer explained the recommendation by stating it was easier to understand the role of protective coatings on many of these electrode materials.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback was somewhat negative in this section. One reviewer described the proposed activities as reasonable. Another reviewer expressed desire to see a concentration on Si electrodes because they seemed to show the best results. This second reviewer observed no discussion during the presentation of which electrodes would be studied in the future, and pointed out that an early success with one electrode would be significantly more impressive and prove the method better than a slower program trying to establish results for several electrodes.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that the project resources were sufficient.

Design of Safer High-Energy Density Materials for Lithium-Ion Cells: Ilias Belharouak (Argonne National Laboratory) – es163

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

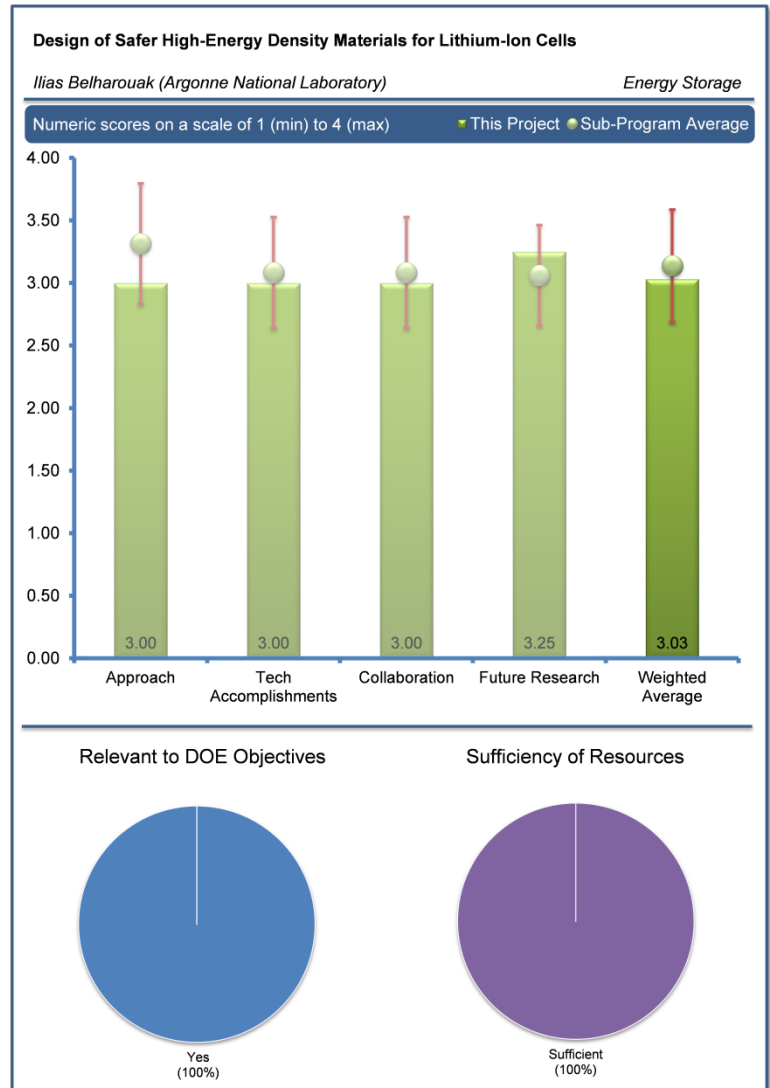
Reviewer feedback in this section was positive. The first reviewer indicated this work provided ANL with a scale-up capability for its new materials and was essential to developing its in-house materials both in terms of making larger samples to enable a more in depth evaluation of the high energy materials, and to help promote manufacturability of the new materials. Another reviewer stated that yes, high energy materials were critical to the objective of petroleum replacement, while a third reviewer asserted that this study was required so that optimal compositions could be determined. The final reviewer explained that batteries could help with electrification of the transportation sector and reduce petroleum imports.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Statements in this section were generally positive. One

of the reviewers observed a logical, sound approach, and another reviewer described the approach of using a CSTR-type reactor for co-precipitation as interesting. The third reviewer agreed that the approach was interesting, and expressed hope that the team manages go all the way towards cell fabrication and scale-up. Additionally, continued this reviewer, the project had an important mixture of very basic science and vastly applied research. This reviewer finally communicated that it was envisioned that the project team was also going to be well-integrated with other efforts from NRL. The final reviewer noted it was a decent approach and very good characterization tools were being used by the project team. Although this same reviewer agreed with the combinatorial approach to exploring the landscape of materials, this reviewer would have thought this was something that could have been framed out to Wildcat Technologies rather than bringing it in-house. Further, Wildcat Technologies was already set up to do similar work and had been pretty successful to date.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, positive feedback was received in this section. One of the reviewers observed significant progress in a short time, but another reviewer cautioned that it was hard to judge at this early stage. This second reviewer acknowledged that the carbonate precipitation and growth mechanism that seemed to go out of control a little was interesting, and opined that the hydroxide precursors seemed to be the way to go for these high energy density materials. The third reviewer reported that this team investigated co-precipitation technique and its scaling for increasing materials production using CSTR-type reactors. Primarily, the



project team identified some issues related to the processing and resulting materials characteristics. This same reviewer indicated that the PI wanted to address this technical barrier by looking at the gas phase technique for producing these materials, and agreed that this should be explored. This third reviewer highly recommended using gas phase techniques to prepare these mixed metal oxide particles. In conclusion, this reviewer recognized that these methods could be highly scalable and cost-effective. The final reviewer stated that finding gaps in some materials and identifying that these could lead to fracture during calendaring was noteworthy, and that the nanoplatelets also looked interesting. Although the project team could make different structures, this reviewer expressed uncertainty that the team fully understood those processes yet.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were somewhat positive. The first reviewer stated good, and a second reviewer acknowledged the team had some partnership with an academic institution regarding gas phase synthesis. This second reviewer strongly recommended that the team seek some partnership with other established groups specializing in gas phase production of materials. Another reviewer opined that collaboration with industry would be important at some point, particularly if the practical aspects of the materials were demonstrated. The final reviewer observed good imaging work and collaboration within the national laboratories, but would have liked to see more interaction with commercial materials companies such as BASF.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, reviewer feedback was mixed in this section. One reviewer praised the description of future work as well thought out, and noted that the synthesis with hydroxide of spherical particles was impressive for hydroxide. This reviewer further offered that stabilizing carbonate particle size may eliminate some of the problems. Another reviewer stated that the planned work involving a gas phase production technique and improving the co-precipitation technique was reasonable. The third reviewer indicated the project team's plans looked fine, but would have liked to have seen more work done to develop and characterize the material produced by the spraying technique. The same reviewer questioned whether the project team was best suited to do the combinatorial exploration, and saw no reason why it could not do this given more time and money. Furthermore, this reviewer did not expect such work to lead to the cause of the voltage fade with the ANL layered material, although it may have an effect. This reviewer opined that understanding would be expected to come from additional, in-depth characterization of the existing materials; any improvements from the combinatorial approach would likely be empirical, rather than fundamental, in nature. The final reviewer remarked that the aerosol particles could be an interesting approach, but noted that the aerosol particles may be of low tap density. Additionally, the reviewer recommended that the authors should, at some point, report their capacity data in terms of mAh/g total electrode weight rather than only active material weight.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer observed the project team was doing well with modest funding. Another reviewer opined that resources may be insufficient if the team managed to make a lot of progress during the year, and that the team may need additional support if the practicality of these powders was demonstrated.

Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes: David Wood (Oak Ridge National Laboratory) – es164

Reviewer Sample Size

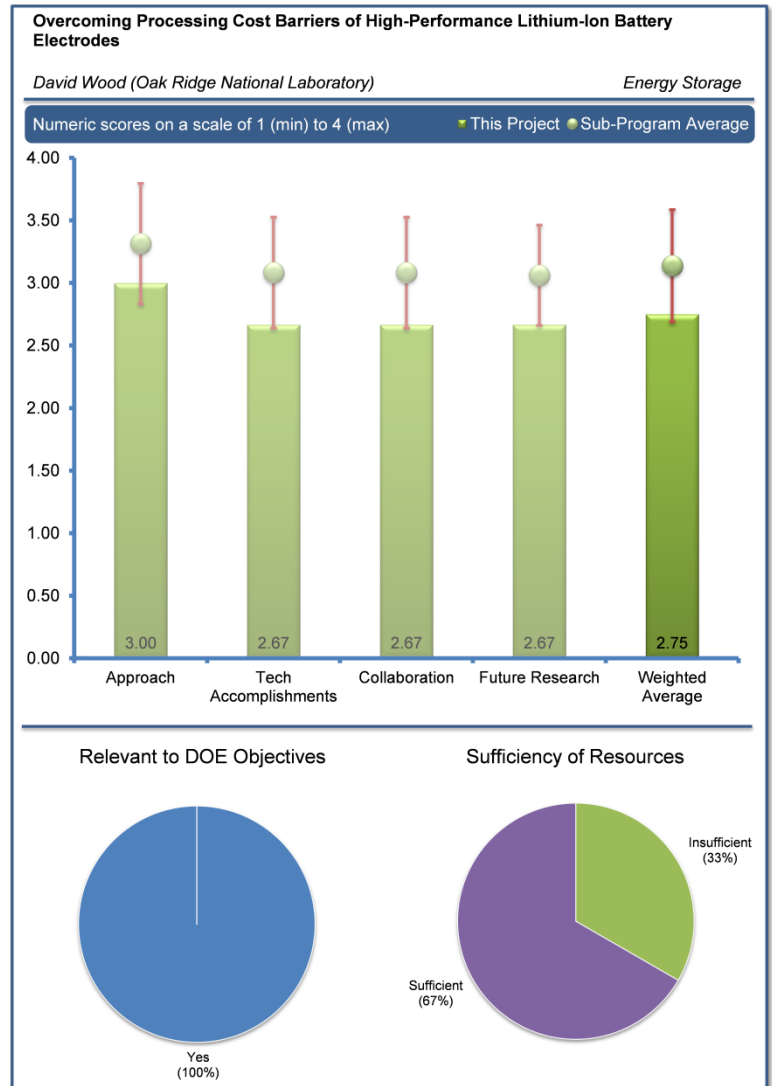
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. The first reviewer indicated that developing an aqueous-based anode and cathode coating process could reduce the cost of Li-ion batteries and the capital equipment to set up new facilities. In addition, the reviewer opined that it was significantly better, environmentally, because it eliminated the use of a somewhat toxic solvent, NMP. Another reviewer observed the relevance was to low cost electrode manufacture, which had an important effect on cell costs. This reviewer pointed out that use of a polysaccharide for the cathode binder was problematic, however, because of the high positive potential applied to this electrode during charge and storage. The same reviewer stated that the additive (PEI) was an easily oxidized compound. Finally, this reviewer remarked that these hydrophilic materials were also known to hold water and the temperature needed to completely remove adsorbed water without dehydrating the polymers it is unclear.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, feedback in this section was mixed. One of the reviewers thought the work was extremely well designed and particularly appreciated the science and methods used to design the process rather than the often used empirical approach. This reviewer explained that water-based coatings for anodes were becoming quite common in industry, but cathodes were still mostly made using NMP solvent. Thus, the reviewer stated that this project addressed a real need. This reviewer praised the project team for working on the cathodes first. Another reviewer opined that replacing NMP with water-based chemistries had huge potential to simplify and reduce the cost of making cells. The third reviewer indicated that the approach should take into account the possibility of carrying adsorbed water into the cell as well as of oxidizing the binder and/or additive. Additionally, this reviewer recognized that offline experiments may be required to establish this binder and additive as inert materials. The same reviewer emphasized it was also important to determine adhesion and cohesion of the materials to the electrode and that these tests should be run routinely with new binder systems. This reviewer further remarked that hydrophobic binders should also be tested as there were a number already in the patent literature. This reviewer opined that the effort should be to test electrodes in finished cells and the facility at ANL to make 18650 or pouch cells should be utilized to test these electrodes in finished cells. Ideally, continued this reviewer, the conventional binder should be used on one electrode while the trial binder was used on the other electrode. In closing, this final reviewer asserted that cycling tests in coin cells were unacceptable measures for coating validity.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback in this section was somewhat negative, overall. The first reviewer was very impressed with the project team's overall progress to date and looked forward to the project team's next debrief. This reviewer stated the project team's zeta potential work highlighted the desirability of using a cationic surfactant. Using surface energy measurements, the project team set clear goals for what it needed in terms of aluminum surface energy and by using corona plasma treatment. Thus, the project team identified key problems and found solutions to both. While the project team did not have time to go into details, this reviewer recognized that it had an appreciation of the importance of mixing order and processing. This reviewer pointed out that the project team did not yet have an understanding of what the corona treatment actually did, but the project team had only been working on this for a very short time. The same reviewer suggested that it would have been helpful to include more direct comparisons of their results with NMP coated electrodes (e.g., visual appearance, etc.), and to revisit and compare the binder choice to SBR and CMC. Recognizing the difficulty in getting such details into such a short presentation, this reviewer assumed that water removal was not a big deal as compared to NMP, but suggested it would be good to see that spelled out in the future. The second reviewer stated that it would be useful to compare the viscosity of NMP versus water-based slurries for different total solid loadings because NMP enabled very high, solid loadings that enabled high throughput coating. This reviewer inquired as to the following: whether the same could be accomplished with water-based slurries; whether it was harder to disperse anode and cathode particles in a water-based slurry; whether higher energy dispersion needed to get the same level of dispersion as for NMP; whether longer dispersion time was needed; and whether drying time with a water slurry was significantly longer as compared to NMP slurries. The same reviewer recommended showing side-by-side results for NMP-based slurry when presenting surface energy measurements, and further suggested that the C-rate studies would be helpful in understanding the quality of dispersion and electrode as a high C rate would magnify any potential issues with electrode quality. The final reviewer observed that the disastrous results with 1.5% PEI were not explained, but this was a concern because if a mistake was made in coating, it implied that only a single electrode was tested. The reviewer added that it should be standard practice to use multiple electrodes of the same formulation to measure these properties. In conclusion, this reviewer stated that the electrodes should be tested in sealed cells for adequate measures of cycling and the LFP cathode should show no fade after 50 cycles to be acceptable.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Remarks were mixed in this section. One reviewer remarked that the project team seemed to be well connected and liked the electrode sharing among the labs for independent evaluation and feedback to the PIs. This reviewer suggested that the project team line up with a battery maker to see if it was interested in evaluating the project team's process and/or giving feedback regarding the quality of electrodes that this group was making. Another reviewer wanted to see a coating company or coating expert brought into the program to provide guidance to the team on battery electrode formulation, mixing, and coating.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was generally negative. One reviewer suggested the team work with cell builders at ANL and SNL to determine the proper electrode thickness and loading for measurements in full cells. While the processing aid (PEI) should not affect the anode, the second reviewer encouraged the project team to get an evaluation in full cells as soon as possible in case the project team got an unexpected adverse interaction. Although it was currently slated to be done by September 2012, this same reviewer recommended that the project team jump ahead and do a rough check for unknown problems while doing the more methodical work planned. This reviewer also suggested that the project team get a better understanding of what the corona treatment was actually doing to the aluminum, through such means as surface roughness and maybe FTIR/ESCA studies. The project team should validate the corona method by using Al foil from a different vendor, although this reviewer believed that this would not be a problem. It was also suggested by this reviewer that the project team examine its coatings at the edges to see how clean they were. The reviewer reported that this was generally a critical QC metric in electrode fabrication, especially if using a pattern-coated system often required for commercial electrodes. Wetting of the mix could be critical in controlling this edge effect, emphasized the reviewer, and if it wets too well, one could get smeared out edges rather than sharp edges. This final reviewer

further recommended that the project team try and run the line at high line speed settings, although the project team could not be expected to mimic commercial production in its lab.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. Two reviewers indicated that resources were sufficient, while another reported that resources were insufficient. One reviewer observed that it was an appropriate funding level and the project team was getting good results with it. Another reviewer suggested an electrode team of several DOE labs and industry experts would be most useful as a resource for this project.

Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries: Claus Daniel (Oak Ridge National Laboratory) – es165

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

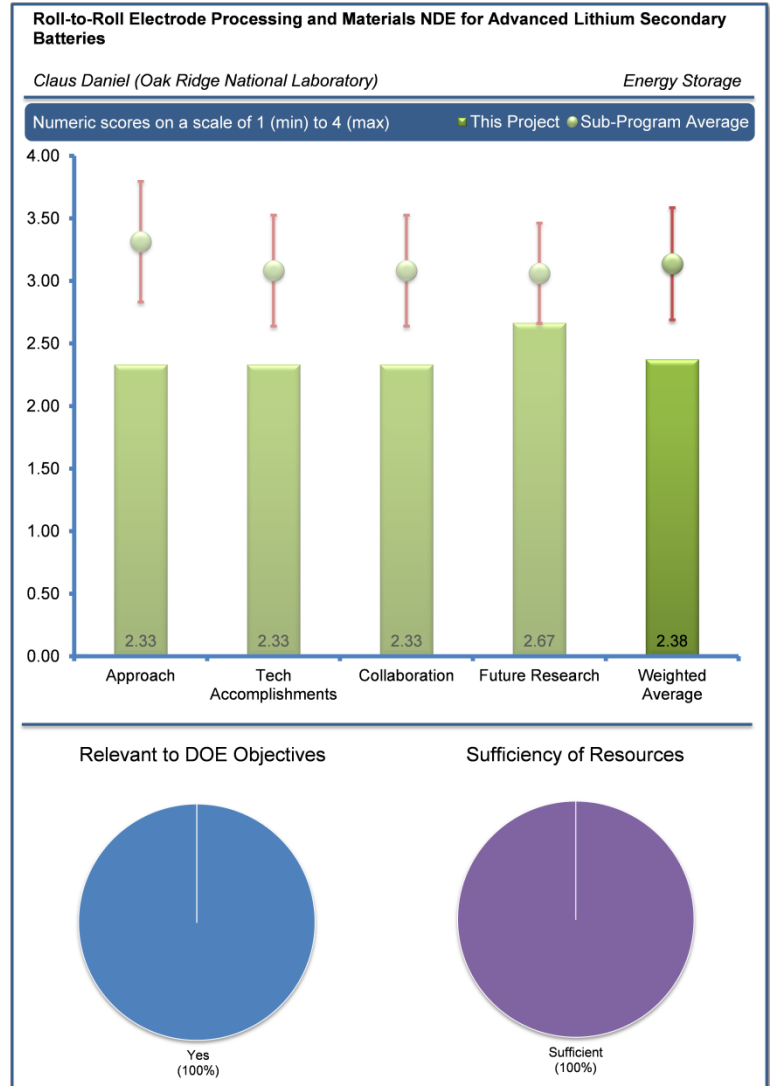
Feedback was somewhat positive in this section. One of the reviewers reported that non-destructive evaluation was already used in the battery industry for electrode manufacture, and that this program intended to improve the analysis to permit higher product yield (i.e., a lower scrap rate) for the process. A lower scrap rate, explained this reviewer, meant lower costs as the scrap electrodes were expensive and not easily recycled. The second reviewer stated the objective was not clear, but this could be part of the program, though. Further, continued this reviewer, defining the quality of what was bad or good (i.e., criteria for passing or failing) is needed. The same reviewer commented that without these criteria, it was difficult to discuss the cost by increasing the electrode yield.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments in this section were generally mixed. The first reviewer opined that relatively small changes in Li/(Ni+Mn) ratio could significantly influence performance of the cell, then queried whether methods described in this work achieved the resolution that would be needed. Another reviewer stated the approach was generally good as the methods suggested were capable of high accuracy. The same reviewer noted that the comparison to existing beta detectors was not included in the approach to the work, and suggested that this was an oversight. Additionally, continued the second reviewer, the means of fairly assessing the laser ranging or the XRF methods to actually reduce scrap rate was not clear. A full production demonstration would seem to be required, but no discussion on this was proposed. This reviewer reported that, at present, the simplest form of electrode making (i.e., tape casting), was employed for the evaluations, but no comparisons had been made. The third and final reviewer identified a need to determine the current quality check being done for the electrode production and address why this approach could achieve the objective. The same reviewer requested clarification regarding why an IR imaging and laser system was better or could achieve the objectives as compared to the industry standard vision and x-ray (Beta ray system) in terms of resolution and detecting speed. Finally, this reviewer recommended verification that the XRF had capability to check with the line speed of 60m/min.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Remarks in this section were generally negative. One of the reviewers observed that the thickness measurements displayed a high degree of inaccuracy on which the authors did not comment. XRF did not seem to show any deviation in composition, which was a



good result. The IR imaging seemed to show inhomogenities, but no comparison to production electrodes was made. The second reviewer stated it was believed that TEM and XRF can analyze the level of powder, but should be too much at the electrode level. Also, the increase in the electrode yield should be conducted on the step of mixing and slurry making process.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally negative in this section. The first reviewer indicated the program would benefit from working with groups that actually do electrode manufacture intended to mimic industrial practice. Another reviewer pointed out the need to investigate the current SOA technology for the quality check of electrodes.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback from reviewers in this section was generally negative. One reviewer suggested that the group attempt to compare actual weight loadings to thickness as measured by the laser ranging system, while the second reviewer reiterated the need to resolve issues stated previously in response to the questions above.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient.

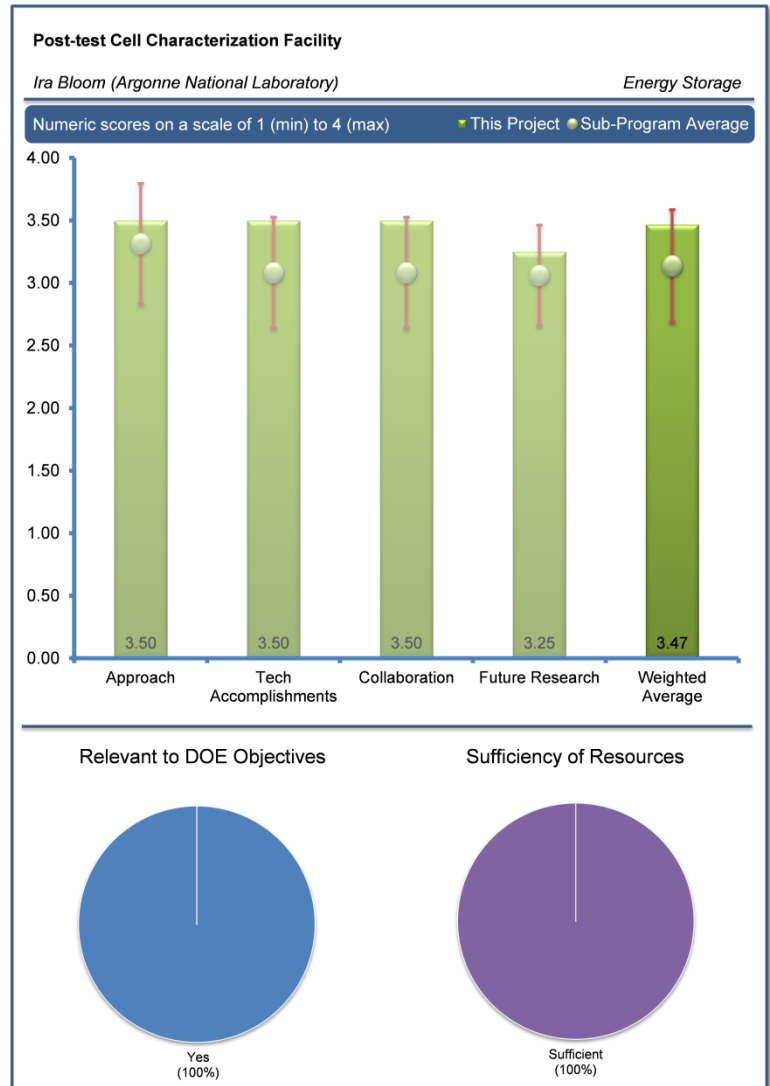
Post-test Cell Characterization Facility: Ira Bloom (Argonne National Laboratory) – es166

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback was positive in this section. The first reviewer explained that this new facility was built to be a central point for studying lithium-ion and other advanced automotive batteries and their morphology after the batteries have aged for USABC and DOE-funded projects. The goal, as indicated by this reviewer, was to understand the factors behind the decline of battery performance so that this knowledge could be implemented in improved battery designs. This reviewer concluded that improving the lithium-ion battery chemistries used in plug-in electric vehicles (PEVs) would encourage consumer adoption of PEVs, which would help to displace petroleum. The second reviewer highlighted the significant need for independent evaluations of new technology developments, and opined that this facility should speed the adoption of new Li-ion and other battery/fuel cell developments. Another reviewer asserted that this was a very useful system for post-test breakdown and analysis. The fourth reviewer remarked that this capability was pretty important to understand the mechanism for capacity fading and impedance growth.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. One reviewer opined that the system had been well thought out and appeared capable of outstanding evaluations of cell operations. Another reviewer acknowledged ANL's long history of battery testing, which goes back to the 1970's, while a third reviewer recognized that a central facility for this purpose of testing batteries to understand the reasons for their decline was new for the ABR program at ANL. The third reviewer further expressed that an entire suite of equipment to perform the diagnostics had been acquired, and applying a more standardized approach of tests to the various types of battery chemistries submitted to the facility should yield datasets that could be used as benchmarks as battery development in the DOE-funded programs continues. The final reviewer recommended that the gas analysis be combined with the post-test capability and storage test, etc.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was generally positive in this section. The first reviewer pointed out that after 18 months of development and funding, the facility successfully opened in January 2012 and was already providing the kind of analysis on aged batteries that it was built to do. From here on out, reported this reviewer, it would be a continuously operating facility. Another reviewer stated

that results on tested cells had been very informative and the analysis methods were state of the art. The third reviewer described the wide range of instrumentation and test equipment as essential. The fourth reviewer remarked that other supporting data, as well as XPS, could be shown.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The comments received in this section were somewhat mixed. One of the reviewers observed the facility was open and had capability to carry out capacity tests, electrode segmentation, analysis of particles of active materials, etc. Another reviewer acknowledged that as a central facility for the national laboratory groups that were investigating lithium-ion batteries and the chemistries beyond lithium-ion, much of the value of this lab lay in its ability to serve the projects coming out of the ABR, BATT, and USABC programs at ANL and other national laboratories. The final reviewer suggested that the more specific objective should be set up for analysis with the specific cell chemistry, and further recommended that this facility be more open to cell developers.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback from reviewers in this section was generally positive. One reviewer indicated initial plans seemed well-chosen and explained that the lab served as a facility, so the general plan was for it to analyze batteries that have already been through the standard testing procedures conducted in other labs. Additionally, continued this reviewer, the purpose of this lab as a final stop for analyzing these batteries was quite clear and straightforward. The second reviewer stated it would continue to provide a service to the DOE battery R&D efforts as well as outside requests.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources were sufficient. One reviewer stated resources were adequate for intended service. Another reviewer noted that while the initial \$2 million given to the lab was clearly enough to get it set up and running, funding would presumably be coming out of a different pathway now because it would be operating as an ongoing facility now.

Process Development and Scale up of Advanced Cathode Materials: Greg Krumdick (Argonne National Laboratory) – es167

Reviewer Sample Size

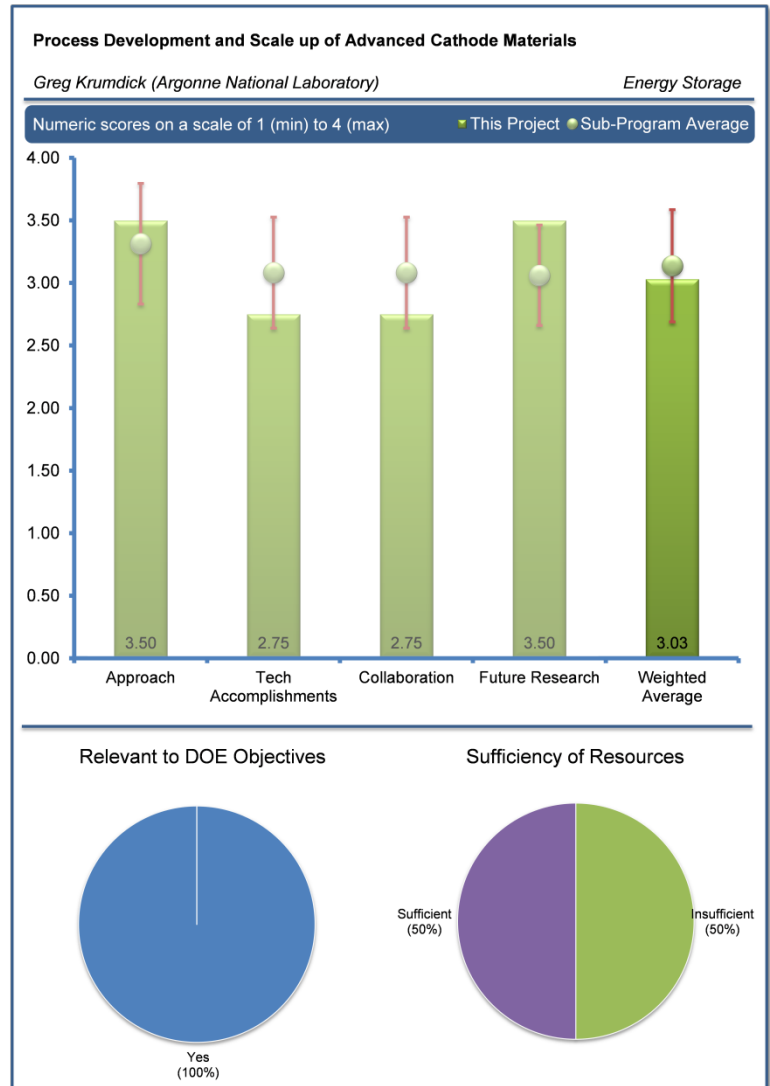
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. The first reviewer stated that new materials program needed a scale up facility of this sort to accomplish DOE goals. It was stated by another reviewer that the scale up was important for process development. The third reviewer observed that a facility to provide a systematic engineering approach to scaling up the production of lithium-ion battery cathode materials from the small quantities required for laboratory bench research had been a missing link for batteries developed by the Vehicle Technologies Program (VTP), according to the PI. The reviewer opined that this program would help industry make decisions as to whether to invest in technologies developed in the program, so that the most promising technologies would become commercialized. Making top-performing lithium-ion batteries that would make plug-in electric vehicles (PEVs) reliable and safe would encourage sales of those vehicles and therefore displace some of the internal combustion engine (ICE) vehicles that use petroleum. The final reviewer explained that DOE was charged with developing new battery and fuel cell systems capable of competing with the present gasoline powered vehicles. That required new battery and fuel cell chemistries and systems. The key element in this process was the ability to demonstrate feasibility of the new systems on a commercial scale. This project, continued this reviewer, represented the first stage in validating a new system, which required pre-commercial process development for new materials and the capability to assemble commercial prototype cell products.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback from reviewers in this section was generally positive. One reviewer indicated that the challenge of scaling up the production of materials for batteries was not one that had been seriously addressed by the VTP battery research programs thus far. This reviewer further explained that this program was very serious about filling in this gap, and the new facility had acquired specialized equipment from Japan and Korea, as well as hired two full-time specialists who had knowledge in this area. The second reviewer opined that the scale up seemed well within the guidelines of a good chemical scale up facility. This reviewer also observed the construction of a reasonable size dry room and the capability to produce pre-commercial quantities of the active materials and components for evaluation. While not yet complete, this project was a key element in finding and qualifying a new technology for further commercial validation. At this stage, remarked this reviewer, it was essential to be able to produce 500 to 1,000 experimental cells to identify the optimum condition to produce the new cell materials, but also to assembly the cells. This



reviewer also stated it was necessary to represent on a statistical basis matching the performance forecast in the research process. Because little infrastructure existed in the United States for Li-ion cell manufacturing equipment, other resources may need to be imported to satisfy the need for experimental samples. The third reviewer asserted work was needed on other process development that the other companies and institutes were working on.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were mixed. One of the reviewers explained that the new facility has so far scaled up one lithium-ion cathode material up to a certain level, and it is in the process of scaling up the production of this material to the kilogram scale. The group has created a process for identifying the materials that should be scaled up, and once it achieved the optimized process for scaling up production, the team would produce technology transfer information packages to make this knowledge available to companies that may wish to license the approach, as well as kilogram-scale quantities of sample materials for evaluation purposes. It was noted by this reviewer that such a facility was absolutely needed because coin cells (i.e., the sort of cell one is limited to making when working with laboratory-scale amounts of materials) did not give enough information on how a product would work when scaled up for a PEV. The second reviewer reported that the tests seemed valid so far for scaled up high manganese materials. However, this reviewer cautioned that coin cell tests were not sufficient and should be backed up with full cell tests. The same reviewer pointed out that cost estimates would probably be somewhat crude because these were only pilot line scale up experiments, but stated that at least some guidance should be available. Another reviewer opined that progress had been slower than desired to meet the goals set by the DOE program. Although this reviewer acknowledged that the materials preparation was being proven, it was noted that the cell assembly capability was not yet in place. Once it is in place, it will require four to six months to prove-in the cell assembly capability, which this reviewer described as a slow time line that would not be tolerated in industry. The final reviewer stated it was well defined to the ANL cathode powder process, but suggested to develop the process that was made by the other companies or institutes. The same reviewer also identified the need for the testing and diagnostics team to set up clear criteria to determine whether to go (or not) for scale up.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer feedback was generally positive in this section. The first reviewer remarked that it was unclear that much collaboration with partners was needed to get this facility underway, but suggested that it would probably benefit, going forward, from collaborating with the laboratories that were testing new sample materials. The second reviewer observed that materials and cell assembly seemed to be inward looking problem areas. Once fully operational, this reviewer asserted, collaboration with other institutions should follow.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The comments received in this section were mixed. One reviewer indicated that the cathode materials research and scale-up facility expected to do two to four materials in the coming year. The approach appeared sound to this reviewer, even though the facility would be relocating shortly, which would briefly hinder its progress. Another reviewer opined that the time frame for this essential facility was to the detriment of the ANL and DOE materials programs. Efficient and timely (i.e., the sooner the better) evaluation of new materials would benefit the entire ANL materials program, concluded this reviewer.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. Two reviewers indicated the resources were sufficient, of which one of further indicated the resources looked sufficient to cover the costs of the equipment as well as that of two full-time engineers with specialized skills in materials production scale-up. The third and fourth reviewers reported that the resources were insufficient. The third reviewer opined that more funding was essential because cell assembly and materials preparation required capital and qualified engineers to execute the program in a timely manner. The fourth reviewer observed the need to hire more operators to accelerate the pilot production.

Process Development and Scale up of Advanced Electrolyte Materials: Greg Krumdick (Argonne National Laboratory) – es168

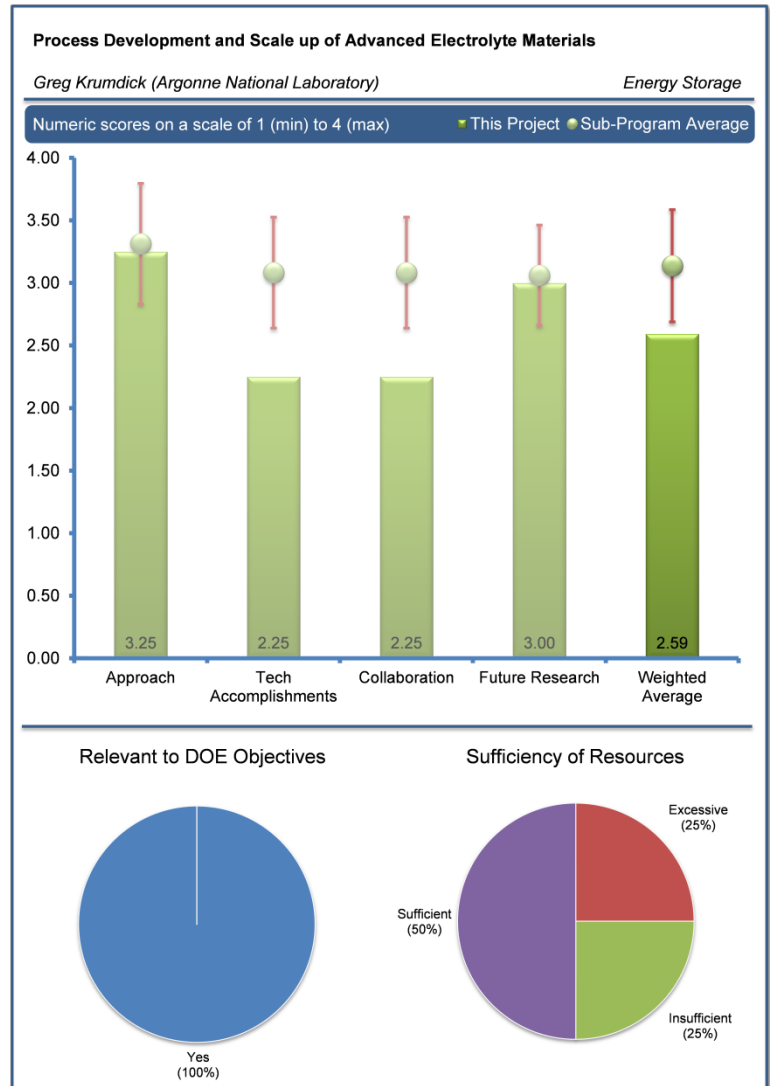
Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, comments in this section were positive. The project supports the creation of a facility to develop processes for scaling up the quantities of electrolyte materials for lithium-ion batteries that are used in plug-in electric vehicles (PEVs), as indicated by the first reviewer. If lithium-ion batteries with improved performance and safety properties could continue to be developed and commercialized at reduced cost, opined this reviewer, this would help speed up consumer adoption of the PEVs that use these batteries. Many of these PEVs would surely replace the purchase of conventional vehicles that run exclusively on petroleum-based fuels and thus, this reviewer asserted, the project did support the DOE objective of displacing petroleum. The second reviewer explained that advanced lithium-ion chemistries with high energy densities were the horizon for PHEVs and EVs, aided by the rapid emergence of new materials for cathodes, anodes, electrolytes, and electrolyte additives for interfacial stability or over charge protection, both within the DOE

laboratories and elsewhere. In addition to the performance improvements with these materials, this reviewer continued, these materials' cost purity and manufacturability were also important factors in the overall cost, life and feasibility of PHEV batteries. The objective of this project, per this reviewer, was to develop scalable processes for manufacturing electrolyte materials, synthesize kilogram quantities of each material, and make them available for industrial evaluation in large-format cells. The second reviewer remarked that this program was a key missing link between the discovery of advanced battery materials, market evaluation of these materials, and high-volume manufacturing, and would also reduce the risk associated with developing and maintaining a domestic, commercially viable, battery manufacturing capability. Another reviewer claimed that, as per the presentation, the project provided a vital link for electrolyte development and improvement that had been missing. Furthermore, noted this reviewer, it appeared that ANL was willing to underwrite this activity as the funds provided clearly did not cover what was being done. The fourth reviewer answered with a cautious yes stating that electrolyte research was critical to the ongoing evolution of battery technology, which was an important factor in petroleum displacement. Beyond the technical merits of a potential electrolyte material, continued this reviewer, it was also critical that the proposed technology had the potential to scale both in volume and cost in order to be considered a legitimate option in the battery development path. This reviewer expressed concern whether a DOE-sponsored program could have the breadth and scope capable of positively impacting the commercial viability of electrolyte materials. On the one hand, described this reviewer, it would seem that if an electrolyte material, whether it was salt, additive, or solvent, was demonstrated to have significant technical advantage, the industry would work diligently to determine if it had commercial viability. What this reviewer questioned was whether an intermediate role within the DOE was



either necessary or sufficient to provide a bridge or incentive to commercialization. The reviewer affirmed that this was not a passing of judgment, but rather a simple note that a program such as this probably required very careful, ongoing evaluation to determine its relevance within the overall scope of battery materials development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback from reviewers in this section was generally positive. One reviewer stated the approach appeared to be logical and well thought out within its scope and mission, while another reviewer indicated that the approach was excellent. This second reviewer suggested that while more description of the analytical specifications and methods would improve the confidence, most of the bases were generally covered. The reviewer concluded that future testing of the materials would reveal whether the analytical and quality control was adequate. The third reviewer remarked that this electrolyte scale-up facility had established a procedure for how it would select which electrolyte materials to develop scale-up processes for. This reviewer further described that the facility staff included scale-up experts who knew how to develop the processes that would allow cost-effective volume-scale manufacturing of these materials. After going through two rounds of scaling up to arrive at the ability to make kilogram-scale quantities of the materials, the reviewer pointed out that the team would write up a technology transfer information package that would be available for licensing by industry. So far, acknowledged the third reviewer, five materials had been successfully scaled up. The fourth and final reviewer reported that the approach for scale up of the selected electrolyte materials, which looked good, involved the following: identifying the desired materials (i.e., electrolyte solvents, redox shuttles, and passivation additives from the ABR material development; developing and managing the materials database, which includes chemical identity and performance characteristics; developing rating criteria (i.e., rate, life, and overall performance; developing a cost-effective, scalable, and safe manufacturing process together with analytical methods and quality control procedures; iterative synthesis and performance validation; creating a detailed technology transfer package; and making the material available for use by industrial partners. This final reviewer expressed it was unclear why the scale up should be limited to the material from ABR only, and added that any promising materials emerged from the external partners should be scaled up to be able to verify the performance benefits with such materials in large-format cells containing ABR chemistry.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were mixed. One of the reviewers described the progress as excellent and accomplishments as very concrete. Another reviewer reported that the facility has thus far reported that five electrolyte materials have been successfully scaled up at the facility. It has also worked on another material that ultimately it deemed unsuitable for scale-up. The reviewer further indicated the facility maintained a database of prospective materials for scale-up, and it appeared that this catalog would help it in deciding which materials to work with next. The third reviewer observed that reasonably good progress had been achieved thus far in developing synthetic processes and synthesizing large batches (kg) of five electrolyte materials, which include four new solvents/redox shuttles from ANL and one electrolyte additive, hexafluoro-iso-propyl phosphate (HFIPP) from ARL. During the synthesis, explained this reviewer, some of the environmentally not-so-friendly solvents were replaced with green alternates and the process waste was reduced. Technology transfer packages were prepared for these materials and materials were sampled for evaluation. It was not clear to this reviewer why the material selection could not be extended beyond the ABR materials. Also, pointed out this reviewer, plans regarding the project team's subsequent evaluation in large-format cells through industry collaboration were not discussed. Nevertheless, the third reviewer concluded that scale-up efforts in this project were in the right direction to enable and expedite technology transfer from laboratory to industry. The final reviewer commented that it would have been good to get some details of how the data generated from the scale up sample matched the original discovery material. Finally, this reviewer highlighted that there were no examples of data back from scientists or industrial feedback from samples that were distributed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer feedback was somewhat negative in this section. The collaborations were limited to two ANL teams and the United States Army Research Laboratory, reported the first reviewer. However, the reviewer continued, facility management was aware that more collaboration was necessary and was actively soliciting the participation of research groups within the ABR program

community. The second reviewer remarked that, as expected from the nature of the project, there were a few contributors and collaborators to provide electrolyte materials. This reviewer further highlighted this needed to be extended to external collaborators beyond ABR and industry. As another reviewer noted from the presentation, the collaboration sphere needed to be expanded on both the material source as well as the ultimate evaluators of the materials. At the same time, this reviewer pointed out that the process technology necessary to develop any given set of materials might be quite different from the process technology developed from a previous campaign. This reviewer suggested it would be good to be able to access subject matter experts in any given process development rather than to try and build the expertise from the ground up. The fourth reviewer observed an obvious need to do better here and emphasized that vaguely offering to collaborate with ABR participants was inadequate. The same reviewer identified a clear need for a salesman and further inquired about the existence of collaborations with chemical manufacturers (e.g., Aldrich, Novolyte, etc.).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The comments received in this section were generally positive. One reviewer stated the approach that the electrolyte materials scale-up facility had developed seemed logical, and with the input of research groups that focus on these materials, it should be able to choose the most promising electrolyte materials for its future efforts in process development. Not all materials may be able to realize the same degree of success in achieving cost savings and simplified processes for volume manufacturing, but this reviewer observed that the team appeared to be off to a good start thus far. Having a facility of this type was very valuable to the ABR program, opined this reviewer, as scaling up materials for volume production was a missing link between the industrial evaluation of material and their commercialization in batteries for PEVs. The second reviewer reported that future plans, which were in tune with the overall objective, included managing the electrolyte materials database, updating it with new materials, and developing scale up/synthesis processes for another four to six electrolyte materials. Another reviewer explained that future plans involved moving into new facilities, which was a bit vague. Future activities would obviously depend on deliveries next year, continued this reviewer, who also pointed out that this would be critical and would then require more concrete plans for improving the processes. The fourth reviewer offered no comment, beyond having observed that it essentially involved moving forward with developing more compounds.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers disagreed regarding the adequacy of project resources. Two reviewers indicated that the resources were sufficient. The first of these reviewers remarked that funding appeared to be sufficient, supporting the acquisition of the appropriate equipment and staff with the skills to develop the processes for manufacturing electrolyte materials at volume scale. The second reviewer agreed that resources seemed sufficient for the task, and further noted that this may vary depending on the forward going nature of the specific materials in question. Any level of commitment to scale up technology would require significant funds, opined this reviewer, and the breadth and scope of such an effort would be a complex issue for which to manage and provide resources. Another reviewer reported that resources were insufficient and expressed that the project was clearly underwritten by ANL funds. In addition, this reviewer emphatically expressed hope that the amount of the subsidy was being relayed to the DOE program managers so that the managers knew how much this really cost. The fourth reviewer disagreed with the aforementioned reviewers and asserted that the budget of \$1 million (i.e., an increase from \$450,000 in FY 2011) was excessive for this effort, even though this project had good relevance to ABR.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
3D	Three Dimensional
A123	A123 Systems
ABA	Anion Binding Agents
ABR	Advanced Battery Research
ABRT	Advanced Battery Research for Transportation
AC	Alternating Current
Ah	Ampere-hour
ALD	Atomic Layer Deposition
AlF3	Aluminum Fluoride
Al2O3	Aluminum Oxide
ANL	Argonne National Laboratory
ARPA-E	Advanced Research Projects Agency-Energy
ARRA	American Recovery and Reinvestment Act
B4C	Boron carbide
BASF	A chemical company
BATT	Batteries for Advanced Transportation Technologies
BDMS	Battery Database Management System
BES	DOE Basic Energy Sciences
BEV	Battery Electric Vehicle
BMS	Battery Management System
BNL	Brookhaven National Laboratory
C	Carbon
CAEBAT	Computer-Aided Engineering of Batteries
CAFÉ	Corporate Average Fuel Economy
CB	Carbon Black
CFF	Cell Fabrication Facility (Prototype)
CMC	Carboxymethyl Cellulose
CNT	Carbon Nanotubes
Co	Cobalt
CO2	Carbon Dioxide
CSCG	Core-Shell with Concentration Gradient
CSTR	Continually Stirred Tank Reactor
DADT	Developmental & Applied Diagnostic Testing
DBBB	2,5-di-tert-butyl-1,4-bis(2-methoxyethoxy)benzene
DC	Direct Current
DFT	Density Functional Theory
DoD	Depth of Discharge
DOE	Department of Energy

Acronym	Definition
DoE	Design of Experiment
DSC	Differential Scanning Calorimetry
EB	Electron Beam
EC	Ethylene Carbonate
EDAX	Energy Dispersive Analysis X-Ray
EIS	Electrochemical Impedance Spectroscopy
EMC	Ethyl Methyl Carbonate
EOL	End of Life
ES124	DOE Energy Storage Program (advanced prognostics modeling tool)
ESCA	Electron Spectroscopy for Chemical Analysis
ESMS	Energy Storage Monitoring System
ESR	Equivalent Series Resistance
EUCAR	European Council for Automotive R&D
EV	Electric Vehicle
EXAFS	Extended X-ray Absorption Fine Structure
FEC	Fluorinated Ethylene Carbonate
FST	Fast Summation Transformation
FTIR	Fourier Transform Infrared Spectroscopy
GHS	Greenhouse
GITT	Grid Integration Tech Team
HCSD	Harmonic Compensated Synchronous Detection
HEV	Hybrid Electric Vehicle
HEXRD	High-Energy X-Ray Diffraction
HF	Hydrofluoric acid
HFIP	Hexafluoro-iso-Propyl Phosphate
HNEI	Hawaii Natural Energy Institute
HWCVD	Hot-Wire Chemical Vapor Deposition
ICA	Interface Control Additives
IL	Ionic Liquid
IMB	Impedance Measurement Box
INL	Idaho National Laboratory
JCI	Johnson Controls, Inc.
JMI	John Marvin, Inc.
L	Liter
LBL	Lawrence Berkeley National Laboratory
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LCO	Lithium Cobalt Oxide (LiCoO ₂)
LEESS	Lower-Energy Energy Storage System
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate

Acronym	Definition
LG	LG Chem
LIB	Lithium-Ion Battery
LiBF4	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalato)borate
LiFOP	Lithium tetrafluorooxalatophosphate $\text{LiPF}_4(\text{C}_2\text{O}_4)$
LiFSI	Lithium bis(fluorosulfonyl)imide
LiMn2O4	Lithium Manganese Oxide
LiMO2	Lithiated transition metal oxides
Li2MnO3	Lithiated transition metal oxides
LiPF6	Effective electrolyte salt for lithium-ion battery
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LLC	Layered Lithium metal oxide Cathode
LMNO	Ni-substituted manganese spinel oxides
LMO	Lithium Manganese Oxide
LMP	Lithium Metal Polymer
LMR	Lithium Manganese Rich
LTDI	Lithium 4,5-dicyano-2-(trifluoromethyl)imidazole
LVO	Lithiated Vanadium Oxide
MAX	Layered ternary carbides, nitrides, and carbonitrides consisting of “M”, “A”, and “X” layers
MXene	Exfoliated MAX phases (2D structures)
MCMB	Mesocarbon Microbeads
MD	Molecular Dynamics
MERF	Materials Engineering Research Facility (Argonne National Lab)
MIT	Massachusetts Institute of Technology
Mn	Manganese
Mo	Molybdenum
MO	Carbon and oxides ($\text{MO}=\text{SiO}, \text{SiO}_2, \text{SnO}_2, \text{MoO}_3, \text{GeO}_2$)
NCSU	North Carolina State University
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	See NMC
NETL	National Energy Technology Laboratory
NG	Natural Graphite
Ni	Nickel
NIST	National Institute of Standards and Technology
NMC	Nickel Manganese Cobalt oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NREL	National Renewable Energy Laboratory
NY-BEST	New York Battery and Energy Storage Technology Consortium
OCV	Open Current Voltage
OEM	Original Equipment Manufacturer

Acronym	Definition
PC	Propylene Carbonate
PEI	Polyethyleneimine
PEO	Polyethylene Oxide
PEV	Plug-in Electric Vehicle
PF6	Hexafluorophosphate
PFOP	Polyfluorene Polymer
PHEV	Plug-In Hybrid Electric Vehicle
PHEV10	Plug-In Hybrid Electric Vehicle with a 10-mile range on a single charge
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PM	Project Manager
PNNL	Pacific Northwest National Laboratory
PRIMET	Primet Precision Materials, Inc.
PS	Polystyrene
PTC	Positive Temperature Coefficient
PV	Photovoltaic
QC	Quality Control
RS2	Redox Shuttle-2
Sb	Antimony
SBR	Styrene Butadiene Rubber
SCP	Spherical Carbon Particles
SEI	Solid Electrolyte Interface
SEM	Scanning Electron Microscope
SEO	Poly(Styrene-block-Ethylene Oxide)
SES	Triblock Co-polymers (polystyrene-block-polyethylene-block-polystyrene)
Si	Silicon
SIC	Single Ion Conducting
SiO2	Silicon Oxide
Sn	Tin
SNL	Sandia National Laboratory
SOA	State of the Art
SOC	State of Charge
SOH	State of Health
SOP	Standard Operating Procedures
SSRL	Stanford Synchrotron Radiation Light Source
SUNY	State University of New York
SW	Software
TCO	Total Cost of Ownership
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscope
TFSI	Bis(trifluoromethane)sulfonimide [(CF3SO2)2N]

Acronym	Definition
THF	Tetrahydrofuran
Ti2C	Type of MXene (HF treated Ti2AlC)
TM	Transition Metal
TMS	Tetramethylsilane
TR	Time-Resolved
TTT	3,5-triallyl-[1,3,5]triazinane-2,4,6-trione
UHEM	Ultra-High Energy Ball Milling Machine
UHMW	Ultra-High Molecular Weight
URI	University of Rhode Island
USABC	US Advanced Battery Consortium
USC	University of Southern California
V	Volts
VC	Vinylene Carbonate
VDA	Verband der Deutschen Automobilindustrie or Association of German Automobile Manufacturers
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XPS	X-ray Photoelectron Spectroscopy
XRF	X-Ray Fluorescence
XRD	X-Ray Diffraction (Crystallography)

3. Power Electronics and Electrical Machines Technologies

Advanced electric drive vehicles such as hybrid-electric vehicles, plug-in hybrid electric vehicles, fuel cell electric vehicles, and pure electric vehicles, require power electronics and electrical machines (PEEM) to function. These devices allow the vehicle to use energy from the battery to assist in the propulsion of the vehicle, either on their own or in combination with an engine. Advanced technology vehicles such as hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell hybrid electric vehicles (FCHEVs), and electric vehicles (EVs) can help meet important DOE goals, such as petroleum reduction. However, modern day PEEM technology is not sufficient to enable market-viable PHEVs, FCHEVs, and EVs. So, the Vehicle Technologies Program aims to develop these technologies by setting strategic goals for PEEM, and undertaking research projects that are carried out through collaboration among government, national laboratories, academia, and industry partners. Achieving the PEEM goals will require the development of new technologies. These new technologies must be compatible with high-volume manufacturing and must ensure high reliability, efficiency, and ruggedness. These technologies must also reduce cost, weight, and volume. Of all these challenges, cost is the greatest. PEEM project partners work together to ensure that technical attributes, vehicle-scale manufacturing, and cost sensitivities are addressed in a timely fashion and that the resulting technologies can be adopted by companies willing and able to supply products to automakers.

In August 2009, the Department announced the selection of ten projects totaling \$495 million that will help accelerate the establishment of a globally competitive, domestic infrastructure for advanced electric drive vehicle manufacturing. ARRA-funded Power Electronics and Electrical Machines Technologies activities support programs to enable production and commercialization of advanced electric drive vehicles, which help to reduce petroleum consumption. Activities include developing low-cost electric propulsion systems; supporting an increase in production capacities for electric drive components, manufacturing plants, and parallel hybrid propulsion systems; and supporting development of electric drive semiconductors. Additionally, AARA-funded activities that support commercialization include accelerating the launch of HEVs/PHEVs through efforts including localizing the design and production of transaxle systems, and developing a lower-cost, higher-control standardized platform.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
A Segmented Drive Inverter Topology with a Small DC Bus Capacitor	Gui-Jia Su (Oak Ridge National Laboratory)	3-4	3.00	3.00	3.00	3.33	3.04
† Benchmarking of Competitive Technologies	Tim Burress (Oak Ridge National Laboratory)	3-7	3.60	3.60	3.60	3.40	3.58
Wide Bandgap Materials	Madhu Chinthavali (Oak Ridge National Laboratory)	3-9	3.33	3.33	3.33	3.00	3.29
High Dielectric Constant Capacitors for Power Electronic Systems	Uthamalingam Balachandran (Argonne National Laboratory)	3-11	3.50	3.33	3.33	3.67	3.42
High Temperature Polymer Capacitor Dielectric Films	Shawn Dirk (Sandia National Laboratories)	3-14	3.43	3.57	3.57	3.57	3.54
† Glass Ceramic Dielectrics for DC Bus Capacitors	Michael Lanagan (Pennsylvania State University)	3-17	3.00	3.00	3.00	3.00	3.00
Beyond Rare Earth Magnets	Iver Anderson (Ames)	3-19	3.50	3.00	3.00	3.00	3.13
Air Cooling Technology for Power Electronic Thermal Control	Jason Lustbader (National Renewable Energy Laboratory)	3-21	3.50	3.25	3.25	3.25	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Power Device Packaging	Zhenxian Liang (Oak Ridge National Laboratory)	3-23	3.00	2.67	2.67	3.17	2.81
Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters	Allen Hefner (National Institute of Standards and Technology)	3-26	3.75	3.75	3.75	3.50	3.72
Development of SiC Large Tapered Crystal Growth	Philip Neudeck (National Aeronautics and Space Administration)	3-28	3.33	3.33	3.33	3.33	3.33
Thermal Performance and Reliability of Bonded Interfaces	Doug DeVoto (National Renewable Energy Laboratory)	3-31	3.67	3.67	3.67	3.33	3.63
Electric Motor Thermal Management	Kevin Bennion (National Renewable Energy Laboratory)	3-33	3.33	2.67	2.67	3.00	2.88
Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets	Christopher Whaling (Synthesis Partners)	3-35	3.80	3.80	3.80	2.40	3.63
Converter Topologies for Wired and Wireless Battery Chargers	Gui-Jia Su (Oak Ridge National Laboratory)	3-38	3.33	2.67	2.67	3.00	2.88
Integration of Novel Flux Coupling Motor and Current Source Inverter	Burak Ozpineci (Oak Ridge National Laboratory)	3-40	3.00	2.00	2.00	2.50	2.31
Motor Packaging with Consideration of Electromagnetic and Material Characteristics	John Miller (Oak Ridge National Laboratory)	3-42	3.00	2.75	2.75	2.75	2.81
† Physics of Failure of Electrical Interconnects	Doug DeVoto (National Renewable Energy Laboratory)	3-44	3.33	3.67	3.67	3.67	3.58
† Two-Phase Cooling Technology for Power Electronics with Novel Coolants	Gilbert Moreno (National Renewable Energy Laboratory)	3-46	3.50	3.00	3.00	3.00	3.13
Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate	Sreekanth Narumanchi (National Renewable Energy Laboratory)	3-48	3.20	2.80	2.80	3.20	2.95
Next Generation Inverter	Greg Smith (General Motors, Advanced Technology Center)	3-51	3.40	4.00	4.00	3.25	3.76
Air-Cooled Traction Drive Inverter	Madhu Chinthavali (Oak Ridge National Laboratory)	3-53	3.40	3.40	3.40	3.20	3.38
Alnico and Ferrite Hybrid Excitation Electric Machines	John Miller (Oak Ridge National Laboratory)	3-56	2.80	3.00	3.00	3.00	2.95
Unique Lanthanide-Free Motor Construction	Jon Lutz (UQM Technologies)	3-58	3.25	3.25	3.25	2.50	3.16
Alternative High-Performance Motors with Non-Rare Earth Materials	Ayman El-Refaie (General Electric Global)	3-60	2.75	3.25	3.25	2.50	3.03
† Smart Integrated Power Module	Leon Tolbert (Oak Ridge National Laboratory)	3-62	3.33	3.00	3.00	3.33	3.13
† Integrated Module Heat Exchanger	Kevin Bennion (National Renewable Energy Laboratory)	3-64	3.50	3.00	3.00	3.00	3.13
† US Electric Drive Manufacturing Center	Judith Giesecking (General Motors)	3-66	3.33	2.33	2.33	3.33	2.71
† Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles	Greg Grant (Delphi Corporation)	3-68	3.50	3.00	3.00	3.25	3.16
† Electric Drive Component Manufacturing Facilities	Richard Thies (Allison Transmission, Inc.)	3-70	3.67	3.67	3.67	3.33	3.63

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† ‡ U.S. Based HEV and PHEV Transaxle Program	Kevin Poet (Ford Motor Company)	3-72	3.50	2.00	2.00	3.25	2.53
† ‡ Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles	JJ Shives (Remy, Inc.)	3-73	3.33	3.33	3.33	3.33	3.33
† ‡ Electric Drive Component Manufacturing Facilities	Luke Bokas (UQM Technologies)	3-75	2.67	2.00	2.00	3.00	2.29
† ‡ Electric Drive Component Manufacturing Facilities: Magna E-Car Systems of America, Inc.	Brian Peaslee (Magna E-Car Systems of America, Inc.)	3-77	3.33	2.00	2.00	3.00	2.46
† ‡ DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles	Johnny Boan (Kemot)	3-79	3.00	2.67	2.67	2.67	2.75
† ‡ Construction, Qualification, and Low Rate Production Start-up of a DC Bus Capacitor High Volume Manufacturing Facility with Capacity to Support 100,000 Electric Drive Vehicles	Ed Sawyer (SB Electronics)	3-81	3.00	3.00	3.00	3.00	3.00
† ‡ Electric Drive Semiconductor Manufacturing (EDSM) Center	Duane Prusia (Powerex, Inc.)	3-83	3.33	2.67	2.67	3.00	2.88
Overall Average			3.30	3.04	3.04	3.11	3.11

† denotes poster presentations

‡ denotes ARRA funded projects

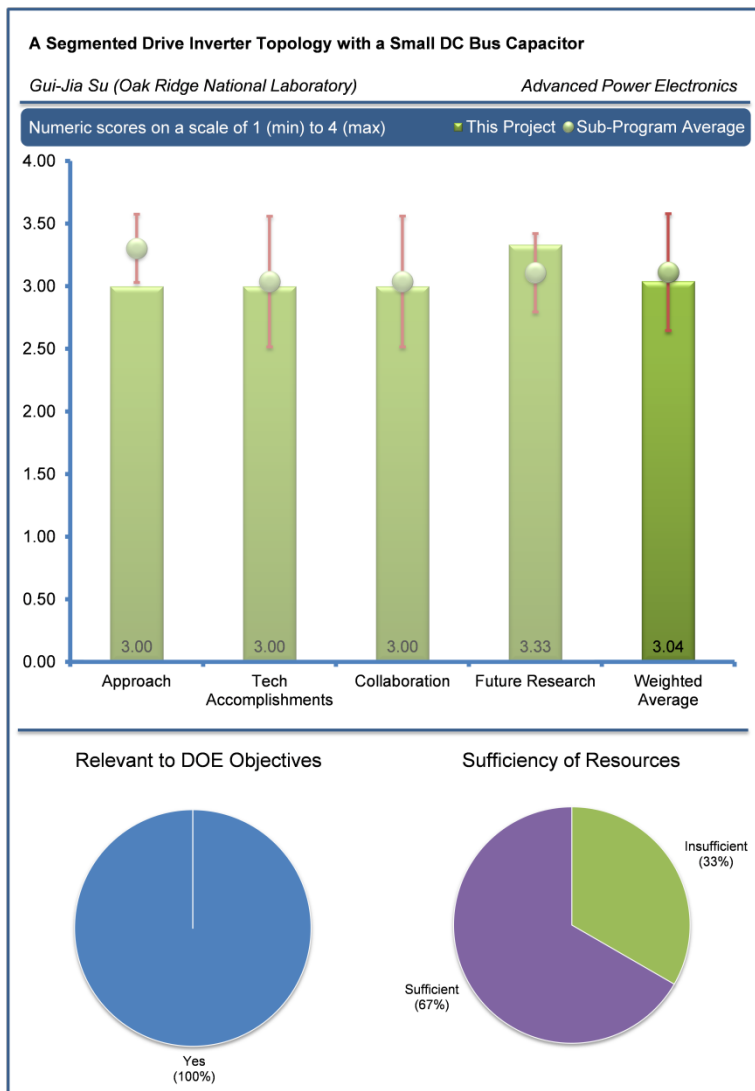
A Segmented Drive Inverter Topology with a Small DC Bus Capacitor: Gui-Jia Su (Oak Ridge National Laboratory) – ape004

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewer comments to this question were favorable. One person stated that the project is focused on meeting the goal of reaching the 2015 cost, 2020 cost, volume, and weight targets. Meeting those targets will help enable the market for electric-drive vehicles (EDV) which will in turn reduce our dependence on foreign oil. Another person asserted that the project is appropriate due to the possibility of improved efficiency for hybrid-electric vehicles (HEV), plug-in hybrid-electric vehicles (PHEV), and electric-vehicle (EV) usage which will increase the viability of these vehicles. The implementation shown is probably more indicative of an EV usage rather than a multi-motor hybrid but the concepts are still viable. The final evaluator had detailed comments, noting that the project attempts to solve capacitor problems encountered in the development of inverters for electric vehicles. The reviewer expanded that capacitor cost and capacitor heating are significant roadblocks to meeting the U.S. Department of Energy (DOE) cost targets for EV inverters. This reviewer added that this work uses interleaved and segmented power electronics architecture to reduce capacitor ripple current, thus reducing the size of the capacitor required and thus the cost and volume of the capacitors.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question were mixed. One person stated that collaboration of other Oak Ridge National Laboratory (ORNL) and industry groups is good. Another person, however, expressed that the details of the approach are not clear because the design is under patent review. One person commented that the results show very good results, but the presenter did not explain why. This person felt that it was not clear that increasing the number of switches (even if the silicon area stays the same) and the number of connections to the motor will reduce cost. The reviewer concluded by observing that the arrangement of separate caps for each switch is good. One reviewer expressed that they are not an expert in inverters and motors, so they felt that it was difficult to assess how well the technical barriers were assessed and whether there are better approaches, but the results thus far are impressive. The final reviewer had detailed comments, stating that the segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets, does not address the system question related to the targets. The reviewer asked whether the segmented motor (which is larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation discussing the system thinking that showed the tradeoffs of this approach could have been presented.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One commenter pointed out that the first prototype 55 kilowatt (kW) inverter resulted in dramatic reductions in capacitor, battery, and motor ripple currents, which permitted a 60% decrease in direct current (DC) link capacitor size. Another person noted that the “Design, build and test...” activity from the Project Objectives is progressing very well, but observed that the details of the design are not clear. One project evaluator was concerned that the extra motor windings required by this architecture may possibly increase the cost/weight of the motor. Another commenter asserted that the goal of eliminating the capacitor hurdle for high-temperature operation was not directly addressed; smaller size and lower ripple caps were addressed but not the high-temperature. One reviewer reiterated comments nearly verbatim to the previous question, stating that this segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets does not address the system question related to the targets. The reviewer asked whether the segmented motor (larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation showing the gains of this approach could have been presented. Another commenter pointed out that the results indicate that the concept is working, however, further data relative to pressure drop and flow rate for the heat sink is required as well as a cost analysis of the total cost of the switches versus the tradition inverter. The expert added that a comparison of the motor cost impact for the segmented approach is needed. The final expert mentioned that project addresses the goal of reaching the 2015 cost, and 2020 cost, volume, and weight targets. The reviewer felt that the researchers appear to be making progress toward the targets on the prototype; however, as pointed out in the presentation, integrating the inverter into the motor (which was not described in the presentation) needs to include vibration and thermal modeling. The reviewer added that the thermal modeling needs to include drive cycles and further asked what the ambient environment is for this inverter packaged on your motor. The reviewer posed two other questions for the researchers’ consideration. Specifically, the reviewer would like to know whether the researchers can comment on other components ratings required to survive in the environment. Additionally, the reviewer would like to know if the researchers can also perform electromagnetic interference (EMI) emission testing on the completed assembly.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One reviewer felt that the collaboration was adequate for the level of funding and that the use of the in-house ORNL packaging group reduces cost and lead-time. Another person observed that using automotive industry suppliers are a good choice for providing parts to prove the concept. The reviewer added that capacitors are interesting looking, but asked if the vibration environment has been considered and specified when selecting parts. One evaluator felt that it was not clear how the various switch manufacturers or capacitor suppliers were involved in the design. This person asserted that collaboration needs to include input from the suppliers, not just from the component suppliers/developers. The final reviewer would like to know why 1,200-volt devices are needed for this inverter (mentioned on Slide 12).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Responses to this question were generally positive. One person simply stated that the researchers have used a great approach and that the updates should be based on results. Another reviewer felt the plans were adequate for this stage of program, adding that the plans include assembling and testing of the final, refined prototype. One commenter described that the future plans include building and testing a second prototype to be integrated with the motor including thermal and vibration modeling/vibration with a focus on targets is the next logical step. One final reviewer reiterated detailed comments to two previous questions, nearly verbatim, stating that the segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets does not address the system question related to the targets. The reviewer asked whether the segmented motor (larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer again suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation discussing the system thinking that showed the tradeoffs of this approach could have been presented.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers responded to this question, one stating funding was insufficient, with the remaining two stating it was sufficient. One person commented that the researchers had made good choices selecting partners. The other reviewer to comment observed that the project is at the point it should be based on the resources versus the plan.

Benchmarking of Competitive Technologies: Tim Burress (Oak Ridge National Laboratory) – ape006

Reviewer Sample Size

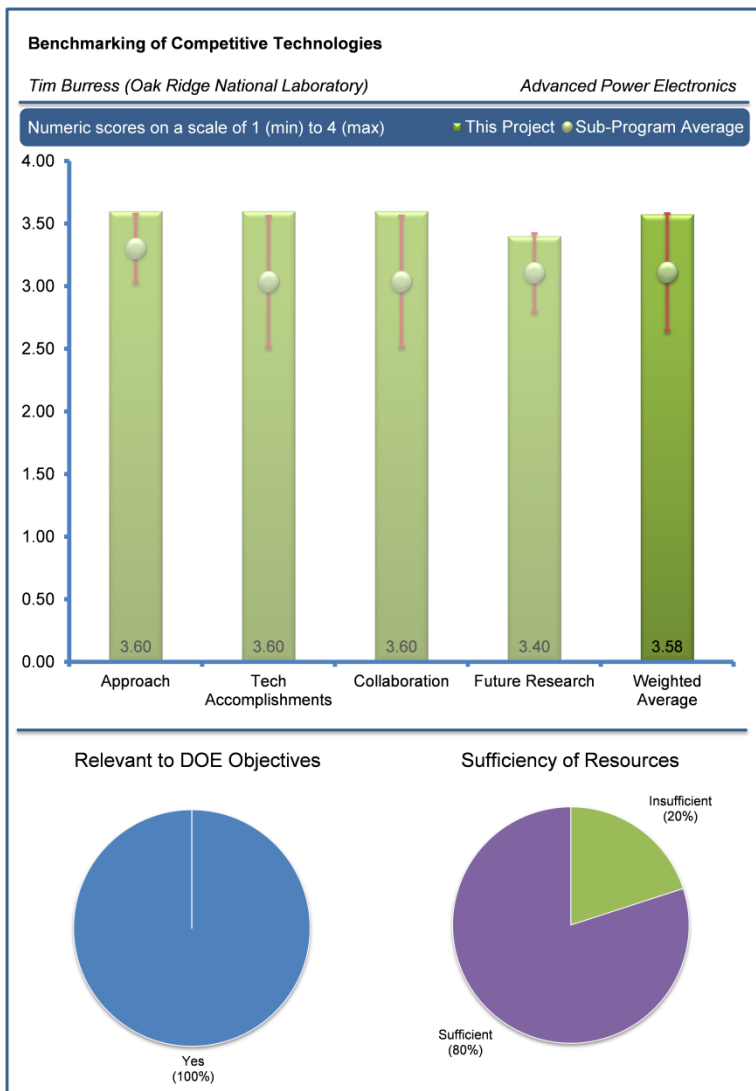
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were positive. One person simply stated this was a good project. Another reviewer commented that benchmarking work should always be a funded activity since it defines the work that has gone into released products (representing many thousands of man-hours). One expert expressed that this work provides a method of understanding the state-of-the-art in production vehicles. This understanding then allows for an understanding of strengths and weaknesses of current production technology and allows for better decisions to be made for research and development. Another evaluator noted that, though not explicatively stated, competitive assessment allows for a detailed look at what is current in the marketplace. The reviewer added that this detailed look develops a set of technical metrics for comparisons to future designs which helps to improve those future designs to meet the DOE Vehicle Technologies Program (VTP) 2015 and 2020 targets, which in-turn helps to lower the cost of EDVs and reduce our dependence on foreign oil. The final reviewer affirmed that this project is one of the best investments of DOE funding; the information provides invaluable guideline for other projects to benchmark their proposed technologies. It also helps DOE to decide funding strategy to achieve the final goal.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One person stated that it appears the barriers have been overcome. Another commenter stated that the systems chosen are appropriate and leading edge in the market; the work presented improves every year, getting to the key attributes of the benchmarked systems. Another reviewer, however, remarked that they would like to see some cost analysis and comparisons. The final evaluator pointed out two issue-solution pairings from the presenter's barrier slide and critical assumptions. The first identified issue was integrating ORNL-developed controller with original equipment manufacturer (OEM) components, and the corresponding solution was to take measures similar to that of previous years wherein troubleshooting, circuit analysis, and literature research is used to identify appropriate technique to interface and communicate with OEM equipment. The second identified issue was adapting a non-standard motor assembly to test cell, and the corresponding solution was to closely inspect functionality of subsystem to ensure any modifications will not aid or hinder operation in comparison with that of typical operation within the vehicle.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person simply stated that the research team seems to have met the project objective. The reviewer added that they liked the summary comparison on Slide 30. One person commented that the project does not directly achieve the targets, but it focuses the efforts and also allows potential issues for reliability and durability to be identified. One reviewer had several comments in response to Slide 3. This reviewer mentioned reveal compositions and characteristics of key components; trade-offs (e.g., magnet strength versus coercivity); general cost analysis; compare results with other HEV technologies; and identify new areas of interest. This reviewer suggested that the researchers evaluate the advantages and disadvantages of design changes; for example, evaluate the complexity of the Lexus LS 600h double-sided cooling system. This expert acknowledged that the researchers have done many teardowns and analysis, which were all done very well, but the reviewer asked whether there are summary slides comparing all the systems that summarizes what enables better power density, higher peak specific power or lower cost from system to system. This commenter asked if it is better thermal, better magnets, smaller caps, better control algorithms, new materials, etc. Additionally, when the investigators evaluate bulk capacitors, this reviewer would like to know if the investigators can also do an impedance plot and measure the bulk cap inductance at the connection points. The final reviewer acknowledged that important results from the Hyundai Sonata were presented, from inverter components and suppliers to the key attributes of the motor. This reviewer questions whether the HSG has an 8-pole rotor; the slot count and resolver lobe count would lead this reviewer to think it is either a six- or 12-pole rotor. The reviewer also wondered if the Nissan Leaf motor really uses 3/0 alternating current (AC) wire gauge or if it uses 3 American wire gauge (AWG) gauge (i.e., 3/0 is substantially larger than 1/0 AWG). The reviewer added that even if these are mistakes (which they may not be), that they always look forward to the new reports and find them very useful in guiding U.S. development work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were primarily positive. One person commented that the collaborations were heavy on government agencies, but that this is probably required considering the project scope. Another reviewer suggested that it would be useful to have an industry partner that may notice different attributes as part of the teardown and testing activities. The final evaluator commented that it appears everyone is working together to provide the appropriate information.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed. Some reviewers answered the question, while others simply provided related thoughts. One reviewer felt that it was not really clear what the future work will be based on slides. Another person commented that competitive assessment seems to be a never ending program; this shows the market is still changing and designs are still evolving. This reviewer observed that many of the DC taxis are hybrid vehicles. The reviewer noticed that taxi ridden in had approximately 120,000 miles on the odometer, which spawned the thought that it may be interesting to do a teardown analysis of one of these high-mileage hybrid vehicles. This reviewer added that hopefully, the taxi company can also provide the service history. One expert asserted that a detailed analysis of the Nissan Leaf system is an excellent use of time spent on this program. Another commenter stated that the speed of work done is very important for its relevance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, but four of the five reviewers to comment stated funding was sufficient, with the remaining person stating it was insufficient. **One reviewer provided an additional comment stating that the resources are applied to the right tasks, but suggested a larger budget and more resources due to the number of new vehicle offerings coming into the market.** The other reviewer comment asked whether having more resources would get the job done sooner.

Wide Bandgap Materials: Madhu Chinthavali (Oak Ridge National Laboratory) – ape007

Reviewer Sample Size

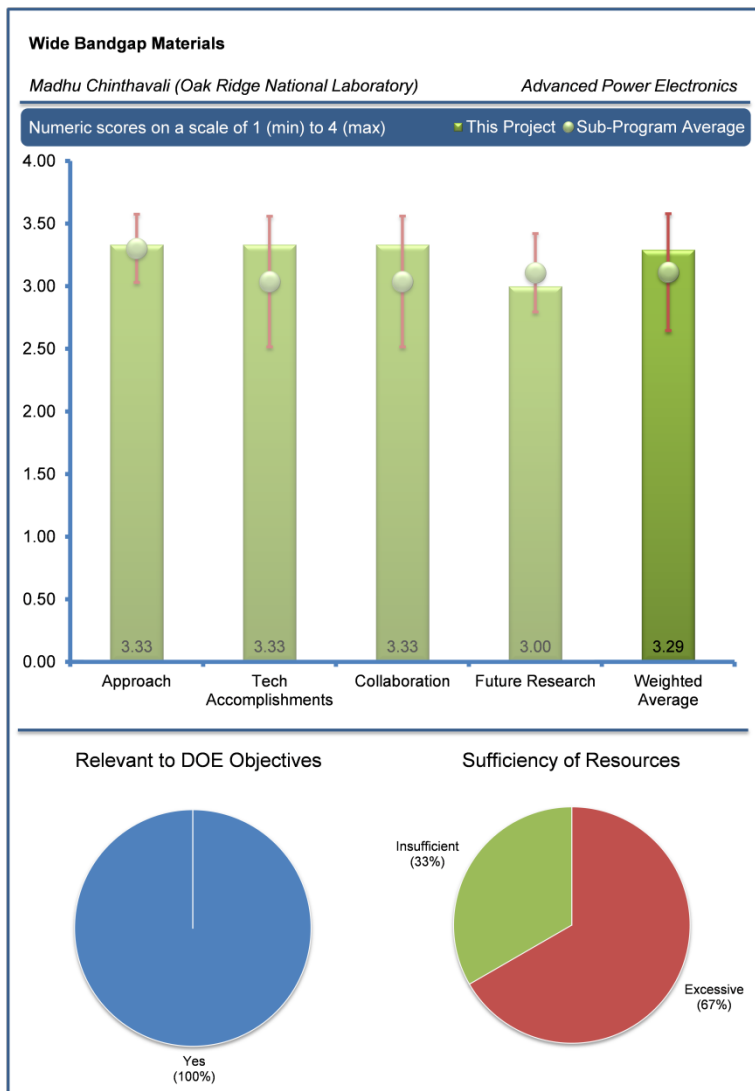
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were positive. One person commented wide bandgap (WBG) semiconductors, silicon carbide in particular, are highly relevant to the future of automotive traction drive systems. Another person commented that the project is focused on possible efficiency gains possible with WBG power devices, particularly by reducing switching losses. The final reviewer had detailed comments, stating that the device characterization activity has intrinsic value in providing a central repository of emerging WBG material-based power switching and rectifying devices. The reviewer pointed out that the effort has evolved to the point that it has become a highly valuable national asset providing unbiased evaluation of these devices. The move toward die level assessments has been very valuable and enables a better comparison. These material systems will provide significantly improved efficiency over Si insulated gate bipolar transistor (IGBT) technology and enable greater range per gallon of hybrid vehicle performance and improved range for plug-in electric vehicles (PEV).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to comment stated that die-level work is a large improvement. The reviewer would like to see capacitance (input primarily) measurement metrics normalized to a per amp or per cm² die area for all the device technologies represented. The reviewer suggested that a metric relating this capacitor to the measured switching losses as a figure-of-merit (FOM) may be also useful. The reviewer noted however that the typical on resistance capacitance metric may be sufficient and that the techniques used to accurately estimate junction temperature should also be included for information. The reviewer concluded by suggesting that the researchers include package thermal impedance (measured) to infrared (IR) measurements of the devices/die under characterization. The other reviewer to comment had detailed comments stating that acquiring parts and performing testing has become a global activity with many reports becoming publically available in the last year (an entire session was devoted to this topic at PCIM in Nuremberg, Germany last week). The same reviewer added that the technical approach is similar to standard methods with the laudable addition of building a PSPICE model for one of the metal-oxide semiconductor field-effect transistors (MOSFET), which is innovative. However, the reviewer added, the effort seems pretty focused on the SiC MOSFET with little justification in terms of the project's stated objective (evaluating wide bandgaps for commercial viability in the automotive industry). In this respect, there are probably better competitive analyses going on in industry and academia and now being reported at different open-source forums, like APEC and PCIM. The reviewer suggested that perhaps ORNL could consult those researchers or their publications for data and methods to address a broader selection of wide bandgap technology.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that the large current MOSFET data and characterization results were very good. The reviewer felt that the inclusion of threshold voltage as a function of temperature was also very relevant for these devices. The only other person to comment remarked that the results are consistent with the methods employed and similar to other reports. The reviewer noted that there seems to be a bias toward the MOSFET which is not found in the more objective open-source reports that are now widely available. The reviewer was concerned about the resistive loading for the dynamic testing; this is not particularly relevant for automotive traction drives and virtually unused by the larger community doing competitive research on power semiconductor technology.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were generally positive. One person noted that there has been excellent inclusion of all the relevant WBG device producers, even those not production viable but with device designs of future interest. The other person to comment stated that the project is pretty much an internal effort with varying degrees of collaboration with technology providers.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One evaluator observed that this project is appropriately focused on a continued execution of these characterization activities as devices evolve and designs mature and scale with current rating. The other commenter described that the primary plan seems to be to await the latest developments in SiC MOSFETs and then test, which possibly misses a more diverse technology competition going on in the commercial market place. The reviewer offered that one explanation for this is the reliance on relationships with product vendors, some of which are cultivated by those vendors. The reviewer noticed that Rohm is not on the researchers' collaboration list even though within the last two years Rohm has begun moving the market in SiC MOSFETs faster than Cree.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed. One reviewer felt resources were insufficient, and two people felt the resources were excessive. One reviewer commented that the project needs more funding to test more devices. Another person mentioned that excellent competitive studies are proliferating and suggested that some aspects of this project could probably be achieved by studying third party reports. This reviewer suggested that although the vendor survey was bravely conducted, acquiring data reports from more experienced market players (e.g., Yole and Darnell) may have offered cost savings.

High Dielectric Constant Capacitors for Power Electronic Systems: Uthamalingam Balachandran (Argonne National Laboratory) – ape008

Reviewer Sample Size

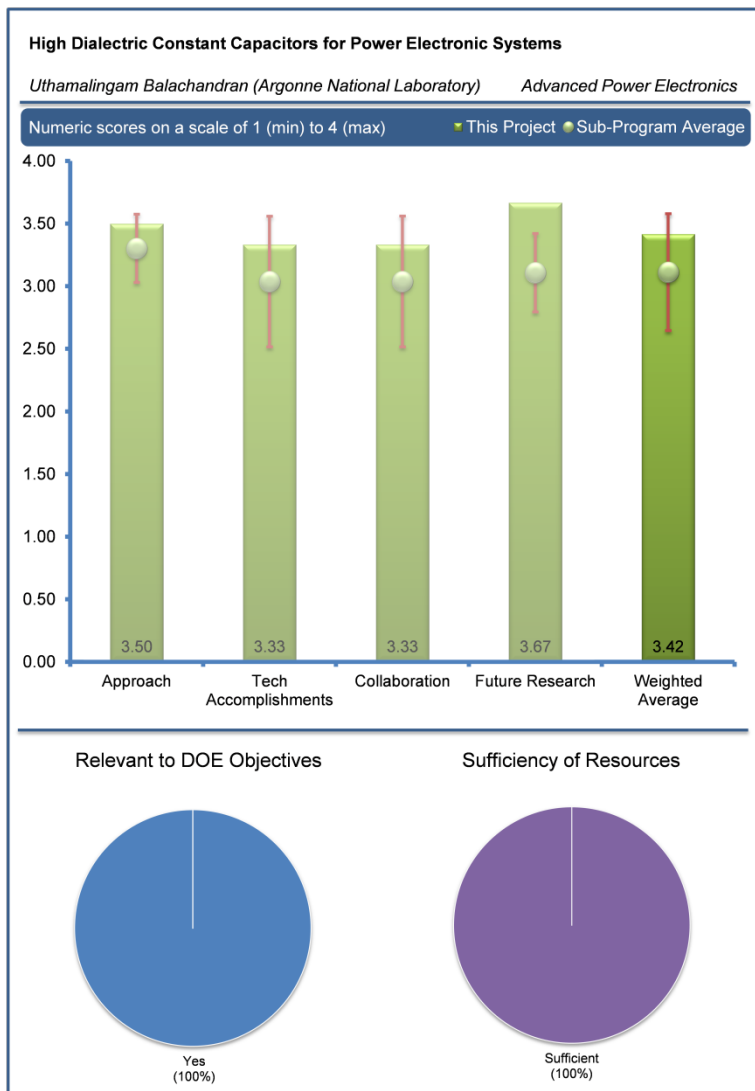
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person asserted that the project supports the Advanced Power Electronics and Electric Motors (APEEM) program goals for a DC bus capacitor to operate at higher temperatures (140 °C at 450 V), and also addresses the challenges to reduce cost, weight, and volume of capacitors in inverters. Another reviewer agreed that pursuing a ceramic-based DC Link capacitor with goal to reach two-inch cube. This person also stated the project’s cost target range is \$30 to \$50 which they pointed out meets DOE goals of 1) cost focus and 2) good understanding of targets and goals. One commenter remarked that capacitors are a necessary component within the inverter, and as such, need to be improved. The reviewer added that this project addresses the need to reduce the size of the component while maintaining or improving the desirable attributes of the device. Another person also asserted that DC link capacitors are critical component in power inverters. This reviewer also mentioned that capacitors with high thermal stability can address the thermal management challenges in HEV power inverters and that it is known that ceramic capacitors have higher thermal stability than commercial polypropylene film capacitors. The final reviewer had detailed comments, explaining that reducing the cost of EV is a vital step toward consumer acceptance and use. A less expensive and lighter weight DC-link capacitor will reduce the inverter cost in all electric vehicles and hybrids, but it is only one of many technical and manufacturing steps needed to slash EV costs by about half to attain consumer affordability. Attaining that goal will create the need for an EV charging infrastructure that supports higher consumption rates of electricity. That electrical demand also creates the additional problems of insufficient grid capacity and much higher outputs from coal and natural gas fired power plants.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments for this question were generally positive. One person simply stated that the approach was very methodical. Another reviewer had similar thoughts, stating that the approach was methodical and systematic and that the goals of the DOE for the DC Link Capacitor were all met or exceeded based on the trajectory of the project. One commenter felt that the approach and strategy are clearly focused on the research and development of the next generation capacitor with high-dielectric-constant, high-temperature ceramic films on base-metal foils, that are either stacked on or embedded directly into printed wire boards, and addresses the technical barriers in an innovative manner. One evaluator remarked that the mitigation of electrical breakdown in the PLZT layer by an additional layer of TiO₂ is innovative and effective. The reviewer thought that this advancement makes a



significant step forward in turning a laboratory activity into a functioning capacitor. Simultaneously, the reviewer felt that it is a step backward from producing a commercial product because it adds another expensive process step (TiO_2 sputtering by RF) to an already expensive process. Additionally, DC-link capacitors for EV will always be a relatively small market for new material process techniques, so the reviewer asked whether there is another, much larger-market use for a PLZT- TiO_2 sandwich that will stimulate private-sector investment in all this work. Another expert noted that the ceramic compositions are designed and optimized to combine high thermal stability, high dielectric constant, and low dielectric loss. However, the reviewer felt it was unclear from the presentation what the advantages are for the film on foil design as compared with traditional multilayer ceramic capacitors (MLCC). The final reviewer affirmed that the work on the capacitor is great and relevant to solving the issue of reducing the size of the bulk capacitor, however the reviewer did not think that the typical inverter will mount the bulk capacitor within a printed wiring board (PWB) as described – most designs try to keep high currents off of the PWB board. The reviewer added that there has been some work done relative to thick copper PWBs which might be appropriate. The reviewer concluded by noting that packages more conducive to mounting on bus bars should be investigated as well as how this technology will help reduce the temperature limit of the cap.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were generally positive. One expert simply stated that good progress has been made. One reviewer highlighted the outstanding achievements and accomplishments in this project including patents, publications, awards, and technical results. Argonne National Laboratory's (ANL) film-on-foil has the potential to be the next generation capacitor to demonstrate high dielectric constant at high voltages, exhibit high-temperature capability, and meet volumetric and cost targets. Another project evaluator agreed that progress on the capacitor approach is very good and shows promise; this technology has a very good chance of being successful but needs to be packaged in a manner that will allow inverters to be built. Another evaluator commented that the team has successfully improved the dielectric breakdown strength and reduced the dielectric loss by introducing TiO_2 layer. According to this reviewer, 10-layer capacitors were fabricated and tested and that systematic tests were performed to evaluate the effect of sample diameter and temperature on the breakdown strength and lifetime. This reviewer felt that it seems that the team understands the challenges associated with scaling-up the capacitor from a mm size patch to large size 1,000 μF capacitors, although the test results show the significant drop in performance even at 20 mm size capacitor. The improvement in dielectric breakdown strength by using segmented design is quite interesting, as it is widely used in PP film capacitors. This expert suggested that as the dielectric layer of PLZT will be 3-5 μm for the 450 V DC link capacitors, spin coating is not the best process to produce capacitors; traditional tape casting and MLCC are more practical. Another reviewer had scale-up concerns, stating that the performance of the small test capacitor was acceptable, but that the challenge will be to scale it up to a larger size. The reviewer concluded by mentioning that the innovative sputtering of the titanate had a major impact on breakdown voltage. One reviewer felt that the project is making good technical progress, within the confines of the contract and the stated problem; progress toward larger DOE goals in the energy marketplace, however, is not so clear.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments for this question were generally positive. One person simply stated that there was a good set of partners and suppliers. Another reviewer pointed out that the researchers are working with Penn State University, Delphi, Sandia National Laboratories (SNL), and ORNL. Another person had similar comments, acknowledging that the collaboration with Penn State University, SNL, and Delphi is very good. This expert also mentioned that test results have been verified by Delphi, the potential customers. The reviewer suggested that since the technology is related to ceramic capacitors, that it would be great if there is an industrial partner who is producing commercial ceramic capacitors (e.g. KEMET, AVX, or Murata) on the team. The reviewer suggested that these production capacitors can help the team to scale-up the capacitor manufacturing using their established production process and tools. One evaluator commented that the level of R&D collaboration appropriate, but also recommended expanding industry collaboration and coordination in order to adequately address manufacturing and end-user requirements. Another commenter observed that the results show full participation from the team which is appropriate for the where the project is at this time; test data correlates which is good.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One evaluator commented that the researchers presented a very detailed path forward to extrapolate the research and lead to prototype at 1,000 μF , 450V which is the size needed in automotive applications. This reviewer reinforced that industry is looking for a low-cost, volumetrically efficient, high-temperature reliable DC Link capacitor. Another person agreed, simply stating that they like the plan. One expert commented that the future work is planned in a systematic order and achievable; emphasis to advance proven laboratory scale and overcome technological barriers is clearly defined, and with alternate pathways. One reviewer commented that the presented plans indicate a logical plan towards meeting the goal. The reviewer felt that the 10 μF capacitor is reasonable for filtering use in a PWB and should provide meaningful data in terms of achieving the goal of 1000 μF bulk cap. The reviewer concluded by suggesting that the researchers may want to include a separate package for mounting on a PWB. Another evaluator reinforced that the DOE VTP goal is to produce large size 1,000 μF capacitors with 450 V rating which can be directly tested in a power inverter, adding that the team has been working on this goal in the last two year. The evaluator said that it will be great to see a large size capacitor delivered to Delphi and tested in a real power inverter with ambient temperature of 140 °C. This reviewer suggested that engineering and production scale-up should be the single priority for the next year. Another person stated that the future work proposes experimental activities that are sensitive to important issues, including the following: sub-scale capacitor at full voltage; process cost reductions; graceful failure with advanced electrode design; and multi-layer construction. This reviewer commented that unfortunately, the future work provides no criteria for success or failure. They felt that the research simply cascades on into the future to discover the next problem and apply the next fix. The reviewer concluded by asking when will the work be judged as a practical or impractical solution to power conversion in EVs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six reviewers to comment felt that the resources were sufficient. Several reviewers provided additional comments. One person agreed that the project appears to have adequate resources established and defined in order to achieve stated milestones and Go/No-Go decisions. Another commentator asserted that the team, together with their collaborators, has all the material and test expertise and facilities. The same person suggested that the researchers may need help from MLCC manufacturers on the fabrication of the 1,000 μF capacitor bank.

High Temperature Polymer Capacitor Dielectric Films: Shawn Dirk (Sandia National Laboratories) – ape009

Reviewer Sample Size

This project was reviewed by seven reviewers.

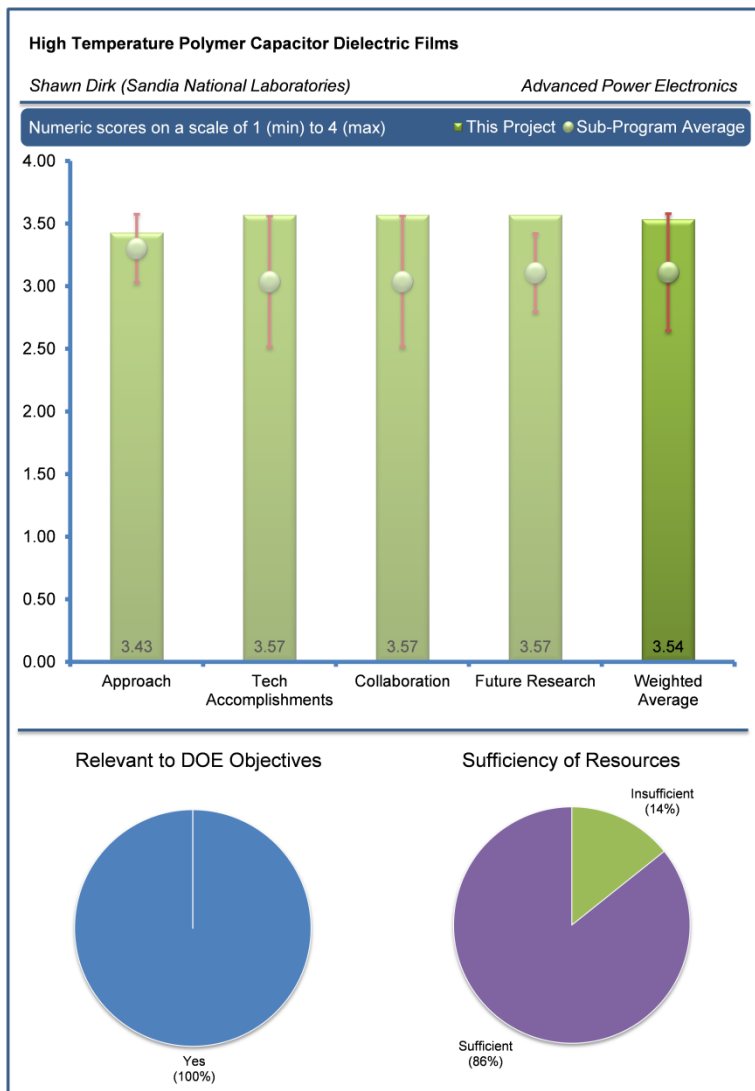
Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were generally positive, with some tempering reactions regarding the relative importance of the results of this project. One person agreed that the project supports the overall DOE goals to reduce cost, weight, and volume of capacitors, and simultaneously increase operational temperature (greater than 140 °C) through the development of inexpensive high-temperature polymeric material systems and nanofillers. Another evaluator agreed that this is very relevant work for reducing cost and size of bulk capacitors required for traction motor inverters, required by electric and hybrid-electric vehicles that can substantially reduce the requirement for petroleum by personal and commercial vehicles. One person simply commented that the project addresses the bus capacitor issue with appropriate goals. Another evaluator agreed that the project is relevant because the industry is looking for a low-cost, volumetrically efficient, high-temperature reliable DC Link capacitor. Another person had similar comments noting that a low-cost, high-temperature film would be a very important breakthrough of the DC Link capacitor manufacturers.

One person agreed that the project is relevant because widespread adoption of HEVs and EVs will reduce the use of petroleum in the United States, and high-temperature DC link capacitors will facilitate the reduction of the HEV and EV cost. The final reviewer cautioned that reducing inverter weight and cost is a small step toward reducing EV costs, which moves closer to widespread consumer acceptance and use. The reviewer continued that this small step seems even smaller when one considers that EVs must slash their current cost by about half to foster enough consumer interest to affect petroleum consumption. Additionally, consumer interest also hinges on the cost of a recharge infrastructure to support EV ownership and practical operating convenience.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer observed that the approach is focused on the development of a high-temperature extrudable film for a DC Link Capacitor and obstacles, such as the hydrogenation, were overcome as they presented themselves. Another person simply stated that the project uses a good approach. A third expert observed that the team has been working on the optimization of the polymer composition to address issues related to future large-scale film production. The design of the polymer chemistry is consistent with theory and the results are consistent. One expert pointed out that as found in many of previous development efforts, it is very challenging to balance the dielectric constant, dielectric loss, and thermal stability in polymeric materials; high dielectric constant will almost always lead to high dielectric loss. Adding nanoparticles to polymers may not work as found in many other projects.



The reviewer described that high loading nanoparticles (greater than 30%) is necessary to achieve enhancement in K, but it will reduce dielectric breakdown strength by over 50%. Nanoparticles will also increase the cost of the film. From the standpoint of final device cost and performance, a low-cost high-temperature polymer and a low-cost film production process may be the final solution. A fourth project evaluator remarked that the project approach is novel in it uses inexpensive monomers/fillers to develop a high-temperature polymer dielectrics capable of forming very thin films, and controlling polymer composition and molecular weight. This reviewer added that the project demonstrates intense and aligned work with industry to remove technical barriers. Another expert cautioned that it appears that the benefits of this work will hinge upon a new nano-particle filler material that is yet to be defined. The reviewer added that the work appears well-suited to uncover a polymer that can improve the temperature capability, as needed, but it is not yet clear that the work will lead to a capacitor that can reduce size and cost, as also needed. Regardless, this person felt that there is important learning taking place here for the U.S. capacitor knowledge base altogether, to move beyond the limitations of the conventional BOPP film capacitors. Another commenter also agreed that the approach is reasonable and methodical and limited to the characterizations of the test film using small laboratory-grade capacitors in foil-film packages. This person thought that the approach is a great start, but criticized that it does not address the three issues that must be answered for a new film capacitor to be commercially viable: whether it can be metalized; whether clear defects exist; and whether it will accept an end-spray electrode. The reviewer did not see any small-scale test to indicate a yes to all three; without it, the film is not ready for commercial investment. The final evaluator acknowledged that the work performed to date is very good and relevant, but no plans were mentioned relative to packaging. This person asserted that to achieve the 150 °C operating temperature the package will have a big impact. The reviewer also suggested that working with industry suppliers for the film and construction method is very appropriate at this point and that the researchers might also want to investigate methods of removing heat from the inner layers without impacting performance.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had positive input about progress. One reviewer affirmed that showing a pathway to extremely low-cost and high film quantity is the next big step. This commenter pointed out that the following achievements are great: 1) producing a high-temperature thermoplastic by ROMP, 2) defeating polymer cross-linking by hydrogenation, 3) increasing dielectric energy density by nanoparticles, and 4) producing a method to control nanoparticle distributions. A second evaluator noted that good progress has been made in a lab environment and thinks that it will be interesting to see what ECI can do with this material in a manufacturing environment. Another expert remarked that the research team has been able to build small test wound and stacked capacitors, but that they need to expand to full DC Link size. The evaluator added that the researchers have an approach to deal with the dispersion of the nanoparticles. The fourth evaluator remarked that the project demonstrates excellent progress and results towards objectives and has appropriately transitioned the development of high-temperature polymer films from a laboratory to a pilot scale operation. This reviewer recommended continuing work, problem solving, and emphasis with developing a polymer casting or extrusion process and efforts to reduce capacitor size with inexpensive nanofillers. One expert observed that good learnings have been made to date, particularly with respect to improving the temperature capability; however, it might be time to step back and compare the alternative materials for films, to address volume and cost, in addition to the needed higher temperature capability (as a surrogate for reliability/durability). Another project evaluator remarked that significant progress has been made and the new Commercially Available (CA) material looks promising and it appears that the team is following their development plan and making good progress. The final commenter offered that great efforts have been contributed to the pilot scale production of capacitor film using both solvent cast and melt extrusion. It is very impressive to learn that 3 µm thick film has been produced using extruder from Dr. Collin. The team has also tried to produce prototype capacitors using film/foil design and stacking design in the lab.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were generally positive. One person acknowledged that the team has close collaboration with Penn State University, ANL, and ECI. The reviewer felt that Penn State provides very unique expertise on dielectric test and ECI is very valuable on capacitor film production and capacitor winding. The reviewer also remarked that the work with Dr. Collin is also very impressive, but added that to achieve the cost objective, the capacitor film MUST be produced using melt extrusion, not solvent casting. The reviewer concluded by suggesting that the team may need an expert in polymer dielectric materials. Another reviewer

reiterated that the group is working with ANL, ECI, and Penn State University, while another person acknowledged the researchers have a good set of suppliers and partners. Another reviewer stated that the project has appropriate collaboration with laboratories and institutions. This reviewer felt that overall the project demonstrates a sense of urgency, intense coordination, and focused problem solving with industry to manufacture and commercialize polymer thin-film capacitors. Another expert observed that the researchers are working well with other National Labs, universities and industry, to leverage the full knowledge base available. The final person commented that the results show the impact of working with the commercial partners and that feedback of what the partners see as roadblocks and strengths of the approach would be beneficial assuming that it is not proprietary.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person simply stated that the researchers had presented a good plan to move forward. Another person stated that the path forward was clearly stated dealing with nanoparticles and dispersion, extruding, investigation of alternate commercially available material, etc.

A third project evaluator pointed out that the future work builds on past progress and effectively plans for alternate development and pathways, by considering the transition of polymer film technology to industry (fabrication of capacitors with film produced from hydrogenated polymer) and utilizing larger scale experiments with nanoparticle loaded materials. One person detailed that they saw a dual approach to further work where the custom SNL high-temperature film is developed alongside the CA high-temperature film already in use as a packaging material; both must satisfy the temperature and energy-density goals of the R&D contract and both must be capable as commercial capacitor films. The reviewer continued stating that in the world of plastic material processing, the capacitor market is very small and the cost of film materials cannot be supported on EV needs alone. The reviewer noted that the big difference between the two film candidates are that CA is already supported by an adjacent industry and the SNL custom film is not. The reviewer concluded statements by asking whether SNL film has another huge, terrific use beyond capacitors that will drive down the final cost. One expert remarked that the plan is logical but needs a decision point as to when a selection will be made as to the best approach, not sure that all of the approaches need to be continued once the capacitors have been built and tested. Another person felt that the future plans could become, or be made, clearer when more info is made available, or developed, on the nanofill material, as well as reviewing the multiple advantages being pursued (cost, size for weight/volume, temperature capability for reliability/durability), compared to conventional baseline biaxially oriented polypropylene (BOPP) capacitors. The final person noted that the project will be completed by end of fiscal year (FY) 2012 and future work may use existing commercial high-temperature polymers such as polyetherimide, polycarbonate, or others considering the cost target for the film capacitors.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, with six reviewers stating it is sufficient and one stating it is insufficient. One reviewer explained that the resources are sufficient since the researchers are getting an extruder. Another person commented that the project appears to have adequate resources to achieve milestones and complete work by September 2012. Another commenter expressed that the project team does have the resources to complete the project in a timely manner. The researchers have also been actively looking for new resources such as Dr. Collin during the project. The final person commented that it is somewhat unclear whether the resources are sufficient or not, because it is unclear if the CA polymer material being worked is potentially advantaging or not, compared to others. It might be or it might not be, but that it is just not clear at this point. The reviewer clarified that apparently this is not clear, due to the need to address IP protection, so ultimately the better answer was that they cannot determine this.

Glass Ceramic Dielectrics for DC Bus Capacitors: Michael Lanagan (Pennsylvania State University) – ape010

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer simply commented that they just like the idea of flexible glass as a potential dielectric material for capacitors. Another person described that the project is an investigation into utilizing ultra-thin, low sodium glass from the liquid crystal display (LCD) panel industry for the construction of DC Link Capacitors to address higher temperature operation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

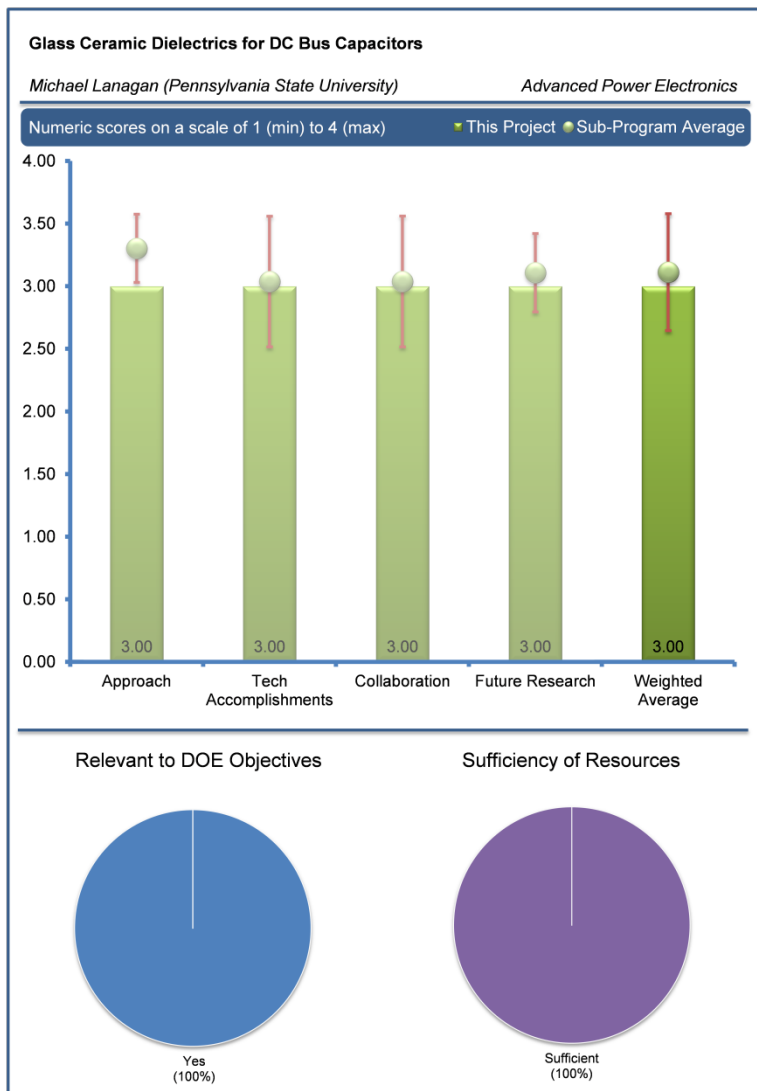
One reviewer commented that the researchers proved the concept by constructing a small simple capacitor. The reviewer cautioned that significant development will be needed to migrate this into a platform usable in a HEV inverter. Another expert expressed that they would like to see thinner material (5 μm or less) quicker. This reviewer would like to see more focus on cost, adding that for any of this stuff to be commercially viable it has to be a lower cost solution to current offerings. The reviewer added that the technology roadmap for any capacitor manufacturer is to build capacitors that offer more capacitance in a smaller package at a lower cost.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person simply stated that good progress has been made to date. The only other person to comment noted that the researchers have demonstrated winding the thin glass coated with silver into a functional small capacitor and taking performance data. The evaluator described that the December 2012 goal is to wind another capacitor and test at greater than 1 kV and 140°C. This reviewer concluded their comments by stating that work also needs to be done related to self-healing by possible application of a polymer layer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One evaluator acknowledged that the collaborators include a good mix of government laboratories, academia, and suppliers, but the reviewer would like to see some end-user exposure. The only other person to comment added details that the collaborators included ANL, SNL, ORNL CA, SPS, and NEG.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter described that the future research includes construction of a glass capacitor from thinner glass and characterizing it at voltages above 1 kV and 140 °C, which will move the technology closer to the goals of the HEV inverter industry needs. The final person to comment stated that the researchers have to get the material thinner and at a commercially viable cost.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers to comment stated that the funding was sufficient. One reviewer, however, remarked that budget was not discussed. The only other reviewer comment agreed that the project has the right mix of resources, but that the plan could use some exposure to end-user (i.e., OEMs).

Beyond Rare Earth Magnets: Iver Anderson (Ames) – ape015

Reviewer Sample Size

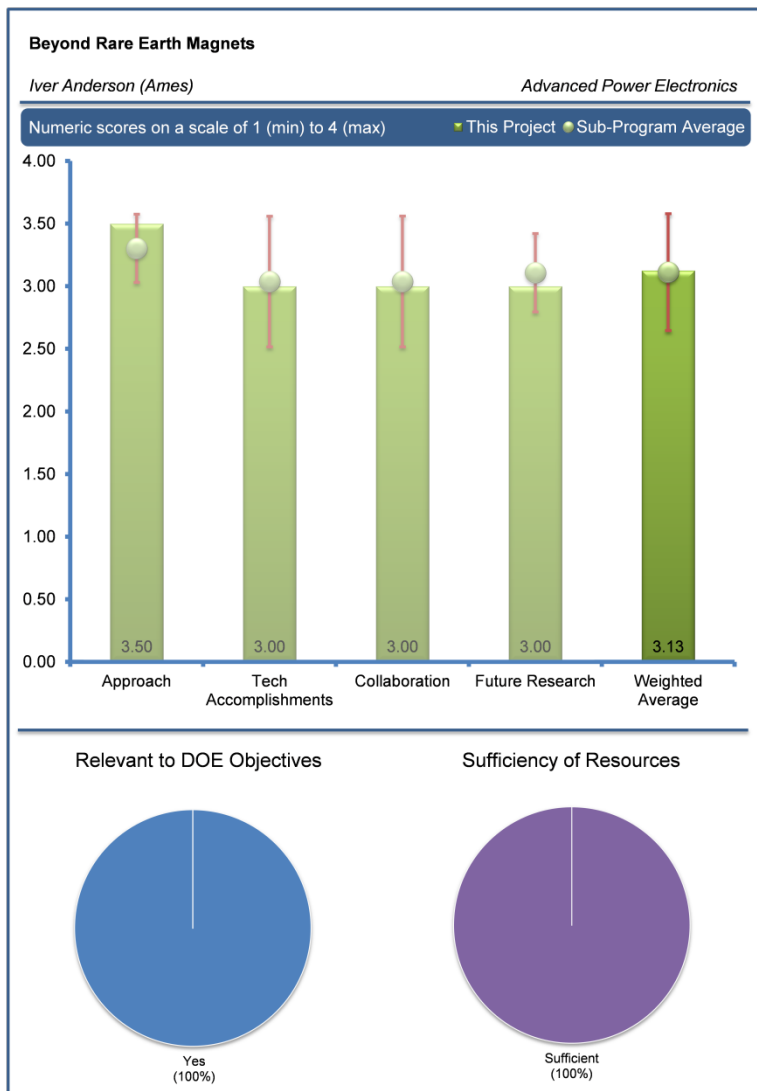
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers had positive comments to this question. One person stated that the project supports the objective of petroleum displacement by developing non rare-earth (RE) magnet materials; if successful these new materials would reduce the cost of permanent magnet (PM) machines, which would enable a faster market introduction of HEVs and EVs. Another person pointed out that the project is aimed at reducing cost and improve thermal management of electrical propulsion systems. One expert affirmed that elimination of RE elements from magnets would provide the high efficiency of interior permanent magnet (IPM) motors at lower cost and in sustainable supply; these all facilitate market adoption of HEVs and EVs. The last evaluator commented that the PM is an important component for electrical machines. The reviewer added that recent rare earth supply chain crisis made it more important for the clean technologies, so development of permanent magnets with less or no rare earth element is critical.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All reviewer comments to this question were positive. One expert stated that the approach is a good circular approach between modeling, synthesis and characterization. Another evaluator felt that that approach uses a very good combination of known principles and empirical data to guide direction of investigation. The reviewer also thought that the approach is a great use of multiple approaches and teams to improve chances for success. One person commented that the direct texturing strategy showed reasonable feasibility, but with limited potential. The reviewer acknowledged that development of rare earth free magnets is still at its early stage. The final reviewer had detailed comments, stating that the main goal of the project is the development of new permanent magnet materials with reduced cost and improved performance. A multitude of sub-projects have been defined to achieve these goals. The first general approach is the reduction or elimination of the most expensive component in rare-earth magnets (Dysprosium), both in bonded and sintered magnets. The second general approach is the “Beyond Rare Earth Magnet” initiative in which existing materials are improved (e.g., AlNiCo) and completely new material compositions are synthesized. The commenter concluded by pointing out that the overall approach is very well-designed and it could be extended, or changed, if necessary, depending on the intermediate results of the sub-projects.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were all positive. One person simply commented that the results are promising so far, while another person stated that the milestones are met. One person commented that the Technical Accomplishments are good so far and the research team is within the project schedule. They added that significant progress has been made to overcome barriers, which is a difficult achievement due to the fundamental research nature of this project; in other words, the technical progress of the sub-projects is somewhat unpredictable and several of the sub-projects might not result in a viable solution in the end. A significant achievement in the improvement of rare-earth magnets is the reduction of Dysprosium by diffusion in the grain boundaries. The commenter added that one important next step in this sub-project should be the prediction of the specific cost reduction for this magnet material due to this change in material composition; this cost prediction has to include the changes in manufacturing process. Continued this reviewer, one of the most promising achievements in the Beyond Rare Earth Magnet initiative is the potential improvement in AlNiCo magnets. It was mentioned that a 3-times increase in coercivity might be achievable. The collaboration with an electric machine supplier, which is developing a new AlNiCo PM machine concept, is an excellent set-up that will guide the work on both sides in the right direction.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were positive. One person simply stated that there was a good collaboration network. Another reviewer commented that there was a good combination of industry, university, and national lab partners. The last expert to comment said that a number of research organizations and universities are collaborating on this project with Ames Laboratory as a lead. The assignment of the separate tasks seems to be based on the specific expertise of the research organizations and is thus well coordinated. Recently, collaborations with electric machine suppliers have been defined with specific focus on the permanent magnet material improvement needed for the different electric machine design concepts.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Only one person commented to this question, stating that the project has well-defined milestones for FY 2012 and a clear plan for FY 2013. The future research plans are based on the past progress and the barriers are identified as good as possible. The identification of barriers is difficult at times due to the fundamental research nature of the project which makes predictions of future progress difficult or even impossible.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers to comment to this question stated the funding was sufficient. One person stated that the project has sufficient resources for the defined tasks. The other person to comment described that the allocation of the resources to the sub-projects seems to be good.

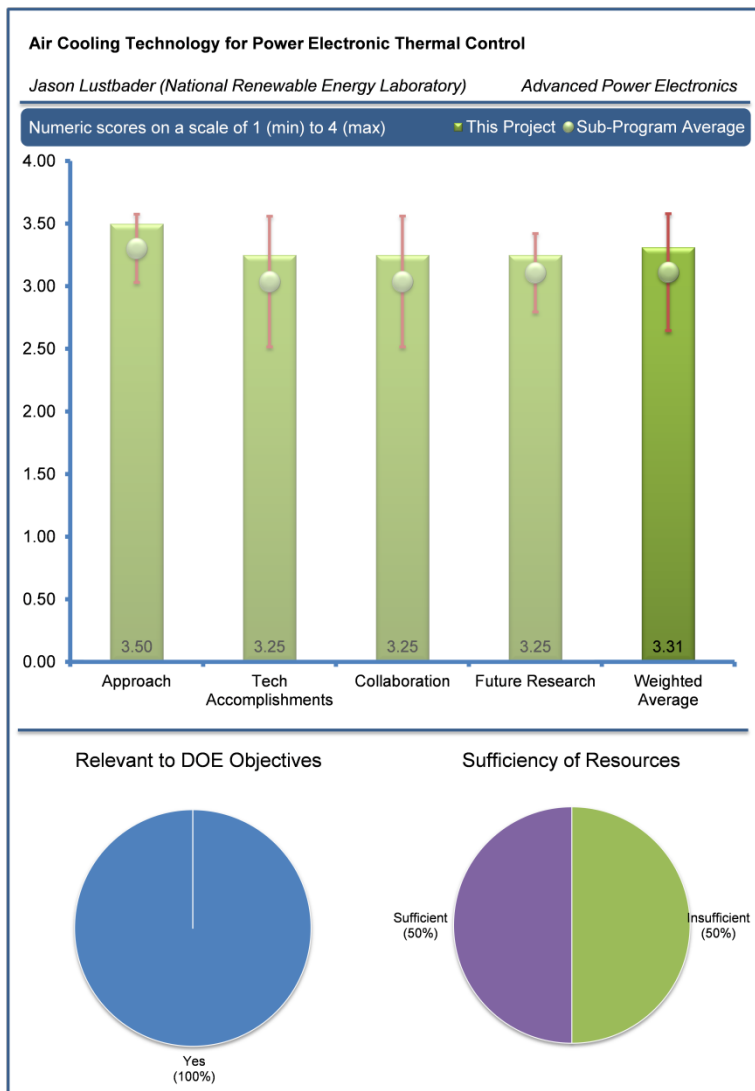
Air Cooling Technology for Power Electronic Thermal Control: Jason Lustbader (National Renewable Energy Laboratory) – ape019

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked that the presenter’s introduction before the Overview slide really hit this point home and offered thanks for such a great overview on the impact to not only the DOE objectives but also for the industry. Another person agreed that air-cooled inverters for automotive traction drives are very relevant to the goals of VTP. This project examines feasibility, which is consistent with the current S&T need. The final reviewer commented that efficient, optimized thermal management systems will be key to the broad implementation of hybrid vehicle technologies. Two primary considerations will drive this fact. First, cost as a fundamental driver of the ultimate market penetration is impacted dramatically by undesirable dedicated cooling loops presently used for power electronics cooling. Secondly, the optimization of thermal subsystem interactions and performance will enable reduced operating temperatures and enhanced performance/reliability. The reviewer added that factors will ultimately dictate the pervasiveness of these technologies in the market and that greater penetration equals reduced petroleum consumption. The reviewer concluded by stating that this is a well-designed project with detailed focus on key areas requiring development.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer asserted that the project is well-designed around scope. The reviewer added that the dynamic environment will be the next barrier to technology. Another evaluator said the project is a well-balanced steady heat transfer project and experiment design. The reviewer’s score would have been a 4.0 with the inclusion of some second law analysis to provide fidelity to the dynamic heat load conditions and thus management. Another commenter felt that the use of diagrams and images to describe the approach was great and it really helped tie everything together. The last reviewer to comment provided very detailed comments, stating that this is the second half of a well-conceived air-cooled inverter program. Frankly, delaying Madhu's project a year to allow professional thermal people to contribute was a wise decision. The reviewer found the engineering on this project to be outstanding and compelling; it is far better than past attempts to do the thermal part of the air-cooling. One issue that was raised in the Q&A period should be addressed in the future, and that is the consideration of all first order operating conditions on the thermal design of the system (meaning the power semiconductors, NOT just the conventional thermal management system). In other words, continues this reviewer, the thermal system begins with the semiconductor junctions and so steady-state analysis, no matter how good the engineering (which was quite good in this case), may not meet a real-world traction drive requirement. Al Hefner's presentation gave an excellent example of a use case that a real-world air-cooled inverter would have to consider (e.g.,

short-circuit conditions). In this reviewer's opinion, any design reported to meet the DOE VTP metrics for size/weight/cost could be invalidated on the spot if key operating conditions like this are ignored, for example, because the margin needed to meet the additional requirements was already consumed in the steady-state design. The reviewer added that one can argue that such considerations could be left to a later prototype, but this is not an acceptable position to me because the DOE VTP metrics, set by the automotive industry, are intended for real-world systems, not objects of research where key characteristics of a working system are ignored. The reviewer encouraged the project team to resist the natural inclination of a research project to make this kind of compromise. After the session the reviewer got the impression that this excellent group of researchers has no intention of knowingly falling into this trap.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were nearly all positive. One person commented that the researchers have shown very good progress shown over 2011 review. Another evaluator noted that a good approach to determine feasibility and step through fundamental achievements was used. One person offered that the researchers' accomplishments thus far are great, but the reviewer felt that it seems that the researchers are much farther along than what the project time would have allowed. The reviewer concluded by stating that this was one of the best project presentations they saw this year, and commented, nice work. The final person to comment said that with the exception of the transient conditions addressed in previous questions, which the researchers showed an eager interest in learning more about after the issue was brought to their attention by the excellent work of Al Hefner, one reviewer thought that the researchers have done an outstanding job with the thermal engineering side of this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person lauded that this is one of the few projects where intelligent decisions about dividing work between National Labs have been made. The reviewer felt that the decision to delay the ORNL work in FY 2011 to allow a well-qualified thermal engineering team from National Renewable Energy Laboratory (NREL) to contribute has been reflected in the outcomes: engineering that is more than the sum of the collaborators. Another expert wanted to see interaction between Dr. Hefner's device dynamic temperature response project and this cooling activity. This reviewer also felt that greater inclusion of dynamic heat loads will make the project much stronger. The final commenter remarked that they would have been interested in hearing a little more about the work with other partners (besides ORNL). The reviewer concluded their comments by asking what the researchers are doing with the OEMs, suppliers, etc.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were all positive, with one person offering a suggestion for improving the research plan. One person simply noted that the project's 2012-2013 task plan is very well organized and appropriate for the project objectives. Another reviewer agreed that future plans are outstanding (rather than just good) after the totality of a full-scale air-cooled inverter requirement is addressed in the specification of the working prototype. This reviewer was confident that the electrical and thermal teams working together can incorporate a real-world requirement into their objectives. Another evaluator highlighted the great description of the approach of the future work and breaking them down by year. The reviewer added that again, the diagrams and detailed descriptions in the verbal presentation were wonderful; one of the best this reviewer saw this year. The final person to comment suggested that dynamic system environment should be considered as early in the work as possible.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed with two reviewers stating funding was insufficient while two reviewers stated it was sufficient. The only person to provide detailed comments mentioned that it seems like a great match of resources with project approach and milestones. Nice work!

Power Device Packaging: Zhenxian Liang (Oak Ridge National Laboratory) – ape023

Reviewer Sample Size

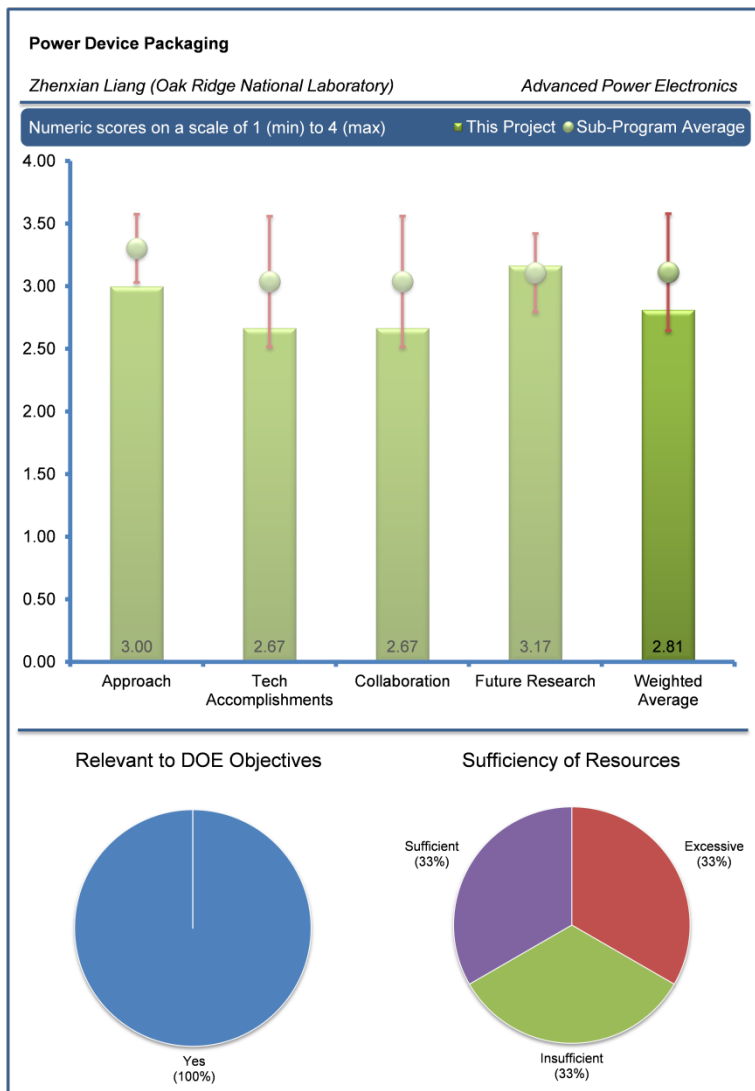
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive, with one person providing suggestions. One expert commented that the power module is the primary cost and performance driver in the EV inverter. The reviewer explained that this work has two purposes: 1) to reverse-engineer and benchmark existing state-of-the-art in power modules, and 2) use that knowledge and innovation to develop higher performance, lower cost power modules. This person pointed out that electric vehicles are necessary to reduce the U.S. consumption of gasoline. One commenter stated that the project is directly related to the highest cost component in the inverter; increasing the ability of the power switch to handle more current and dissipate heat better will allow smaller, higher power density and more reliable power electronics to the vehicle which will enable a more attractive product and will thus enable more sales. Another project evaluator had detailed comments, describing that power packaging is a critical aspect of hybrid and electric vehicle technology due to the primary dependence of vehicle reliability on electronics functionality. Thermal cycling, thermal exposure and voltage stresses will dictate useful life and thus cost of ownership viability. As such this effort is key to determining competing technology efficacy to provide the highly efficient and reliable parts for traction drive inverters and converters for drive train application. Integration of WBG devices and the resulting characterization has to be accomplished to determine if the material system performance entitlement can be leveraged to achieve the efficiencies required to measurably displace petroleum use. The final reviewer affirmed that electronics packaging is an essential technology for automotive electric traction drives; it drives performance, size, weight, reliability, and cost. One evaluator agreed, stating that the project supports APEEM Vehicle Electrification Technical Targets to reduce cost, weight, and volume in power electronics within the packaging device, including packaging innovations for higher temperature operation. This reviewer suggested a simple glide path matrix demonstrating targets from current to 2020 calendar year. The reviewer added that the 40% cost reduction and 60% power density targets reported were not transparent to the reviewer, so asked to what baseline and metric were they being compared.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed, with all but one having positive comments. One reviewer stated that benchmarking state-of-the-art modules is a good approach to assess what technologies are promising. This reviewer observed that the funding level only permits one or two independent new developments. This reviewer mentioned that the existing new module development is good since it addresses three key issues: reducing parasitic inductance, reducing thermal resistance and potentially reducing cost. This



reviewer added that the collaboration with other ORNL projects is also a plus. Another evaluator asserted that the researchers' approach is correct in addressing the items listed. The reviewer stated that they would also include the needs of the inverter packaging since that will also impact the design of the package. The reviewer concluded by pointing out that the focus is clearly on the package and determining the weaknesses and how to improve them but eventually these packages have to be used in power electronics. One expert agreed that the approach of benchmarking existing power device packaging was appropriate for baseline data and analysis; however, the reviewer questioned why domestic device packaging was not assessed and evaluated in the comparison. The reviewer concluded by stating that thermal, electrical, and structural analysis of state-of-the-art benchmark modules represented strong testing and results. Another reviewer commented that the characterization tasks focused on existing Toyota Prius, Nissan Leaf, etc. modules was well-executed and focused on relevant aspects of packaging performance and construction. The novel module design aspect of the subject project was less compelling. First, the advanced integrated cooler should have been more detailed in terms of what were the typical pressure drops, flow rates, convective heat transfer coefficient, and water channel dimensions. Electronics cooling in an integrated package necessitates a detailed design with consideration of the device loss characteristics (including dynamic effects) to specify the cooling system boundary conditions. Thermal cycling reliability testing must be completed on the planar laminated package to determine suitability for the intended application. The final person explained that they could not understand what the Technical Objectives or approach are for this project. The long introduction seemed to suggest something about improving packaging.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer asserted that the development of the Planar_Bond_All (PBA) power module packaging technology was brilliant and innovative. This person felt that the analysis and results of PBA electrical and thermal properties are significant to support further testing, application, and commercialization. The reviewer concluded by mentioning that the progress and milestones appear to be on schedule and suggest on-time project completion. Another reviewer also noted that the accomplishments and progress to date are very promising. The PBA package addresses the weaknesses identified and the results are an improvement over the existing designs. It was not clear to the reviewer how this package will be used in a mainstream inverter. They asked whether the cost impact of a dual-sided cooled package versus a single-sided package has been investigated. The reviewer also asked if the costs to support dual-sided cooling using this package versus additional switch area in a single sided cooled version of this package are known. One person commented that the researchers had done a good comparison and characterization of the import vehicle module packaging. The reviewer added that the custom module design needs additional information and characterization data hopefully included next year. Another person, however, observed that the reported results were mostly a survey of OEM traction drive packaging, followed by a chart showing the various custom packaged parts done for other projects (which were not commercially relevant). The reviewer added that the discussion of the planar bond power module was mostly pictures and then some results without meaningful benchmark against the state-of-the-art. The reviewer's confusion about the results was a natural consequence of confusion about the objectives and technical approach. Another person explained that the PBA package exhibited significant reduction in parasitic inductance and thermal resistance, which is a good proof of feasibility, but needs more work before it is mass-production ready. The reviewer added that their concerns about this package are assembly yield due to blind locating of components, temperature cycling capability, and dielectric isolation (internal and external) due to close proximity of layers.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person commented that collaboration with NREL, other ORNL and university groups is adequate. Another person agreed, stating that cooperation among the team is clearly very good and that the results are impressive. Other reviewers had more critical comments. One person pointed out that the project seems to be mostly an internal effort of one National Lab. The reviewer felt that it is not clear if it is at the state-of-the-art with the community of electronic packaging, let alone automotive packaging. The reviewer remarked that the cited partners seem selected more for convenience than for excellence in packaging technology. Another expert commented that there are many groups performing excellent packaging development and research on rugged packaging for power applications. The reviewer did not feel that these resources were being leveraged to the degree possible. The final reviewer recommended coordination with industry to strengthen

manufacturing engineering, design, and process with the PBA application. The reviewer cited the Principal Investigator (PI) for identifying reliable bond of multiple large-area planar layers, dies, and substrates as a manufacturing problem and critical issue.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mostly positive. One person simply stated that the proposed benchmarking should continue. This reviewer added that the proposed high-temperature and reliability testing of PBA package is necessary for proper evaluation of the technology. One reviewer remarked that hopefully this critical technology research focus will evolve into the areas of deficiency described above. The reviewer felt that the project has a potential for outstanding contribution. A third commenter asserted that the future work is logical, defined and proceeds with ongoing development and reliability improvements with the PBA technology, while recognizing the need to continue benchmarking state-of-the-art (SOA) technologies within module performance, materials, and processing. The reviewer suggested stronger focus and emphasis with industry and commercialization of PBA power module packaging technologies – manufacturing cannot be negotiated, the PBA module must be designed for manufacturing and assembly at low-cost, and superior quality, reliability, and durability. Another reviewer felt that the future work is the next logical step in the development of the package and would benefit from additional input from inverter developers. The performance of the package in terms of inductance is very good, but the reviewer asked if any work has been done in terms of how the fast switching performance of WBG devices will behave in this package. They concluded by asking what the limitations of the package are in terms of current and voltage spacing. The final reviewer to comment simply hoped that maybe it will get better.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were equally mixed, with two people each responding that resources were insufficient, sufficient, and excessive. One expert warned that future funding may be insufficient considering the broad scope of the program. One person commented that resources appear sufficient and well within the requirements of meeting stated milestones on time. Another person remarked that the appropriate resources are apparent at all of the collaborators. The final person suggested that the government's objectives might be better served by competitively awarding this to somebody else.

Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters: Allen Hefner (National Institute of Standards and Technology) – ape026

Reviewer Sample Size

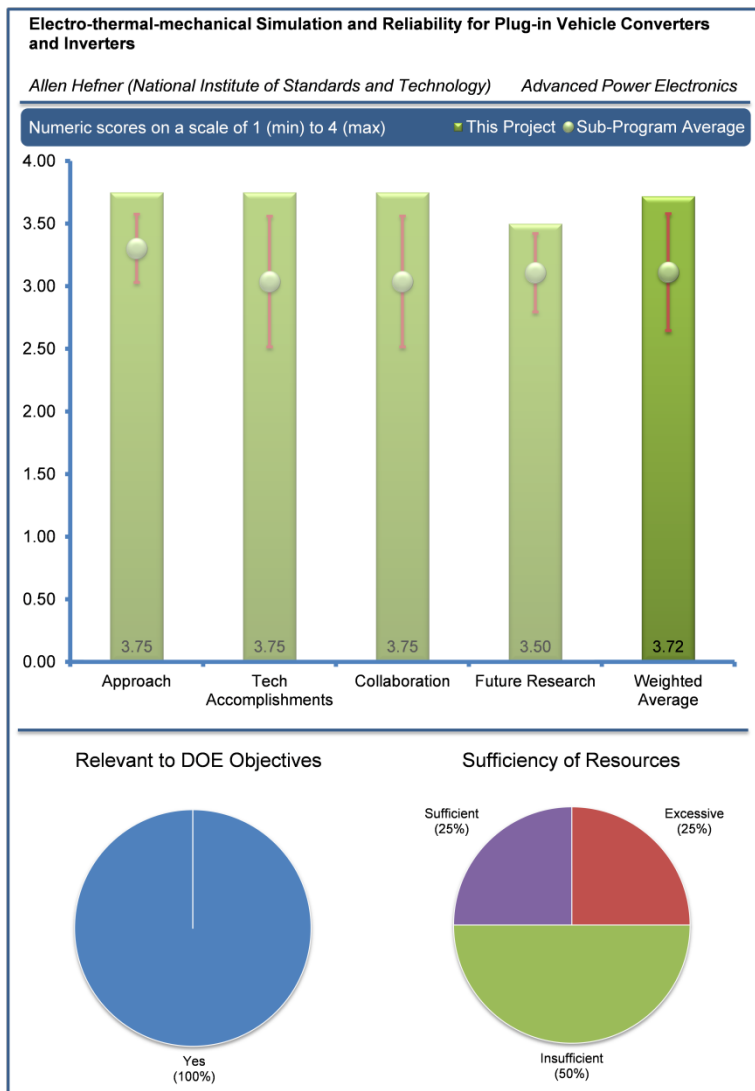
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person described that this work develops computer models for the power modules in an EV inverter, aiding the designer in developing higher performance, higher reliability modules and inverters. The reviewer continued stating that the coupling of the device performance and reliability models have not been done before and will provide designers with the ability to characterize and improve reliability. Another person affirmed that this modeling is very important to improve the efficiencies of modules in electric vehicles and will aide in decreasing the time to market and thus meeting the objectives. The reviewer applauded that this is a great project and truly beneficial to the whole industry. One expert pointed out that an integrated tool considering electrical, thermal, and reliability mechanisms in a coupled self-consistent way would be very valuable to the larger power module industry, not just automotive. The last person to comment had detailed comments, describing that better physics-based models and modeling activities will enable the optimal leveraging of power device performance capabilities based on material property entitlements. The subject effort is an outstanding example of an application of device subject matter experts being brought to bear on a crucial aspect of electric power, namely dynamic adiabatic heating events in devices and the resultant predicted impacts to reliability. Reliable, high efficiency electrical drive components will be a requirement prior to widespread adoption of the PHEV vehicle paradigm.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were all positive. One person agreed that the approach is good and that this work builds on prior work done at National Institutes of Technology (NIST) and accesses the reliability work done at CALCE (UMD). The reviewer added that the approach combines model development followed by validation by simulating modules developed/tested under other DOE Advanced Power Electronics (APE) Programs. Another person expanded that the technical approach builds upon decades of experience and is thoroughly thought through, as is typical of an AI Hefner project. One expert explained that the technical approach of the modeling was explained very thoroughly and easy to understand the value of the approach and outcomes. The reviewer affirmed that the researchers have developed a very good approach, but added that they did not get an understanding of the approach beyond what was already accomplished though. The final person explained that fundamental physics-based modeling activity is being applied in highly relevant electro-thermo-mechanical prediction capability establishment activity which is



ultimately focused on reliability prediction of electric power components. As such, the effort is focused on the physics driving adiabatic dynamic events and their implications as well as the prediction of steady-state junction temperatures. The extension of the E-T-M models to include reliability prediction models, can dramatically impact PHEV design activities and result in more reliable packaging and operating space definitions leading to enhanced vehicle performance, reliability, and customer acceptance.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were generally positive. An expert remarked that the slides and verbal explanation were very thorough; adding that the progress for such a short usable time (after the NIST issues) was wonderful. The reviewer concluded by mentioning that it seems that the researchers are much farther along than what was told in the original overview slide. Another project evaluator observed that excellent progress was demonstrated during the first year of the effort. This person would have liked to have seen more of the progress related to the reliability prediction modeling effort. Another commenter stated that the technical progress on both the Viper and the Virginia Tech modules seem significant. The reviewer, however, felt that it was a bit hard to understand what the metrics for progress are from the presentation. One person commented that the progress has been good against the current milestones. The agreement between simulations and experimental results shown was quite good. The reviewer concluded by criticizing that there was little discussion about the reliability modeling; they were not sure if this was due to lack of results or lack of presentation time.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were positive. One person applauded that the collaboration between NIST, CALCE and NREL constitutes the country's leading experts in their respective areas of research. The reviewer added that the modeling/testing of industry-supplied modules developed under other DOE APE programs is a good move. Another person highlighted that close collaboration, even with collaborators in the room, was shown. The reviewer also noted that AI is extremely well networked in a way that promotes the quality of his work. One expert observed that this is a great use of private, public, and educational collaboration. The reviewer noted that the researchers have a wide range of contributors, adding that it would be interesting to see how these areas all managed through the program and what issues you might have realized. The final reviewer suggested that it would be interesting to see what a second law analysis would predict for the adiabatic heating events.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the FY 2012 and early FY 2013 goals/work were very detailed and good; however, the future work listed in Slide 22 is very broad and probably too broad for the existing funding levels. The reviewer suggested that the future work needs to be re-examined later this year/early next year in light of the progress made and the focus needs to be refined at that time. Another person encouraged the researchers' commitment to extend device models to the junction gate field-effect transistors (JFET). The final person to comment stated that the talk focused a lot of attention on what has been accomplished and the approach; unfortunately, this came at the cost of a little less effort on the future work. The reviewer offered that since the researchers have significant time left in the program, that the reviewer would have been interested in hearing a little more of what you are going to do throughout 2012 and 2013.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, with two people stating they were insufficient, one person stating they were sufficient, and one person feeling the resources were excessive. The first expert pointed out that the resources seem to be insufficient, particularly if a significant level of reliability testing needs to be performed to validate the reliability model. Another reviewer simply stated that the resources look well-funded, but certainly not excessive. One person stated that it seems like a great match of progress and resources thus far. The reviewer concluded by applauding the great work.

Development of SiC Large Tapered Crystal Growth: Philip Neudeck (National Aeronautics and Space Administration) – ape027

Reviewer Sample Size

This project was reviewed by six reviewers.

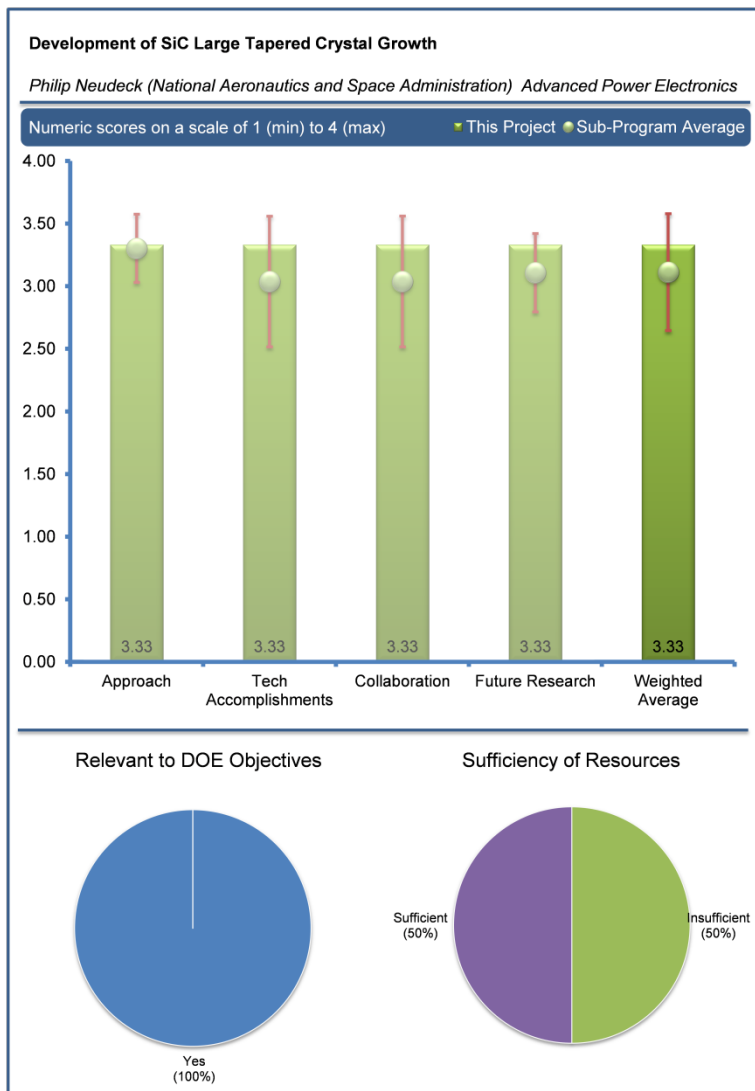
Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that scaled production of efficient power electronics is vital to electrification technologies. Another expert noted that one of the methods of increasing the efficiency of today's electric vehicles is to use the more efficient WBG switches. This requires that these devices be economically viable also and this project is addressing a method to reduce the cost of SiC switches. One commentator described that this project supports research and development objectives to improve power electronics performance, in addition to weight, volume, and cost reductions. The reviewer stressed that it is important to recognize the complexity of the project and tasks and that the benefits of SiC power semiconductor devices extend beyond electric vehicle applications and have potential to significantly advance industry-wide technology to a next generation. Another evaluator remarked that silicon carbide power semiconductors are recognized innovations leading to achieving DOE VTP APE objectives and that this project is a high risk, high reward exploratory development project targeting, ultimately, improved SiC economics. One reviewer affirmed that advanced semiconductor devices are one of the keys for future reduction of size and volume of power electronics system. The reviewer added that this will further help push electric and hybrid vehicles into the market place and that the work on SiC material is important in terms how to produce material for advanced wide band gap semiconductor devices; hence it is relevant to the DOE overall objectives of petroleum displacement. The final person had detailed comments, describing that one of the primary impediments to widespread SiC power technology adoption has been the cost of utilization in products and systems. Certainly, limited production volumes that presently characterize the manufacturing supply base contributes, however, fabrication yield limiting factors are significant. Understanding that the subject project is fundamental science and as such high risk, it has the potential to dramatically impact SiC material defect densities and thus directly enhance device yields. Widespread adoption of SiC power technology will significantly enhance and improve component efficiencies which directly reduces fuel consumption. Thus, the subject project has the potential to contribute to petroleum use reduction.

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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed, but were generally positive. One person simply stated that the researchers have presented a clear scope of barriers to be addressed through experiments. Another person expressed that the technical approach is innovative and the team uniquely qualified for the work. The reviewer added that extreme risk is an appropriate description for the technical



approach. One expert said that the project approach is unique in that it developed a new alternative SiC growth process from the present vapor transport. The NASA Large Tapered Crystal (LTC) growth patent opens a new technology glide path and learning cycle to produce large diameter SiC wafers, with improved dislocation at lower cost. The reviewer offered accolades to the PI and team for demonstrating resilience and tenacity to overcome technical barriers, cost, and schedule challenges, and misfortunes (i.e., the RF generator). Another evaluator described that the project uses lateral and vertical growth simultaneously and continuously (creates tapered shape) instead of the traditional growth method that leads to limited crystal thickness. If successful, the reviewer added, it will radically change the SiC growth process geometry to enable full SiC benefit to power systems. One commenter observed that this project is very focused on one method to grow wafers. The reviewer felt that the approach could prove valuable if it is successful, so need to continue to monitor the alternative approaches to supplying wafers as the field is not standing still. The final reviewer criticized that the fundamental premise is not well established thermodynamically. They added that whether the screw dislocation-growth coupling is a cause or effect is not compelling one way or the other at this point; however, the focus to establish the required components of lateral growth and SiC whisker or fiber formation should enable a determination of the suitability of continuing the development of this process in the future.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed, with several people mentioning progress falling behind the anticipated schedule. One person felt that excellent progress and significant accomplishments were made during the last year. The reviewer described that controlled experiments and quantitative data demonstrated a gain in epitaxial growth rate, film thickness diameter being mostly epitaxial, and smooth tapered hexagonal facets. The progress and results suggests that risks will be mitigated or eliminated, and barriers will be overcome. Another evaluator pointed out that the project is behind schedule, but it seems barriers can be overcome in the short-term and additional progress will be made to accelerate the project. The reviewer added that the team has demonstrated epitaxial radial (lateral) growth of a 5 mm diameter boule starting from a simulated SiC fiber crystal and laser-assisted fiber growth of a SiC fiber crystal greater than 10 cm in length. The reviewer asserted that these demonstrations are key to further demonstration of the project objectives, i.e., LTC. One expert mentioned that progress has been good in spite of setbacks; progress continues to show promise but technical issues remain. Another person commented that it is still very unclear that the results show promise, but the project team is doing everything within their power to overcome scientific and technical obstacles. The final reviewer had detailed comments, asserting that the initial growth results are not compelling. They added that the difficulty is evaluated to be one of preventing the nucleation of new defects during growth from the polytypic nature of SiC in general or the relaxation of thermal stresses during crystal growth. Suppressing these other defect formation mechanisms has to be a primary focus of the effort from this point forward. The preliminary growth on surrogate SiC fibers showing lateral crystal expansion is encouraging. Evidence exists to indicate that cubic crystal formation will be problematic as the project moves forward.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were all positive. One person commented that the project has appropriate collaboration and coordination with institutions and subject matter expertise. The reviewer recommended continued augmentation of funding to permit wider search of parallel paths with industry in order to realize SiC fiber growth and shapes. Another person simply stated that there was a solid team and that Mike Dudley is key to credibility of outcomes. One expert observed that the research team has collaboration with academia institutions and also highlighted that it is also important to work with SiC device companies to validate the technology. The final person noted that the collaboration appears to be very good as the technical issues are being overcome. Additional partners added to support risk mitigation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed, with several people making suggestions for improvement. One person noted that the plans are directed toward solving demonstrated problems, but suggested that it could include financial benchmarking analysis. Another reviewer pointed out that the future work appropriately planned for radial/lateral CVD Epi-Growth, growth of larger mini-boules, and Fiber Growth (smaller, well-ordered seed with hexacone tip). The reviewer stated that the project clearly recognizes that

crystal size, crystal quality, and production rate are central to the NASA LTC technology effort and a Go/No-Go decision milestone. Another project evaluator commented that the focus on the smaller float zone seed interaction area is prudent and appears necessary to success. This reviewer noted that fiber formation will be problematic and the inclusion of a new NASA partner with expertise in this area is excellent. One expert explained that the future work is planned to support solving the technical issues seen to date as well as an alternative risk mitigation plan. The reviewer would like to see the potential cost savings of this process versus today's standard industry progress. Another commenter asserted that the process is very complex and fraught with show-stopping problems in serial process steps. They described that the point-faceted seed crystal is both critical to future success and cool looking. They concluded their comments by stating that this is good for risk-management that NASA can do this step internally, but is also investing in an alternative to the LHFZ process. The final person reported that it is not certain whether the project will be able to make sufficient progress and match the milestones.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, with two people stating the resources were insufficient and three stating they were sufficient. One person simply noted that there was good support from NASA. Another person expressed that the project appears to have adequate resources to achieve stated research milestones and go/no-go decision, in spite of challenging goals, behind schedule, and obstacles (i.e., equipment malfunction). The reviewer added that the project has demonstrated significant quantitative milestones and quality metrics over the last year, and must continue to focus and overcome the technical barriers with producing desired long, single-crystal fibers. The final reviewer suggested that more resources might de-risk, but cost-benefit of a successful outcome remains unclear.

Thermal Performance and Reliability of Bonded Interfaces: Doug DeVoto (National Renewable Energy Laboratory) – ape028

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Both reviewer comments to this question were positive. One person commented that the reliability of bonded interfaces is an essential concern when integrating power semiconductors into automotive traction drives. The other person remarked that the presenter clearly communicated the benefits to the thermal performance of bonded materials with a very nice explanation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

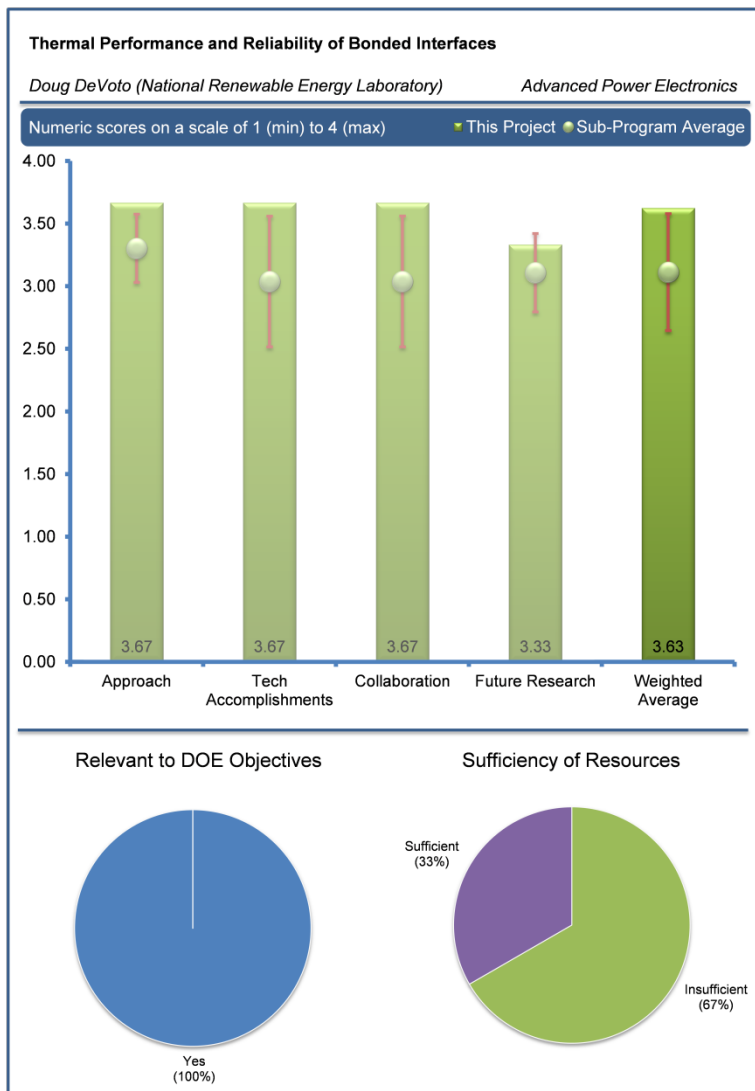
Reactions to this question were all positive. One person appreciated the up-front analysis and use of existing production techniques for samples. Another person noted that the technical approach appears scientifically sound and quantitative in most aspects. The last reviewer to comment felt that the approach seems to be a very straight-forward approach to performing the work. They added that it was very clear and concise, but did not know what performance specifications the researchers were going to be testing in the future work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One evaluator described that the up-front analysis addressed potential failure modes and technical issues to date are understood. Another expert commented that the presenter is highly knowledgeable and the results reflect depth in understanding them. The final reviewer to comment stated that that the presentation gave a very good explanation of the delamination results, but added that they would have been interested to see more Hi-Pot testing results, but that might be more relevant for next year's AMR presentation. Ultimately, the reviewer felt that the presenter gave a very clear and descriptive explanation of the charts and graphs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were positive. One person commended the presenter's collaboration slide was very nice in that it not only stated who you were working with, but also described how/what each partner is contributing to the project, which they found to be very helpful. The other person commented that the collaboration appears adequate or better, especially with industry such as Semikron.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the presentation showed a good list of alternate materials identified. One person pointed out that it was hard for them to say much about the future plans, but the research seems well-conceived. The last reviewer mentioned that the presenter seemed to go a little too fast over the future work. The reviewer was not clear what was different in the next year than was done in the prior year, asking if it was just more cycling or were other materials going to be added to the test.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed. Two people felt the resources were insufficient while one person thought they were sufficient. One person commented that it seems like a very efficiently managed program and the resources used are appropriate. They concluded their comments by praising the nice, clear presentation.

Electric Motor Thermal Management: Kevin Bennion (National Renewable Energy Laboratory) – ape030

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

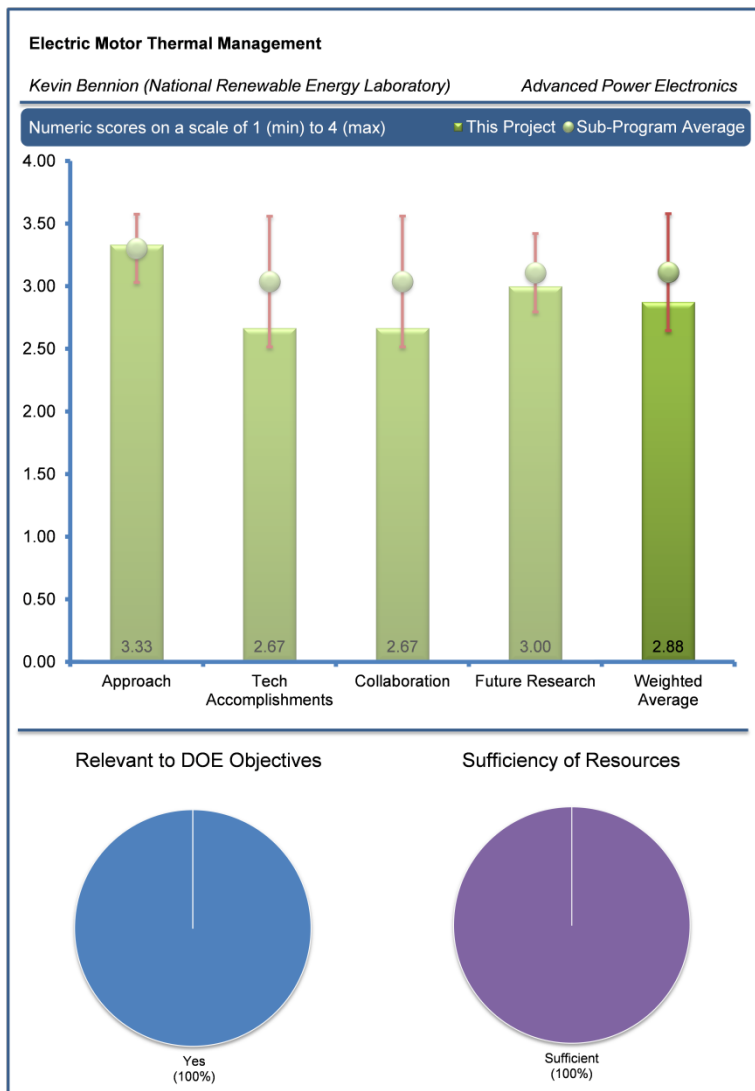
Reactions to this question were all positive. One person described that thermal improvement on electrical machines is key to size and price reduction. Another person agreed, adding that the project supports the objective of petroleum displacement by improving the thermal performance of electric machines. If successful this improvement would result in smaller machines with higher power density, which would enable a faster market introduction of HEVs and EVs. The final reviewer acknowledged that improving thermal management for motors allows motors to run cooler, which improves efficiency and enables use of lower Dysprosium content in magnets. The reviewer added that these improvements reduce operating cost and initial cost, which facilitates adoption of HEVs and EVs in the market.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were all positive. One person explained that the main goal of the project is the cooling parameter sensitivity analysis for electric machines and the derivation of improved cooling techniques. The approach consists of material property tests and thermal finite element analysis (FEA) modeling of different PM machine types. Test and simulation results in publications from other researchers and test results from other National Labs are included in the validation of the simulations and tests in this project. This reviewer observed that the overall approach is very well-designed and the technical barriers and limitations of the simulations models and test procedures are identified. One evaluator noted that the project is identifying trend for improvements added to making intelligent choices by using different type of motors and comparing model and test results seems to me to be a good approach to reach valuable results. The last person commented that this is a very broad and multi-faceted subject, and so difficult to tackle. The reviewer felt that the research team has done a good job of systematically breaking down the subject, working from basic building blocks (measuring material properties) and working toward more complex system issues. Their approach also lends itself to providing data useful for many motor types (e.g., IPM, induction, etc.).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were all positive. One person stated that the Technical Accomplishments are very good and the results are summarized in an excellent manner. This expert highlighted that some of the test results for the determination of thermal material properties confirm the data in the literature, which is a good achievement. The reviewer added that additional results, as



the thermal conductivity of lamination stacks, are valuable for the electric machine industry. This expert also observed that thermal sensitivity analyses were conducted for both surface and interior PM machines and the results will support the optimized design of these electric machines. The reviewer noted that the researchers successfully tried to generalize the results in order to avoid results which are only applicable for a specific machine design. Another evaluator commented that the project used good analysis of the targeted area to improve relative to motor usage. The final person commented that the project accomplished a very good characterization of stator materials, lamination stacks, and winding. The reviewer added that the data would be more useful if it was in terms of quantities that are more familiar to motor designers (e.g., stacking factor instead of lamination stack pressure, so it is very difficult to know what stack pressure is retained after the lamination stack is welded and assembled into a housing). They concluded by suggesting that the researchers should also consider real-world interface resistances between wire and slot liner and liner and lamination.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The responses were generally positive, but with some questions being raised. One person noted the good use of industry motor designer experience, as well as other National Labs. The second reviewer acknowledged that the researchers are collaborating with another National Lab and a university on this project and that the contributions from the collaborators are mainly in the area of electric machine design support. This expert cautioned that although collaborations with industry representatives are mentioned, it was unclear what areas are covered by these collaborations and who are the partners. The reviewer felt that it would be beneficial if the collaboration with OEMs could be intensified in order to guide the work in the right direction regarding the choice of machine topologies of interest.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person suggested that the future effort should be more emphasized on cooling technology. Another person suggested adding the effect of rectangular wire (versus round wire) in distributed and concentrated windings. The final person had detailed comments, describing that the project has well-defined milestones for FY 2012. The future research plans are based on the past progress and the barriers are identified as good as possible. The researchers plan to extend the project scope to oil cooled machines, starting with oil cooling for the stator winding. This is a very good choice as this cooling technique is of great interest for the industry due to the significant machine performance improvement. In a second step it would be good if the investigation of oil cooling is extended to the rotor.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers to comment stated that the resources were sufficient. One person added that the project has sufficient resources for the defined tasks and that a milestone review in September 2012 will determine the work and resources for FY 2013.

Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets: Christopher Whaling (Synthesis Partners) – ape032

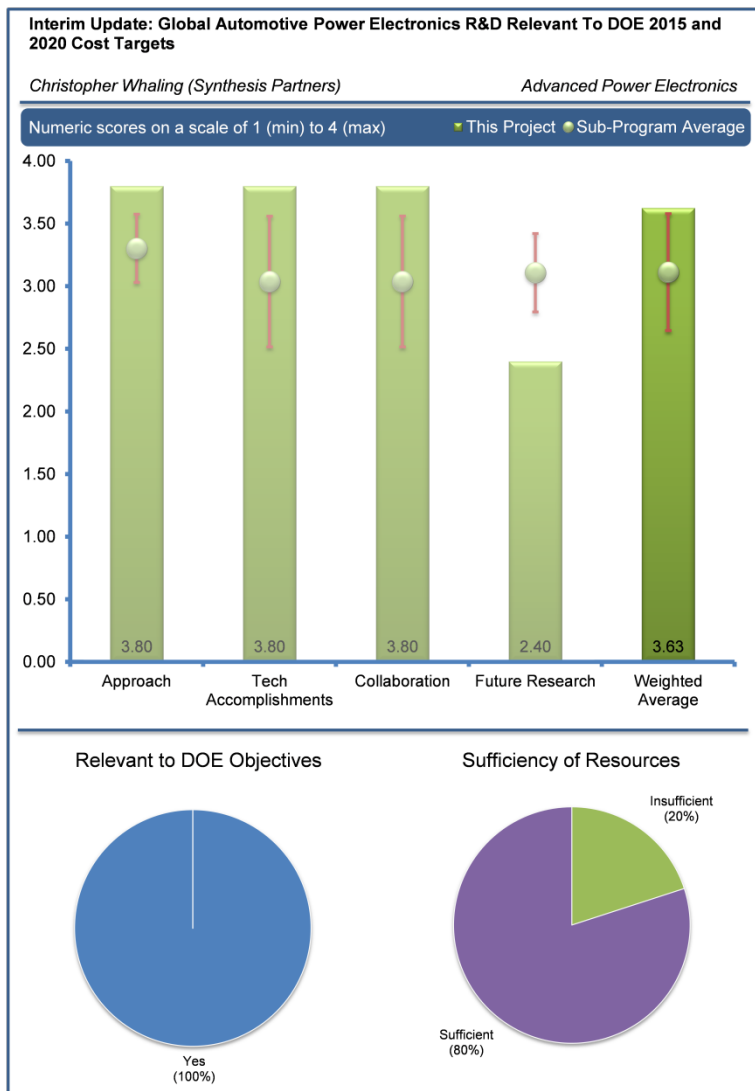
Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person noted that yes it does meet DOE's needs, as it is looking at the cost structure roadmap to see if it will meet cost targets. The reviewer noted that all data were taken from publications, OEMs, National Labs, etc. Another reviewer agreed, stating that the project supports cost targets, roadmaps, and information for the DOE to make future decisions with power electronics. This reviewer viewed the pending data and reports useful to the DOE when evaluating future R&D projects and funding. One expert commented that in a way looking for radical reductions in propulsion system costs to achieve DOE 2015 and 2020 VTP targets addresses the objective of petroleum displacement. They added that if you can find the architecture, part or process that helps to lower cost, thereby enabling the EDV market, which in-turn reduces our dependence on foreign oil. They concluded their comments by asking how that information will be shared. One evaluator explained that the project is a valuable tool to help the DOE assess the current status of

Global Automotive Power Electronics Market; this tool will help adjust the targets for DOE goals. The last reviewer had very detailed comments, noting that this work is very important for understanding the cost reduction and performance improvement potential for inverter technology in particular, but also for power electronics more generally. This cost-reduction potential will remain very important to understand, particularly for its sensitivity to: 1) economies of scale/volume production, 2) the increasing performance (power density, specific power and efficiency) possible with further improvements in the technology, 3) the increasing value of reducing dependence on petroleum as an automotive fuel, not only via energy efficiency improvements, but also via shifting energy usage from petroleum to U.S. energy sources, as well as the increasing value (which is largely unrecognized today, economically-speaking or otherwise, compared to what is needed to halt global warming before feedback effects send it completely beyond any reasonable possibility of our control), and 4) the consumer value of changes in fuel prices, up or down, and impact on demand and, thereby, sales/production volume available to manufacturers. This factor is particularly important for understanding the ability of the United States to attract investment for these advanced energy technologies, since the United States continues to heavily subsidize petroleum as an energy source, as it has been for decades, and U.S. incentives for alternatives to petroleum are at a relatively very low level compared to most of the nations where most of our global competitors are based.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One person commented that there is a strong approach to gather meaningful and useful data, while still addressing technical barriers to cost targets. Another person cautioned that the project is relying solely on other research and has not made any projections or recommendations yet; however, the reviewer acknowledged that the study is only 40% complete. One expert expressed that it is not easy to obtain the information that this work is based upon, since most of it is considered highly proprietary for the companies that can supply it. The reviewer added that these companies are also in business to make a profit, so are negatively motivated when it comes to revealing the true details of the lowest costs that are even known to be possible, let alone what might be possible with reasonable extrapolations from just today's technology, let alone totally different approaches. Another person had related comments, observing that the approach is very good but will be hampered by suppliers' reluctance to provide cost information as well as the issues identified in the presentation; however, even with these limitations the reviewer thought that the results will be viable. The last person to comment stated that the researchers seem to be looking everywhere for information, but the lack of a common vocabulary and different partitioning of hardware makes the comparisons difficult. The reviewer concluded by saying that they would like to see a format of how the final report will look.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. One person simply stated that a methodical approach focused was used on the work statement. Another expert felt that the progress has been good for this project, but that they would like to have seen more information on the articles mentioned in the presentation but understand the time delay. The reviewer added that the description of where the data came from is insightful and allows one to judge the usefulness of the data for their purpose. One reviewer cautioned that as a reviewer, producing initial results and report findings over the next five months appears as a risk with meeting project end date. The reviewer suggested that effort should have been made to present an example of initial data and report, even at a preliminary level. The final reviewer commented that the information could be very useful if a common ground(s) for comparison can be found and understood. The reviewer asked how the researchers will know when they are done, also asked what the form of the final report, table or analysis looks like.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were all positive. One person simply stated that the researcher seems to be looking everywhere. Another reviewer acknowledged the close collaboration with National Labs, universities, Tier 1 OEMs and other research publications. One commenter explained that the project commands diverse and wide band collaboration in order to collect and analyze the data. Another project evaluator commented on the outstanding review of the other studies that are being conducted, as well as the original survey work being attempted. The final reviewer praised that the results are impressive, but no mention was made as to the number of industry partners who responded was given so it is hard to judge how well these parties cooperated. This is going to be a difficult problem to address as most commercial entities are unwilling to provide cost information. The reviewer thought that researchers will be able to get enough information to enable trends to be seen.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed. One expert described that the future work is still under development, but the ideas presented were interesting and could prove to be valuable if the databases are kept up to date. Another reviewer remarked that this was not clearly stated except for future discussions with DOE. A third person had similar comments, stating that future work needs to be better defined other than discussions with DOE. Another person expressed that they would like to see more efforts to go back to some of the other sources to uncover the difference between full costs versus incremental costs versus production volume (scale) versus actual and projected generations of technology improvements. The final reviewer had detailed comments, describing that detailed results are due later this year. The interim report does not address the form of the final report. If it is a wealth of information, the reviewer asked how does one go from a system to a module to a component or architecture or process to find the game changer technology, or understand cost. The reviewer felt that it would be interesting to know the value comparison of the

OEM patents by OEM. This reviewer cautioned that it is not how many you have, but what their value is, and which ones are the most valuable. To evaluate a patent's strength, or value, several companies have developed algorithms to measure a patent's strength (Innography is one of several companies). The algorithms use several criteria such as strength of claims, citations, (and other things the companies do not reveal) to make that determination. The reviewer concluded by noting that the real value of a patent is ultimately based on what the buyer is willing to pay for it.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed, with one person finding resources were insufficient, and four of five people finding them sufficient. One reviewer stated that even though they marked the resources as sufficient, the project probably needs more funding support to best accomplish its objectives. One person commented further that the project appears to have adequate resources to meet research milestones. Another person commented that the resources are sufficient since the project is not basic research, but rather primarily just compiling and analyzing existing data. The last reviewer to comment noted that the project is working to a schedule, and the researchers did not mention a need for additional resources.

Converter Topologies for Wired and Wireless Battery Chargers: Gui-Jia Su (Oak Ridge National Laboratory) – ape033

Reviewer Sample Size

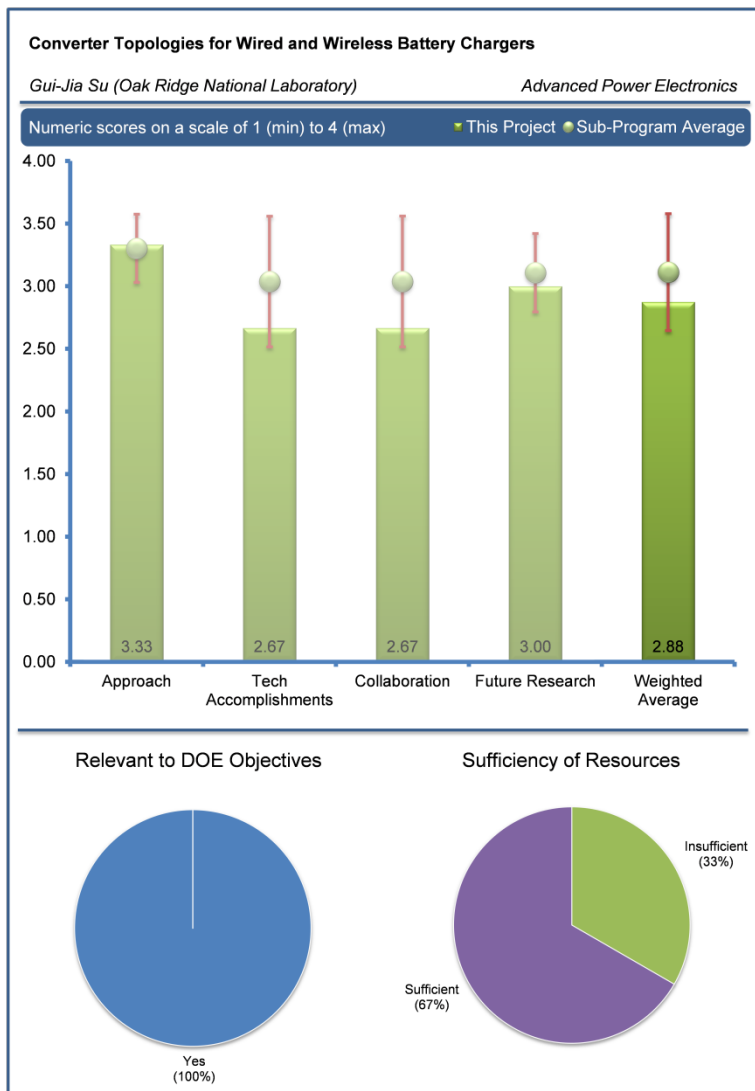
This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person affirmed that the cost reduction opportunity for the Level 1 and Level 2 charger from using the power electronics already integral with the inverter seems very significant. The reviewer added that the ability to plug-in cost-effectively will enable a major displacement of petroleum, far beyond the petroleum reduction possible with even the highest efficiency non-plug-in hybrids. Another commenter remarked that reducing the cost, weight and size of the onboard battery charger helps to enable the market for EDVs; this will help to reduce our dependence on foreign oil. The final reviewer commented that this task addresses the need to charge the on-vehicle batteries in a cost-effective manner; by increasing the efficiency and reducing the mass of the vehicle this project could increase the miles per gallon equivalent (MPGe) and overall efficiency of the vehicle.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Only two reviewer provided comments. The first person noted that the project’s goal is to design build and test an isolation converter for use in the on-board charger. The barriers are cost, weight and volume, but the reviewer asked if these can be quantified (not a percentage of metric) for the researchers’ particular charger. The reviewer added that other barriers are high efficiency, but again asked if this can be quantified with respect to today's chargers, and inquiries how high is high. The reviewer concluded by noting that the simulations from 2011 look promising, but criticized that the isolation converter was not included. The reviewer explained that the isolation converter is under patent review and no details were disclosed. The other reviewer to comment had very detailed comments, stating that this approach is interesting and can potentially meet the desired goals. There are a couple of issues that need to be clarified because they will impact the cost of the system. The first relates to the motor(s): the diagram shows the neutral point being brought out; this is not normally done and will increase the cost for the motor. The second is related to the isolation method; the diagram indicates a separate isolation unit between the inverter and the battery that may have to support not the typical charging currents but the full motoring current which will have a large effect on cost and size of this component. Another area of concern is the thermal requirements during charging. The thermal needs of the vehicle need to be defined and the impact on the 12-volt load during charging has to be addressed. If the cooling system is required to be operational, the reviewer asked what the load is on the high-voltage system, since the load cannot be provided by just the 12-volt battery due to the extended time of the charge process. If the accessory loads require significant 12-volt power and/or high-voltage power then



the overall impact may be that it is not feasible for a Level 1 charger. For instance, an air cooled battery requiring conditioned air may require most of the charge power just to operate the air-conditioning system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. This person mentioned that they could not comment on details of the concept since it is under patent review. This person acknowledged that a design exists, but there is not enough information to comment. Another commenter observed that the simulations show promise, but more information is required on the auxiliary loads and the connection scheme (the reviewer qualified this by stating that they realize that protection for the idea is required). The final person commented that the researchers need to learn more about the details of the approach, but it appears that this approach is yielding a major opportunity for reducing cost and size of the on-board power electronics needed for the Level 1 and 2 on-board chargers. The reviewer wondered if this might make possible a lower-cost approach for higher levels of charging as well, but details are lacking on this (perhaps due to the lack of IP protection).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer suggested that the researchers may want to involve a Tier One supplier to verify the results. They added that if it is practical working with a Tier One, or multiple Tier One suppliers, it could possibly get this into production faster. Another person had similar comments, suggesting that more industry involvement might be helpful (e.g., with Delphi) to consider system issues early-on in the design optimization. The final reviewer to comment felt that the high-level requirements have been successfully provided by the collaboration effort but some of the details are still required since they will have a large impact on the viability of this approach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer simply stated that the current design is an evolution of previous work. The other reviewer to comment acknowledged that progress is excellent if the assumptions are correct, but the reviewer cautioned that the risk is high that the assumptions are not correct. The reviewer added that if the 12-volt loads and high current paths are defined and do not impact the design then the plans are correct, otherwise the plans need to be modified to provide answers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed with one person feeling that they were insufficient while two others felt they were sufficient. One person described that the resources appear sufficient for on-board wired charger, but not for including wireless charging as well (which is probably one reason that the project's scope has been reduced from wired and wireless charging to just wired charging). One reviewer suggested that the researchers may want to involve a Tier One supplier to verify the results. The final person commented that the direct resources are appropriate providing a significant change is not required once the questions from above are answered. The reviewer concluded by suggesting that the researchers might need some additional support from the vehicle team.

Integration of Novel Flux Coupling Motor and Current Source Inverter: Burak Ozpineci (Oak Ridge National Laboratory) – ape034

Reviewer Sample Size

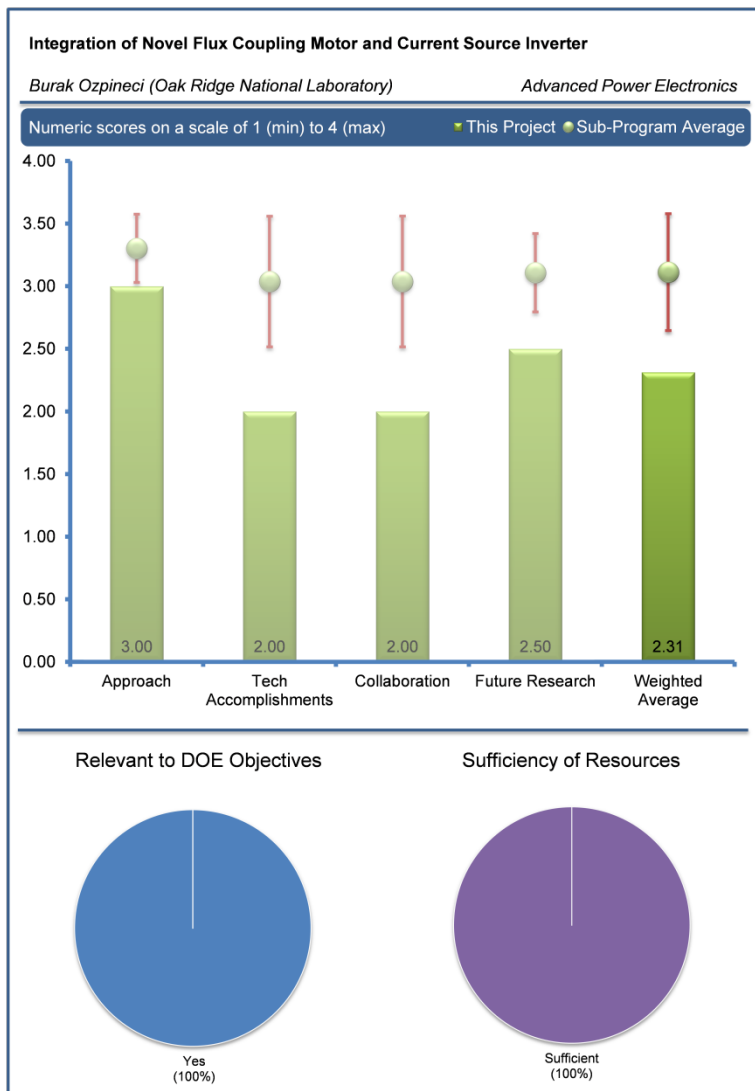
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that the project supports the objective of petroleum displacement by developing a new inverter and motor concept. If successful this new concept would result in cost savings and performance improvement for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another evaluator described that the proposed motor has no rare earth magnets, no DC link capacitor, and no extra DC link inductor in current source inverter (CSI). These features offer the possibility of a lower total system cost without reduction in performance, which facilitate adoption of EVs and HEVs. One expert noted that meeting the DOE VTP 2015 cost targets and the VTP 2020 drive system targets will help to lower the cost of the power electronics for EDVs. They added that this lower cost will help to enable the market for EDVs and reduce our dependence on foreign oil. The final person pointed out that the project strives to address the technical (temperature) and cost problems associated with large conventional DC link capacitors by utilizing a current-source inverter. The reviewer added that the project also addresses the need for a series inductor by attempting to utilize the inductance of the propulsion motor, as well as addressing current rare earth magnet material availability problem by using a non-PM motor.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One evaluator noted that the program builds on earlier successful program for CSI inverter and marries it with development of a non-PM motor. Another person simply stated that the project had shown good use of FEA and system simulation to design core and inverter. The third reviewer had detailed comments explaining that the main goal of the project is the integration of a current source inverter with a new flux coupling machine without permanent magnets. They added that the flux coupling machine has a DC excitation coil and core. The high inductance in the motor will also be used as the inductor for the current source inverter. **This commenter asserted that the overall approach is generally well-designed and some of the technical barriers are identified, but many of the uncertainties about the viability of the concept remain at this point in time, which is acceptable for a research project in an early stage. The final reviewer described that the concept depends on the ability to utilize the excitation coil in the motor to function in two roles. In addition to providing motor excitation it will also function as an inductor for the CSI. It has not been shown, yet, that the DC and AC flux can be separated.**



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that the CSI inverter was demonstrated with separate CSI inductor and with motor excitation coil. One expert explained that the researchers evaluated the system efficiency using separate CSI inductor and then NFC machine field coil as inductor. They also mentioned that the researchers developed a shorting ring concept to reduce effects of AC flux components in machine. Another commenter asserted that the Technical Accomplishments are only fair so far and the progress in overcoming the identified barriers is only modest. The reviewer felt that the achievements in the former project about the design of the flux coupling machine itself are not sufficient yet to fully prove the statement that it is on par with an IPM machine. Within the project here, so far it is only proven that the excitation coil and core can generally be used as the inductor for the current source inverter but with only very low efficiency. It seems that it is not fully understood at this point in time why the efficiency is low and how it can be improved. It is also unclear at this point in time how the operation of the flux coupling motor is effected by the AC flux in the excitation core. The final reviewer also had detailed comments, explaining that using the excitation coil in the motor as the inductor for the CSI has not been proven. The reviewer asked, from a system standpoint, if there will be a need for more electronics to separate the DC and AC flux components. The reviewer also asked what are the impacts of cost, weight, and complexity of those other components. Conversely, if the CSI inverter's big inductor is ignored, and efforts are concentrated on the non-permanent magnet motor aspects, the reviewer asked how would that compare to the DOE VTP 2015 and 2020 motor targets, and also would like to know if the motor could stand on its own. If so, this reviewer would like to know if a CSI inverter would be needed for this motor, or are there other alternatives.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person stated that there is no collaboration with other researchers outside ORNL at this point in time. The reviewer, however, felt that it would be beneficial if collaboration with drive system OEMs could be established in order to provide guidance for the project about what is of interest for the industry. Another person simply stated that the only non-ORNL collaborators are core material suppliers. The final reviewer to comment observed that the researchers are working with soft magnetic core vendor(s), but asked if the researchers have considered a motor supplier to evaluate if the NFC machine can be manufactured.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer simply stated that the future research plans provide an appropriate emphasis on increasing efficiency. Another person simply stated that the plan appears adequate. Another commenter remarked that the milestone definition in the project is relatively vague. It was not obvious to the reviewer if the researchers have a concrete plan of how to overcome the identified barriers as, e.g., the very low efficiency. A lot of uncertainties remain in this project, which is acceptable for a research project, but the future research plan needs improvement. The final person commented that the researchers **need to focus on overcoming the ability to utilize the excitation coil in the motor to function in two roles. The reviewer concluded by stating that in addition to providing motor excitation it will also function as an inductor for the CSI.**

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers to comment felt that the resources were sufficient. One person provided additional detail, observing that the project has sufficient resources for the defined tasks; a milestone review in FY 2012 will determine if the concept has merit.

Motor Packaging with Consideration of Electromagnetic and Material Characteristics: John Miller (Oak Ridge National Laboratory) – ape035

Reviewer Sample Size

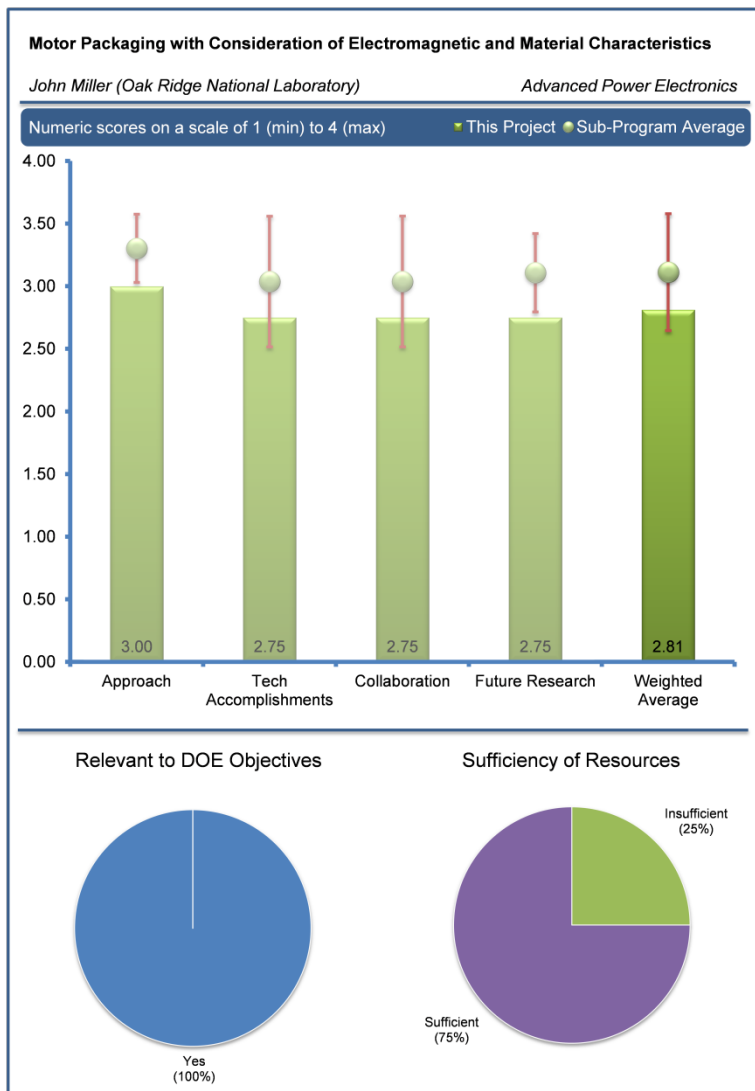
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that the project supports the objective of petroleum displacement by developing new motor packaging concepts and improved materials. If successful, these would result in cost savings and performance improvement for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another expert explained that efficiency improvement in PEV is essential to make the best use of battery, so working directly on the design of electrical machine to improve efficiency is working at the source. One person highlighted that improving motor efficiency improves EV range or reduces battery cost, and also improves continuous performance. The reviewer added that each of these helps improve market adoption of EVs and PHEVs. The final person to comment mentioned that improved materials and use of novel materials for higher efficiency directly relate to petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person explained that the main goal of the project is the development of more efficient electric machines by means of improving lamination material properties and improving cooling materials and processes. For a better understanding of the loss mechanisms in IPM machines, an example machine was analyzed regarding its loss distribution. This is a good approach as it helps to guide the work on improvements in the right direction. The reviewer explained that the overall approach is generally well-designed and some of the technical barriers are identified. They felt the milestones were well-defined and the manufacturing of prototype machines is coupled to Go/No-Go decisions-based on simulation results. Another commenter acknowledged the researchers' very good systematic approach to mapping core loss and then evaluating possible improvements by utilizing grain-oriented silicon steel. The final person explained that the project's focus on grain oriented silicon steel and the money/time investment required to optimize it for traditional motors is recognized as outside the scope of the program. Later in the presentation, however, items like potting compounds could become very useful and may be worth a closer look. The reviewer added that one important thing to note is that improved heat rejection at heavy loads can translate into smaller machines that have lower light-load losses, which the investigators note is the most important region for efficiency gains.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally noted good progress. One person described that the Technical Accomplishments are good so far and the progress in overcoming the identified barriers is adequate for the current status of the project. The reviewer added that for a better understanding of the loss mechanisms in IPM machines, an example machine was analyzed regarding its loss distribution. Guidelines for the development of optimized lamination steel were derived from the loss and magnetic flux analysis. The reviewer concluded by pointing out that the specific accomplishments in the investigation of the thermal material development for better heat transfer are somewhat unclear. The reviewer felt that it seems as if this part of the project is in a very early concept phase. Another reviewer commented that the researchers showed that significant improvement was possible by radial and circumferential aligned GOSS in the teeth and stator yoke, respectively. The researchers also evaluated steels and steel processing that could reduce loss at high frequency, allowing more efficient operation at higher speeds and power densities. The final person commented that substantial effort was spent on grain-oriented steel that will likely not proceed, but technologies that do not pan out (for whatever reason) do not mean they were not worth pursuing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person offered that collaborations with several divisions within ORNL and other National Labs have been set up. The reviewer said that it would be beneficial if collaboration with an electric machine OEM could be established in order to provide guidance for the project about what is of interest for the industry. The final reviewer asserted that partnering with industry is encouraged; vehicle and motor manufacturers will provide a slightly different view that may lead to new approaches.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback was mixed. One person said that the milestones in the project are generally well-defined. Surprisingly, the PI suggested that the project could be cancelled as a stand-alone project and could be combined with another project in which the same PI develops a new machine technology. The reviewer added that even though this suggestion makes sense from a technical point of view, it has to be asked, why the two projects were not been set up as only one project from the beginning; this might have given other rejected project proposals a better chance for receiving an approval. The second reviewer suggested looking at other winding types to improve ratio of continuous to peak power. The reviewer thinks that hairpin windings, for instance, already exceed the 58% target for the project, particularly when spray oil cooling is used. The final reviewer pointed out that it was said that this program will not move forward.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were primarily positive, with one person commenting they were insufficient and three of four reviewers stating the resources were sufficient. One reviewer stated that it was said that this program will not move forward. Another person, however, felt that the project has sufficient resources for the defined tasks, but the suggested combination with another project by the PI requires a re-evaluation of the resource allocation.

Physics of Failure of Electrical Interconnects: Doug DeVoto (National Renewable Energy Laboratory) – ape036

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

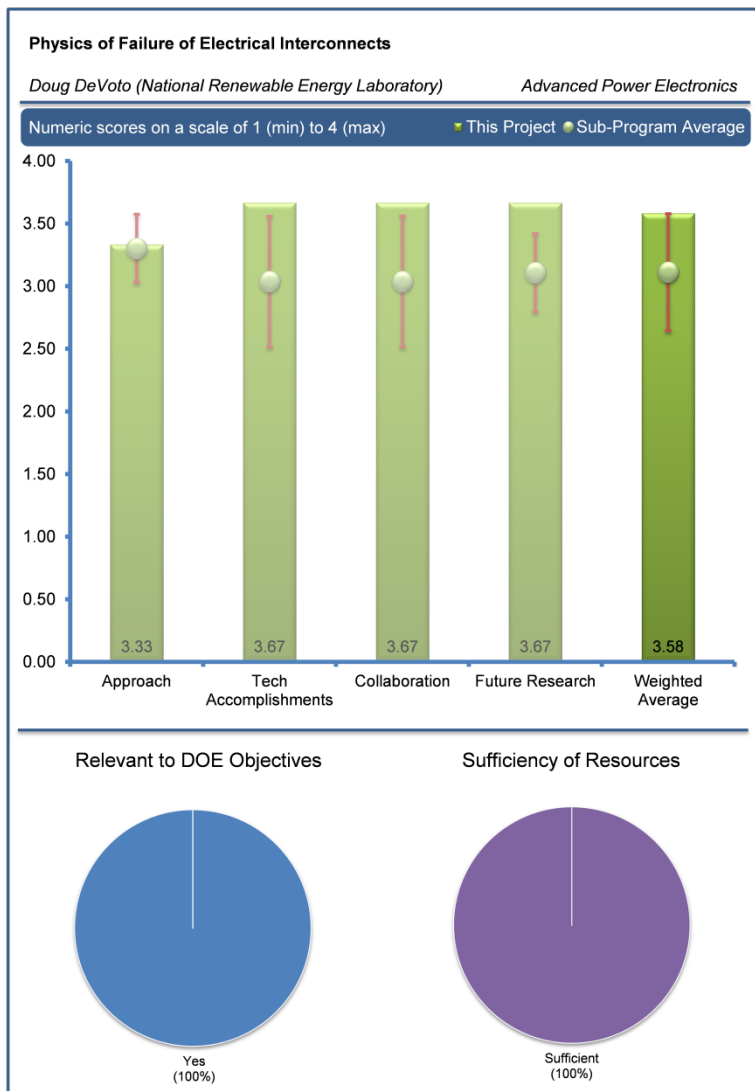
One reviewer noted that the reliability of electrical interconnects is a core issue in automotive traction drives. Another reviewer noted that this project is focused on power electronics packaging reliability. The reviewer felt that poor reliability with a lack of understanding of the physics driving failure modes will lead to very poor market penetration and petroleum displacement, and as such, projects such as this will be key to wide spread adoption of the technology. The third reviewer stated that the project addresses the reliability of the power switch and thus directly impacts the cost of the system to the final customer. The reviewer also noted that a more reliable part will allow the warranty cost to be reduced and also provide the customer with a vehicle that is environmentally friendly but also reliable.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the project is organized with the proper focus on the study of the physics of failure for the interconnection wire bond fatigue and stress-strain characterization. Another reviewer liked the emphasis on increasing the understanding of interconnect models to de-risk and de-cost qualifying this essential and risky part of electronics packaging. The reviewer did note that they felt the project does had a hint of corporate welfare, specifically that the reviewer thought Orthodyne would be the subject matter experts on what this project is trying to do, but the presenter claimed otherwise. The third reviewer indicated that the project has identified a failure mode that is significant in today's devices and an alternative method of accomplishing the function. The project approach compared the two approaches using the appropriate testing methods to precipitate the failures. The reviewer felt that the only improvement would be to add some vibration testing during the process.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that although this is a new project just getting started, the work appears to be progressing satisfactorily. Another reviewer felt that, though they expressed reservations about being able to provide a quality opinion, the results appeared to be on track with expectations. Another reviewer indicated that the approach has been determined and will provide the appropriate type of stress to accelerate the failure mode being addressed. The reviewer felt that using a common layout for both ribbon and wire bonding should eliminate any concerns that the testing was not performed correctly. The reviewer additionally stated that the simulations looked encouraging.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that the project had very good coordination with academia and Department of Defense (DOD). The second reviewer stated that the selection of industry leaders in this area is very good. The reviewer felt that using one supplier capable of providing both ribbon and wire bonding (sells both types of machines) was great. Additionally, the reviewer encourages a similar type of test for the PBA package from Oak Ridge National Laboratory (ORNL) either be added or planned for the future. Another reviewer felt that there was an excellent collaborative relationship with an industry leader (Orthodyne). The reviewer indicated that the presenter described Orthodyne as being fully behind the project. The reviewer noted one thing during questions: The presenter corrected statements multiple times following challenges by the reviewers. One specific example the reviewer cited was as follows: the failure mode of ribbon connects was described as catastrophic in contrast to multiple wire bonds which are graceful. It was noted that ribbon connection failure modes need not be all or nothing and the presenter agreed when this was pointed out. The reviewer attributed this issue to youth but recommended a more careful attention to detail in the future.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the projects future research looks good, but they felt they were not fully qualified to provide the most effective critical review. Another reviewer noted that it was a very important aspect of traction drive and DC-DC converter power module reliability. The third reviewer noted that the future plans represent the logical next steps to this problem and include adding state of the art commercial methods.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers noted that the resources were sufficient.

Two-Phase Cooling Technology for Power Electronics with Novel Coolants: Gilbert Moreno (National Renewable Energy Laboratory) – ape037

Reviewer Sample Size

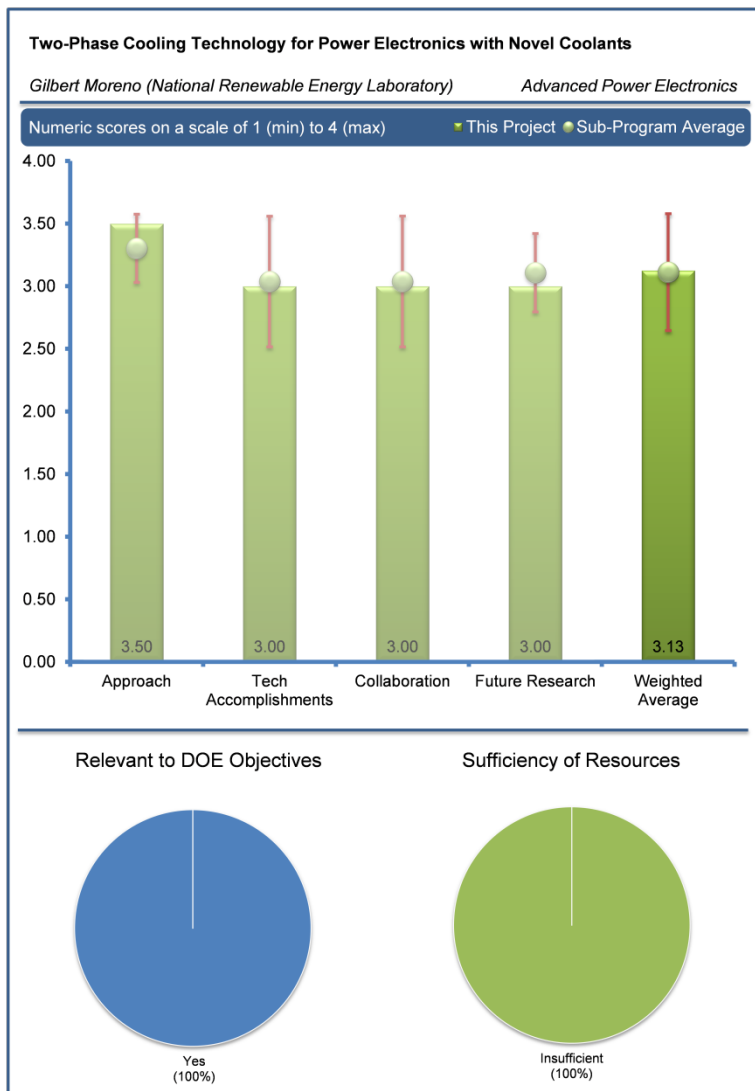
This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that the project met DOE's goals because advanced cooling for power electronics is an essential topic for the Vehicle Technology Program (VTP). The second reviewer noted that thermal system design and performance are required to achieve reliable and efficient electric traction system and can be complicated and relatively expensive. The reviewer indicated that this project addresses one approach to address this issue.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed responses to this question. One reviewer liked the project. The reviewer felt that it makes sense assuming the sizing of the components fall out in favor of the two-phase technique with available refrigerants. The reviewer also felt that the argument was compelling in that phase change represents a large advantage over non-phase change cooling, and the advantage can be used smartly in design trades to make a working system feasible in automotive applications (wide band gap semiconductors are similar in that respect). The reviewer noted that critical factors such as size and weight after the various parasitic losses of a real system are accounted for need to be addressed before one can really believe this is a disruptive technical approach. The reviewer also noted that reliability is, of course, also going to get close scrutiny by real-world automotive engineers. The first reviewer's main criticism was twofold, which they thought should be addressed in the future plans. First, the quantitative case is made using a scientific approach, rather than an engineering approach or measures of performance (i.e., graphs and charts of coefficients and normalized heat transfer calculations are used, rather than a point design of a working system) in which things like real-world heat exchangers and the need for filters and receivers and whatever else goes with a refrigerant-based system increase system size. The reviewer notes that these parasitic losses must be accounted for. Second, a collection of technologies of questionable relevance are amalgamated for no firm purpose into one project. The reviewer questioned why coating technologies were convolved with the core project. The reviewer wanted to know if they were needed and, if so, would have liked an explanation why and to have the presentation address whatever risk is added as a result; if the coating technologies were not needed, the reviewer recommended not including them in the project. The reviewer felt that including coating technologies detracts from the sense that the core technical approach is feasible. When pressed on this subject, the presenter agreed that the coatings were included because they were interesting new technologies, which the reviewer felt was the wrong answer. The reviewer indicated that in the real world of the automotive commercial market place, it is necessary to be clear and concise what you are doing and why it solves a problem or risk unnecessary delay potential adoption.



The second reviewer noted that, while the approach has shown the capability to provide excellent thermal performance at the device level, little has been done to address the system issues identified last year. While the use of this method has been shown on a power switch designed to be double side cooled, the reviewer wanted to know about switches designed for single sided cooling. The reviewer stated that the use of an intermediate coolant medium requires the addition of another interface to remove the heat from that medium. The reviewer granted that a simple liquid to liquid or potentially liquid to air exchanger may suffice, but that the cost of this must be investigated as well as its impact on the overall vehicle coolant system. The reviewer noted another area of concern with this approach in the interconnects required between each switch in the design shown; the reviewer wanted to know how will this be accomplished on the production line because of the significant number of connections to make and leak proof.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that this must be a young project because most of the results seemed to be based on previous pre-proposal work. The reviewer did not feel that this lack of progress detracted from the overall project and noted that they liked the underlying concept and wished the project success. The second reviewer stated that the progress in demonstrating that the concept is valid has been very good but noted that practical implementations have not been demonstrated. The reviewer felt that the involvement of Delphi to assist in testing the design is a good next step but felt that a conventional module maker may also need to be involved.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the use of new coolant fluids and surface treatments is very interesting. The reviewer wanted to know if these surface treatments can be used with today's coolants. The reviewer felt that, if the interface between this coolant system and either the air or vehicle coolant system can be economically and efficiency implemented, this may be a viable solution. The reviewer cautioned that the solution must provide cost benefits in terms of the overall system, i.e., either less switch area needed or a reduction in the load on the in vehicle coolant system for this to work. Another reviewer felt that they did not get a good sense at what collaboration was bringing to the project. The reviewer indicated that all of the activity related to coatings is an example of how collaboration sometimes needs to be better justified as core to the project. The reviewer recommended a more focused effort in which collaboration produces more than the sum of the parts. The reviewer noted an excellent example of collaboration was the two air-cooled projects that combine power electronics expertise and thermal engineering expertise to make a very effective project team.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the project is relatively new. The reviewer went on to state that this would be a good time to consider the issues raised in the technical approach critique so that the disruptive nature of the concept can be communicated while maintaining a focus on reducing to practice quickly so that we can all become believers. As previously indicated, the reviewer felt that the air-cooled projects have an excellent model for this project to follow. The second reviewer noted that the future plans as stated will support the development of this cooling approach at the switch level but not necessarily at the inverter level. The reviewer suggested getting some involvement from a vehicle integrator to assist in determining the impact at the vehicle level to assist in bringing this technology to the level required to actually implement at the vehicle level. This reviewer would also look at tying this coolant system into the on-vehicle air conditioning or perhaps the battery coolant system if there is one.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers felt the project resources were insufficient. One reviewer indicated that they would like to see a larger project on the scale of the air-cooled projects. The other reviewer noted that vehicle level resources need to be added since this project has the potential to have a large impact at that level and it will create significant discussions.

Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate: Sreekant Narumanchi (National Renewable Energy Laboratory) – ape039

Reviewer Sample Size

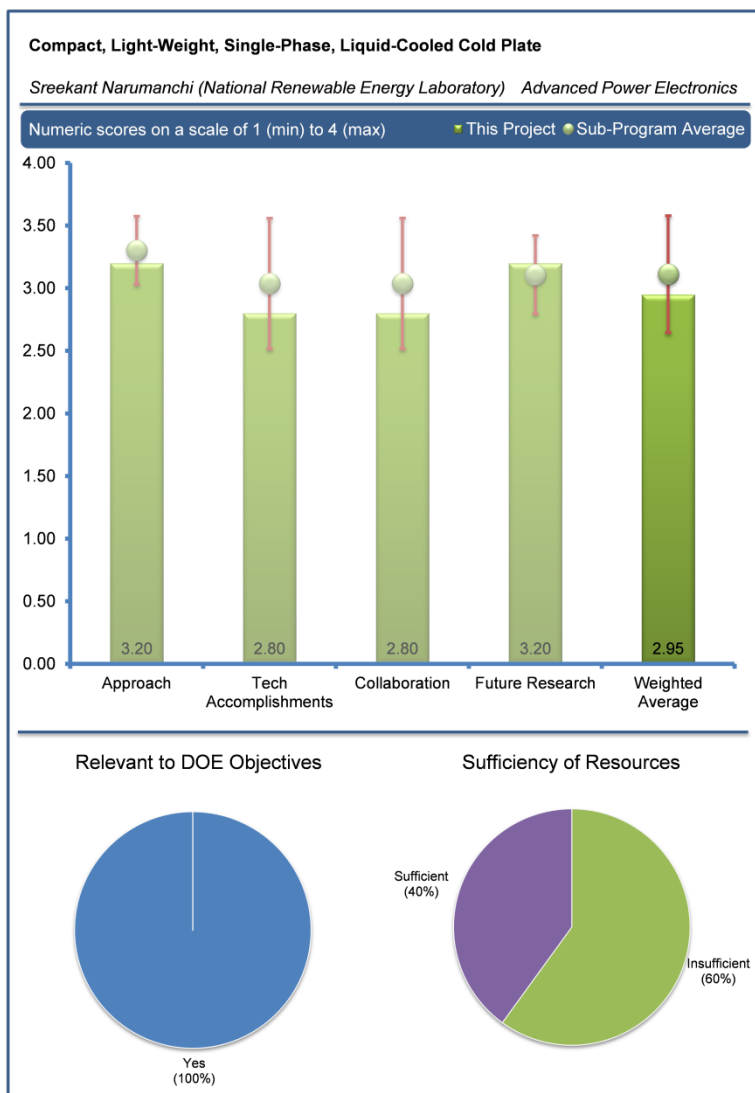
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers had positive responses. One reviewer stated that integrating practical but advanced liquid cooling techniques in a production automotive traction inverter is highly relevant. Another reviewer stated that advanced thermal control technologies are critical to enabling higher power densities which are key to the success of Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV) in the market place. The reviewer noted that good management system can reduce size, weight, and improve performance. These things lead the reviewer to conclude that the project is relevant to the Department of Energy (DOE) overall objectives of petroleum displacement. A third reviewer noted that the reduced power electronics thermal system weight and cost will help to provide a more attractive system for end-users. The use of plastic with glass fibers not only decreases the weight, but also offers more options for the manufacturability of the final product. Also, the increased thermal performance of this system will provide significant improvements to multiple private industry inverters, as well as potential other power electronics systems. A fourth reviewer indicated that this project addresses the need to improve the heat removal from the switches to allow smaller, lighter and more efficient inverters to be developed. This will lead to meeting the cost and size goals of the DOE leading to more electric vehicles on the roads.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed responses. One reviewer noted that the project is a good match between low cost materials and commercially available processes and components. Another reviewer indicated that the approach is generally through modeling and simulation, and that fabrication of prototype and testing of the prototype has been carried out. The reviewer also noted that discrepancies have been identified between modeling and prototype test results with a base line from a UQM inverter. The reviewer felt that the key is to reduce thermal resistance and increase heat transfer rates through the WEG jet. A third reviewer felt that the program is very short, and is being managed very well for the time frame allocated. Simulation is needed to increase efficiency of the program, and is now being compared to real-world experimentation. In addition, according to this reviewer, the corrosion and change in thermal characterization has been provided, starting at nearly the very beginning of the program. The reviewer remarked that it will be interesting to see if this changes over the remainder of the program and/or if there is a way to accelerate this life testing. The fourth reviewer said that the approach using spray cooling/jet impingement presented is a good approach but has several issues that need to be resolved before it is accepted by the vehicle manufacturers. While this project is presently defining the performance that can



be achieved by this cooling approach, the reviewer felt that it is not addressing the issues from wide spread acceptance in the auto industry. The reviewer additionally noted that spray cooling can achieve improved thermal performance at least in the controlled environment of the lab, but has not been proved to survive or be cost effective at the vehicle level.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers noted that the project has had good progress. One reviewer commented that the results are incremental in nature rather than transformative, but the results are positive and involve consideration and concern for economics which is essential. Another reviewer listed the project steps and noted the progress for each: the modeling was done, the prototype was fabricated, and preliminary testing was performed. A third reviewer noted that their comments were similar to the previous section in the project was utilizing the short timing very well. The reviewer felt that the accomplishments and progress were very easy to understand from the presentation and additionally commented that it was very nice work. A fourth reviewer stated that the progress to date has shown good results and has data to prove it along with simulations. The reviewer felt that the results indicate that there is high potential here but the performance and cost of the rest of the system need to have the same level of effort before it can be considered.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed input on the collaborations. One reviewer noted that the project has the right team. Another reviewer felt that the collaboration within the team was very good to excellent but system level involvement was required. The third reviewer noted that there seems to be a good deal of collaboration with private industry, but other than providing the components, it seems that industry partners have not been actively involved in the simulation or management of the project direction. The reviewer was unsure if this was actually the case, but felt that this was not clear in the presentation. The reviewer would have liked to know if there were other things that UQM and Wolverine were doing. One reviewer felt that there is no true collaboration as UQM is providing the inverter and Wolverine Tube provides materials and components. The reviewer would like to see more collaboration with automotive Original Equipment Manufacturer (OEM)/supplier on the prototype and commercialization, connections with the real world applications, and possibly collaboration with academia institutions on the theories that support the technology.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer commented that the initial results with respect to reliability and lifetime are good and that focus on this topic is essential for the work to transition to practical use. Another reviewer noted that the future plans appear to be well thought out and follow a natural progression of the technology and the project simulation and testing results. The reviewer felt that it would be helpful to get a better understanding of what accomplishments are expected from the planned second prototype build. The reviewer wanted to know if there were going to be other differences besides the micro-fins and if the testing performed on the second prototype would be different from the testing on the first prototype. A third reviewer indicated that the future plans need to specify what good results are in terms of device, unit, and system performance. The reviewer would have liked to see what the pressure drop and flow rate values are for the first prototype and if they are reasonable compared to today's vehicle coolant systems as well as the performance using the typical contaminated coolant fluid specifications for particle size. The reviewer noted that the nozzle size seemed adequate but felt that only data will provide a definitive indication of this impression. One reviewer noted that the project could use more risk mitigation regarding material selections (plastic creep, operating temp limits, etc.) Another reviewer noted that the projects will finish by the end of 2012. However, it was unclear to this reviewer whether all project objectives can be fulfilled by then, which raised questions for this reviewer. In particular, the reviewer wanted to know the following: the plan for commercialization; the advantage in comparison to the traditional heat exchanger, other than an increase in cooling efficiency and cooling uniformity; whether the new approach is able to compete in price/performance; and how the project plans to evaluate the success of the new approach.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers felt there were insufficient resources. Two reviewers felt the resources were sufficient to complete the project. In particular, one reviewer commented that the results are promising but not transformative, that the path to commercial use is clear, but that risk remains in regards to long term reliability. Another reviewer stated that the program seems to be running very well with the resources provided. The reviewer did not see any area of needed improvement with regards to resources and felt that there was nice project management.

Next Generation Inverter: Greg Smith (General Motors) – ape040

Reviewer Sample Size

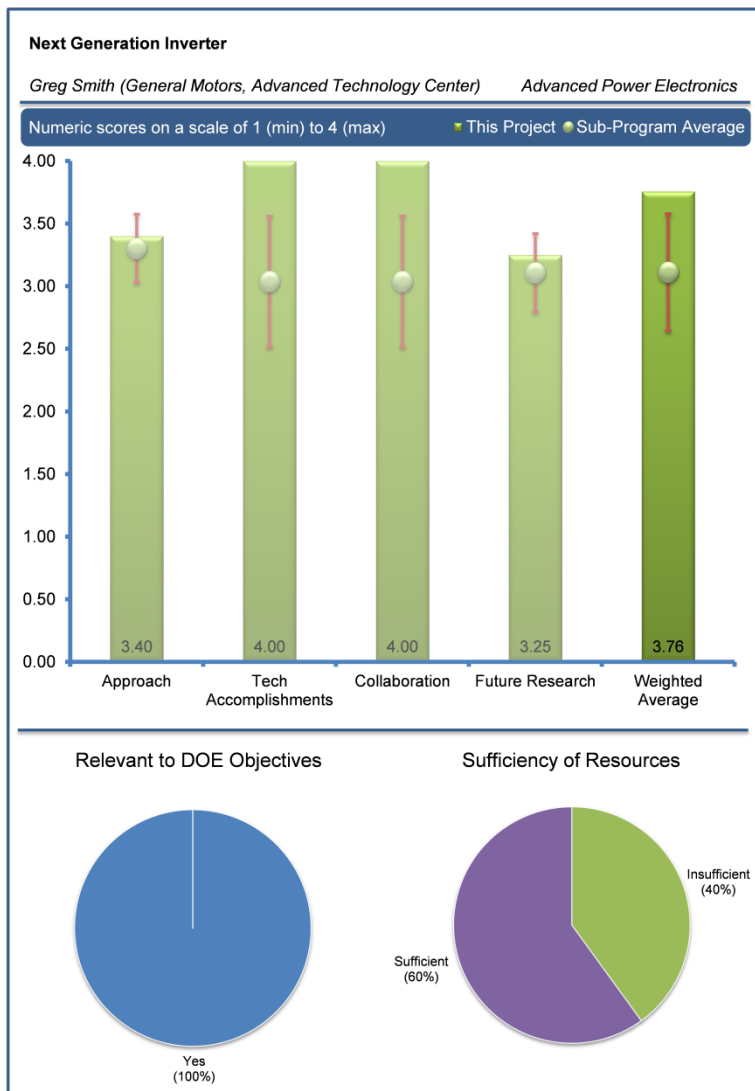
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that the project was working with multiple suppliers and that the focus on low cost was positive as it is a key element for consumer acceptance. Another reviewer agreed, indicating that development of low-cost, high-performance inverters are key to the success of acceptance of electric vehicles. The reviewer stated that this program builds on the foundation of a previous successful inverter development program. Another reviewer noted that the technology is essential for electric and hybrid vehicles, which are critical for reducing petroleum usage. A fourth reviewer commented that this effort is to support electric or hybrid vehicles, which will reduce the dependence on petroleum products. The fifth reviewer stated that this project is directly related to develop next generation low-cost high performance power inverter for HEVs and EVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer noted that the approach to develop a comprehensive understanding of the inverter requirements and flow those down to the sub-component level was good. The reviewer also felt that the involvement of suppliers and General Motors' (GM) questioning of/understanding their cost drivers and impacts on performance/reliability was a very good approach. One reviewer noted that the project is working with a variety of supplies and has a co-development approach. The reviewer noted that the approach has a basis in conventional technology, and is considering modularity, scalability, volume, and mass. Another reviewer noted that GM is potentially one of the largest customers for the power inverters, and that they address the issue from the system level in this project. One reviewer commented that the technical requirements and barriers are extremely well understood and described; however, no specific technologies for overcoming the barriers were described. The reviewer noted that, it is not known if they have identified such technologies and are not describing them for proprietary purposes or if they have not identified promising technologies. The reviewer suspected the former to be the case but could not be sure. One reviewer expressed some concern that GM's desire to spec/develop a universal inverter that is adaptable to all vehicles, etc. is laudable, but may be too large an undertaking and take too much time. The reviewer was concerned that they may end up with something that does not meet the goals.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Several reviewers noted that the project is in its very early stage, with one indicating that it was only 2% complete, and two indicating that it was too early to make an assessment of accomplishments or progress. One reviewer felt that the team has made great progress to address the technical and market challenges. A reviewer noted that the team is considering cost reduction and performance, has a specification developed, has a test plan developed and has started testing, and had key suppliers identified. One reviewer felt that the descriptions of progress were vague, and suspected that this was probably for some of the same reasons the reviewer discussed when making comments on the previous question regarding overcoming of barriers to completion.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Several reviewers noted that the set of partners and suppliers for this project were well selected. One reviewer noted that the project is working with a good set of partners and suppliers. Another reviewer concluded that working with suppliers from multiple tiers, along with ORNL and the National Renewable Energy Laboratory (NREL), as the right thing to do. The third reviewer also noted the involvement of ORNL and NREL, and observed that an extensive group of potential suppliers are involved in the project. This reviewer noted that GM is providing strong leadership and coordination. The final reviewer observed that GM has been working with different vendors to develop the next generation inverter.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the approach seem to be sound; another reviewer agreed, stating that the plan looks good. A third reviewer indicated that GM understands exactly what the customers are looking for in a next generation inverter.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers felt the resources were insufficient. Three reviewers felt that the resources for the project were sufficient. The two reviewers who felt the funding was insufficient commented that GM's contribution to the project of \$10 million is sufficient to supplement the smaller funding provided by DOE.

Air-Cooled Traction Drive Inverter: Madhu Chinthavali (Oak Ridge National Laboratory) – ape042

Reviewer Sample Size

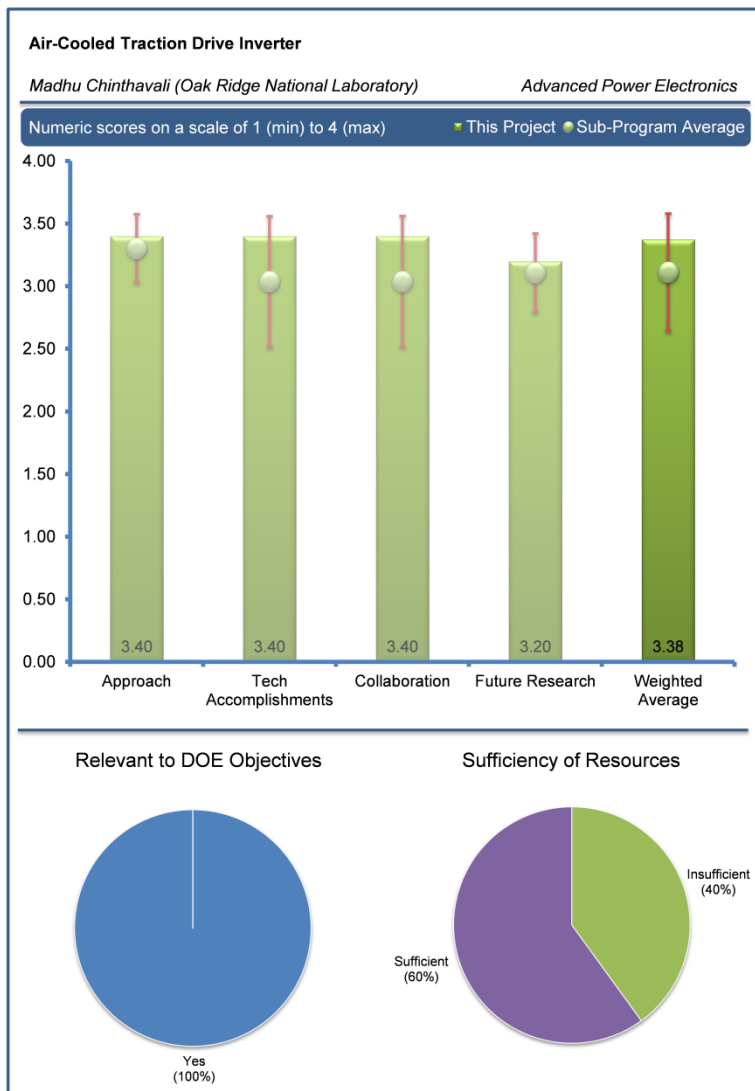
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer commented that air cooled inverter for automotive traction drives is a definite option for future electric vehicles. Another reviewer agreed, indicating that that air cooling has the potential to reduce the cost of the power electronics and the overall system in the vehicle and is thus relevant to the DOE goals. A third reviewer indicated that highly efficient traction drive inverters will directly impact the amount of petroleum being consumed by the vehicle and/or increase range and reduced recharge frequency. The fourth reviewer stated that the project targets VTP 2015 targets which help to enable the market for Electric-Drive Vehicles (EDVs); this, in turn, lowers the United States' dependence on foreign oil. The fifth reviewer noted that the project's work supports innovative design of EV inverters to determine if DOE volume/weight/thermal/cost targets can be met.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the multidisciplinary design approach implementing a practical integrated thermal and electrical prototype, including capacitor issues, is the correct approach. The reviewer really liked what they saw. Another reviewer found that the inverter topologies are innovative. This reviewer asked about the number of discrete devices, whether the Printed Circuit Boards (PCBs) used are conventional or polyimide, and what are the estimated heat transfer coefficients of the finned structures for each case. The reviewer did not see any aspect of the project that looked at thermal cycle testing of the components or the complete inverter. The reviewer felt that this kind of analysis will be crucial for PCBs especially when temperatures of the die approach 250°C and beyond. A third reviewer noted that meeting 2015 VTP targets are being addressed. This reviewer indicated it was not clear what the allowable temp rise is for this inverter using Wide Band Gap (WBG) materials. In particular, the reviewer wanted to know if, for the air cooled inverter the θ_{ja} target can be quantified and what it is based on; the reviewer indicated drive cycle or 55kW for 18 seconds or some other criteria should be explicitly stated. The reviewer indicated that it is also not clear how 50°C ambient air was chosen as the test case in Slide 10 and requested an explanation of the selection process, and how does the selected temperature effects vehicle mounting locations. The reviewer indicated that those assumptions can have an impact on size and weight of the inverter. In addition, the reviewer noted that acquiring high temperature devices was discussed in the presentation but acquiring high temperature passives was not discussed. The fourth reviewer noted that the axial concept accommodates use of an annular capacitor and its low internal inductance/Equivalent Series Resistance (ESR) capabilities and that the capacitor appears



to be cooled by the same air as the Insulated Gate Bipolar Transistors (IGBTs). The reviewer also noted that the rectangular approach is fairly conventional but that details of how the capacitor is cooled were not obvious. The reviewer felt that both designs are strongly focused on the barriers. The fifth reviewer indicated that the approach taken addresses the issues related to designing an air cooled inverter. The reviewer felt that the postponement while waiting for thermal advances was smart but they were not sure why there was a need to look at package inductance unless there are plans to change the design of the package. The reviewer also felt that the other items investigated were appropriate. While the reviewer felt that performing analysis on two different form factors very useful, they felt that there was a need to include impact of connectors on the design as well as where the inverter is located relative to motor. The reviewer noted that if the inverter is connected to the motor with very short leads then the inverter can act as a local heat sink for the motor thermal load which is more heat than is typically assumed for the motor leads from an inverter.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted good progress and that reported data seems reasonable. A second reviewer felt that there were innovative designs compared in a simulated environment. This reviewer would like to have seen the boundary conditions listed for the simulations (thermal). However, according to this reviewer effort appears to be progressing appropriately. One reviewer noted that the results of the thermal modeling for the axial design indicate that the design is not feasible due to the high IGBT junction temperature. Also, the reviewer noted that there was no mention of how effectively it will cool the capacitor. In addition, the reviewer noted that the results of thermal modeling for the rectangular design indicate that it is feasible, but, again, there was no mention of cooling the capacitor. A fourth reviewer noted that the analysis results indicate that it is possible to air cool an inverter based on the conditions stated. The reviewer felt that measurements related to the noise level generated by the blower and the effects of less than clean air being used, such as blockage of the heat exchanger as a function of life, were missing. The reviewer wanted to know where the ambient air temperature comes from. The reviewer was curious to know if transient conditions such as heat soak analyzed. The reviewer believed that this information should not be too hard to get given the quality of the analysis performed to date. One reviewer noted that 2010 simulations look interesting, but would like to know what assumptions being used in 2012 relating to ambient air coming into the power stage. These assumptions could have an impact on the design. The reviewer wonders if the PI can comment on what happens when the inverter goes through the dew point, and would like to know whether are all of the high-voltage/current connections are sealed. The reviewer wonders if the PI can comment on the ratings of the capacitors and other passive components. Furthermore, the reviewer would like to know where the 50°C ambient air comes from, and what happens to the power stage at 85°C. The reviewer inquires if it has been considered what are target noise levels of the power stage and fan, specifically how it was measured and was the current level acceptable. The reviewer would like to know are the new 200 ampere SiC switches packaged in a TOxx package or is it custom. Finally, this reviewer asked whether the packaging can handle the current and temperature cycles.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that the collaboration with NREL for thermal modeling was good, and a second reviewer commented that collaboration with suppliers for parts and NREL for thermal seems sufficient. This reviewer suggests working with the task team to define ambient air conditions in the vehicle as it could be helpful. A third reviewer noted that collaboration between NREL and ORNL to date has been great. This reviewer would like to see additional ambient conditions simulated and some effort made to simulate the fouling of the heat exchangers due to dirt, etc. The fourth reviewer referred to the work division as one of the few projects where the decisions made were intelligent. In particular, one reviewer noted that the decision to delay the ORNL work in fiscal year (FY) 2011 to allow a well-qualified thermal engineering team from NREL to contribute has been reflected in the outcomes. The reviewer remarked engineering that is more than the sum of the collaborators.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers provided mixed feedback and some offered suggestions. One reviewer felt that the plans would advance the knowledge of what needs to be performed to accomplish an air cooled inverter. A second reviewer remarked that plan and milestones for

future work are okay. A third reviewer did not see the intent to focus on the highly relevant thermal cycle reliability evaluation. The reviewer felt that second law thermal analysis should be considered for the modeling/simulation portion of the effort. A fourth reviewer thought that plans were good, but wanted to know why the project was not using the lowest specific on-resistance technology (i.e., smallest SiC area per unit ampere) because lowering losses for a given total semiconductor area is especially important for air cooling. Additionally, the reviewer noted that cost is king with automotive applications and felt that the feasibility is ultimately better served by using the SiC Junction-gate Field Effect Transistor (JFET) than the Metal Oxide Semiconductor Field Effect Transistor (MOSFET). The final reviewer noted that updating simulations and models based on the current concept was a good thing to plan to do. The reviewer indicated that the project team may want to reexamine the ambient environment and test case conditions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two felt that the resources were insufficient, and three reviewers felt that the resources were sufficient. One of the reviewers who felt the resources were insufficient commented that funding for FY 2013 will have to be increased for system build and test phase. Two reviewers who noted resource sufficiency reiterated this in their comments. Another reviewer felt that the resources that the project had relating to design and simulation studies were adequate.

Alnico and Ferrite Hybrid Excitation Electric Machines: John Miller (Oak Ridge National Laboratory) – ape043

Reviewer Sample Size

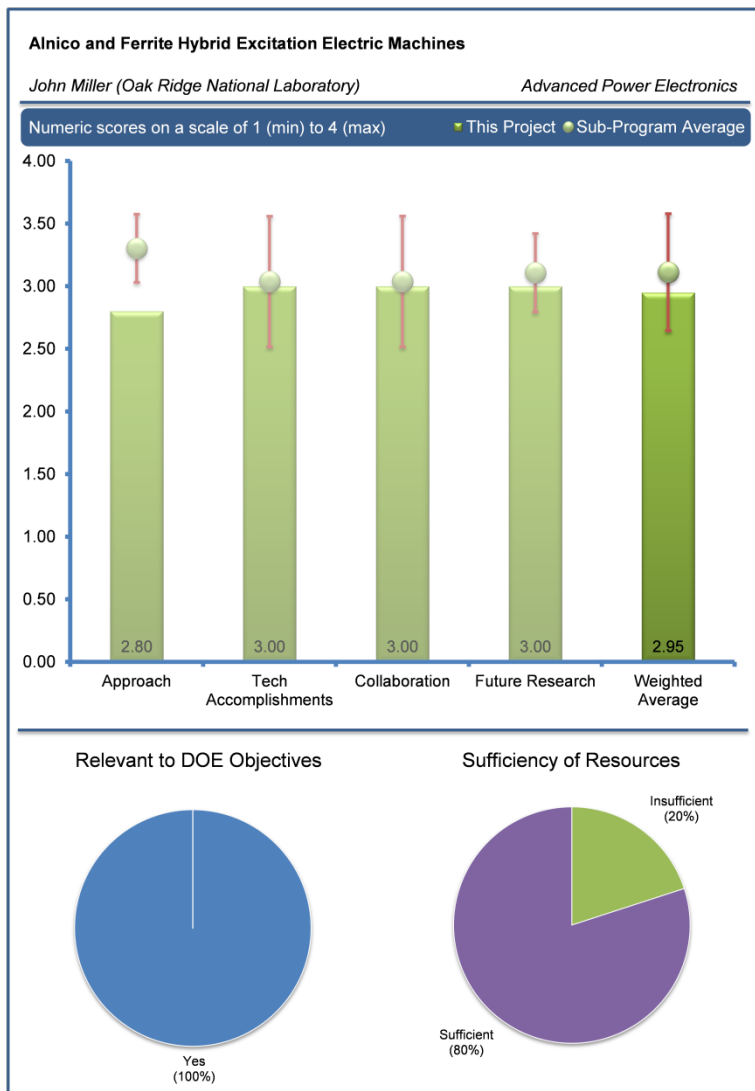
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers indicated that this project would either reduce the dependence on petroleum or facilitate adoption of HEVs and EVs. One reviewer commented that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare earth magnet materials. The reviewer felt that, if successful, these new motor concepts would result in cost savings for electric drive systems. Another reviewer concurred, stating the elimination of rare earth elements from magnets would provide the high efficiency of Interior Permanent Magnet (IPM) motors at lower cost and in sustainable supply. The third reviewer indicated that motors and generators without using rare earth magnets would potentially reduce cost for electrical machines, which will in turn reduce the dependence on petroleum. A fourth reviewer stated that out-of-the-box thinking with regard to rare earth elimination is appropriate and supports vehicle electrification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that the project is in its early stage. Another reviewer indicated that there was good evaluation of flux switching machines. The reviewer was unclear on the reason for the dismissal of the transverse flux machine simply because of 3-dimensional flux path and use of SMC. The third reviewer stated that the main goal of the project is now the development of novel flux switching electric machines without the use of rare earth magnets. The initial broader range of the machine types to be investigated in the project has now been focused, which the reviewer felt was generally a good approach. The reviewer cautioned that, the flux switching machine topology may not be the right choice at this point in time as this machine topology is known for its relatively low magnetic utilization. Additionally, the reviewer noted that the research in the area of high speed machines requires an evaluation of the complete drive system including gear box and inverter. Overall the reviewer indicated that the approach is generally well designed and some of the technical barriers are identified. The milestones are also well defined and the manufacturing of prototype machines is coupled to go/no-go decisions based on simulation results. The fourth reviewer stated that the use of different magnet technologies inside the motor, taking advantage of their respective strengths, is worth a close look. The reviewer felt that high speed gearing and transmissions are challenging, and the reviewer cautioned the project team not to develop such a high speed motor concept without engaging a gearing/transmission resource.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed comments on technical accomplishments. One reviewer felt that the presenter provided a good explanation for why flux switching machines are not a competitive solution. Another reviewer commented that the technical accomplishments are acceptable so far and the progress in overcoming the identified barriers is adequate for the current status of this new project. Additionally, the reviewer noted that the transverse flux machine has been dismissed as a candidate but the described reasons are very vague and based on subjective evaluations of the work of others. The reviewer continued that the same can be said for the selection of the flux switching topology as candidate, which seemed to also be a subjective decision to the reviewer at this point in time and not really based on comparative simulation results to other machine types. The researchers claim that initial simulation results for the flux switching machine are promising but the presented information did not allow an evaluation of this statement. The third reviewer noted that the progress is difficult to gauge at this point, since this is a new program and the flux switching machine architecture has not been disclosed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that the partnerships appear to be appropriate. Another reviewer noted that the collaborations with several divisions within ORNL and other national labs are set up. The reviewer felt that the collaboration with Ames Lab and their work on AlNiCo magnets is a very good choice. Additionally, the reviewer indicated that it would be beneficial if collaboration with an electric machine OEM could be established in order to provide guidance for the project about what is of interest for the industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer indicated that the milestones in the project are generally well defined. Another reviewer noted that if this program continues, the approach of year one modeling, year two proof-of-concept, and year three refinements is a good formula. Another reviewer was in agreement with the presenter that existing non-rare earth magnet materials are unlikely to provide solution, and that project should be merged with efforts to enhance magnetic materials. A reviewer indicated that the initial machine design with currently available magnet and lamination materials will be refined if better materials like AlNiCo with higher coercivity become available, which is a good plan. The reviewer cautioned that in case that the simulation shows that the flux switching machine concept cannot reach the goal of at least 80% of the performance of a conventional IPM machine, the researchers should set up a plan B, e.g., investigate other machine topologies. The reviewer encouraged the team to include an alternate course of action in the future plans.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt the resources were insufficient. Four reviewers felt the resources were sufficient. One reviewer commented that the suggested combination with another project by the principal investigator would require a reevaluation of the resource allocation if it occurred.

Unique Lanthanide-Free Motor Construction: Jon Lutz (UQM Technologies, Inc.) – ape044

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

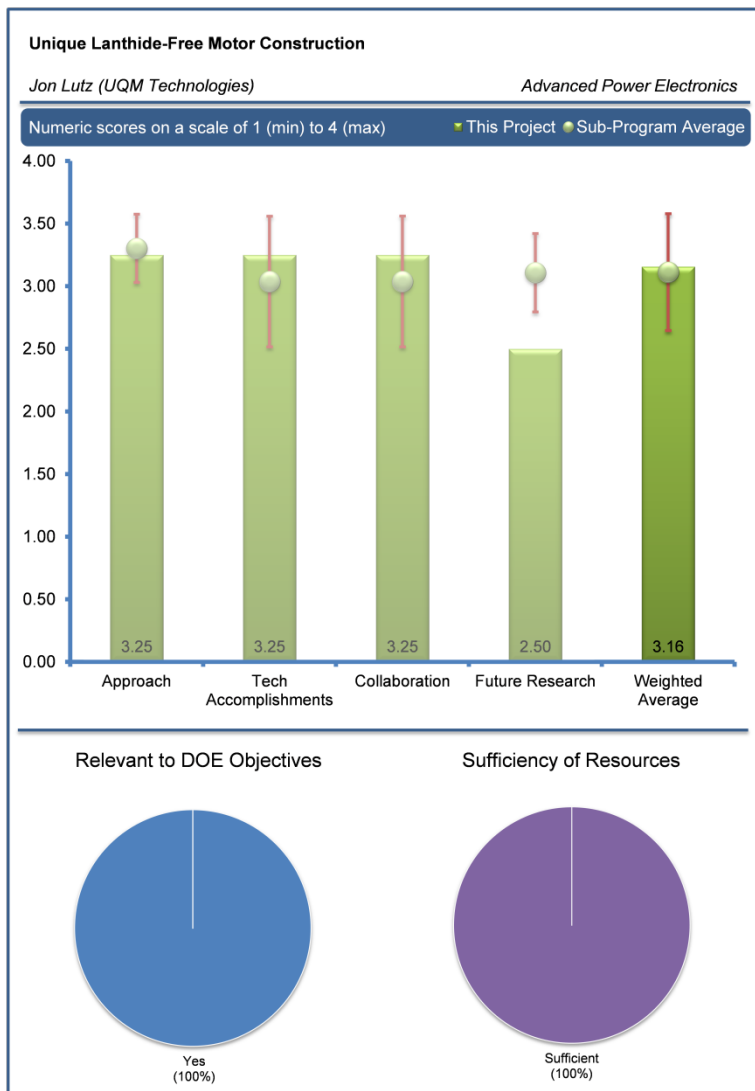
One reviewer commented that the project supports the objective of petroleum displacement by developing a new motor concept without the use of expensive rare earth magnet materials. The reviewer noted that, if successful, these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer commented that elimination of rare earth elements from magnets would provide the high efficiency of permanent magnet motors at lower cost and in sustainable supply. These all facilitate market adoption of HEVs and EVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that the main goal of the project is the development of a new electric machine concept with AlNiCo magnets instead of rare earth magnets. The reviewer felt that the researchers have specific ideas from the very beginning of the project of how to solve the known issues with AlNiCo magnets in electric machines, which is rare because many projects an initial study phase is needed to determine what the actual scope of the work should be. This reviewer felt that the overall approach is generally well designed and the technical barriers are identified. The reviewer also felt that the milestones are well defined and the manufacturing of prototype machines is coupled to go/no-go decisions based on simulation results. Another reviewer felt that not much detail was given on approach, so the reviewer is giving the project team the benefit of the doubt. The reviewer noted that the premise of increasing the permeance coefficient and reducing the demagnetizing field is sound, as is pursuing enhanced coercivity AlNiCo magnets.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the technical accomplishments were good considering that this is a new project. The reviewer noted that the requirements for the machine design have been defined and the collaboration with Ames Lab for the development of improved AlNiCo magnets is set-up, and initial finite element analysis simulations have been conducted and the results are claimed to be promising. The reviewer lamented that the researchers can not reveal any details about the new machine concept at this point in time as patent applications are pending. The reviewer found this acceptable because the project is in an early stage. Another reviewer found it difficult to judge the projects accomplishments without more detail. The reviewer noted that the structural integrity of the rotor will probably require sleeving, which will, if nonmagnetic, increase magnetic air gap and decrease the permeance coefficient, or, if magnetic, increase iron loss.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers noted good collaboration, especially with national labs. One reviewer commented that the use of national labs for support on thermal management and magnet material improvement was good. Another reviewer noted that collaborations with several national labs are set up. The reviewer felt that the collaboration with Ames Lab and their work on AlNiCo magnets is an excellent choice. The reviewer also felt that the other collaborations with NREL and ORNL will support the progress of the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the milestones in the project are well defined for FY 2012 progress and the barriers are identified as good as possible. The reviewer continued, stating that a milestone review in June 2012 with a go/no-go decision will determine the concepts potential based on simulation. The reviewer felt that the initial machine design with currently available AlNiCo magnet materials could be refined if AlNiCo with higher coercivity becomes available, which is based on the results in other projects. One reviewer suggested adding structural analysis for the rotor.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt the resources for the project were sufficient. One reviewer remarked that the project has sufficient resources for the defined tasks.

Alternative High-Performance Motors with Non-Rare Earth Materials: Ayman El-Refaie (General Electric Global) – ape045

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare earth magnet materials. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer commented that the objective was very attractive but that the program was ambitious. A third reviewer stated that the elimination of rare earth magnets would provide a significantly lower cost motor, and therefore facilitate market adoption of HEVs and EVs. A fourth reviewer indicated that the project supports DOE objectives by reducing the cost and supply chain risk for motors, which can be used in electrical or hybrid vehicles.

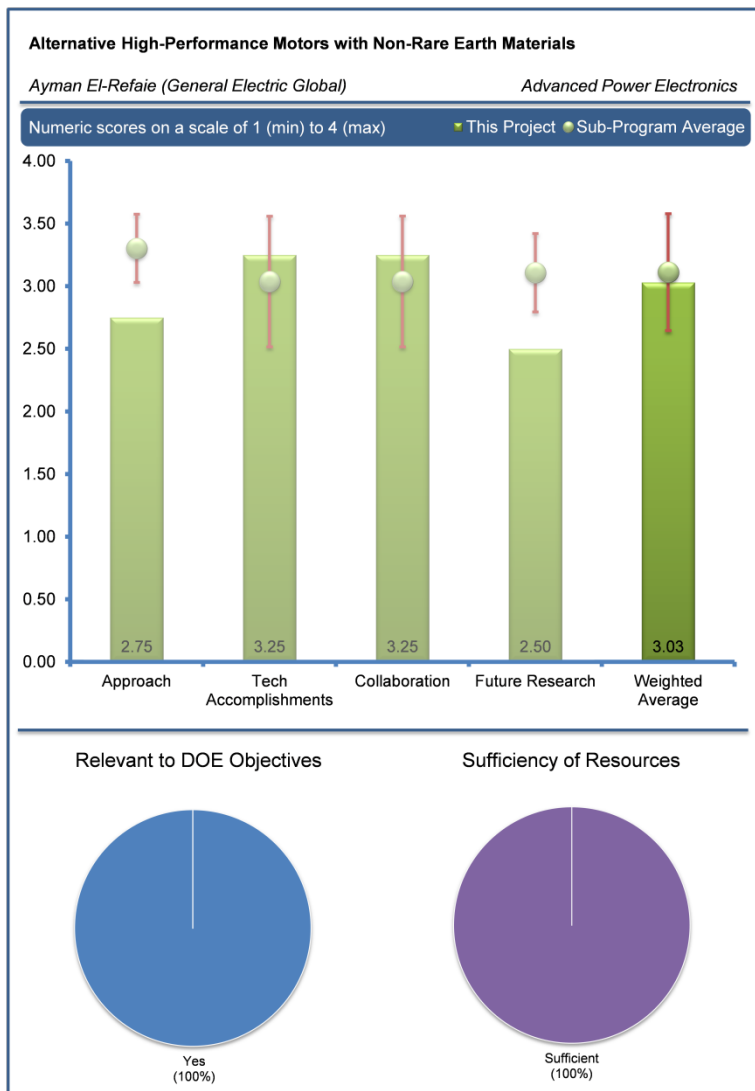
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that the main goal of the project is the development of new electric machine concepts with non-rare-earth magnets or with no magnets at all. The approach is to investigate ten different motor topologies and to identify promising new materials. The reviewer noted that, even though the researchers surely have a project plan, there is absolutely no information provided about the ten topologies or materials at this point in time. The reviewer felt that this makes it basically impossible to evaluate the approach at this point in time. Another reviewer noted that the description of the approach was pretty generic, but it makes sense to evaluate multiple topologies and also improve basic building block materials at the same time.

The approach is to investigate ten different motor topologies and to identify promising new materials. The reviewer noted that, even though the researchers surely have a project plan, there is absolutely no information provided about the ten topologies or materials at this point in time. The reviewer felt that this makes it basically impossible to evaluate the approach at this point in time. Another reviewer noted that the description of the approach was pretty generic, but it makes sense to evaluate multiple topologies and also improve basic building block materials at the same time.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that there was not enough detail given to evaluate the project. The reviewer stated that it seemed like a long delay to get legal contracts signed with collaborators, noting that it was now seven months after the project award date, and only two contracts were about to be signed. Another reviewer noted that it was basically impossible to evaluate the accomplishments and the progress at this point in time. The reviewer cited that the principal investigator stated that the selection of the ten motor topologies has been finalized and the initial design work on some of the topologies has started but there are no details provided about the motor topologies or preliminary results. The reviewer also noted that the selection of promising materials for development in this project contained a similar lack of details or preliminary results.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that the combination of collaborators was great, but that lack of legal contracts has prevented collaboration so far. Another reviewer noted that a number of collaborations with universities are set up for the motor development. The reviewer felt that, in particular, the collaboration with Ames Lab and Arnold Magnetics and their work on alternative magnet materials is a good choice. The reviewer did indicate that the project team must insure that the design of different motor topologies at different universities is well coordinated in order to facilitate an apples-to-apples comparison of the results. The reviewer also noted that all modeling assumptions have to be the same for all of the different motor designs.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the milestone and future plan definition is relatively vague at this point in time. The reviewer understands that the project is in a very early stage; nevertheless, the reviewer felt that the definition of milestones and future plans could be more detailed even with only a small amount of data or information available at this point in time. Another reviewer indicated that it was difficult to judge the proposed future research since the approach is very generic.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers indicated that the resources were sufficient. One reviewer noted that it was difficult to evaluate this point as no details about the project content were revealed.

Smart Integrated Power Module: Leon Tolbert (Oak Ridge National Laboratory) – ape046

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer noted that the final goal is to produce a 55 kW inverter phase leg modules that can work at high temperatures and meet 2020 targets of 14 kW/l, 14 kW/kg, and 2015 targets of 5\$/kW, and 98% efficiency. The reviewer felt that meeting the VTP targets helps to enable the market for EDVs which reduce our dependence on foreign oil. Another reviewer commented that this work supports the development of a power module with integrated gate drive and current sensing for incorporation in an EV inverter system to reduce size, weight and possibly cost of the invert while potentially improving the reliability. A third reviewer felt that this is an important area of work because it is necessary to increase integration and the use of WBG devices.

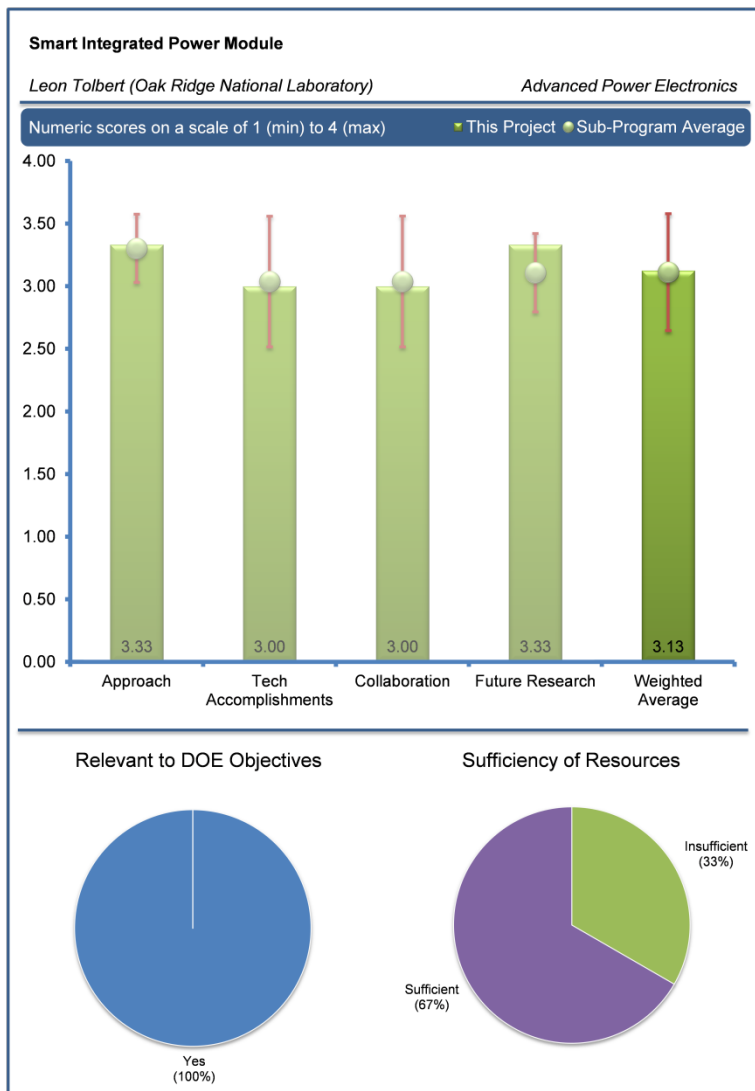
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented that this project has several parallel objectives, all of which are important and seem to be well coordinated and complementary. The reviewer cautioned that integrating all of the developments together in one module will be a considerable challenge. Another reviewer felt that, by up integrating more functions into the IPM, cost size and weight will be reduced and WBG materials are proposed to address the high temperature capability. The reviewer noted that the details of how using WBG materials will reduce cost needs to be documented.

The reviewer noted that the details of how using WBG materials will reduce cost needs to be documented.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that progress on the current measurement activity and gate drive activity appear to be okay and roughly on schedule but no mention was made about the temperature measurement progress or the high temperature packaging portions of the program. Another reviewer indicated that the development of the current and temperature sensor Application Specific Integrated Circuit (ASIC) could have wider applications for other power electronics applications. The reviewer felt that a comparison of accuracy and repeatability over temperature when properly shielded, of the hall sensor versus the traditional LEM sensor would be helpful. Also, the reviewer felt that packaging this part as a Small Outline Integrated Circuit (SOIC) for circuit board applications and evaluation would also be helpful. The reviewer commented that buffer and isolation circuits that work at higher temperature are a challenge and wanted to know the temperature rating the project team is targeting for the module.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer suggested that the team may want to consider collaboration with industrial power module suppliers, gate driver suppliers or current measurement probe suppliers. Another reviewer felt that finding a partner to assess and or commercialize this ASIC could be useful.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the program plans and milestones appear adequate. The reviewer noted that the primary focus is currently on gate driver and current measurement tasks. Another reviewer noted that although this is a new project it is evolving previous work. The reviewer felt that the cost tradeoffs of using WBG materials needed to be addressed in the future.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer indicated the resources were insufficient. Two reviewers indicated the resources were sufficient. One reviewer noted that finding a partner to assess and or commercialize this ASIC could be useful as part of the ASIC development.

Integrated Module Heat Exchanger: Kevin Bennion (National Renewable Energy Laboratory) – ape047

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers agreed that the project meets DOE objectives. One reviewer commented that increased heat dissipation is necessary to reduce power semiconductor cost, weight, and volume. Reducing cost, weight and increasing performance helps to meet the DOE VTP 2015 and 2020 targets. Additionally, this lower cost helps to enable the market for EDVs which reduces our dependence on foreign oil. Another reviewer indicated that the approach of solving the thermal issue at the power module is a good approach as it has the potential to have the biggest impact on cost and size of the unit. The reviewer felt that this is directly applicable to the DOE goals.

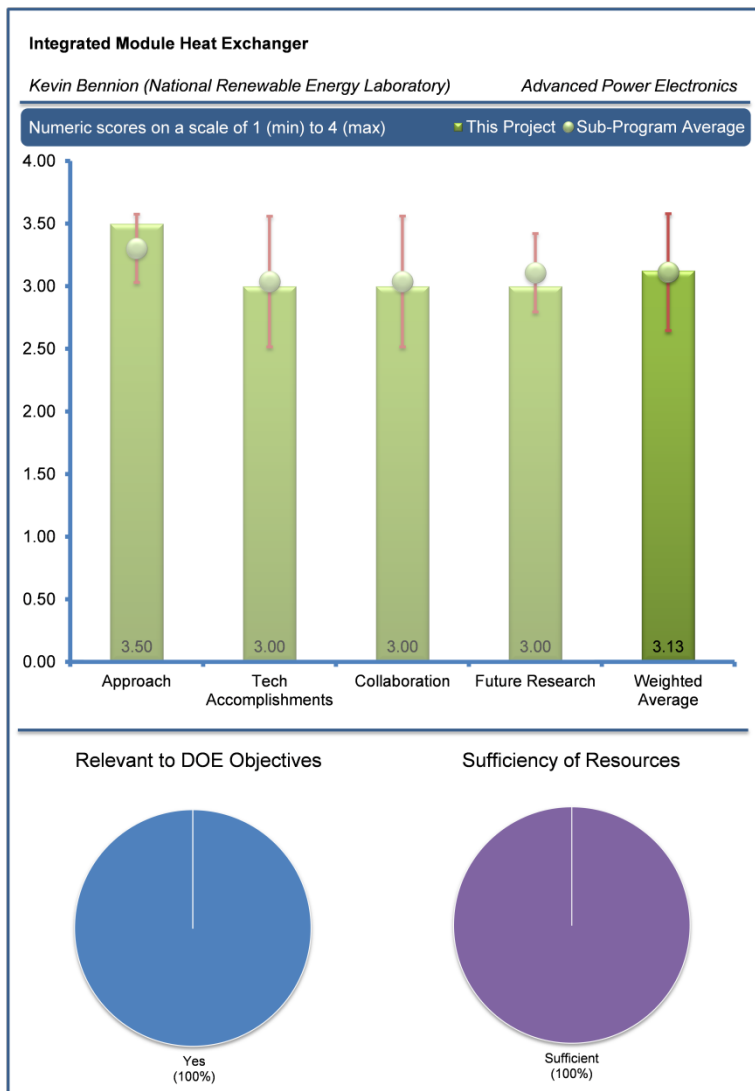
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers provided suggestions on the approach. The first reviewer commented that the approach is logical and following a documented path that provides insight into the path to the expected results. The reviewer noted

that the decision points are identified which will enable discussion on the results to be clarified based on the path taken, the performance is compared to today's standard design along with the different approaches taken and the strategy used to select the design. The reviewer did take time to indicate that the use of device simulator (heater) is good but care needs to be taken to duplicate the thermal density of a power module. Another reviewer felt that the approach was excellent, but did not understand why the project team was stopping at doubling heat flux improvement. The reviewer suggested that another project may be needed to determine what the maximum heat flux capabilities of the die and its package. The suggested new project could focus on a thermal system and package that is capable of 100% die utilization. A simple example of this idea is a die soldered to a substrate that is attached to a heat rail using a thermal interface material that is capable of 100W of heat dissipation. Next, make the same die and attach to two heat rails, one on top of the die and one on the bottom of the die using the same bonding materials. This dual cooled system is capable of approximately 200W of heat dissipation. If you continue this example out with more aggressive cooling strategies, the reviewer felt it was important to ask if you get to the point that the die, not the thermal system, needs improvement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the results of the modeled approaches look promising. The reviewer liked that cost was a potentially deciding factor in the project. The reviewer felt that the iterative approach was also very good and was supportive of a project that



makes decisions based on results. Finally, the reviewer felt that the approach in developing the model was very good. Another reviewer noted that the presented results look encouraging but the details are under patent review and not presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that the information flow between team members looked good as well as the plan to get an industry partner for module work. The second reviewer commented that it might be possible for the project team to find a partner in the semiconductor area or the national labs that could help answer the die utilization question.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the plans appear relevant to expected results. The reviewer indicated a need to review results to verify that the appropriate path is selected. The reviewer cautioned that the approach may be driven by selected industry partner if the project team is not careful. Another reviewer indicated that the proposed future work is consistent with the current work that is ongoing but reiterated that, since it is under patent review, it is difficult to understand the details.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers felt that the resources were sufficient. One reviewer commented that adding resources to answer the die utilization question might be helpful. The second reviewer noted that the results indicate that the team has the appropriate resources.

US Electric Drive Manufacturing Center: Judith Giesecking (General Motors) – arravt021

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers agreed that the project meets DOE objectives. One reviewer indicated that this project establishes a manufacturing facility for traction motors for both hybrid as well as pure electrical vehicles in the United States. The reviewer felt that this will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer noted that the project involves construction of a facility to manufacture motors for electric and hybrid vehicles, which will use much less gasoline than conventional internal combustion engine vehicles. The third reviewer stated that the project provides motor manufacturing capacity to enable economies-of-scale price reductions for EVs and HEVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented that the phased approach to establish the plant was good. Another reviewer noted that the quality of the approach is reflected in the record of progress as documented in the following question. Another reviewer noted that the project had manufacturing flexibility through use of robotics, induction and permanent magnet rotor flexibility, and potential for capacity expansion.

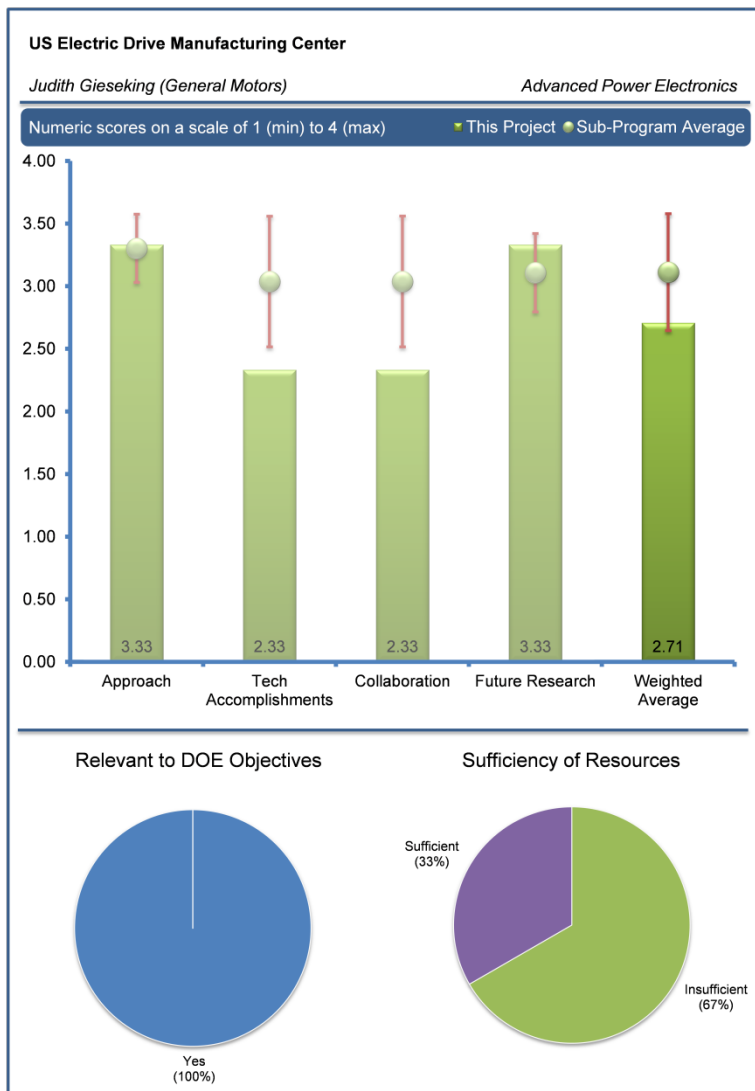
Another reviewer noted that the project had manufacturing flexibility through use of robotics, induction and permanent magnet rotor flexibility, and potential for capacity expansion.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers indicated that the project is on schedule. The first reviewer noted that the project passed product and process development criteria on time. A second reviewer observed good progress according to plan and production is expected as scheduled. A third reviewer indicated that the project is on schedule, and it employs more than 200 people.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented that an award was only given to GM. A second reviewer noted that the collaboration was limited, basically only including suppliers. Another reviewer noted that the only collaboration was with DOE, but that this was appropriate for the project. The reviewer did not feel other collaboration was required.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the manufacturing plans have been made and explained thoroughly. Another reviewer indicated that the plan to finish the plant on time was good.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers felt that the resources for the project were insufficient. One reviewer felt the resources for the project were sufficient. One reviewer noted that despite the insufficient resources, the project is on schedule.

Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles: Greg Grant (Delphi Automotive Systems, LLC) – arravt022

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that the project is focusing on technology that will reduce the overall cost of EDVs and create U.S. jobs. Another reviewer indicated that the project involves construction of a facility for manufacturing power electronics for EVs and HEVs, which use much less gasoline than conventional internal combustion engine vehicles. A third reviewer stated that the project promotes EV and HEV economies-of-scale, and therefore market adoption. The reviewer indicated that there is a broad range of vehicle and industrial applications as well for the inverter.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

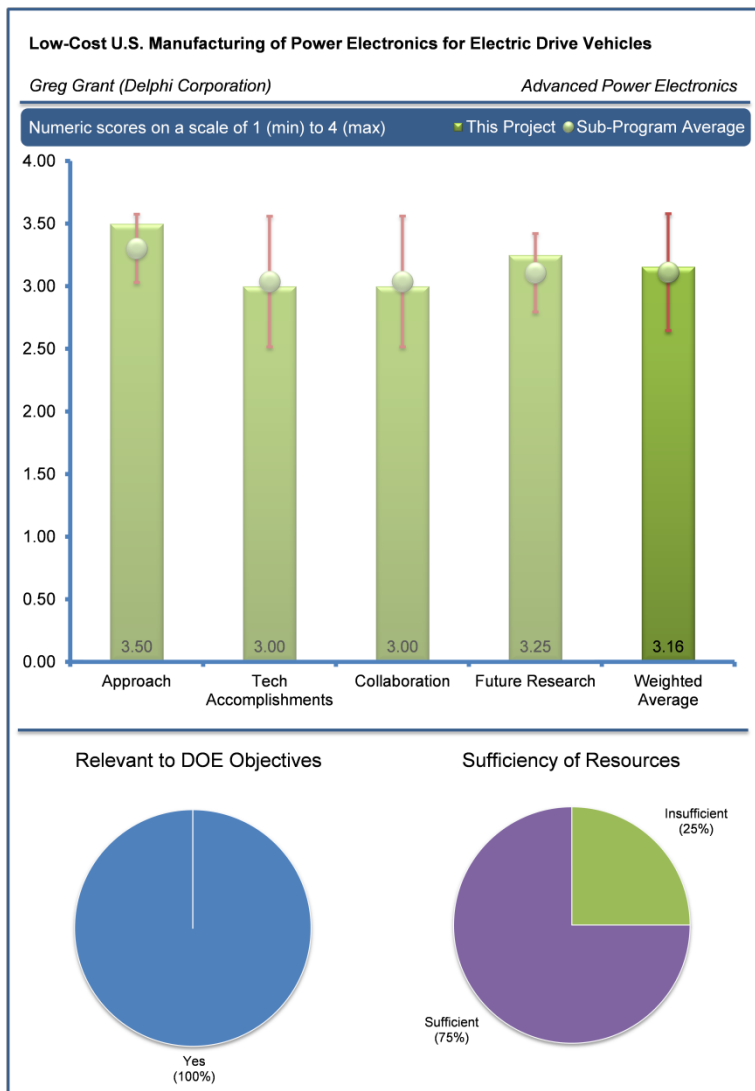
One reviewer noted that the project is leveraging the depth and breadth of Delphi resources and experience in automotive technology. The reviewer felt that this was a good use of supplier and customer strengths. Another reviewer commented that the suitability of the approach is reflected in the quality of the results. A third reviewer noted that the project is addressing needs on a component basis first, then system level. The reviewer felt that that the project team was leveraging supplier strengths, and taking a modular building-block approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three reviewers noted that the project was on schedule, with one reviewer remarking on target to date, a second commenting that the project is on schedule, and a third noting that the project is on track with design validation testing. One reviewer felt that there was a lack of development of technical talent necessary for desired growth.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed collaboration. One reviewer noted that the project has a good mix of OEM customers, suppliers and government. Another reviewer indicated that Delphi has in place the customer base, strategic partnerships, and supplier foundation necessary to achieve the goals of this project. A third reviewer noted that the project was leveraging a large supplier base.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers commented that the future plans are good, with one reviewer finding that there like a good plan moving forward, and a second reviewer commenting that future plans are well formed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt the resources were insufficient. Three reviewers felt that the resources were sufficient. One reviewer noted that the project had the right mix of resources. Another reviewer commented that the project is on schedule.

Electric Drive Component Manufacturing Facilities: Richard Thies (Allison Transmission, Inc.) – arravt023

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that this project establishes a manufacturing facility for electric drive trains for large trucks as well as buses and delivery trucks in the United States. This reviewer felt that the project will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer noted that the project involves converting a building to make it suitable for manufacturing powertrains for hybrid trucks, which use less diesel fuel than conventional trucks. The third reviewer responded with a hybrid powertrain that has widespread applicability in commercial vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented that the approach to establishing the plant was good. Another reviewer indicated that the adequacy of the approach is reflected in the progress and success of the project. The third reviewer noted that the project demonstrated high sense

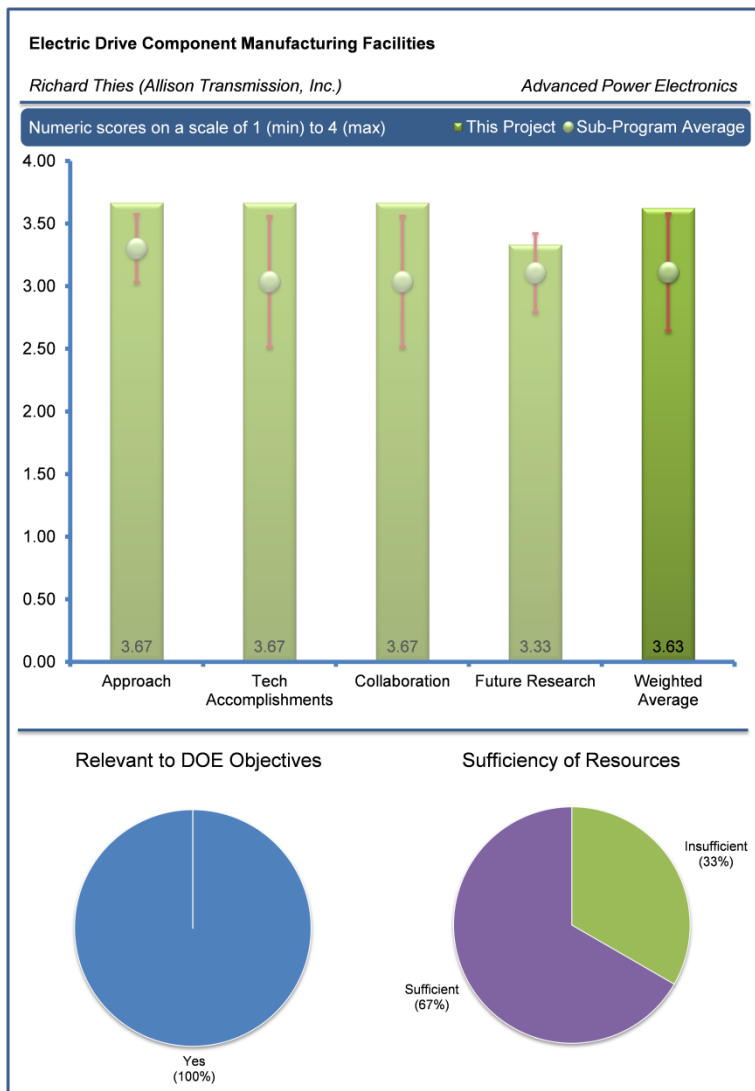
of urgency upfront in overcoming technical problems and it is now reaping the benefits of that, with relatively few quality or durability problems with system. The reviewer indicated that the design was built on established automatic transmission platform with wide acceptance in industry.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that all desired accomplishments have been realized. Another reviewer agreed indicating that there was good progress according to the plan and production was expected as scheduled. The third reviewer felt that the project was on track with timing and that there were no substantial quality or durability problems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer indicated that the battery and inverter were from Delphi and that the motor was from Remy. Another reviewer also highlighted these collaborations in addition to collaborations with potential customers. The third reviewer also noted that the project was leveraging inverter and motor manufacturer expertise.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan to finish the plant on time was good. Another reviewer indicated that the future activities have been established.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt the project resources were insufficient, and two reviewers felt that the project resources were sufficient. One reviewer observed sufficient resources. Another reviewer noted the project was on schedule.

U.S. Based HEV and PHEV Transaxle Program: Kevin Poet (Ford Motor Company) – arravt024

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that this project establishes a manufacturing facility for transaxles for both HEVs as well as PHEVs in the United States. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer felt that the project was pushing the technology envelope of HEV and PHEV. A third reviewer noted that the project provides economies-of-scale to reduce the cost of a hybrid powertrain.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the phased approach to establishing the plant was good. Another reviewer noted that the project based the manufacturing line on a dual path with conventional and hybrid transmission concept, utilizing 70% common manufacturing processes for the two products. The reviewer feels that this allows the manufacturing to flex with the market demand.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the project completed product validation on time. Another reviewer indicated that the progress according to plan was good and production was expected as scheduled.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

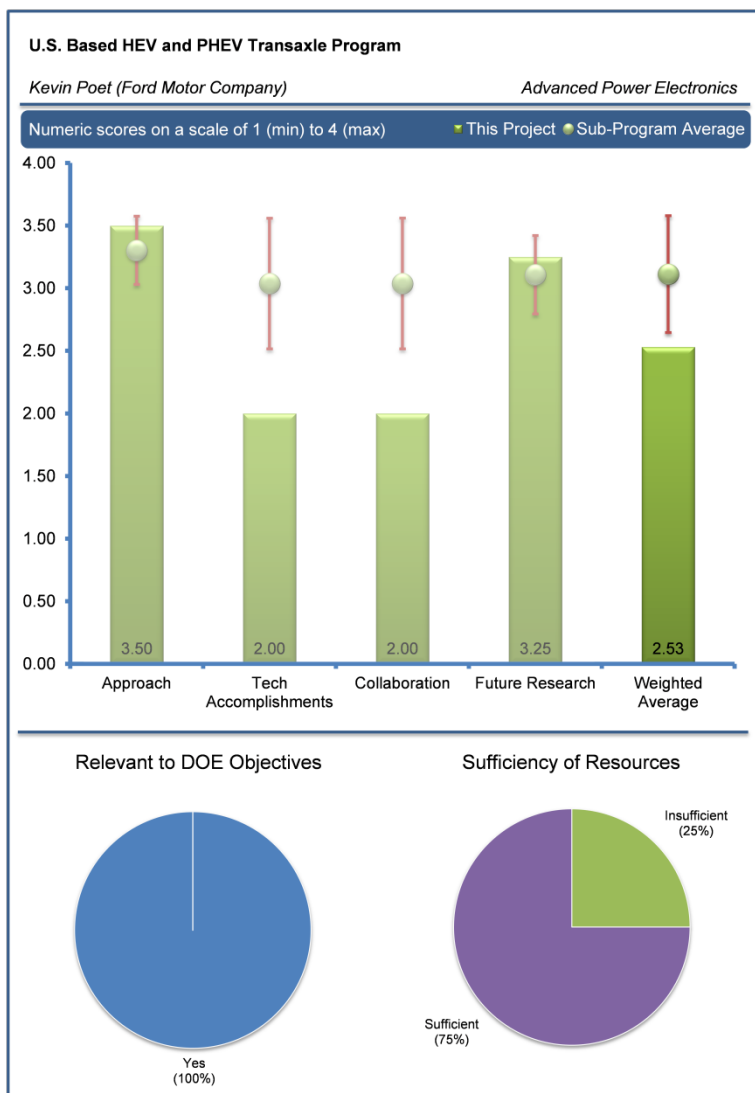
One reviewer felt that the project leveraged supplier expertise well. Another reviewer noted that an award was only given to Ford Motor Company. One reviewer wanted to see more formal partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers felt the plan was good. One reviewer noted that the only item left to complete the project was a complete run-at-rate.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer indicated that the resources were insufficient. Three reviewers indicated that the resources were sufficient.



Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles: JJ Shives (Remy, Inc.) – arravt025

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

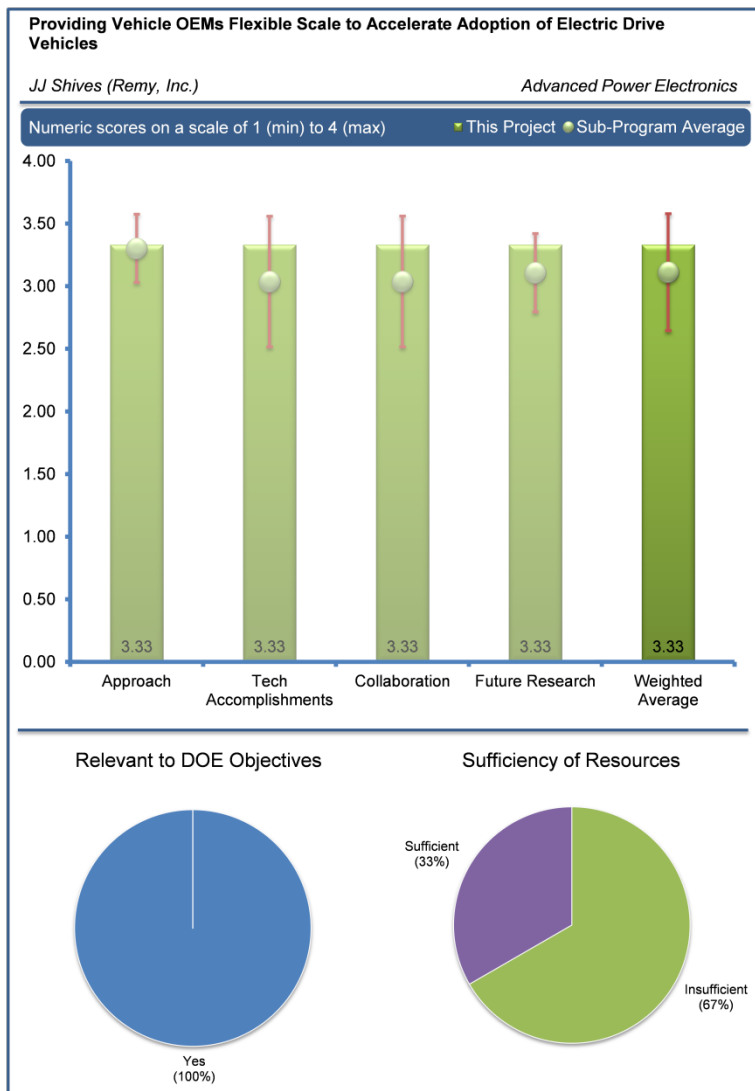
Reviewers found that the project supports DOE objectives. A reviewer commented that the project supports the objective of petroleum displacement by developing a standardized platform for the production of lower cost electric motors and inverters. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer noted that this project establishes a manufacturing facility for traction motors and drives. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. The third reviewer stated that the project involves refurbishing some existing properties to enable manufacturing components for EVs and HEVs, which use less petroleum fuel than conventional vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated that this was a good phased approach to establish the plant. Another reviewer agreed, stating that the approach had resulted in successfully meeting project goals. The third reviewer observed that the inverter products are based on existing designs and processes which should ensure the technical feasibility. In a first phase existing facilities are refurbished for initial production volumes while a second phase includes the addition of production capacity for high volume production. Moreover, the approach focuses on the abilities to deliver a commercial ready product and to accurately estimate the manufacturing costs. Finally, the development of recycling processes will be based on experience with recycling of conventional low voltage automotive motors and generators.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that all of the desired accomplishments have been realized. Another reviewer commented that there was good progress according to the plan and production was expected as scheduled. The third reviewer noted that the technical accomplishments are very good for the first phase of the project, which is the implementation of the initial smaller volume production environment. Two motor designs with different diameter and thus output power and torque are ready for production. The reviewer felt that scalability is ensured with possible variation in motor length, cooling technology and winding patterns. Validation of the motors and performance and durability testing is claimed to be complete. Two different inverter sample hardware will be released for production in August and October 2012.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers noted the collaboration with Phoenix International. One reviewer felt that the collaboration with Phoenix Electronics was good. Another reviewer noted this collaboration, commenting that, for the development and production of the inverters, collaboration was set up with Phoenix International, a division of John Deere. The reviewer felt that the project must ensure that the overall system optimization of inverter and motor together has a high priority in the collaboration. The third reviewer indicated that Remy has collaborated with Phoenix International as a sub-awardee to this grant and that the inverters will be developed and produced by Phoenix in Fargo, North Dakota.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan to finish the plant on time was good. Another reviewer agreed, noting that the future activities have been well defined. The third reviewer indicated that the milestones in the project are well defined for FY 2012 and FY 2013, which are the start of production at the Phase 1 facility and the selection of a Phase 2 site for production based on the estimated market demand. A milestone review in June 2012 with a go/no-go decision will determine the estimated production capacity increase for the Phase 2.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers felt the resources were insufficient. One reviewer felt that the resources were sufficient. One reviewer remarked that the project was on schedule, and a second reviewer commented that the project has sufficient resources.

Electric Drive Component Manufacturing Facilities: Luke Bokas (UQM Technologies, Inc.) – arravt026

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that the project supports the objective of petroleum displacement by making manufacturing investments for the production of lower cost electric motors and inverters. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer noted that this project establishes a manufacturing facility for traction motors and drives. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. The third reviewer indicated that the project provides capacity for economies-of-scale production of EV powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that the project has a good phased approach to establish the plant. Another reviewer felt that the overall approach and the milestones are both well defined. The reviewer indicated that the new motor

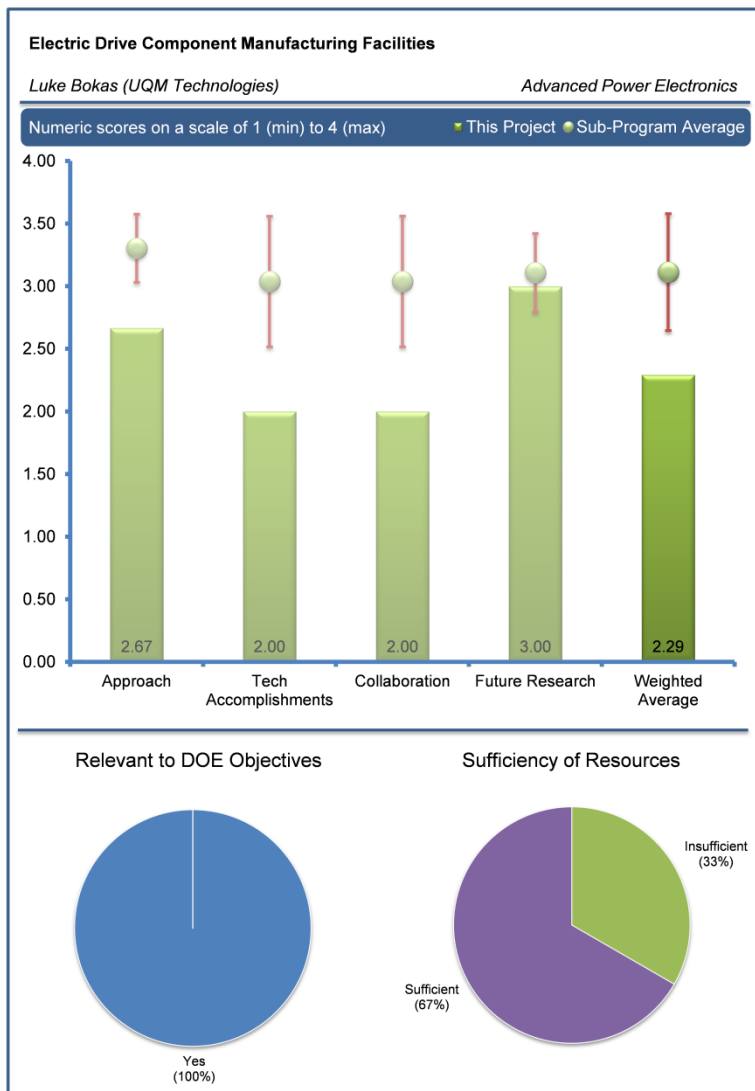
and inverter products are based on existing designs and the principles of design for manufacturing and design for assembly are applied. In addition, manufacturing facilities for initial production volumes have been created and suppliers for key components have been established. The third reviewer noted that there was not much detail in the poster regarding technical barriers, but that there was no presenter at the poster to explain these to the reviewer.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that the progress according to the plan was good and that production was expected as scheduled. Two reviewers noted that the project had completed the Production Part Approval Process (PPAP) of automotive (100 kW) motor and controller. The second of these reviewers indicated that the technical accomplishments are very good for the first phase of the project which is the implementation of the production lines for motor and inverter for the initial volume. The reviewer also noted that the initial production work on a higher power system with 220kW has been started, that the automotive production system is complete, and the products are supplied to customers.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that UQM established the production of the motor and inverter without the collaboration with another company which is generally a good approach because this should ensure that the overall system optimization of inverter and motor



together for both design and production has a high priority. The reviewer noted that that multiple suppliers for key components have been established. Another reviewer noted that the award was only given to UQM.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the plan to finish the plant on time was good. Another reviewer indicated that the project ends in FY 2012 with the production line for the automotive product in place and the completion of the implementation of the production line for the truck/bus system. A milestone review in June 2012 with a go/no-go decision will determine if enough customer interest supports the investment for the truck/bus system production.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that the resources were insufficient. Two reviewers felt that the resources were sufficient. One of the reviewers noted that the resources for the project were not mentioned in the project, and the reviewer assumed that they were sufficient.

**Electric Drive Component Manufacturing:
Magna E-Car Systems of America, Inc.:
Brian Peaslee (Magna E-Car Systems of
America, Inc.) – arravt027**

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that any petroleum displacement will include using hybrid components as part of the drive train. Those components will also require control modules, software, and calibrations. This project enhances industry readiness to produce those components and controls. A second reviewer commented that the project provides economies-of-scale for EV power plant and supporting electronics modules.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated that the project takes a system wide approach, developing not only components, but the controllers, and includes integrating the hybrid system into a vehicle. The reviewer felt that the system level approach allows appropriate levels of optimization to occur. Another reviewer commented that there was no clear sign of development of the technical talent necessary to support an expansion of the product market.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

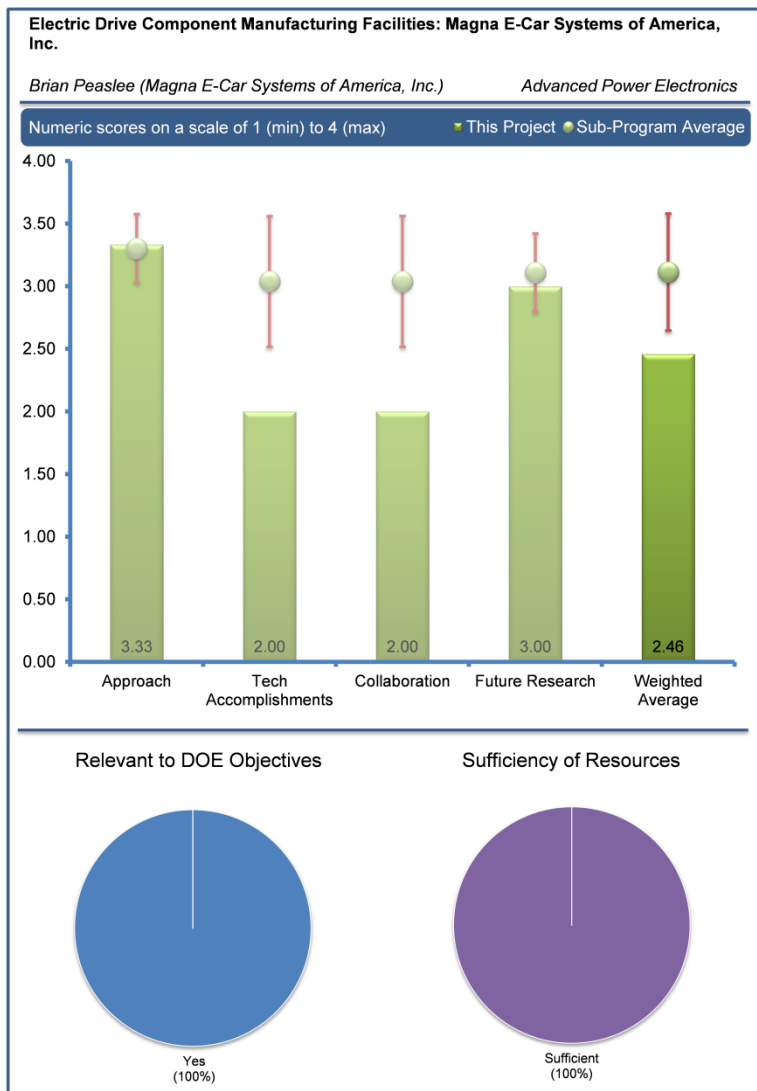
One reviewer commented that preparing PPAP ready components is a difficult task; preparing several is extremely difficult. The reviewer noted that the tasks are complete, and that it is not possible to eliminate the barriers of OEM schedule changes.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that all of the collaboration is within Magna divisions. Another reviewer felt that significantly reduced collaboration opportunities was part of the nature of preparing products for production in the marketplace.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that these are the appropriate tasks that would take the components to real production.



Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the resources for the project were sufficient. One reviewer commented that the tasks are all either fully complete or nearly complete.

DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles: Johnny Boan (KEMET Corporation) – arravt028

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

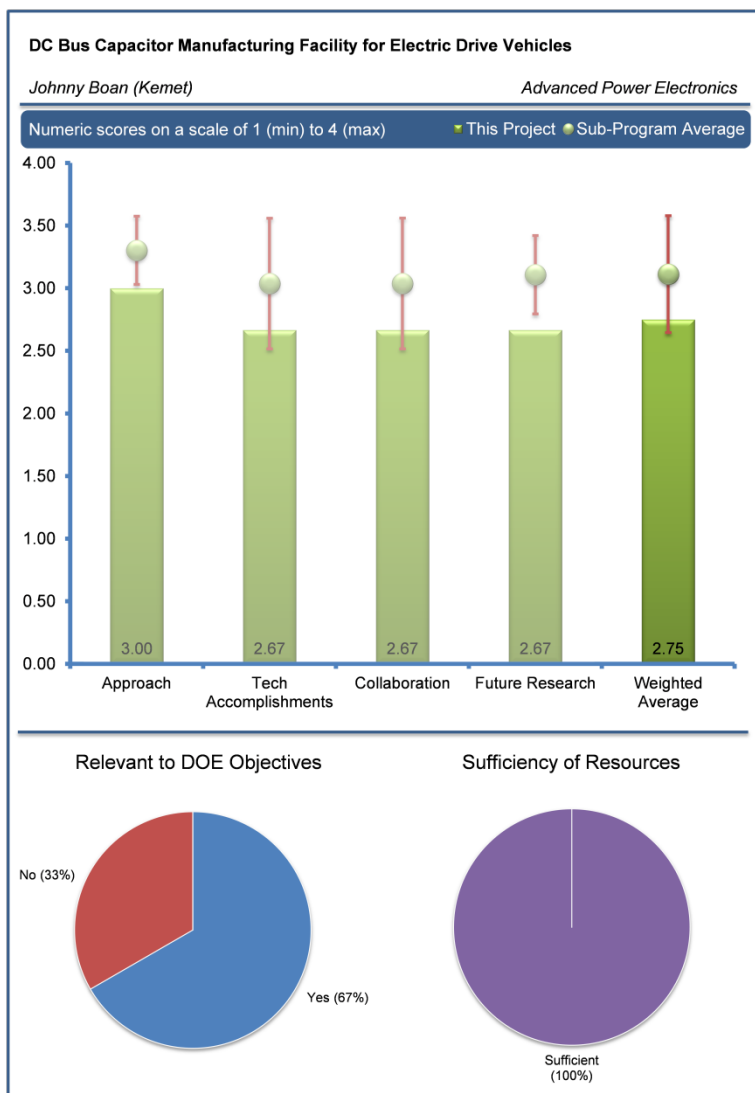
One reviewer felt that development of components for electric vehicles will reduce the dependence on petroleum products. Another reviewer commented that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which typically require large Direct Current (DC) bus capacitors. Having ready access to DC bus capacitors is an enabling technology for inverter design. This project addresses the issue by preparing a facility to provide those capacitors. One reviewer was not sure that the project supported the overall DOE objectives. The reviewer felt that the emphasis of the project seems to be on increased manufacturing capacity for DC capacitors in the United States. The reviewer was unsure what the global capacity already is in this area, or if additional capacity would really drive down global price substantially.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer provided a suggestion. This reviewer felt that the approach of first determining which type of capacitor is most likely to be needed by hybrid component designers, then preparing the factory is correct. The reviewer additionally commented that the presentation could be improved by expanding the technical barrier section. It is true that market acceptance of HEV and EV technology is a significant risk, as is mentioned. However, the reviewer felt that a description of the barriers that this project addresses would be a welcome addition. The reviewer suggested a statement along the lines of: Ready access to HV DC bus capacitors can be a barrier to hybrid component development. The project addresses that barrier by preparing a facility to produce a variety of DC bus capacitors in the volume needed. The ready availability of a production facility will speed the development of new designs. This reviewer noted that the suggested statement is true of this project, and suggests that the presentation could take credit for addressing this important barrier.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that there were no real technical barriers to progress. The reviewer felt that the challenge in the project is investing and creating flexible capacity and jobs without large market demand. Another reviewer noted that the project is meeting goals, and on schedule. The reviewer felt that the plan of creating capacity in incremental volumes is correct, as there is risk that the volumes might not materialize. The reviewer found it impressive that the plant has produced some production level capacitors in a relatively short time frame.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that the nature of preparing products for production in the marketplace significantly reduces the opportunity for collaboration between independent companies. Despite these barriers, the reviewer felt that the degree of cooperation between federal and local governments is impressive.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the future work is properly planned, starting with a flexible product line capable of producing a variety of components, followed by a series of high volume lines once a few designs have been chosen. Another reviewer commented that this is a manufacturing facility and not a research project which made it difficult to rate the proposed future research.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the resources for this project were sufficient.

Construction, Qualification, and Low Rate Production Start-up of a DC Bus Capacitor High Volume Manufacturing Facility with Capacity to Support 100,000 Electric Drive Vehicles: Ed Sawyer (SBE, Inc.) – arravt029

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

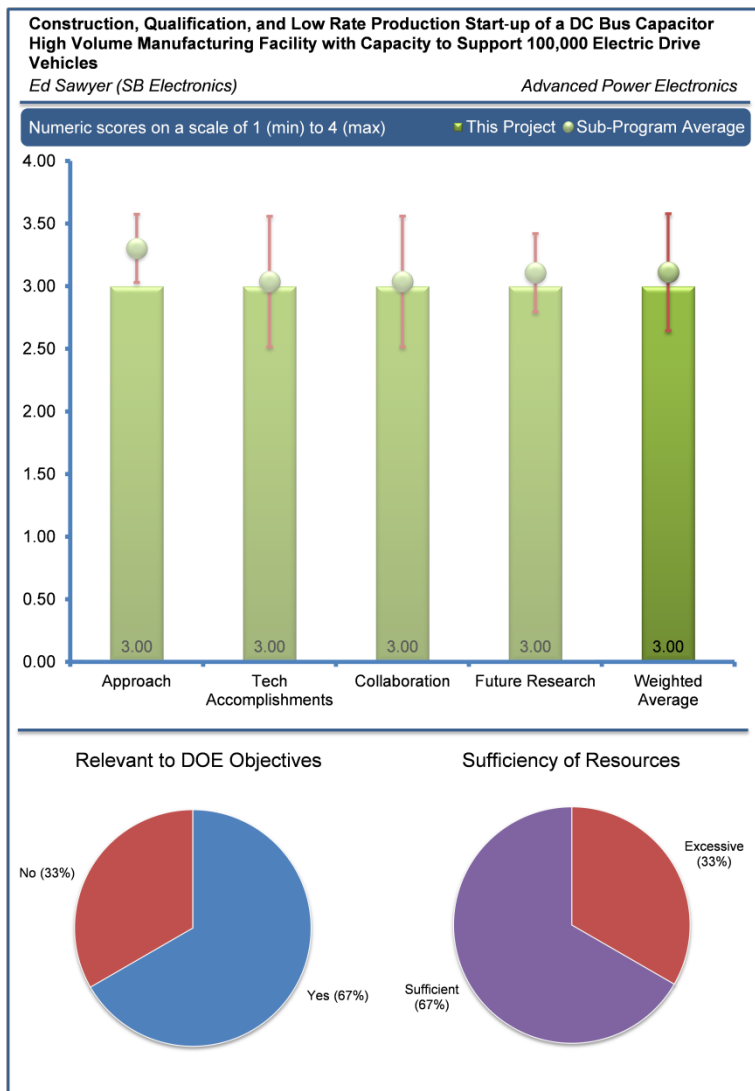
Reviewers had mixed responses. One reviewer commented that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which typically require large DC bus capacitors. Having ready access to DC bus capacitors is an enabling technology for inverter design. This project addresses the issue by preparing a facility to provide those capacitors. A second reviewer indicated that the project was to perform a build out of production capacity for the Polypropylene based DC Link Bus capacitor for use in inverters for HEVs and to provide added technical support to aid customers to develop solutions to mate the capacitor into the inverter. A third reviewer was not sure that the project supported the overall DOE objectives. The reviewer felt that the emphasis of the project seems to be on increased manufacturing capacity for DC capacitors in United States. The reviewer was unsure what the global capacity already is in this area, or if additional capacity would really drive down global price substantially.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated that the project is nearly complete with factory built out. The reviewer felt that there were questions about how the industry will fully utilize the production capacity since it is centered on Power Ring architecture. Another reviewer commented that the approach is appropriate to addressing the technical barrier (need for high voltage DC bus capacitor production capability). The reviewer felt that the objective and targets addressed were clearly stated. Additionally, the reviewer noted that the target of achieving TS16949 is critical to completing the production ready objective. The third reviewer commented that a low Equivalent Series Inductance (ESL) capacitor design, providing packaging advantage. The reviewer also noted that the project leveraged some common processes and resources with conventional capacitor manufacturing to reduce costs. This reviewer felt that the presentation could be enhanced by describing more fully the types of DC bus capacitors that will be produced in the plant.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed feedback on technical accomplishments. One reviewer noted that the project is 90% complete with only major remaining milestone being TS16949 certification. The second reviewer noted that the technical accomplishments and



progress are appropriate for this phase of the program. The reviewer felt that the presentation could have been enhanced by more detailed breakdown of timeline for FY 2012 approaches and challenges. The reviewer thought that showing three bars spanning an entire year (Slide 16) did not provide as much ability to judge progress as the reviewer had hoped. The third reviewer felt that there was some question remaining regarding how quickly the market will develop to utilize the production capacity now online.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that there were collaborations ranging from contractors and suppliers (EF Wall, API and Steiner) to ORNL. The reviewer noted that the customer collaborator, Azure, went bankrupt. Another reviewer commented that the nature of preparing products for production in the marketplace significantly reduces the opportunity for collaboration. Including ORNL in the process provided a valuable second set of eyes on the project to insure that the capacitors are appropriate for the hybrid market.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that there was the potential for further expansion of capacity, TS16949 certification, and customer development. Another reviewer felt that the plan to complete the factory and obtain certification is realistic and aggressive, yet achievable.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers felt that the resources were sufficient. One reviewer felt that the resources were excessive. The reviewer who felt the resources were excessive noted that SBE put in place the capacity before market adoption so the capacity will be underutilized for some time.

Electric Drive Semiconductor Manufacturing (EDSM) Center: Duane Prusia (Powerex, Inc.) – arravt030

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that power electronics are critical to vehicle electrification and support the objective of petroleum displacement. Another reviewer commented that the project promotes economies-of-scale in an area of high cost for EV and HEV applications. A third reviewer indicated that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which require high voltage power semiconductor devices. The reviewer felt that having ready access to power semiconductor devices is an enabling technology for inverter design and that the project addresses the issue by preparing a facility to provide those devices.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

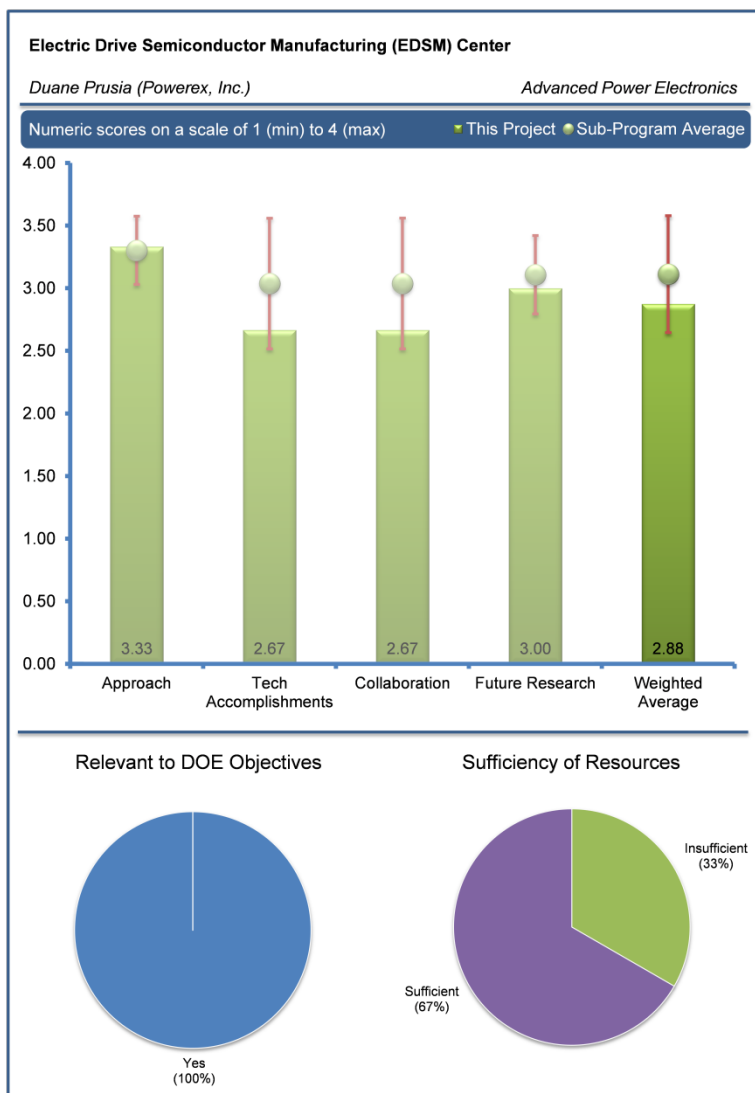
One reviewer commented that it was good to see a prototype center and reliability center in addition to the manufacturing center. The reviewer noted that for the reliability center specifically, it will be important to publish test results and help guide inverter manufacturers. A second reviewer indicated that the planned approach demonstrates knowledge of the steps required to complete the task. The reviewer felt that the approach reflects the fact that simply building a power electronics manufacturing area is not enough. Supporting areas including the reliability center and the prototyping center are required for a fully viable facility.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the program has moved quickly and is on track for near-term completion. Another reviewer stated that the technical accomplishments for this program were on track to complete the project on time and within budget.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that this type of project does not lend itself to collaboration. The second reviewer agreed, stating that collaboration is not a requirement of this type of grant. The reviewer felt that it would be useful to report on how the prototype and reliability center work will involve users and researchers.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the project has moved quickly toward completion. The second reviewer felt that the proposal appropriately describes the tasks required to finish the project and that they must be completed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt the resources were insufficient. Two reviewers felt the resources were sufficient.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
AC	Alternating Current
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APE	Advanced Power Electronics
APEEM	Advanced Power Electronics and Electric Machines Program
API	American Petroleum Institute
ARRA	American Recovery and Reinvestment Act
ASIC	Application-Specific Integrated Circuit
AVX	AVX Corporation
AWG	American Wire Gauge
BOPP	Bi-axially Oriented Polypropylene (film)
CA	Commercially Available
CALCE	Center for Advanced Life Cycle Engineering (UMD)
CSI	Current Source Inverter
CVD	Chemical Vapor Deposition
DC	Direct Current
DOD	Department of Defense
DOE	Department of Energy
EDV	Electric-Drive Vehicle
EMI	Electromagnetic Interference
ESL	Equivalent Series Inductance
ESR	Equivalent Series Resistance
ETM	Electro-Thermo-Mechanical
EV	Electric Vehicle
FEA	Finite Element Analysis
FCHEV	Fuel Cell Hybrid Electric Vehicle
FOM	Figure of Merit
FY	Fiscal Year
GM	General Motors Corporation
GOSS	Grain-Oriented Silicon Steel
HEV	Hybrid Electric Vehicle
HSG	Hybrid Starter Generator
HV	High Voltage
IGBT	Insulated-Gate Bipolar Transistor
IPM	Interior Permanent Magnet
IP	Intellectual Property
IR	Infrared
JFET	Junction Gate Field-Effective Transistor

Acronym	Definition
KEMET	KEMET Electronics Corporation
Kg	Kilogram
KW	Kilowatt
LCD	Liquid Crystal Display
LEM	LEM, Inc.
LHFZ	Laser Heated Floating Zone
LTC	Large Tapered Crystal
MLCC	Multilayered Ceramic Capacitor
MOSFET	Metal-Oxide-Semiconductor Field-Effective Transistor
MPGe	Miles Per Gallon equivalent
NASA	National Aeronautics and Space Administration
NEG	Nippon Electric Glass Co., Ltd.
NFC	Novel Flux Coupling
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PBA	Planar Bond All
PCB	Printed Circuit Boards
PEEM	Power Electronics and Electrical Machines
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator
PLZT	Pb _{1-x} LaxZryTi _{1-y} O ₃
PM	Permanent Magnet
PP	Polypropylene
PPAP	Production Part Approval Process
PWB	Printed Wiring Board
RE	Rare Earth
RF	Radio Frequency
ROMP	Ring Opening Metathesis Polymerization
SMC	Soft Magnetic Composites
SNL	Sandia National Laboratory
SOA	State Of the Art
SOIC	Small Outline Integrated Circuit
SPS	Strategic Polymer Sciences, Inc.
UQM	UQM Technologies, Inc.
V	Volts
VTP	Vehicle Technologies Program
W	Watts
WBG	Wide Bandgap

Acronym	Definition
WEG	Water Ethylene Glycol

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4. Advanced Combustion Engine Technologies

The Advanced Combustion Engine R&D subprogram of the U.S. Department of Energy's Vehicle Technologies Program (VTP) is improving the fuel economy of passenger vehicles (cars and light trucks) and commercial vehicles (medium-duty and commercial trucks) by increasing the efficiency of the engines that power them. Work is done in collaboration with industry, national laboratories, and universities, as well as in conjunction with the U.S. DRIVE Partnership for passenger vehicle applications and the 21st Century Truck Partnership for commercial vehicle applications.

Research and development (R&D) efforts focus on improving engine efficiency while meeting future Federal and state emissions regulations through a combination of: combustion technologies that minimize in-cylinder formation of emissions; aftertreatment technologies that further reduce exhaust emissions; and understanding fuel property impacts on combustion and emissions. Technologies that improve the overall engine performance are also pursued.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Mark Musculus (Sandia National Laboratories)	4-5	3.75	3.67	3.67	3.42	3.66
Low-Temperature Automotive Diesel Combustion	Paul Miles (Sandia National Laboratories)	4-9	3.58	3.25	3.25	3.08	3.31
HCCI and Stratified-Charge CI Engine Combustion Research	John Dec (Sandia National Laboratories)	4-12	3.36	3.55	3.55	3.27	3.47
Spray Combustion Cross-Cut Engine Research	Lyle Pickett (Sandia National Laboratories)	4-15	3.55	3.82	3.82	3.27	3.68
Automotive HCCI Engine Research	Richard Steeper (Sandia National Laboratories)	4-18	2.92	3.00	3.00	3.00	2.98
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research	Joe Oefelein (Sandia National Laboratories)	4-21	3.45	3.45	3.45	3.18	3.42
Free-Piston Engine	Terry Johnson (Sandia National Laboratories)	4-24	2.17	2.00	2.00	2.17	2.06
Fuel Injection and Spray Research Using X-Ray Diagnostics	Christopher Powell (Argonne National Laboratory)	4-27	3.70	3.30	3.30	3.20	3.39
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Steve Ciatti (Argonne National Laboratory)	4-30	2.91	3.27	3.27	2.82	3.13
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Dan Flowers (Lawrence Livermore National Laboratory)	4-33	3.36	3.73	3.73	3.09	3.56
Chemical Kinetic Research on HCCI & Diesel Fuels	Bill Pitz (Lawrence Livermore National Laboratory)	4-36	3.73	3.45	3.45	3.45	3.52
2012 DOE Vehicle Technologies KIVA-Development	David Carrington (Los Alamos National Laboratory)	4-39	3.17	3.08	3.08	2.67	3.05
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Stuart Daw (Oak Ridge National Laboratory)	4-42	3.46	3.23	3.23	3.00	3.26

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Scott Curran (Oak Ridge National Laboratory)	4-45	3.54	3.08	3.08	3.23	3.21
High Efficiency Engine Systems Development and Evaluation	Dean Edwards (Oak Ridge National Laboratory)	4-48	3.38	2.85	2.85	2.92	2.99
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Margaret Wooldridge (University of Michigan)	4-51	3.08	3.17	3.17	3.00	3.13
Optimization of Advanced Diesel Engine Combustion Strategies	Rolf Reitz (University of Wisconsin)	4-53	3.82	3.55	3.55	3.09	3.56
Flex Fuel Optimized SI and HCCI Engine	Gouming Zhu (Michigan State University)	4-55	2.82	2.64	2.64	2.73	2.69
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Stuart Daw (Oak Ridge National Laboratory)	4-58	3.80	3.60	3.60	3.00	3.58
CLEERS Aftertreatment Modeling and Analysis	George Muntean (Pacific Northwest National Laboratory)	4-61	3.17	3.67	3.67	3.00	3.46
Development of Advanced Particulate Filters	Kyeong Lee (Argonne National Laboratory)	4-64	3.25	2.75	2.75	2.75	2.88
Combination and Integration of DPF-SCR Aftertreatment Technologies	Ken Rappe (Pacific Northwest National Laboratory)	4-66	3.00	3.17	3.17	3.00	3.10
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-69	3.50	3.00	3.00	3.00	3.13
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology	Chuck Peden (Pacific Northwest National Laboratory)	4-71	3.50	3.60	3.60	3.33	3.54
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels	John Johnson (Michigan Technological University)	4-73	3.40	3.67	3.67	3.20	3.54
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Michael Harold (University of Houston)	4-75	3.33	3.67	3.67	3.00	3.50
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control	Puxian Gao (University of Connecticut)	4-78	3.17	2.83	2.83	3.00	2.94
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (Oak Ridge National Laboratory)	4-81	3.50	3.40	3.40	3.00	3.38
Emissions Control for Lean Gasoline Engines	Todd Toops (Oak Ridge National Laboratory)	4-83	3.75	3.50	3.50	3.75	3.59
Advanced Boost System Development for Diesel HCCI/LTC Application	Harold Sun (Ford Motor Company)	4-85	3.50	3.17	3.17	2.67	3.19
Advanced Collaborative Emissions Study (ACES)	Dan Greenbaum (Health Effects Institute)	4-88	4.00	3.75	3.75	3.50	3.78
Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications	Clay Maranville (Ford Motor Company)	4-90	3.50	3.50	3.50	3.50	3.50
Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices	Jeffrey Bozeman (General Motors Corporation)	4-93	3.50	3.00	3.00	3.50	3.19

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Neutron Imaging of Advanced Engine Technologies	Todd Toops (Oak Ridge National Laboratory)	4-96	3.50	3.50	3.50	3.33	3.48
Collaborative Combustion Research with BES	Steve Ciatti (Argonne National Laboratory)	4-99	3.20	3.10	3.10	3.10	3.13
Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-102	3.00	2.75	2.75	3.00	2.84
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Mark Stewart (Pacific Northwest National Laboratory)	4-105	3.67	3.67	3.67	3.00	3.58
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	David Koeberlein (Cummins)	4-107	4.00	3.38	3.38	3.75	3.58
SuperTruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Kevin Sisken (Detroit Diesel)	4-110	3.00	2.63	2.63	3.00	2.77
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Dennis Jadin (Navistar International Corp.)	4-114	2.88	3.00	3.00	2.75	2.94
SuperTruck Initiative for Maximum Utilized Loading in the United States	Pascal Amar (Volvo Trucks)	4-118	3.25	2.75	2.75	3.13	2.92
ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Michael Ruth (Cummins)	4-121	3.40	3.40	3.40	3.40	3.40
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Ron Reese (Chrysler LLC)	4-124	3.29	3.14	3.14	3.00	3.16
Lean Gasoline System Development for Fuel Efficient Small Car	Stuart Smith (General Motors)	4-127	3.33	3.17	3.17	3.00	3.19
Gasoline Ultra Fuel Efficient Vehicle	Keith Confer (Delphi Automotive Systems)	4-130	3.14	3.00	3.00	3.14	3.05
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Corey Weaver (Ford Motor Company)	4-133	3.43	2.71	2.71	3.14	2.95
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Hakan Yilmaz (Robert Bosch)	4-136	3.33	3.67	3.67	3.00	3.50
High Fidelity Modeling of Engine Combustion Systems	Sibendu Som (Argonne National Laboratory)	4-138	3.40	3.50	3.50	3.20	3.44
Advanced Numerics for High-Fidelity Combustion Simulation	Matthew McNenly (Lawrence Livermore National Laboratory)	4-140	3.20	3.30	3.30	3.20	3.26
CRADA with Cummins on Characterization and Reduction of Combustion Variations	Bill Partridge (Oak Ridge National Laboratory)	4-142	3.33	3.50	3.50	3.00	3.40
Mixed Oxide Catalysts for NO Oxidation	George Muntean (Pacific Northwest National Laboratory)	4-144	3.43	3.14	3.14	3.29	3.23
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control	Rangachary (Mukund) Mukundan (Los Alamos National Laboratory)	4-147	3.33	3.67	3.67	3.00	3.50

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Thermoelectric Waste Heat Recovery Program for Passenger Vehicles	John LaGrandeur (Amerigon)	4-150	3.50	3.50	3.50	3.50	3.50
Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power	Greg Meisner (General Motors)	4-153	3.50	3.50	3.50	3.25	3.47
Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery	Chris Taylor (GMZ Energy Inc.)	4-156	3.50	3.50	3.50	3.50	3.50
Overall Average			3.37	3.27	3.27	3.12	3.28

Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratories) – ace001

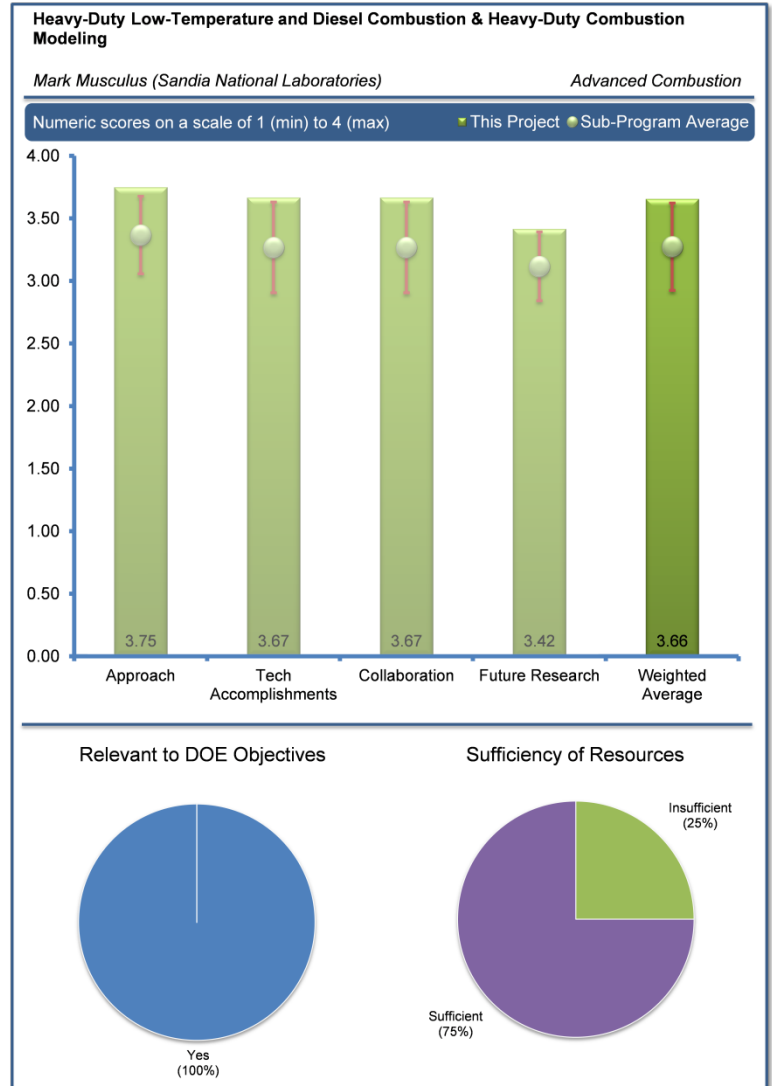
Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

According to the first reviewer, the project supports DOE objectives, and this reviewer noted a focus on combustion and emissions for HD. According to the second reviewer, this work is key to gaining a fundamental understanding of the mechanisms of LTC and RCCI, which strongly supports the objective of petroleum displacement. The work increasingly considers some of the more complex fuel injection and combustion strategies, offering valuable insight into the mechanisms through which these strategies reduce fuel consumption and criteria emissions. The third reviewer asserted that the focus on improved fundamental understanding of the in-cylinder processes should help enable the development of engines with higher efficiencies that will be more fuel efficient and thus help to reduce fuel/petroleum requirements. The fourth

reviewer emphasized that the project leverages exceptional experimental techniques to further understand the combustion and emission phenomena in diesel combustion, including the application of LTC modes. The same reviewer observed that the author gave a clear picture of the combustion process, covering first and second stages of ignition, and late cycle oxidation. The fifth reviewer commented that understanding fuel spray impacts on low temperature combustion is a crucial step toward developing improved engine behavior for lower fuel consumption and emissions. Another reviewer indicated that research to improve efficiency and expand usage of diesel engines will reduce fuel consumption. Furthermore, continued this reviewer, understanding in-cylinder processes, particularly LTC but also things like multiple injections for diffusion combustion, will help overcome issues emissions-fuel consumption tradeoffs in diesel engines. The seventh reviewer commented that the project supports increased engine efficiency. The eighth reviewer commented that the project provides fundamental understanding of LTC and RCCI combustion processes that could be important to industry in developing the next generation of engines that are focused on improving brake thermal efficiency of today's engines. In particular, added this reviewer, injection strategies and dual fuel strategies under investigation in this project can provide limits of what is possible within practical combustion devices. Per the ninth reviewer, the project aims to provide fundamental understanding of low-temperature combustion so engine design for high



fuel efficiency and low pollutants can be accomplished. The final reviewer found that the project supports DOE objectives. This reviewer commented that this fundamental work is critical to extending the understanding and modeling of extending combustion ignition analysis to diesel LTC.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the focus on high fuel pressures were well aligned with the industry's current and mid-term direction. This reviewer suggested that, for pre-competitive research, identifying challenges and opportunities in medium and ultra-high pressure should be considered for investigation. This reviewer pointed out that parasitic with high pump pressures were of course undesirable in the systems perspective. According to this reviewer, more effort to use a representative combustion chamber needed for at least part of the work (optical limitations). A second reviewer stated that the PIs deserve much credit in addressing key technical areas, and suggested that more attention should be given to metal engine data with regard to multiple injection strategies because this effect may be highly geometry-dependent. The same reviewer felt that understanding representative geometry effects in a metal engine would also be critical to one day extending this work to light-duty applications. The third reviewer stated that the approach of coupling optical engine experiments with modeling was excellent. This reviewer added that actual use of diesel fuel in the optical engine (vs. the typical approach of using only clean model components) enhances direct applicability of results to real fuels. According to the fourth reviewer, the combination of experimental work and modeling to provide insight into sprays and combustion was good. The fifth reviewer commented that the suite of diagnostic techniques coupled with simple models gave a good understanding of combustion, which allowed the PI to develop conceptual models. This reviewer further noted that there was a question of what influence the simple geometry used for optical diagnostics had on the result; however, it eliminated many complications for optical diagnostics. The same reviewer went on to say that it would be useful to investigate the effect of real combustion system geometries on this picture. This reviewer noted that this was done somewhat with the conceptual model through collaboration with the light-duty lab, but doing so in the heavy-duty lab as well would be useful, particularly as post injection studies progress. The reviewer remarked that it sounded like there were possible avenues to add that capability and that the PI had considered it. Another reviewer also felt that the project covered possibly too much ground when it extended its work to RCCI and that it was unclear if the multi-fuel work should be treated here. The project explores the phenomena of post injections. This reviewer stated that the work seemed to be in a beginning stage and that the results published were rather narrow in scope (few operating conditions) and hard to interpret. The reviewer went on to say that this work should align better with practices present in industry. The reviewer also suggested that experiments should be closely coupled with real multi-cylinder engine data. The seventh reviewer stated that developing conceptual models for LTC was good. This reviewer stated that the project could improve its approach by continuing to add noise factors into the combustion process, and added liking the idea of testing a condition that marginally produced soot. This reviewer had concerns about real world implementation of LTC due to the influence of noise factors. The eighth reviewer stated that the approach was solid for studying combustion processes with LTC, but there did not appear to be much attention paid to the impact of this combustion mode on indicated thermal efficiency. This reviewer felt that it would be helpful to the engine research community if the indicated efficiency impact was included in future work efforts. Also, this reviewer continued, it would be helpful if there was additional focus on wall impingement effects. Lastly, this reviewer commented that the LTC conceptual model should start additional positive discussions and future research toward better understanding this combustion phenomenon for heavy-duty diesel applications. The final reviewer commented that the gaps in experimental knowledge as well as model deficiencies were understood well and work was focused on addressing critical gaps in knowledge and that the work was integrated well with modeling work being done at the University of Wisconsin.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that commissioning of the new Delphi injection system was a key milestone for experiments. This reviewer felt that the diagnostic of close coupled post injections were insightful. reviewer recommended doing much more work in this area. A different reviewer commented that the work represented a very important step toward firmly establishing a connection between optical engines and modeling to heavy-duty engine development, through well-reasoned hypotheses and well-designed experiments. This reviewer felt that working through the next stage of understanding the role of heat transfer would be important

going forward. The third reviewer observed important results obtained in better elucidating a number of aspects of the LTC process. The reviewer explained that using injectors that were closer to state-of-the-art injectors that were being used for multiple injections by the industry was also very good. According to the fourth reviewer, this project gives a clear picture of the LTC combustion process. Good progress has been made to integrate the new Delphi injector. This reviewer felt that the work on close coupled injections seemed to yield relatively limited results towards soot reduction. This reviewer also felt that the RCCI versus conventional study seemed rather incomplete and the heat transfer reported appeared limited to the in-cylinder. This reviewer recommended that the project should include other heat rejection sources (e.g., EGR stream). The fifth reviewer remarked excellent and extremely useful conceptual model of LTC. This reviewer stated that it was not clear what was accomplished in the past year versus previous years. This reviewer commented that the finding of increased entrainment and over-leaning at the end of injection was a breakthrough and has been invaluable to the understanding of HC emissions in LTC. It would be useful to understand the relative contribution of this mechanism versus other HC mechanisms in LTC. The sixth reviewer said that there was great work to date utilizing a combination of various optical techniques and the modeling capability of the University of Wisconsin in understanding RCCI combustion. This reviewer felt that such work was thought provoking and would lead toward future research at other institutions and industry partners that would explore other limits of these combustion processes from a production specification view point. The seventh reviewer summarized by stating that progress has been made to distill years of knowledge into a conceptual model of LTC. In addition, this reviewer indicated that progress has been made to upgrade capability in the fuel system and multiple injection area by procuring hardware and getting early results. The reviewer stated that conceptual model of LTC is compared and contrasted to conventional combustion. Additionally, this reviewer felt that behavior of spray is better understood, especially that of the liquid length and that End-of-Injection phenomena, with increased entrainment and mixing, has been predicted by various models. The reviewer also stated that large structures were predicted that promoted faster entrainment and that first stage ignition (with presence of formaldehyde) had been observed as predicted by kinetics model. The reviewer reported second stage ignition with the presence of OH; soot and PAH were also observed during second stage ignition and where equivalence ratio is around two. Additionally, this reviewer commented that CO and UHC were near the high mixing region at the end of injection near the injector, where ϕ was less than one. The same reviewer also stated that details of the conceptual model were in the PECS paper and that initial experiments with high speed movies have been conducted with post injections. This reviewer commented that the experiments complement RCCI work in University of Wisconsin have been conducted that show that auto ignition processes dominate rather than flame propagation. This reviewer also pointed out that the project also found that main efficiency benefit of RCCI is due to reduced heat transfer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt there was extensive Advanced Engine Combustion (AEC) working group cooperation, and suggested that additional interactions with the light-duty industry may be helpful for further insight. A different reviewer commented that collaboration with other lab projects, academia and with industry is well-structured for the success of the project and felt that continued close collaboration with KIVA and LES modeling is showing great progress, but continued exploration in this area will be invaluable. A third reviewer mentioned that the project was a very well collaborated project and has interacted and received parts from Delphi and Cummins and interacted with the University of Wisconsin on modeling. The reviewer also stated that the project also had interactions with reps from OEMs and energy companies through semi-annual AEC memorandum of understanding meetings, but that it was not clear if there were interactions with those reps outside of those meetings. A fourth reviewer felt that the project has done well to incorporate the Delphi injector, being a modern and capable unit. This reviewer felt that there could be stronger collaboration with the chemical kineticists at this facility or at Lawrence Livermore National Laboratory. This reviewer also said the project should collaborate with a diesel engine manufacturer that could provide data to corroborate the optical results. The fifth reviewer noted good collaboration in the AEC MOU. The reviewer observed that the project is engaging industrial support to define project to look at post injection. The reviewer also stated that the collaboration with Paul Miles and Lyle Pickett was very useful for understanding how the conceptual model applied to various environments. This sixth reviewer stated that this effort has been an ongoing key AEC MOU project for many years and has included close collaboration in the past few years with the University of Wisconsin. The same reviewer noted that the PI mentioned a possible collaboration with Wayne State University that could be of value to future work and that this was a very well collaborated project. The seventh panelist noted a solid connection with University of Wisconsin existed where a lot of the pioneering work in low-temperature combustion work is being performed. The panelist felt that a wider relationship with partners in the engine

combustion memorandum of understanding exists. This panelist went on to say that industry input is sought to become familiar with operating conditions and strategies with multiple injections. The final reviewer noted that the project was responsive to industrial partner's queries on continuing areas of research.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted plans for combustion chamber design, LTC soot and PAH. The reviewer suggested more focus on in-cylinder heat transfer correlations and recommended coupling with real engine work. Another reviewer stated two areas where more progress was possible included the correlation with metal engine data to better understand the effects of heat transfer, as well as the effects of multiple injections, which tended to be highly geometry-dependent. The same reviewer also believed that more progress was possible in the fuel effects on RCCI area, including optically exploring the effect of low cetane number fuels and oxygenate fuels (e.g., alcohols) on pollutant formation (especially PM, but also CO and UHC). The third reviewer noted that the plans seemed well developed to build on progress and accomplish goals. The fourth reviewer felt that the author showed a rather comprehensive examination of the in-cylinder combustion and that the proposed work was adequate as it furthered the task at hand. The reviewer added that the project should align with testing in a modern diesel engine that could provide data to corroborate the optical results. The reviewer felt the question may be asked as to how the present study has impacted engine design of combustion development. A fifth reviewer felt that there was a need to solidify plans to look at post injection, but it sounded like the PI was engaging industry to help define the project well. A sixth reviewer noted excellent proposed future research but suggested that the project figure out how to extrapolate results to production type engines including piston design variations and also more representative injection rate profiles as related to current and future heavy-duty engines. Another reviewer cautioned that proposed measurements of heat transfer would have to be done carefully going forward, because of the uncertainties in making such measurements in an optical engine. The reviewer went on to say that multiple injection schemes have to be carefully tied in to industry practice so that it is relevant. This reviewer added that since the combustion geometry significantly affects efficacy of multiple injection, the optical engine geometry would have to be mimicked as closely as possible to realistic engine geometry. Per the final reviewer, modeling LTC soot and PAH formation would be an area of useful future research.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers had mixed responses regarding the sufficiency of project resources. Three reviewers felt that resources were insufficient. One reviewer noted that resources were sufficient to achieve project objectives. Another reviewer indicated that it was a well-funded project, while a different reviewer recommended expanding the work scope for more fuel sensitivity. The final reviewer stated that very good progress had been made with the current level of resources and that there was no indication that that should not continue to be the case.

Low-Temperature Automotive Diesel Combustion: Paul Miles (Sandia National Laboratories) – ace002

Reviewer Sample Size

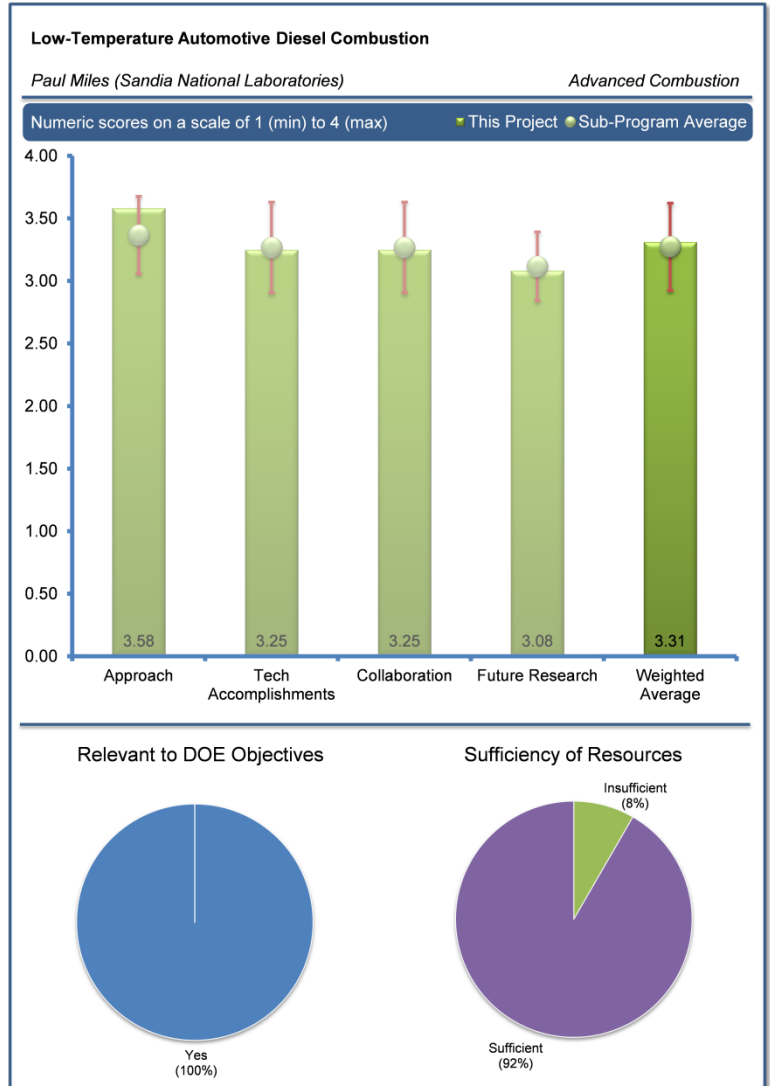
This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that a better understanding of in cylinder conditions (such as equivalence ratio distribution), combustion, and emissions formation processes should enable development of better designed, more fuel efficient engines which use less fuel/petroleum. A second reviewer pointed out that improved understanding of diesel combustion will potentially expand the use of clean light-duty diesel technology, which will help reduce fuel consumption. The reviewer elaborated by saying that enhancing models that are used to design engines would have an impact on the efficiency and emissions of future engines. The third reviewer simply stated that the project supported engine development for high efficiency and clean emissions and that the project was well established and organized. A fourth reviewer simply stated that there was a light-duty-focus using a 1.9L GM engine with optical access. The fifth panelist commented that this was another fundamental project that could aid engine developers in developing the next generation of small bore diesel engines through improved understanding of injection rate, bowl design, and swirl on engine performance. The sixth reviewer added that this project addressed the lack of fundamental knowledge of combustion and lack of combustion models in light-duty diesel engines. The final reviewer commented that diesels do reduce fuel consumption, so, in this respect, this project supported the objective. Yet this reviewer wondered why the focus was on CIDI in light-duty engines, since the reduced GHG emissions come at fairly significant cost in the light-duty sector. As a result, this reviewer said that very few in the industry, with the possible exception of Volkswagen, were forecasting a diesel revolution in light-duty vehicles in North America in the next 15-20 years, particularly under the constraints of California LEV3/T2B2. Moreover, this reviewer felt that the project should evaluate whether it is in the United States' interest to promote significant use of diesel fuel in the light duty sector as a national strategy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer summarized that the focus was on real combustion chamber geometry and at least two to three geometries would be beneficial, budget and time permitting. Another reviewer stated that this project was focused with strong contributions between optical engines at Sandia National Laboratories and metal engines as University of Wisconsin-Madison and Oak Ridge National Lab. A third reviewer stated that the optical engine, in collaboration with CFD modeling, was an effective means for gaining an understanding of the basic effects of geometry and charge motion in light-duty diesels. However, this reviewer stated that the load limitations of the optical engines prevented an understanding of those areas of the engine load-speed range that posed the greatest



challenge to meeting T2B2 emissions in diesels. According to a fourth reviewer, use of optical engine with clean model fuel having similar heat release rates as real diesel is a good approach for viewing/determining evolution of in-cylinder equivalence ratio as function of position and time. To this reviewer, it was also very good that the platform is a production model that others are also using. Another reviewer felt noted close ties exist to the modeling work at the University of Wisconsin. According to this reviewer, this ensures that models get the benefit of the latest findings from experiments. A sixth reviewer commented that it is important to understand mixing processes, and the data sets will be useful to help validate CFD models. This reviewer felt that it would be useful to more clearly define what would be learned from the experiments beyond validation data, such as what barrier was being overcome. The reviewer went on to say that future work seemed to be more focused on that through the study of multiple injection in LTC. The reviewer also felt that it was not clear how collaboration with CFD and metal engine studies were being leveraged to further understand this dataset. A reviewer stated that light-duty LTC needed to carefully address the emissions attribute, as LEV III/Tier 3 emissions would be difficult, even with a spark ignition engine with three-way catalysis. The reviewer went on to say that the project should consider how to develop rough guidelines on engine out emissions supporting low emissions. This reviewer observed that validating model predictions with experimentation was good. The reviewer also asked how the grid coarseness was established without experimental results. The final reviewer pointed out that much work has focused on developing advanced optical techniques for measuring equivalence ratio and local mixing rate, and that this was great work. The reviewer added that it would be helpful if this effort also considered multi-zone analysis in addition to CFD, including a couple of piston design changes, and more of a discussion on indicated thermal efficiency impact of using LTC in small bore diesel engines.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer felt that the background slide on the image processing technique was useful. The same reviewer further remarked that the swirl and injection comparison was insightful and that more of these types of studies were needed. The reviewer went on to say that understanding physics was a goal, but design sensitivity assessment was equally important to progress. The second reviewer observed very good progress in determining equivalence ratio distributions. Although progress in identifying discrepancies between measured and simulation of UHC/CO sources and improved soot models was listed, this reviewer noted a lack of time devoted to discussing this progress. A third reviewer commented that this project gave impressive visualizations of the fuel distribution in the cylinder during the combustion process and felt that the author captured key points during the combustion process. The reviewer detailed that the work captured various contributions such as injection pressure and swirl, and related their impact primarily in the over-mixing phenomena. The reviewer noted that the project did not give any updates or references to the work at ORNL, specific to contributing transient, aftertreatment, and controls work. The expert also added that the project was framed within the relevance to improve fuel economy and emissions, but no mention was made on these quantities, and the reviewer felt that it would be good to incorporate these performance numbers. A fourth reviewer observed excellent datasets investigating not only the equivalence ratio field, but also the influence of swirl, injection pressure, and etc., with good interpretation of the data. This reviewer felt that the data set will be very useful for model validation. The fifth reviewer stated that there were great in-cylinder pictures that showed the mixture. The sixth reviewer felt that there was outstanding progress in toluene LIF imaging work and that the project would greatly increase understanding of mixing of the fuel jets under swirling conditions. The reviewer also observed the Coanda effect and pointed out that asymmetries from jet to jet and swirl center asymmetry suggesting full chamber modeling rather than sector mesh modeling would be needed. The seventh panelists wondered if the geometric effects identified in the study could be varied in a more controlled manner to demonstrate the parametric influences more clearly and perhaps identify some benefit. The panelist elaborated by saying that using the optical engine to further explore the effects of geometry experimentally would be an interesting contribution for light-duty diesels, and that the focus on light load in the optical engine limited the spray duration and penetration to a fairly small range. This led the panelist to again wonder if some effects of longer spray duration could be explored, which might be representative of what would be seen at a higher load. The eighth reviewer stated that documenting the Coanda effect is interesting and wondered if a similar mechanism would be at play in a GDI engine relating to HC emissions. Another reviewer felt that given the discrepancy between the experimental results and the model results, there needed to be some explanation for the difference or a plan to improve the model.

The final reviewer observed that great progress was made, overall, in more accurately measuring local equivalence ratio in a light-duty diesel that would lead to additional productive research on understanding LTC combustion in spray-wall interaction

environments. This reviewer pointed out that there was no discussion on the impact of LTC on indicated thermal efficiency and that this discussion needed to occur in the future based on lab measurements and possibly zero-dimensional engine simulations. Also, according to this reviewer, it was not clear if the swirl could be decoupled enough from the optical engine bowl design to provide enough qualitative information to engine designers—time would tell if this was or was not the case. The same commenter added that including various piston bowl geometry (especially squish area) would aid in sorting out this situation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the level of collaboration in this area was appropriate for the success of this project. The collaboration with modeling was especially critical. The second reviewer noted good collaboration with the University of Wisconsin, GM, and Ford, as well as engagement with industrial partners at semi-annual AEC memorandum of understanding meetings. The third reviewer specified that the project has a good partnership with UWM but that the work appeared to be mainly focused on providing benchmarks for the simulation. It was unclear to this reviewer, however, whether the simulation was providing any significant value to the work yet. A different reviewer also pointed out that collaborations exist with many organizations in the MOU and that monthly teleconferences took place with GM and Ford. The fifth expert noted that this effort has been a key AEC MOU project for years and well connected with various industry partners and historically the University of Wisconsin. The final respondent noted excellent collaboration with the modeling community, industry, metal engine research on the same engine, and other optical engine research and spray facilities, which help develop a complete picture. However, this respondent indicated that it was unclear how the metal engine studies were being leveraged. The reviewer went on to say that there was some exploration of model agreement against the data set, but that it was not clear that there was a plan to improve the models based on the measurements.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One of the reviewers stated that further application of this diagnostic was an excellent endeavor and that it was critical to use it, not only to create a unique data set, but also to address key barriers for LTC. The second reviewer recommended that more vertical plane work, combined with combustion chamber sensitivity (squish height, bowl/squish geometry) would be helpful. A third reviewer said that vertical plane imaging should complement the information obtained so far especially the interaction between the radial outward squish flow and HC and CO emissions. The fourth panelist stated that given that this project was directed toward light-duty engines, at least some of the focus should be redirected toward fundamental understanding of SIDI combustion, rather than CIDI. The reviewer went on to say that some valuable work remained in the basic understanding of mixture prep in spray- and wall-guided direct injection gasoline systems. The fifth commenter strongly suggested better quantification of the injection rate profile as soon as possible to aid in better understanding optical engine measurements and also in the associated CFD analysis. The reviewer felt the transient nature of the injection event might have a stronger impact on LTC combustion behavior than what appeared to be the case today. Another reviewer simply stated that current plans looked like it would build on previous results and advance goals. The seventh commenter noted that several extensions to the work were provided, nevertheless, this work should be kept in sight of engine efficiency and emission improvements. The eighth reviewer felt that a plan to improve the model to match experimental results was needed. The last reviewer said there was limited detail on future research.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer found that resources were insufficient. The remaining reviewers found that resources were sufficient. One reviewer noted that the resources were sufficient to achieve the objectives of the optical engine study. The second reviewer indicated that good progress with existing resources had been made, thus there was no indication that changes were needed. One reviewer stated that it was not clear what new work more funding would allow. The final reviewer remarked that this was a well funded project.

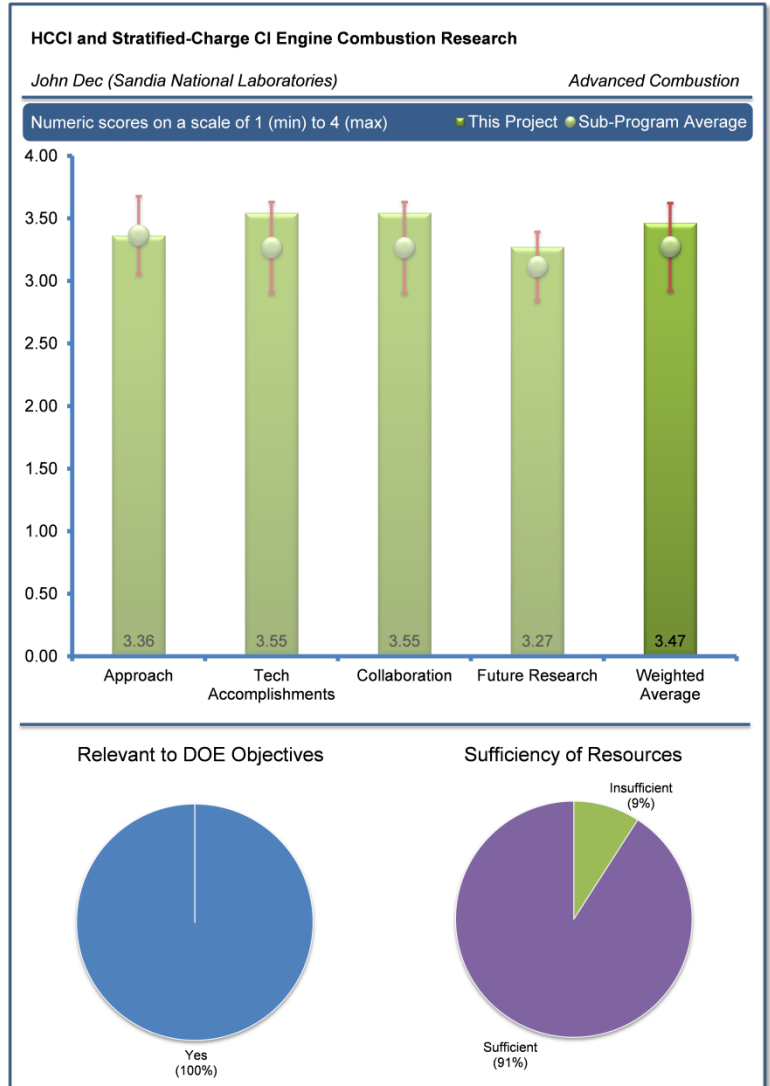
HCCI and Stratified-Charge CI Engine Combustion Research: John Dec (Sandia National Laboratories) – ace004

Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer summarized that the project contributed to reducing fuel consumption of internal combustion engines. The second reviewer noted that the project boosted HCCI at high loads. A third reviewer added that HCCI supported the DOE objective for petroleum displacement through reasonably high efficiency, with the potential for low emissions. A fourth reviewer said HCCI provided an avenue to clean efficient lean gasoline combustion, which was a high risk technology for gas engines, and that the project was looking at expanding the load limit of HCCI, which was a key barrier. The fifth reviewer said that this was an excellent experimental project addressing the continual push toward advanced combustion modes for driving up indicated thermal efficiency. A sixth reviewer elaborated that the difficulty was if this could ever be implemented given the control complexity and fuel sensitivity. The last reviewer pointed out that the project aims to understand and remove barriers in gasoline low temperature combustion, which include efficiency of HCCI and the application of HCCI to higher engine loads.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer simply stated that the objectives and several partners (e.g. LLNL, University of Michigan) were clearly indicated, but little or no information was given regarding the outcome from this collaboration. For example, this reviewer wondered what information was transferred to the kinetic modeling group from LLNL. Also, the reviewer wondered how this information was used by LLNL to refine its models. The second reviewer described the approach as very sound and outstanding. The third reviewer said that extending the load range, looking at representative future fuels and examining the NVH/efficiency tradeoffs were important for advancing HCCI. Yet, the reviewer believed that these do not represent the chief obstacles to high-load HCCI engine development. The reviewer went on to say that turbomachinery development, cold start emissions, low-temperature aftertreatment and transient control may be more important areas to explore going forward. The fourth reviewer stated that isolating aspects of HCCI to understand their effect was a good approach. However, continued this reviewer, the noise constraints and metrics may need to be reevaluated, there did not appear to be a consensus on what metric should be used, and at least one of the light-duty OEMs did not seem to agree with the limit that was being applied. The fifth reviewer said that there was an excellent combination of optical engine, metal engine, chemical kinetics modeling, and CFD analysis approach. The reviewer acknowledged and expressed thanks that this project was one of the few fundamental engine research projects explicitly addressing the impact of various engine boundary conditions on indicated thermal efficiency (such as fueling rate, speed, fuel type, intake

conditions). A sixth reviewer wondered how the results were constrained with boost, inlet temperature and ringing index limits. The final reviewer had concerns about how this approach would be used in a production engine; primarily the controls aspect. The reviewer also wondered what the key roadblocks were and if there was work in place to address these roadblocks.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that there was good progress showing higher thermal efficiency at high load HCCI using partial fuel stratification and the parameters that influence efficiency and that there was a useful investigation of the influence of various parameters on thermal stratification. The second reviewer said that accomplishments directly addressed the limited load range barrier to practical implementation of HCCI. A third reviewer stated that the new focus now on boosted HCCI and SCCI was appropriate and in keeping with the megatrend of boosting. The new work on looking at ethanol content (E0, E10, E20) and its effect on increasing load capability with HCCI was particularly relevant and interesting. The same reviewer also felt that the new work on supporting the kinetic modeling work at LLNL would also go a long way in understanding HCCI combustion. This expert also said that determining the effects of main operating variables on efficiency was very practical. The fourth reviewer wondered if this efficiency and emissions were good enough to compete with that of a T2B2 modern gasoline engine. The reviewer said that now that the project has shifted attention to boosted operation, some attention needed to be given to reducing PMEP with real boost systems. The reviewer pointed out that 48% indicated efficiency looked impressive with free boost, but this likely implied mid-30's actual efficiency, which was not significantly better than a projected MY 2020 high-BMEP boosted gasoline engine; besides that, the reviewer said, the HCCI engine would be more expensive and larger. The reviewer provided an example of comparing a 2.4L HCCI/boosted with a 1.3L SI/boosted engine and asked where HCCI offered real-world efficiency and emissions benefit for a relevant torque/power level. This reviewer felt that this should be where this technology was focused, which may lead back to studying light load. A fifth reviewer stated that the work demonstrated 47-48% indicated thermal efficiencies and that these appeared to be very similar or even lower than conventional diesel combustion engines. This reviewer went on to say that naturally, the benefits resided in cleaner engine out NO_x and soot emissions but stated that efficiency was very important. The same reviewer also said that the author clearly showed the impact of highly premixed combustion and that efficiency closely tracked the combustion phasing. This emphasized the overall importance of phasing, possibly overshadowing other effects. The reviewer also felt that the fuel strategy (increased stratification) results were unclear. The results were insightful from the limiting of rates of heat release, according to this reviewer, but it was unclear what the combustion phasing impact was since it seemed it had not been kept constant. The same reviewer suggested that a comparison of pressure traces would be useful. Lastly, this reviewer was not sure if the study had significantly improved the fundamental understanding of HCCI/SCCI. The sixth reviewer summarized the project by saying that a large amount of experimental data had resulted from this project which was very helpful in sorting out combustion variances between ethanol and gasoline under advanced combustion modes such as HCCI and PCCI. The only question was whether the PI could accurately determine the indicated thermal efficiency to sort 0.2 to 0.5 percentage point variations based on combustion phasing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the collaboration and connection with the industry and academia remained outstanding. However, the reviewer would have liked to see collaboration with turbomachinery and aftertreatment suppliers. The second reviewer went into more detail by saying that there was good collaboration with GM, LLNL and various universities, but that a closer connection to other industry partners would be helpful, and it was important to agree on what the acceptable combustion noise level was. Additionally, this reviewer remarked that providing data to LLNL to validate the project gasoline surrogate mechanism was very useful. However, the reviewer felt that collaboration with metal engine work at Argonne National Laboratory would be useful. The third reviewer noted that the project was another ongoing key AEC MOU project with close collaboration with various industry partners, a couple of Universities, and another national lab. The fourth reviewer noted that there was AEC cooperation, and the fifth reviewer observed the project has a good collaborative team. The final reviewer noted detailed collaboration with GM and that several other collaborations existed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert said that it was useful to look at different fuels, particularly the use of ethanol as an octane enhancer (including the influence this would have on HCCI), and felt that it would be important to understand the tradeoff between noise and efficiency. The second reviewer recommended some key areas for consideration: cold start and transition to HCCI from spark ignition (if needed); optimizing tradeoffs of efficiency and potential aftertreatment performance; and stability margins during transients. The present focus on efficiency, steady state combustion performance and emissions, and NVH already appeared to be more- or less adequate. The third expert noted SA-HCCI work. A fourth reviewer felt that the overall the project had excellent proposed future research, and suggested the exploration of piston design changes on thermal stratification. This reviewer felt that this detail could be important in the design of future pistons for engines that utilize these combustion strategies. A fifth reviewer felt that the increase of compression ratio or the sensitivity to it would be a good next step. This reviewer also wondered what the advantages were for SNL to install spark ignition. Additionally, the reviewer felt it was unclear what the support activity was that was taking place on the HCCI modeling. The sixth reviewer said that given the variability of fuel in the marketplace, it would be useful to consider this as a noise parameter rather than a control parameter. For example, the reviewer said the combustion seemed to be quite sensitive to ethanol content, but commercial fuel ethanol content as permitted to vary from the nominal ethanol content. The reviewer asked what could be done to evaluate the impact on combustion control given that commercialization of this concept would have to be robust to variations in fuel. A seventh commenter also liked the addition of SA-HCCI and real world fuels, but said that the project could address controls approach and challenges. The final reviewer reiterated that the project was going to look at spark-assisted HCCI and pointed out that this was a very geometry dependent concept. The reviewer was concerned for the ability to have a geometry that would aid partial fuel stratification, which would be a component that controls the flame propagation during the initial portion of combustion.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Only two reviewers provided comments, with one stating that the resources appeared to be sufficient to achieve the project objectives and the second simply stating that the project was well funded.

Spray Combustion Cross-Cut Engine Research: Lyle Pickett (Sandia National Laboratories) – ace005

Reviewer Sample Size

This project was reviewed by eleven reviewers.

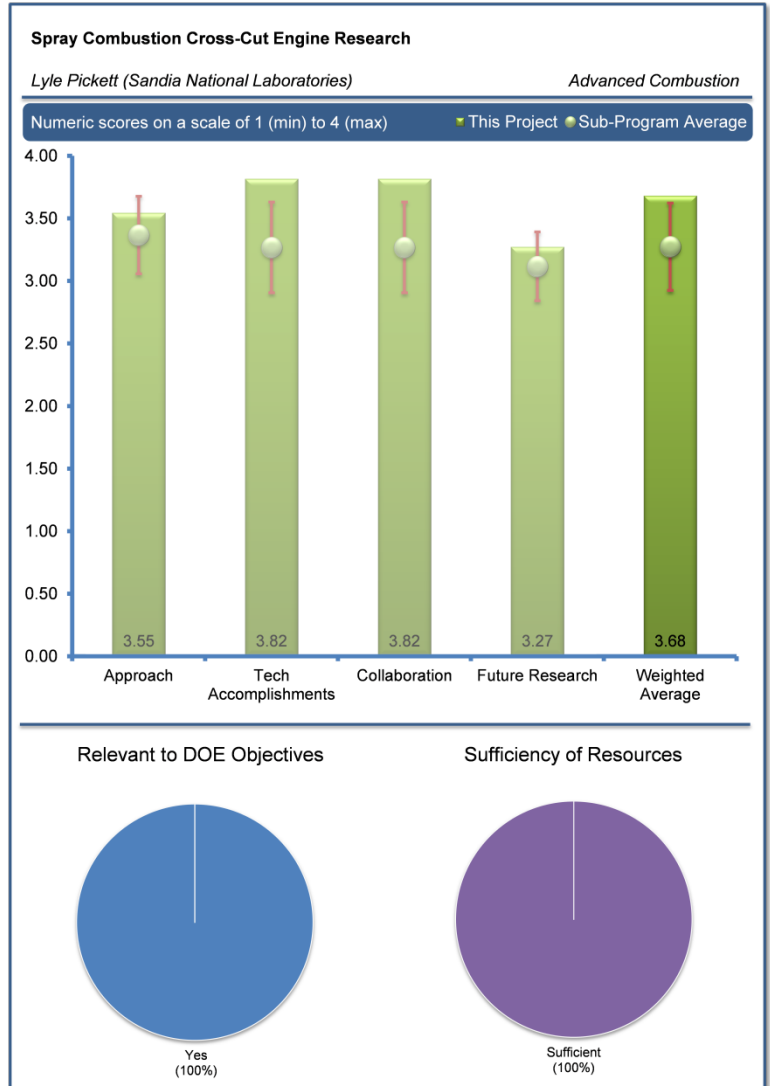
Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that this work represented a key fundamental study to improve the efficiency of heavy-duty engines. The second reviewer said that direct injection is the linkage to efficiency of the future. A third reviewer stated that the project contributed to reducing fuel consumption of internal combustion engines. A fourth reviewer noted that good predictive spray models were critical for improving the design of engine systems and improving engine efficiency leading to improved fuel economy and thus lower requirements for petroleum. The fifth commenters stated that improving spray models was an important step toward improving combustion for improved engine efficiency. The sixth respondent indicated that the research will improve fuel spray modeling and that it supports engine efficiency improvements. Another reviewer said that this project aimed to provide an understanding of direct-injection fuel sprays. The reviewer felt that the shortcomings in modeling of sprays were a key barrier to understanding conventional as well as low temperature combustion. The final reviewer commented that this project indirectly addressed DOE needs by hopefully

leading toward an improvement of today's spray models that was critical in evaluating advanced combustion modes, but that this project eventually needed to link fuel spray formation to indicated thermal efficiency at some point in the future.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the liquid penetration distance focus was well placed. The second reviewer said that the project had a good approach of using optical diagnostics to view sprays and then develop and fine tune models. A third reviewer felt this project leveraged a wide range of partners with very capable facilities and that a worthy effort was made to coordinate these activities. The fourth reviewer said that the project produced some of the best fuel spray pictures the reviewer had seen and that it was great to see the results at temperature. A fifth reviewer commended the project by saying that the project had completed excellent work in deciphering issues with measuring evaporation rate (liquid length) depending on the technique and experimental apparatus. Also, the reviewer felt that the project did excellent work in pulling together various spray experts around the world in sharing data, comparing ideas, and also modeling sprays. The only suggestion from this reviewer was to more widely vary the spray boundary conditions, e.g., pressure and temperature and injection rate profile, and also to figure out how to link various spray formation processes on indicated thermal efficiency. The sixth expert felt that multiple organizations conducting similar analysis/measurements to gauge repeatability and establish common techniques were good. A seventh reviewer felt that the work, in collaboration with computational efforts and optical engines, represented an important piece toward gaining a fundamental



understanding of combustion in heavy-duty engines. This reviewer stated that it was especially important going forward was the contribution to the evolution of near-field spray development, particularly at elevated temperature and pressure. Finally, the last reviewer said that experiments in a constant volume chamber had limitations as far as applicability to an engine because it did not have the correct flow and ambient conditions. However, it provided a first, idealistic view of spray structure.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that the collaborative study of many different aspects of spray development was invaluable. The reviewer recommended that extending this work to include gasoline sprays would be important for light-duty engines as well. The second reviewer said that there were interesting results on what happens at injector startup and excellent progress in coordinating Engine Combustion Network efforts to cross compare and calibrate/align results across the various facilities doing spray modeling work. A third reviewer liked that the project had results at realistic cylinder-like conditions. The fourth reviewer stated that the work is excellent and has brought new understanding on how to measure liquid length and correlate measurements to spray models. The reviewer felt that the PI had spent much time and effort to bring together the various spray research facilities around the world in order to commonize experiments; the reviewer felt that this should also be considered a technical accomplishment. A fifth reviewer said that high speed microscopy movies have shown increased features and phenomena of the spray in the near-injector region. The reviewer felt that these new insights into the atomization process would be very valuable in guiding the modeling efforts. The sixth expert remarked that repeated measurements at multiple facilities to understand repeatability and understanding measurement sensitivities to noise and control factors were good. The same reviewer asked how these observed differences in spray structure translated to differences in combustion and how to go about answering this question. The seventh reviewer summarized that the project sought to study the complex interactions between sprays, mixing and chemistry and that the work aimed at improving engine designs by providing more predictive, cost effective modeling. The work presented gave a very well organized description of the injection event. The reviewer felt that this included the beginning stages of the injection event, the discovery of vapor injection leading liquid injection, and the discovery of gas entrainment in the sac during first needle movement. The reviewer summarized that the work scope focused on spray, liquid-phase penetration, and spray structures. The reviewer then pointed out that what was unclear however was the impact that these had on overall the predictive modeling. The reviewer then wondered what the impact was on the emissions (NO_x, soot, HC) and performance (combustion, cycle efficiency). It was also not clear to this reviewer what came out of this collaboration and what was being transferred into modeling packages such as KIVA or commercial codes. The reviewer also asked what benchmarks had been made to demonstrate the effectiveness of this work, and queried the before and after performance of the models. The final reviewer questioned why there were no cursory investigations with closely spaced split injections, and gasoline-like fuels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the Engine Collaboration Network (ECN) collaboration was exceptional and highlighted its alignment on hardware (e.g., Spray A). This was reiterated by two other reviewers, one who said that ECN was a good example of collaboration, and the other remarking that the engine combustion network was an excellent vehicle for collaboration. The fourth reviewer noted that excellent ties existed with the modeling community as well as industry through the AEC and ECN networks. Another reviewer said that the collaboration with other labs, academia and industry remained outstanding, and that future collaboration on gasoline sprays would only improve the usefulness of this work. A sixth reviewer went into more detail by saying that the ECN appeared to be providing an excellent mechanism for mostly universities and national labs to share results and collaborate. The reviewer also noted that a couple of industrial companies also appeared to participate and interactions with industry apparently also occur at the semi-annual AEC memorandum of understanding meetings. A seventh reviewer said that this work was needed with different nozzle hole geometries, primarily Kf and amount of nozzle honing. Both of these have effects on engine emissions and performance and it must be due to the effect on the spray. The reviewer felt that this work would lead to guidance on how to set up the spray model differently in a CFD run for different nozzle holes, and specifically pointed out that this was needed in the industry. The reviewer elaborated by saying that today a difference in emissions was seen, but that it was not known how to change the spray setup to get these differences. The eighth reviewer pointed out that this project was another key AEC memorandum of understanding project that has included much interaction from the industry over the years and that the combustion network that included global research partners at various institutions such as Pennsylvania State, ANL, Cambridge University, University of Wisconsin, CMT, and Caterpillar. The final reviewer suggested that the project could have a larger collaboration with partners that could exercise a real world evaluation of the outcome of these activities. The reviewer went on to say that one or several industrial partners could be engaged and supported to see how the present work could translate into successful

implementation of improved models, validated by testing and added that many industrial entities performed extensive modeling exercises that were experimentally validated.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that the project was well-planned and offered no specific recommendations. The second reviewer suggested that the project needed to greatly accelerate gasoline injection diagnostics. Another reviewer indicated that it is good to include gasoline injectors. The fourth reviewer's suggestion was to also investigate various injection rate profiles as part of future experimental and modeling activities. Otherwise, this reviewer felt that the future work plan is logical. A fifth reviewer commented that measurements of liquid volume fraction would be very valuable in validating models and that what was uncertain was if measurements could be made closer to the injector. This reviewer pointed out that some of the X-ray diagnostic work done by Professor Jerry Faeth at University of Michigan should be reviewed to see if any knowledge already gained for the near-injector, dense spray region under low-temperature ambient conditions was applicable to the current work. The reviewer added that, in the diesel area, the modelers should be allowed to catch up the data and insights already obtained. On the other hand, this reviewer said that gasoline injector and spray work should be accelerated to start getting results because the potential for impacting the passenger-car fleet and reducing petroleum usage was greater. The sixth commenter said that the physics of the phenomena was well represented and that the level of detail on the phenomena described would need to be further generalized so that it could or would be applicable to more universal conditions, other sets of hardware, wider rates of injections, and temperatures and pressures at which the fuel is injected. The reviewer added that the work continued into direct-injection gasoline, but encouraged the authors to ensure the work done is leveraged onto modeling tools. Similarly the seventh reviewer noted that the project did not have too much time to go into much detail on future work, but information on plans in the slide deck seemed reasonable. The final reviewer said that the project needed a roadmap to determine how these observations could be translated into engine attributes.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Of the two reviewers providing comments, both agreed that resources were sufficient for this project and one said the resources seemed sufficient for continued progress.

Automotive HCCI Engine Research: Richard Steeper (Sandia National Laboratories) – ace006

Reviewer Sample Size

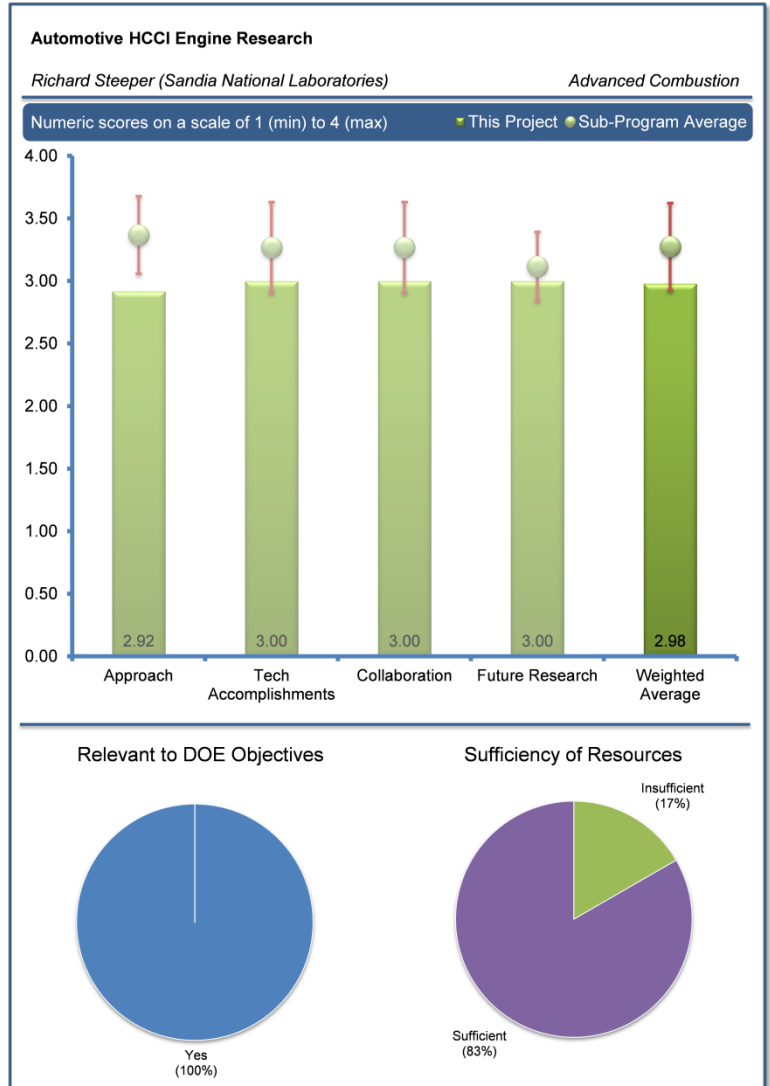
This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One of the reviewers said that HCCI combustion has the potential to significantly improve light-load efficiency in light-duty engines, while another agreed that it had potential for lower emissions and improved efficiency which would lower demand for petroleum. The third reviewer simply stated that the project contributed to reducing fuel consumption of internal combustion engines. The fourth reviewer indicated that the project aimed to improve understanding of automotive HCCI engine combustion for higher fuel efficiency. A fifth reviewer recognized that HCCI was one possible path to improving gasoline engine efficiency, enhancing the load range was critical to implementation, but there were also many other technical barriers. This reviewer also said that it was not clear what influence NVO would have on efficiency. The reviewer continued that fundamentally, it should be bad for efficiency, so it was not clear that this path would yield a solution that would improve fuel consumption. The sixth reviewer said the project directly addressed DOE goals for improving gasoline engine thermal efficiency by exploring the control and use of HCCI to improve part-load indicated efficiency and thus improved composite drive cycle fuel consumption. A seventh felt that the HCCI barriers remained significant (noise, ringing intensity, controls) and that unless progress could adequately remove barriers for light-duty applications, the reviewer suggested placing funding elsewhere in the combustion portfolio. The final reviewer stated that improved efficiency was the goal but felt that what was missing was a mathematical calculation predicting how much efficiency gain was planned to be achieved. Without this, the reviewer did not know if it was worth pursuing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said this project sought to explore fundamental knowledge of engine combustion, looking into fuel injection, evaporation, mixing, heat transfer and thermal stratification; and that it targeted 25% gasoline fuel economy improvement and Tier II, Bin 2 emissions with less than 1% thermal efficiency penalty. The reviewer went on to say that the work was approached via experiments in an optical engine equipped and configured for automotive HCCI combustion strategies, diagnostics to acquire in-cylinder measurements of fundamental physical processes and computer models to guide and interpret engine experiments. The second reviewer felt that the acetylene seeding experiments were useful, but that there was not enough emphasis on realistic constraints on pressure rise rate. The reviewer also felt that more results on ISFC (efficiency) were needed in the material. A third reviewer said that the approach of coupling optical engine experiments with modeling was good and appropriate. One key question from the reviewer was whether the use of NVO in HCCI would be a key enabler to advancing the commercialization of high



efficiency and clean combustion processes. The fourth reviewer noted that the project uses optical engine experiments to increase insights and knowledge. The fifth expert said that the approach to date has been logical and appeared to address some of the key issues with NVO approaches on gasoline HCCI, though pressure rise rate effects were not discussed in much detail. Also, the reviewer did not see a discussion on the impact of various HCCI control strategies on indicated thermal efficiency. The reviewer felt that it would be helpful to see a quantitative discussion of this subject matter in the future. A sixth observer commented that the experimental study had so far focused on a narrow range of conditions; the reviewer would have liked to understand the limitations of deploying this strategy over a wider range of operating conditions and questioned what the potential to extend this approach to higher loads was. The reviewer also asked if the range was too limited to achieve the overall targets for engine efficiency outlined in the advanced combustion roadmap, while achieving Tier2/Bin2 emissions. The reviewer wondered if a metal engine would be useful for mapping out the potential for this approach. A seventh reviewer stated that the project focused on NVO looking at different methods of NVO injection and that fundamentally NVO should be bad for efficiency, so it was not clear that this path would yield a solution that would improve fuel consumption. The reviewer said that it sounded like low load limits for HCCI was potentially the main barrier being investigated, but that it would be useful to create a clearer picture of what barrier was being overcome. The final reviewer said that it was difficult to determine if NVO was a viable path to production-capable HCCI engines.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that there were very interesting results and comparison of early NVO and late NVO in HCCI. The same reviewer also felt that there were interesting results with the acetylene seeding experiments. Similarly, the second reviewer stated that the Chemkin versus Experimental for C_2H_2 seeding was highly significant for insight. The third reviewer stated that understanding differences in early and late NVO injection was beneficial if NVO was employed and went on to say that this was a fundamental study, that it was important to reform fuel rather than fully consume it during NVO and identification of C_2H_2 as an important species. The reviewer felt that the connection to the model and leverage of the model would be useful. The fourth panelist felt that this was very good work to date in addressing the impact of fuel injection timing during NVO on heat release rate and piston fuel film formation. The reviewer suggested that it would have been nice to see more attention paid to the effect on indicated thermal efficiency using the various NVO injection strategies. A fifth commenter pointed out that last year's focus was on using TDL to identify other species during NVO and wanted to know if this work succeeded, and if it had been reported. The commenter stated that comparing with last year's work suggested relatively little progress in the past year. The sixth reviewer noted that the project focused on NVO to extend low load operation, but wondered why the authors were focusing on just NVO. The reviewer asked if this was the key and only enabler to promote HCCI load extension and asked what other mechanisms had been considered. This reviewer went on to say that large NVO gives off poor efficiency, and asked what efficiencies were being run in this work. Detailed images of combustion were shown, but the reviewer wanted to know how insightful it really was. The reviewer wondered why there were no correlations to engine out emissions of NO_x , HCs, and/or soot, and pointed out that the authors spoke of contributing to very stringent emissions and fuel efficiency standards, but no reference was made in their work to these. The reviewer also noted that the introduction of acetylene arises from apparent chemical effects of late NVO injection on main combustion phasing and that the imaging experiments show NVO fueling linked to rich flames. The reviewer then stated that since acetylene is a known product of rich flames and a known ignition enhancer, the project hypothesized its role as a reformed NVO product that can help control main combustion. The reviewer then pointed out that this was corroborated in the project's extensive experiment, but that the authors did not communicate the significance or practicality of this information for the HCCI application. A final reviewer noted that early and late NVO fuel injection strategies have been investigated, the effect of which has been simulated with acetylene seeding experiments. This reviewer reported that similar effects were observed, suggesting that late NVO fueling produces species that enhance ignition. The reviewer also wondered regarding the observed increased peak apparent heat release rate for the seeded cases, particularly, how the project was sure that all of that could not be attributed to the participation of the seed acetylene in the combustion process, providing a kick in the peak burning rate, per abrupt drop off in C_2H_2 profile in Slide 13.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer felt that the collaboration with industry and academia was good and that continuing to pursue new collaboration with the industry to help refocus the objectives would be helpful. The second reviewer said it looked like there were good interactions with OEMs (GM and Ford) and LLNL and that those main interactions with energy companies mainly appeared to be through the semi-annual AEC memorandum of understanding meetings. Similarly, a third reviewer stated that the main collaboration was through the AEC, however there were additional collaborations with universities and engagement with light-duty OEMs. The fourth reviewer noted that collaborations with the modeling community and input from industry were frequent. The final reviewer said that the presentation reserved a minimum discussion to the modeling work from LLNL and University of Wisconsin and that no details were given to the interaction with the OEM partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that, overall, the project had a very logical approach to continue pushing the understanding of use NVO approaches for gasoline HCCI as a means to improve part load engine efficiency, and recommended that it would be helpful to also include attention on the impact of indicated thermal efficiency as part of the future experimental and modeling activities. The second reviewer suggested refocusing research on dilute, spark ignition research areas. The third reviewer said that understanding the effects of various fuels on kinetics may be important and that adding an oxygenate component (given certainty of E10) may affect the C_2H_2 mechanism. A different reviewer said that the presenter did not have enough time to discuss future plans, but that from the slides, the plans appeared to be reasonable. Another expert said that it was not clear how useful this work was to further promote the implementation of HCCI, but that the authors linked this work with the overall goals of efficiency and emissions targets cited in their opening slides. Another reviewer said that leveraging the model to understand what species would be useful, but that it was not clear how one would be able to control which species were generated. The reviewer also indicated that looking at fuel effects on this process would be helpful and asked if ethanol content or other gasoline properties altered the effect. The same reviewer remarked that focusing solely on NVO without having a clear path to improving efficiency with it suggested that the PI should potentially expand research to other techniques to expand the HCCI operation regime. One expert simply felt that a path to viable mass produced NVO HCCI engines was not clear. The final reviewer asked if it was necessary to quantify mass and duration of piston-top fuel films associated with late NVO fueling. Eventually, the reviewer wondered if the project could anticipate that depositing fuel on piston surfaces had to be avoided due to soot, piston deposit formation, or other reasons.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that there was no evidence that the resources were not sufficient, while another said that funding was adequate. A third reviewer felt that upgrading the hardware to the new optical engine head would be important for future work.

Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) – ace007

Reviewer Sample Size

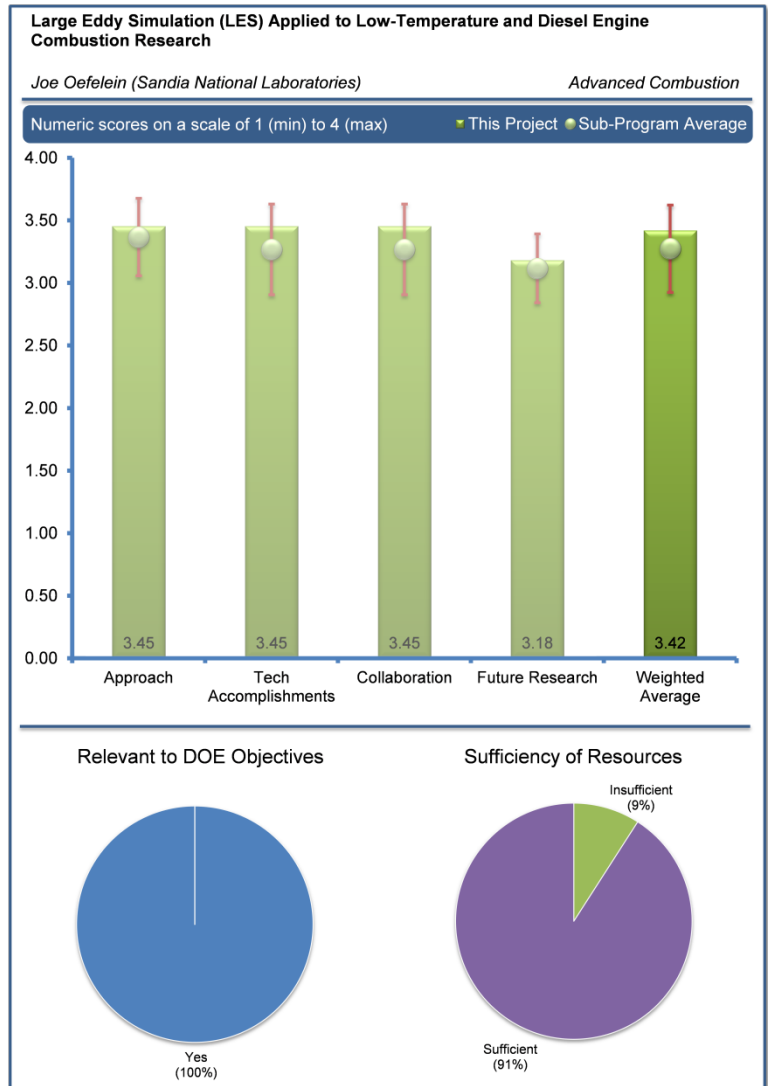
This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer identified the project as a fundamental high pressure liquid injection process. The second reviewer noted that the development of affordable predictive tools was important for advancing the development of high efficiency, clean combustion engines which would rely less on petroleum. The third reviewer agreed that the project contributed to reducing fuel consumption of internal combustion engines. The fourth reviewer said that improved engine models would help contribute to improved engine efficiency. A fifth reviewer noted that this modeling effort was being well leveraged to compliment both optical studies and less rigorous CFD. This reviewer felt that the efforts would enhance understanding, and ultimately allow improvement of measurements and models which would be used to increase engine efficiency through combustion system design. Another panelist said this was a very fundamental spray model development project whose projected positive results would occur a few years from now. The panelist went on to say that the question of supercritical spray behavior modeling could be valuable to engine designers in future toward addressing both conventional and non-conventional combustion models by linking spray formation to heat release, PM formation, and NO_x formation. The final commenter said that this project was highly fundamental in nature, used very expensive and powerful computers that typical industry would not have access to, and that in the long run, it provided a pathway to accurately model complex spray and combustion phenomena.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the Rayleigh vs. Large Eddy Simulation (LES) comparisons were interesting, but thought that more examples of specific applications would be useful. Similarly the second reviewer thought that the approach of coupling LES simulations with actual experimental results was very good. A third reviewer summarized that the approach sought to bridge the gap between basic and applied research, focusing on coupling of LES to key target experiments (at SNL). The reviewer went on to say that the models worked toward predictions at engine conditions of high-pressure, low-temperature, multiphase flow and combustion. A different panelist noted that the project used high fidelity models to provide information to validate more efficient models and that it could inform everyone about what physics to focus on when improving efficient models. The panelist went on to say that working with the ECN was a great use of these tools, because there was critical mass in that area and that these tools could have maximum impact with minimal resources. The fifth reviewer specifically commented that there was good collaboration with



using Lyle Pickett's test results, which led the reviewer to ask whether the project could predict results for Pickett's future case. Another reviewer said that the physics retained in this work was comprehensive and that the conservation equations were fully coupled, with detailed transport and chemistry. The reviewer remarked that this project was conducted on a computer platform that was unique in its power and capability. The final reviewer said that the approach was logical, but suggested the exploration of more experimental validation as mentioned below.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panelist felt that this project was challenging current modeling practices for high pressure sprays and to date had shown some evidence of the importance of supercritical behavior of spray mixing layer formation. The panelist felt that accomplishments were slow to date, but that this work was important for future use in modeling next generation direct injection combustion systems. A second reviewer also opined that beginning to understand and sort critical noise and control factors with respect to sprays was great progress. The third reviewer felt that the full field thermodynamic analysis was impressive and recommended additional comparisons at various pressures, etc. to see effects (a sensitivity study). A fourth reviewer observed good progress in developing LES simulations that matched fairly well with Pickett's optical spray experiments. A different panelist pointed out that while LES models were still impractical for engine development because of computation time, it provided an important benchmark to evaluate the faster RANS approach. Therefore, the panelist felt this was valuable work to show simulation potential. A sixth reviewer summarized the project by saying that the project used the model to inform ECN experiments, providing a new understanding of diesel sprays where the spray does not actually have droplets, and helped identify what was different about the cases where droplets were identified and ones where it was not. The seventh reviewer stated that some good speed up improvements had been shown and that the work was key to guiding industry combustion CFD engineers in how to correctly set up their fuel spray models for different operating conditions, which had always been a challenge. The eighth reviewer noted that the experiments of Lyle Pickett at SNL were being modeled and that supercritical conditions had been identified under some engine conditions. This reviewer felt that this had been a significant step in understanding fuel injection and mixing. The final reviewer summarized that the project described injection of fuel under subcritical and supercritical cylinder pressures and pointed out that the latter showed turbulent diffusion dominating mixing prior to atomization. This led the reviewer to look for more information regarding if this detail was significant and to what extent. The same reviewer also said that the presentation stated the capability of real-fluid models to capture the behavior of multi-phase mixtures at high-pressure supercritical conditions, but noted that these details were not captured in traditional models. This led the reviewer to wonder if these more refined features were significant in the modeling of ICEs, and how it was significant. The reviewer also wanted to know if the colleagues in the applied teams had been able to assess these new features in the engine models. Lastly, the reviewer wanted to know how consistent the results were. This reviewer pointed out that the author showed two fairly wide temperatures of 440 K and 900 K. The reviewer would like to know what the case was for mid and even higher ranges.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that significant collaboration existed but that a few examples of benefits would be useful. The second reviewer noted that it looked like there was close collaboration with Sandia National Laboratories experimentalists (Lyle Pickett and soon John Dec) as well as with others at University of Wisconsin, Pennsylvania State University, University of Michigan and the ECN. However, this reviewer indicated that there was no real mention of direct collaboration with industry, although maybe the industry did not have as sophisticated modeling tools. The third reviewer noted that there was good collaboration with a few universities and some connection to the combustion network but thought that it would be beneficial to see an engine development company more involved in this project. The fourth panelist noted that the project was well connected to the ECN. A fifth reviewer noted that the alignment with Lyle Pickett's work and ECN was good. Another reviewer reiterated great collaboration with ECN. The final panelist thought the work team appeared to be very extensive, but suggested that highlights from key contributors and examples of benefits would have been useful.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the plans to continue the focus on spray modeling and also extending work to attempt to match John Dec's HCCI experimental results should yield useful results and advance the state of simulation technology. A second reviewer summarized that there was a plan to build on the ECN collaboration and suggested that it would be useful to clarify what specific problems would be the focus of future work and to define a path to improve efficient RANS models used for engine design. The third reviewer stated that the work appeared to be well coordinated with that of Lyle Pickett, and soon onto the work of John Dec. The reviewer felt that it appeared there was a need to close the loop to validate these results beyond the visual assessment, such as in the chemistry and ultimately the effectiveness on real environments. In other words, the reviewer wanted to know how the added modeling fidelity contributed to the combustion modeling process. A fourth expert simply stated that the project needed a clearer path on how this fundamental research cascaded to production engines. Another panelist felt that the computational aspects of this work are outstanding in addressing the historical question concerning supercritical spray behavior. Nevertheless, according to this reviewer, there was a real need for more experimental work to further validate any proposed new spray model. The reviewer suggested that three to five additional experiments be designed to address the research question including sprays that have projected large portions in the supercritical regime versus very little supercritical regime. Also, this panelist suggested that exploring the effect of injection rate profile could be valuable in addressing this question given its impact on the spray formation process. The final reviewer felt that the approach should be applied more to spray characteristics at common gasoline direct-injection engine operating conditions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that the resources seemed sufficient. The second reviewer stated that the project was well-funded for a project strictly focused on computations.

Free-Piston Engine: Terry Johnson (Sandia National Laboratories) – ace008

Reviewer Sample Size

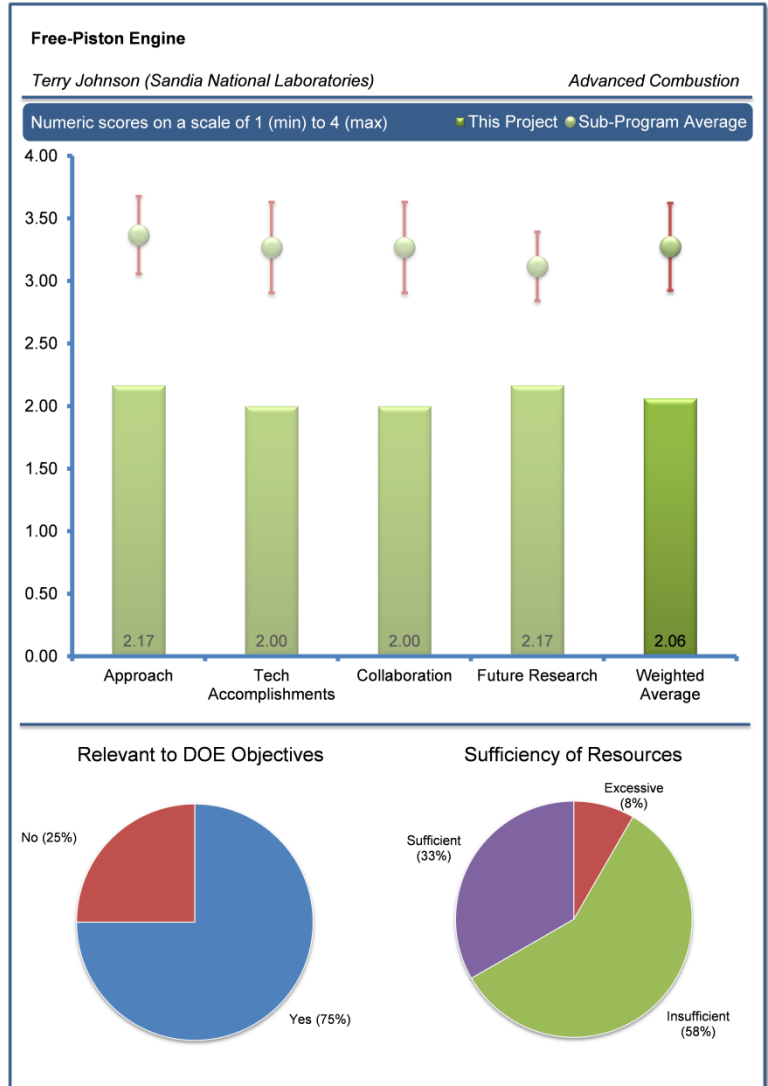
This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first panelist simply stated that the development of engine systems with higher efficiencies would decrease the requirements for petroleum and that this engine was portrayed as being capable of using alternative fuels. The second reviewer acknowledged that the project was looking at creating an engine that obtained high thermal efficiency via high compression ratio. A third commenter felt that the project aimed to obtain very high efficiency via direct conversion of a high-efficiency engine output to electricity. The fourth reviewer found it very hard to imagine that this technology would ultimately have much impact on petroleum displacement. This reviewer thought for certain that there were better (more efficient and cleaner) ways to convert hydrogen. A different expert said that it was not obvious why a free piston engine would be more efficient than a conventional engine. The expert stated that there might be a friction benefit by elimination of the crank shaft, but the pistons in the project engine were very long and may offset this improvement in friction. The expert also pointed out that the same combustion barriers were still present in the opposed free piston, and that no work had been done to investigate these. The sixth reviewer said that if the project worked, that it would support overall DOE objectives. Similarly, a seventh reviewer asserted that it would address objectives if actual combustion and efficiency were to be demonstrated. The eighth reviewer commented that this high risk project if successful could show the impact of high compression ratio combustion on indicated thermal efficiency improvements versus today's engines. The final reviewer stated that the project may need to be reviewed as to its readiness to provide realistic input to the DOE goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that focus was needed on initial engine operation and that complimentary mechanical opposed piston engine operation would be useful. A second reviewer stated that the concept of conducting research on alternative engine designs was very good and useful. The third reviewer said that the project failed to provide a means to discern the potential benefits of the technology, if it were to exist. This reviewer indicated that there did not appear to be a clear means for separating out the heat loss, friction, and linear generator losses in such a way as to permit the results to be interpreted in more general fashion, such that the work might have longer-term reference value. A fourth reviewer stated that the goals and proposed roadmap to complete the project was unclear. The further remarked that opposed piston design was said to be simple and capable of high efficiency but that the concept appeared rather delicate as described (such as the startup procedure) and that there was no indication that this could translate to high efficiencies (either mentioned or referred to). The fifth expert noted that the project was creating a prototype;



however, it was not clear that the end result would provide something that was better efficiency. This reviewer pointed out that heat transfer from the various chambers increased blow-by, increased friction, and electric energy conversion efficiency were likely to erode the theoretical benefits. Following in the path of the other reviewers, the sixth panelist said that what was missing was a slide that showed how this device would actually lead to improved efficient engines, and that something that showed the thermodynamic calculations would be great. The seventh reviewer questioned the value of developing a free piston dynamometer to demonstrate combustion efficiency, and asked if there was a more cost-effective approach. One area of major concern for the eighth reviewer was lubrication with the engine concept. This reviewer felt that very little effort appeared to have been invested in addressing this key issue with free piston engines. The reviewer recommended that the PI should focus more energy on this issue. The final reviewer felt that in retrospect, this project was scoped poorly; and indicated that too much was taken on for the resources available.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that the target provided in 2011 was for a running engine and wondered if the exchange of the PI was perhaps a factor. This reviewer went on to say that the friction force model provided a good correlation with data and was useful for future work. The second reviewer specifically acknowledged the small budget, but still felt that the progress was too slow. This was reiterated by another reviewer who said that progress on this project has been slow over the years (but not necessarily attributable to those who were new to project and that fortunately the engine was now assembled and shakedown tests had been conducted. The fourth reviewer reiterated that the progress has been slow, but was finally close to producing data. The reviewer stated that the project still has not shown convincingly that it will overcome any of the technical barriers that it purports to address. A fifth expert commented that the author had made significant progress in the assembly of the engine and that the project had appeared to recuperate well from the loss of the previous PI, noting specifically that this included helium starts. This expert also pointed out that the time traces on the slides varied quite a bit, from milliseconds to seconds when describing the piston motion and asked if this was a typographical error. The expert noted that the project moves soon into motoring and combustion tests and that the work showed no estimates as to the target performance of the engine other than seeking to attain the Otto cycle efficiency. A thermodynamic and energy balance analysis would be useful. The expert wondered what issues were expected to be encountered as the project sought to run at higher compression ratios and what the implications were on emissions. A sixth reviewer noted that while the project has traditionally demonstrated slow progress, there has been better progress this year. A seventh reviewer indicated that there was good progress creating a prototype and that the project was starting to get some data. The eighth expected to see combustion results at this review. The final reviewer observed moderately slow progress this year and stated that according to last year's presentation, this engine was supposed to have been subjected to combustion with some type of operable capability. The reviewer noted that it looked like funding was reduced and that it was not clear if this change caused the schedule to shift to the right, or if there were other issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer said that the GM/CRL and Matlab/Simulink work was of interest and wondered if any results would be available in 2013. The second reviewer acknowledged the collaborations with one OEM (GM), one university (University of Michigan), and one other national lab (LANL). The next reviewer said that to the extent that this project has long-term value for gaining an understanding of high compression ratio HCCI combustion, that the level of collaboration was appropriate. A fourth expert felt that the work team, especially the University of Michigan, could contribute more extensively especially in the area of cycle simulation and predicted engine efficiency. A fifth reviewer asked if there needed to be collaboration with someone on the electronics side. The sixth reviewer went into more detail by saying that it was not clear how involved GM was with the concept. Based on this involvement, the reviewer's rating could change to good. This reviewer stated that it was important that GM ensures that the engine is properly tested and evaluated with good measurements to assess this engine concept's validity toward 50% thermal efficiency. Finally, the last reviewer said that while there was good collaboration between the OEM and modeling partners, this project could have done with help from organizations that have some experience with free-piston engines and linear alternators. According to the reviewer, that would have left this project freer to focus on the issues and problems of marrying the two.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first expert stated that given engine operation issues, plans to test different fuels at various compression ratios by year end seemed a bit too optimistic, but hopefully achievable. Another reviewer indicated that when looking at friction reduction, it would be important to understand whether these technologies are unique to the free piston engine or that their benefit was somehow more synergistic with that engine than standard engines. The third reviewer pointed out that the control of linear actuators was consuming all the resources, while significant combustion/efficiency challenges remained. A fourth reviewer questioned whether the project should start with H₂ combustion, as it raised the degree of difficulty on a project that was already in danger of providing very little progress. Also, the reviewer felt that it was unclear whether the models of the free-piston engine (FPE) were detailed enough to adequately interpret the data so as to understand the potential of this technology. The fifth reviewer said it appeared that the motoring and especially the combustion work was very aggressive as the authors sought to complete the work in the current academic year. A sixth reviewer said there was not enough time before the projects end to adequately investigate the combustion peculiarities of this engine. The next reviewer pointed out that there were many years of development on the engine and dynamometer, but only four to six months of combustion research were planned. This reviewer felt that this was very little return on investment with respect to combustion research. The eighth reviewer said that this engine needed to be assessed as soon as possible to evaluate the claims made by the original PI. Doing so, continued this reviewer, would determine the future of this ongoing project, which had significant technical challenges that have been discussed throughout the last three to five years. The final reviewer summarized by saying that it was unlikely that the list of future plans could be accomplished in the time available. The reviewer recommended that two or three key barriers to making this concept viable should be chosen and focused on as the project wound down. One example would be demonstrating the stability of the pistons.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer stated that initial engine firing experiments were absolutely needed in 2012 to continue funding research. The second reviewer felt that the resources were sufficient. The third reviewer was unsure that current plans could be achieved by year end. The same reviewer was also not sure though that it was worth putting additional resources into this project. This reviewer recommended that researchers who were fairly knowledgeable about free piston engines should provide recommendations on whether this project should be terminated or had enough potential to continue. A fourth reviewer pointed out that the project was high risk, though it had the potential to offer a new engine platform with unique characteristics. This reviewer went on to say that it was not clear however what guides the work, and what advantages were sought and expected with respect to current technologies. The reviewer felt that possibly more resources could help this team do a more complete job. The fifth reviewer opined that resources were excessive given the results. A different reviewer did not know if there was enough time to wrap up the project given the number of things left to do. The final reviewer said that there might not be enough funding to support a reasonable experimental assessment of the engine concept, which is a necessary step to close out this project.

Fuel Injection and Spray Research Using X-Ray Diagnostics: Christopher Powell (Argonne National Laboratory) – ace010

Reviewer Sample Size

This project was reviewed by ten reviewers.

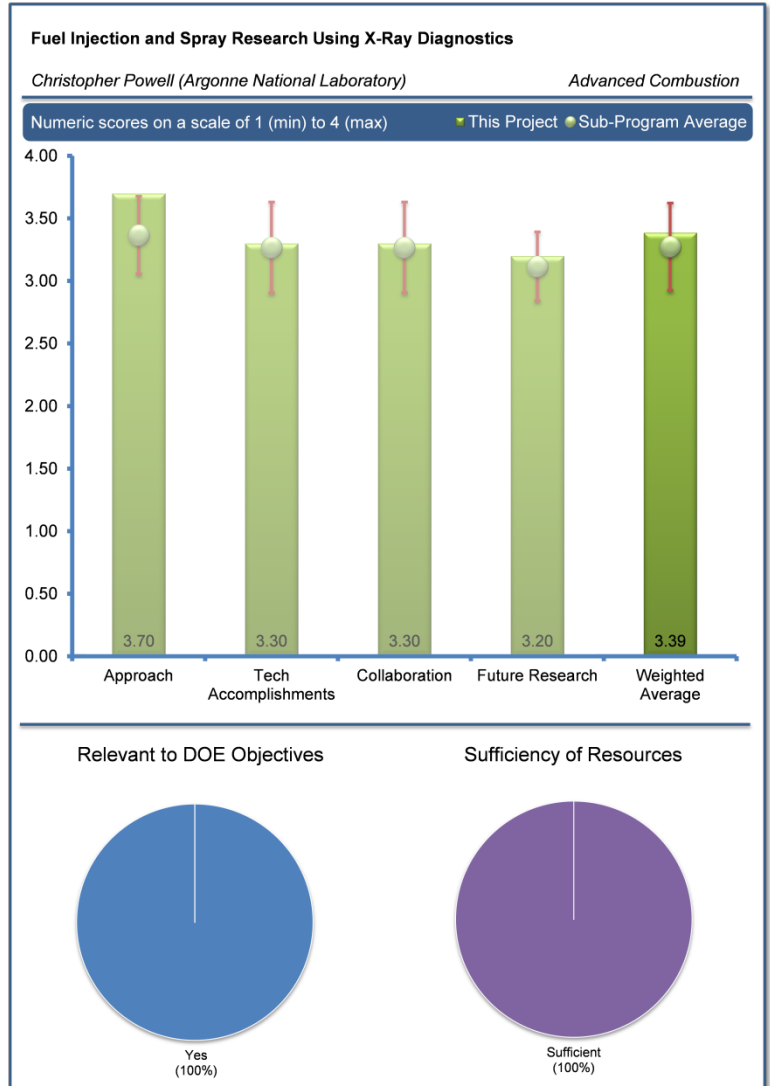
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer expressed that better understanding of fuel injection processes had the capability to reduce emissions and improve engine efficiency which would translate to reduced need for fuel/petroleum. The second reviewer acknowledged that fuel injection was a significant barrier to improving efficiency and emissions. A third reviewer noted that spray characterization and modeling were critical to developing efficient advanced combustion modes and that X-ray techniques added to the capability to compare models to experiment. The fourth expert said that understanding diesel fuel injection was important for diesel combustion modeling. The reviewer went on to say that diesel would reduce fuel consumption and increasing efficiency would depend on the tools used for design optimization. The fifth reviewer commented that fundamental knowledge of fuel sprays was needed to understand the effects on engine combustion. The sixth reviewer summarized by saying that this project supported spray targeting for advanced combustion modes where injection took place at mild pressures and temperatures in comparison to direct injection diesel engines. The reviewer said that the injection process is critical for enabling potential improved indicated thermal efficiency combustion modes such as LTC, PCCI, and HCCI which was clearly pointed out in other presentations. The final reviewer noted that the project aimed to improve engine efficiency by providing data and insight into the behavior of sprays and fuel injectors.

The reviewer said that the injection process is critical for enabling potential improved indicated thermal efficiency combustion modes such as LTC, PCCI, and HCCI which was clearly pointed out in other presentations. The final reviewer noted that the project aimed to improve engine efficiency by providing data and insight into the behavior of sprays and fuel injectors.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the reason for using x-ray versus visible light seemed reasonable. The second reviewer felt that the techniques were aimed precisely at overcoming barriers of existing methods. Similarly a third reviewer felt that this was a unique spray diagnostic technique providing quantitative measurement of the fuel location within the spray. The reviewer also liked the idea of leveraging various groups within ANL and thought that it was a good idea. A fourth expert commented that there was an excellent approach, including comparison with measurements from other labs, support of the ANL proposed spray break-up model, value added measurements of shock tube reaction rates, and assessment of nozzle design on near exit flow field behavior. The only suggestion provided by this reviewer was to work closer with other spray modelers beyond the current collaboration with ANL on developing a new spray break-up model. The reviewer mentioned that such data generated in this project could also lead to improvements in more traditional spray model approaches. A different reviewer said that the work appeared focused on spray characterization leveraging the x-ray capability of ANL and followed up by saying some work was being done in shock tubes but



that the work here appeared to be less focused or mature. The final reviewer said that the project used unique APS X-ray light source to study problems of interest and that this could not be done anywhere else.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first expert noted that the gaseous jet diagnostics showing matching disks was very insightful and that there was improved productivity due to a dedicated x-ray lab. The second reviewer stated that ANL should be congratulated for this. The reviewer said that the project started work on Spray A of the ECN and that it was significant that nominally identical injectors produced very different sprays and noted that the elliptical shape of the spray has been correlated to the elliptical shape of the nozzle exit. The reviewer also felt that the validation of the KH-ACT model was very encouraging. Finally, this reviewer claimed that the imaging of a gaseous jet was remarkable and that the new work on cavitation in nozzles and shock-tube measurements was equally remarkable. The third reviewer said there were interesting comparative measurements demonstrating similarities and differences of nominally identical nozzles. The reviewer also noted the application of this technique to several areas for the first time (measurement of gaseous fuel jets, measurement of shock tube boundary layers). The fourth expert said that measurements of Spray A were very useful to the ECN community and that imaging of gas jet for natural gas injector was a new result and a very useful contribution. The reviewer did note that productivity has increased with the dedicated lab. A fifth reviewer found the results showing elliptical results from the fuel sprays to be fascinating and stated that the challenge now was to show how to incorporate this into engine modeling. The sixth reviewer said that there was good continued progress towards identifying contributors to spray geometry, but that the project needed to consider how these measured differences affect engine attributes. The seventh reviewer opined that there was very good experimental results to date and also in supporting a new spray break-up model development effort at ANL. The reviewer felt that one area of possible additional progress was supporting more traditional spray modeling efforts such as those at the University of Wisconsin or University of Michigan to name a couple. The eighth reviewer remarked that the x-ray images of the injector nozzle geometry were shown along with other images from various facilities and noted that the images showed a propensity for elliptical features on the nozzles under study. The reviewer thought it was hard to assess, however, the true implication of these features. This reviewer wondered how the eccentricities compared with production-like nozzles and if the authors had a sense of the variability found in the nozzle manufacturing. The same reviewer also wondered how much consistency was necessary and recommended that it would be useful to document these nozzles with standard deviations based on sufficient samples. The work, as observed by this reviewer, extended to gas injection and shock tube boundary layers. This reviewer noted that the presentation finally discussed nozzle cavitation and commented that the study had great potential but seemed to lack direction. The reviewer suggested that the project couple this work with production hardware with field data of wear, or a wider sample of hardware spanning nozzle geometries of size, consistency, and etc. that is tied to engine performance. The final reviewer said that there were some very nice results, but that it was not yet clear if the modeling methods were being improved significantly.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted that there was a good amount of collaboration with the industry (Delphi, Chrysler, Westport, and AFRL) and also with the Engine Combustion Network. This was reiterated by the second reviewer who noted good partners, especially partners from industry, which was seen as very valuable. The third reviewer said that there seemed to be an appropriate level of collaboration with other labs and industry. The next reviewer opined that there was a very good partnership with Delphi Diesel and the engine combustion network including a CRADA with an industry partner. The fifth reviewer noted good connection of spray and gas jet work to modeling activities, both internal and external and that the project would work on cavitation imaging and that connecting it to Som's modeling activity would be useful. The sixth reviewer commented on the collaboration by saying that the project was playing a key role using unique diagnostics to measure Spray A through nozzle imaging and spray measurements. The reviewer also noted that the project was coordinating the information to create a common geometry for everyone to use when modeling Spray A. The final reviewer felt that the collaboration was very good and that the collaboration with the European partner to do high resolution x-ray measurements was exciting. In addition, this reviewer indicated that the collaboration with KH-ACT modeling work at ANL and the Converge and KIVA codes at ERC was good.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer agreed that the planned future work was good. Nonetheless, the reviewer felt that the team should have greater interactions with engine hardware and engine performance information seeking to improve items such as spray atomization, nozzle flow efficiencies. The reviewer also pointed out that the work was yet to be either incorporated into some modeling platform or that this work needed to be reported. The reviewer wanted to know how the information provided helped improve the accuracy of these models. The second reviewer indicated that the plans for continued work seemed reasonable, and should build on current accomplishments. A third reviewer wanted to know if single shot images were possible. The fourth commenter felt that it was important to continue the contribution to the ECN and that further investigation of the nozzle geometry of Spray A and other sprays in the ECN was a great idea. The fifth panelist recommended closer work with other spray modelers than ANL who had a different perspective on spray modeling including more traditional approaches. The final reviewer reiterated that future plans were generally good; however, that more work was needed on gasoline direct-injection sprays and injectors.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer remarked that resources seemed sufficient. The second reviewer stated that the dedicated facility was greatly improving progress.

Use of Low Cetane Fuel to Enable Low Temperature Combustion: Steve Ciatti (Argonne National Laboratory) – ace011

Reviewer Sample Size

This project was reviewed by eleven reviewers.

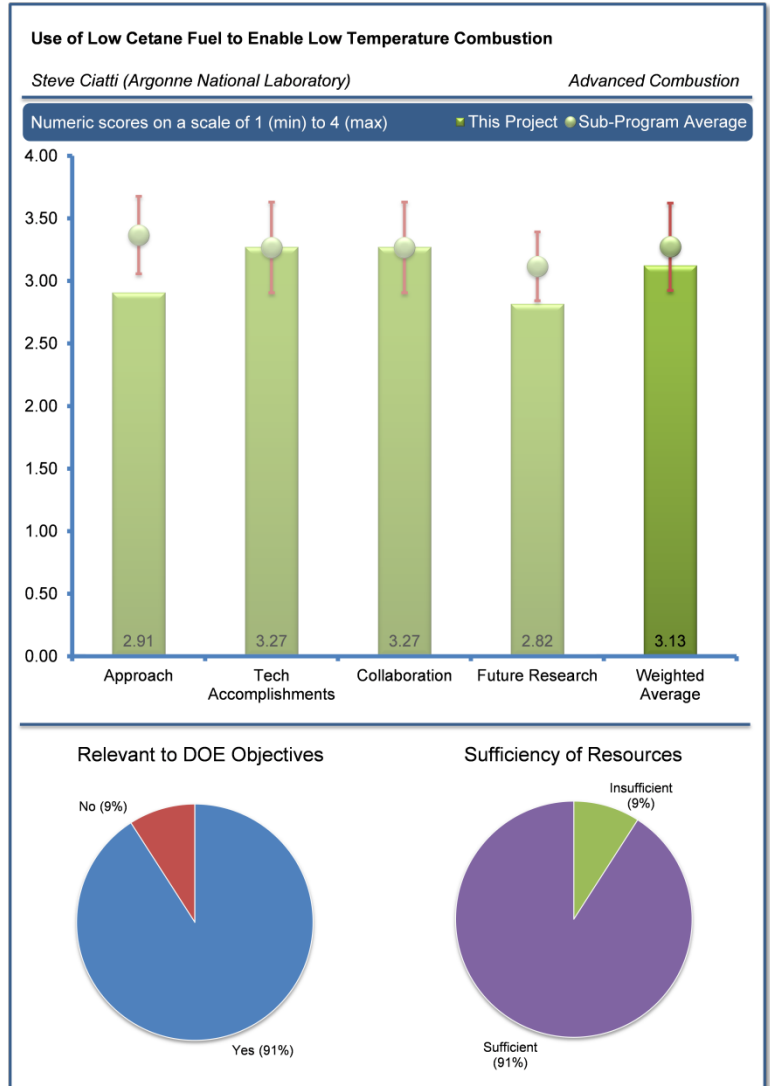
Question 1: Does this project support the overall DOE objectives? Why or why not?

As explained by one reviewer, this project supported DOE goals of improved engine thermal efficiency by exploring the use of low ignition quality fuels using flexible injection and lower levels of EGR as a means to enable LTC and PCCI use on future engines that theoretically could improve part to medium load fuel consumption. Another reviewer stated that high load LTC would possibly be an enabler for light-duty diesel or reduce diesel aftertreatment, which would reduce U.S. fuel consumption. The third reviewer said that RCCI was a potentially important technology for providing a cost-effective solution for both heavy-duty and light-duty engines. The fourth reviewer said that better understanding of improving and optimizing LTC had the capability to improve engine efficiency/fuel economy and thus lower fuel/petroleum needs. A different reviewer noted that the project aimed to achieve diesel-like fuel conversion efficiency with gasoline fuel, with lower emissions. A sixth panelist felt that the topic was relevant but that the work output and state of project (having begun in 2000) shown here appeared to be rather weak. Similarly, another reviewer stated that the project

certainly addressed improved efficiency but the reviewer would have liked to see targets for efficiency and cost to comply with emissions. The final reviewer reiterated that the project tries to demonstrate improved efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that it was great to see LTC work on multi-cylinder engines. The second panelist felt that the connection to cycle simulation was good. The panelist observed that the use of low cetane fuels provided benefits for LTC, but would likely have drawbacks in other areas. Thus, the panelist continued, while this may overcome some barriers, it introduced others. The panelist felt that a greater connection to similar research to use various techniques to better understand results would be useful. Specifically, the panelist pointed out that optical measurements by John Dec were not exactly the same, but wondered if there were ways to connect the work so that both PIs learned from each other. Lastly, this reviewer was glad to see noise metrics in the results. The third reviewer said that there was a very well thought out approach including supplemental CFD modeling for choosing triple injection fuel strategies. The reviewer stated that exploring variable injection pressure though future work more thoroughly addresses this opportunity. The fourth reviewer said that the project had a nice suite of tools in its approach, but needed to outline the primary roadblocks to achieving success with this technique. The reviewer wondered if there were speed/load regimes that would require a supporting combustion system (i.e., glow plug, spark ignition). A fifth reviewer commented that the NO_x/aftertreatment approach required more planning or communicating; the reviewer wanted to know what the plan was and what



the likely challenges and system layout were. Similarly, the sixth reviewer felt that the goals of the program were not particularly clear. The reviewer went on to say that demonstrating efficiency over a broad operating range was important, but that it was difficult to determine whether appropriate operating constraints were applied. The expert believed that a two-fuel system would only be competitive if it offered reduced aftertreatment system complexity, so either engine-out NO_x should be at or below 0.2 g/bhp-hr, or the engine should be run at stoichiometric. The seventh reviewer reiterated that as others have shown previously, use of lower cetane, higher volatility fuel than diesel had potential to improve performance in compression ignition engines. Another reviewer opined that the work lacked a clear definition of targets for success. This reviewer inquired about the fuel efficiency and emissions levels the authors sought. The same reviewer also requested detail on the means to attain the targeted efficiency and emissions levels. The reviewer wanted to know what the expectation and contributions of each were to reach the goals as the authors introduce further technologies (GDI, VVA, endoscope, etc.). The final expert pointed out that this project was started in 2008, and that considering the time that has lapsed, that progress has been slow. The reviewer remarked that the approach seemed like a trial-and-error approach and that there was no unique diagnostic of capability being brought to bear on the problem. As such, it was more like a development project. The reviewer concluded by saying that the project claims to leveraging the ANL APS work (which incidentally is currently focused on diesel injectors) and the ANL RCM kinetics had yet to begin.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that most of the results seemed consistent, but no better than what others had already shown regarding use of gasoline-like low cetane number, high volatility fuels. The second reviewer said there was good work addressing low load operation at two bar BMEP and that high load LTC was achieved, but that there was a question of whether the level of NO_x (<1g/kWh) was low enough. Another reviewer felt that the accomplishments had been very good, though the issues with one cylinder having a lower compression ratio and with low load consistent cylinder-to-cylinder injection quantity seemed to slow progress a little bit. This reviewer also said that much work must be done to continue exploring injection and EGR strategies to enable LTC, PCCI, and or HCCI use at high indicated thermal efficiency. The fourth reviewer said that if this was a light-duty project, then the efficiency and emissions performance (and even the cost) should be compared against a modern turbocharged GDI engine. This reviewer also said that if the focus was on 2020 and beyond, then brake efficiency should not be a prime consideration, unless the project was intending to use an engine that was believed representative of MY 2020. The reviewer felt that more should be done with modeling to extrapolate performance to a modern engine platform, to project the technology potential. Also, this reviewer would like to see the effect of EGR on BSFC extended, to give 0.2 g/bhp-hr NO_x or lower. The reviewer asked to please consider light-duty vehicle test cycles, including FTP/HW/US06, when setting performance goals. A fifth reviewer said that a large part of the results presented appeared to be rather basic, including the effects of EGR on intake manifold temperatures, NO_x , and even HC and CO. The reviewer went on to say that the authors drew rather weak insights when the authors differentiated the effects of temperature and O_2 on NO_x , as the temperature and O_2 were simply tied together (no independent control over boost, cooling seems to take place). This reviewer also said the variability in cylinder-to-cylinder HRRs could only be understood fully by means of a more detailed analysis of cycle-to-cycle variation. To this reviewer, it was unclear why the modeling work did not correspond to the hardware tested (e.g. different compression ratios). The sixth reviewer was curious about variability, stating that experience with the CR effects indicated that variability could be a show stopper with this concept. The reviewer indicated that whenever the reviewer runs engines with reaction controlled ignition like this, a way to have some solid control of ignition timing always shows up as a need. Going into more detail, this reviewer stated that engines have to run in all ambient conditions: high and low temps, high and low altitudes, humidity, etc. The use of uncooled EGR was a good thought to help handle this, said the reviewer, but the reviewer wanted to know where the engine transitioned from cooled to uncooled. The seventh reviewer wondered what the chief control challenges with this technique were. The final panelist said that the BSFC comparison between gasoline LTC and conventional diesel was unclear, and the panelist pointed out that the y-axis of the graphs in Slides 8 and 9 should be plotted on an expanded scale to allow a clearer comparison. The reviewer also felt that gasoline BSFCs seemed higher than conventional diesel and that the total efficiencies in the tables in Slide 10 did not seem up to par for a conventional diesel. This reviewer also inquired about the engine-out- NO_x target for this project. The same reviewer further suggested that more NO_x emissions and smoke emissions should be presented to get a clearer picture of how work was progressing rather than making word statements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One of the reviewers felt that the collaboration was good, but that the industry relationship perhaps suggested little more than hardware support and some technical input. The reviewer recommended that finding somebody more engaged in the project would help provide greater focus, particularly in the area of emissions and aftertreatment. Another reviewer reported a connection to industry through GM and added that there was excellent connection to the University of Wisconsin for CFD and BP for fuels. The third respondent also noted excellent collaboration with GM, a fuel supplier for various ignition quality fuels, and also a university for CFD support. The fourth reviewer stated that collaborations were very weak and that the approach mentioned the use of Autonomie, APS injector, and RMC, and wondered if these partnerships were realistic. A different reviewer observed some collaboration with industry (GM, BP, Drivven) and University of Wisconsin. The final reviewer suggested that more collaboration with others doing similar work (gasoline combustion in a diesel-like engine) may be warranted. Specifically, continued this reviewer, some of the work at SNL on partial fuel stratification and thermal stratification perhaps may be leveraged.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter thought that this seemed to be the right work following on to the accomplishments. The second reviewer said the proposed research was well thought out, including the resolution of injector and cylinder four compression ratio issues. The third reviewer recommended considering an increased emphasis on narrow angle injector angle. A fourth reviewer highlighted that more focus needed to be applied to the goals of the program. Specifically, continued this reviewer, emissions goals did not appear to be consistent with Tier2/Bin5, and especially not Tier2/Bin2. Accordingly, the reviewer also said that despite being a multi-cylinder approach, the reviewer saw no apparent focus on cold start emissions. The reviewer noted that efficiency was adequate, but a comparison of PM emissions should be with GDI engines (since this is a light-duty application). Also, the reviewer said low FSN may not be an adequate measure of PM for a light-duty engine, particularly a LTC engine. The fifth reviewer said that looking at low load challenges of low cetane operation was a good idea, but that it would also be important to find out what could be gained with these fuels at high load and what impact it would have on cycle emissions. The reviewer also thought that the efforts to get cycle projections were key. The reviewer said that the light-duty target of the future was Bin 2. The sixth reviewer observed that the project seemed to be a repeat of tests that others have done (i.e., 70 RON fuel). Another reviewer commented that the data reporting in this project were below the standards expected from a DOE project and that the authors should try to have a more disciplined representation of the engine at each of these operating points. The reviewer also recommended that the effects of equivalence ratio, boost, fuel injection pressure, timing, and intake temperature should be reported. Overall the reviewer felt that there was a lack of direction both near and medium term. The reviewer said this was noted earlier in the mentioning of the use of rather sophisticated techniques without an expectation of the targets. The eighth commenter simply stated that there was little detail on future plans provided. The final reviewer felt that work should focus on multiple fuel injection strategies that created the right conditions for best LTC combustion based on the knowledge that was already out there at the University of Wisconsin, SNL and other places. The reviewer also thought that the design of experiments approach should be exercised to its fullest to minimize testing and trial and error.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One of the reviewers said that given the goals of the project, the resources were sufficient. However, the reviewer also said some resources may be needed to explore LTC aftertreatment. The second reviewer simply stated that resources seemed sufficient.

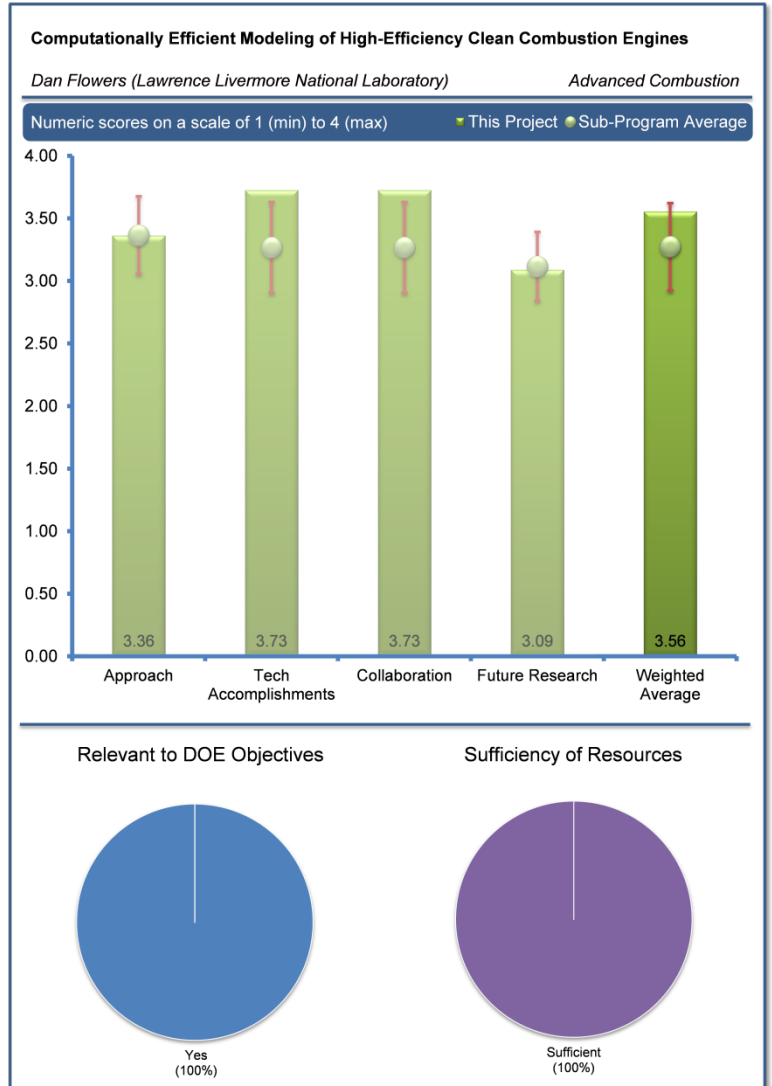
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines: Dan Flowers (Lawrence Livermore National Laboratory) – ace012

Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer simply summarized by saying that the project targets a fundamental study of combustion to enable high efficiency. The second reviewer thought that improved numerical modeling/simulations should enable greater success in understanding and optimizing high efficiency, clean combustion engine designs which, if successful, would reduce fuel/petroleum requirements. The third reviewer said that better and faster combustion models were needed to increase the progress toward engine efficiency. Providing more detail, another reviewer said improving chemistry models and solving them faster had a direct impact on improving engine modeling which would help the industry design better engines. The fifth reviewer noted that improving modeling tools of advanced combustion modes was needed to advanced research on those modes and design engines to take advantage of them. The sixth reviewer added that developing faster and better computer models would help the industry make more efficient engines. The final reviewer said that this project could supply tools that run at reasonable computing times with decent accuracy for engine developers considering homogeneous combustion modes for gasoline and diesel applications as a means to improve upon today's engines' thermal efficiencies at various operating conditions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One of the reviewers stated that the approach seemed good. Another reviewer said that there was a good focus on correlating the model with experiment and improving kinetic models. The third reviewer said that the application of a multi-zone model for coupling kinetics was a good solution for computational efficiency and that connecting it to CONVERGE was useful. The reviewer added that it was always useful to find areas to improve numerics to speed up results without compromising model fidelity. The fourth panelist described this project as sharply focused on a broad area of combustion modeling and was showing great results at effectively getting some models out to industry use. The fifth reviewer said that the modeling approach was reasonable, but that validation was a concern. To this reviewer, there appeared to be some level of validation, but it was limited to few selected operating points. The reviewer said that more validation based on real engines was necessary for continual improvement in the clever multi-zone with chemical kinetics modeling approach. The final reviewer said that the approach described was confusing and wanted to know where the objectives were clearly defined to impact the attainment of precise improvements in light-duty and heavy-duty engines, and commented that the materials provided do not address the necessary

approach to attain these. Furthermore, this same reviewer said that the presentation highlighted the use of PPC, HCCI, RCCI and LTC as strategies to meet emissions/efficiency targets, but wondered if this was even the case. The reviewer commented that heavy-duty engine manufacturers were relying on conventional combustion with more capable and more efficient injection, cooling, and air systems to attain the efficiency goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that very good progress had been made during the past year with the multi-zone work, and suggested that it would be helpful to see more comparison with a larger set of experimental data-and noted that validation was lacking a bit. Another reviewer indicated that the speed up in processing time with the multi-zone model results was very impressive and that it would result in a much wider use of these tools. The third reviewer noted significantly reduced computational time and said that one measure of success was that Convergent Sciences had licensed the LLNL multi-zone model and implemented in their CONVERGE software that is used by a number of OEMs. The reviewer added that the project also had integrated multi-zone model into GT Power for HCCI and PCCI applications and that using engine data to improve reaction mechanisms was very valuable. The fourth reviewer said that licensing of multi-zone chemistry model to Convergent Science had already had an impact on improving engine development in industry and that this was really great. The fifth reviewer said that four major tasks or milestones were reported on Slide 6, but that little evidence was given as to how successful these have been. The reviewer also noted that the author stated that predictions of their detailed chemical mechanisms matched the CONVERGE multi-zone simulations and wanted to know how many cases were examined. Also, the reviewer wanted to know what range of dilution levels and range of loads were used. This reviewer found it a bit surprising that no details were provided. The reviewer also noted that no discussion was provided as to why these multi-zone simulations were so good. The reviewer wanted to know then, if this meant that the author supported treating the multi-zone simulations as black box. The reviewer also commented that the speedup seemed to be well integrated with engine cycle simulations. The reviewer pointed out that the authors had incorporated advanced solvers into parallel CFD models (including multi-zone models). The reviewer also noted that the kinetic rates were revised for elevated pressures based on engine data as the authors performed a screening parameter exercise to highlight the most important ones. A sixth reviewer said that the project demonstrated substantial improvement in computational efficiency with good correlation to more computationally intensive models. The seventh expert said that there was apparently good correlation between experimentation and modeling, but wanted to know if there was a way to do a quantitative comparison rather than subjective comparison. Another reviewer felt that the project showed significant speed up using multi-zone model vs. solving chemical kinetics and that implementing advancements using CONVERGE was very useful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that there were good partnerships with key institutions. Another reviewer identified the collaborations with a number of OEMs (Ford, GM, Bosch, Delphi, and Volvo) and cited other national labs (Sandia, ORNL). The reviewer added that this was a good sign that the industry valued the work. The third reviewer observed good collaboration with Sandia and indicated that that working with CONVERGE was useful because those tools were becoming more popular among OEMs. The fourth reviewer noted that a lot of collaborations were cited and that the collaboration with CONVERGE seemed to be rather useful to implement these new tools and mechanisms onto wide user interface tools. The fifth reviewer said that collaboration with research groups as well as the industry was exemplary. This reviewer felt that working with Convergent Sciences allowed the industry to rapidly utilize tools developed. In addition to great collaboration with the industry and working with CONVERGE, the sixth panelist cited that working with ERC-UW (KIVA), and GT-Power as the right level to get these tools into the hands of engineers. The final reviewer said that this project has historically strong collaborations with other national labs, universities, and certain industry partners. Furthermore, continued this reviewer, it appeared that much progress had been made in the last two years and that the multi-zone work in particular had drawn great interest from the research community due to its reduced computational time and apparent accuracy in comparison to CFD at select operating points.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that continuing to improve simulations and kinetics models and the goal of transferring models to industry/MOU partners was very worthwhile. The second reviewer said that it was good to continue with the present plan. Another reviewer remarked that further validation of the multi-zone model with additional test cases would be useful. A final reviewer commented that the computational aspects of the planned future work were reasonable, but that validation was really lacking in future plans.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer said that the resources seemed sufficient to maintain progress, while another reviewer felt that this was a well-funded modeling project.

Chemical Kinetic Research on HCCI & Diesel Fuels: Bill Pitz (Lawrence Livermore National Laboratory) – ace013

Reviewer Sample Size

This project was reviewed by eleven reviewers.

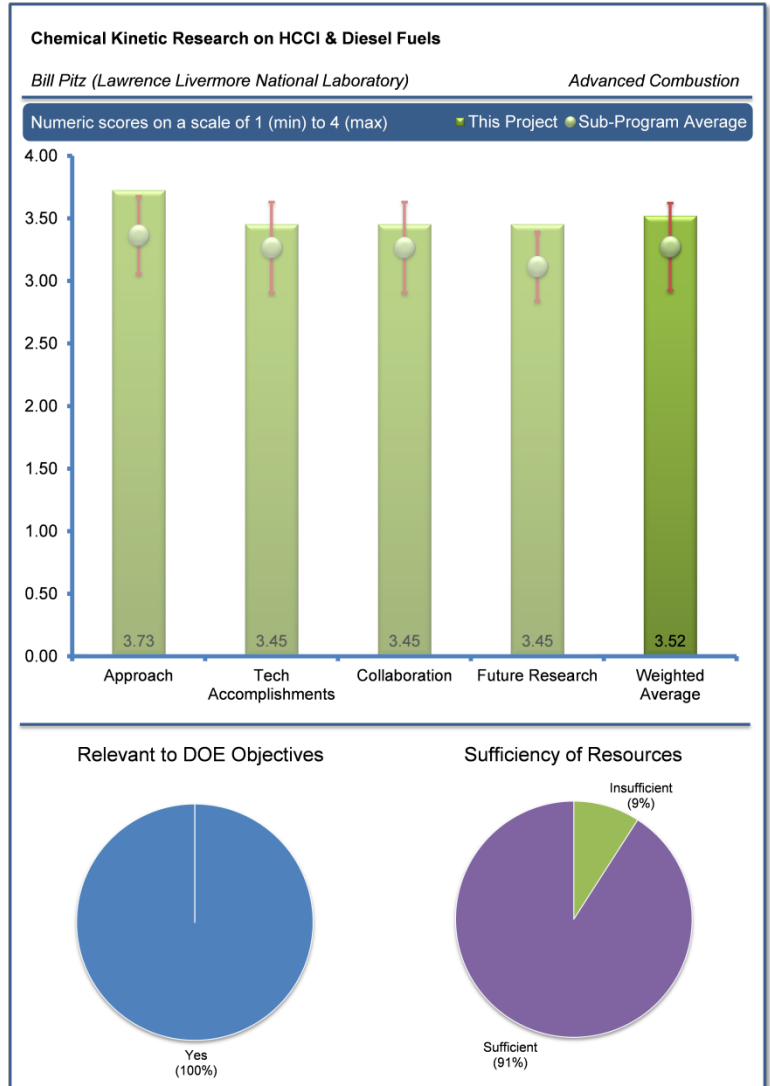
Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer responses on this question were positive. An observer stated that the development of kinetic mechanisms was needed to model advanced clean efficient combustion modes, adding that the development of full kinetic schemes was the first step to creating and validating skeletal mechanisms that would be used in computational fluid dynamics (CFD) models used to design engine and research. A commenter noted that advanced low temperature combustion (LTC) concepts and highly dilute combustion processes both offer gains in fuel efficiency and that both need increased understanding and improved models of the combustion process. The commenter also said that this work was the only one of its kind that is relevant eventually to modeling chemical kinetic processes. A reviewer said that this was crucial work to improve combustion models to be able to predict engine behavior, and that this is an important tool for engine developers to improve engine efficiency. One evaluator said that improved chemical kinetic models were critical for improving and optimizing the performance of advanced combustion engines, which should improve efficiency and reduce fuel/petroleum demands. A reviewer said that the chemical kinetic models were needed as inputs to effective combustion models. A reviewer noted there was very high value for model development. One commenter stated that the project targeted a fundamental study of combustion to enable high efficiency. A commenter described this project as very fundamental in nature and supported advanced combustion strategy development at low temperature and high exhaust gas recirculation (EGR) boundary conditions that might enable higher part to medium load thermal efficiency in both diesel and gasoline engines or possibly some type of future hybrid gasoline-diesel engine. The reviewer added that such strategies would rely more on kinetics as a key controlling chemical process that would either yield controlled initial combustion rate with high thermal efficiency or high combustion rates which will limit the development of such combustion strategies. This reviewer ended by saying that better understanding of low temperature chemistry was critical toward finding the optimal control strategy.

A reviewer said that the chemical kinetic models were needed as inputs to effective combustion models. A reviewer noted there was very high value for model development. One commenter stated that the project targeted a fundamental study of combustion to enable high efficiency. A commenter described this project as very fundamental in nature and supported advanced combustion strategy development at low temperature and high exhaust gas recirculation (EGR) boundary conditions that might enable higher part to medium load thermal efficiency in both diesel and gasoline engines or possibly some type of future hybrid gasoline-diesel engine. The reviewer added that such strategies would rely more on kinetics as a key controlling chemical process that would either yield controlled initial combustion rate with high thermal efficiency or high combustion rates which will limit the development of such combustion strategies. This reviewer ended by saying that better understanding of low temperature chemistry was critical toward finding the optimal control strategy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were generally good. One reviewer said that the approach of developing and validating mechanisms for fuel components, combining them for surrogate fuels, reducing the mechanisms for faster computational time, and validating versus engine results were excellent and critically needed. This evaluator stated that the objectives were clearly defined, and included continuing development of surrogate fuel mechanisms to improve engine models for homogenous charge compression engine (HCCI) and diesel engines. The reviewer added that reduced mechanisms were included. Another reviewer noted that real fuel



surrogates were needed to identify which components were critical to accurately model the fuels. The commenter also said that creation of mechanisms for numerous components would have a large impact as other researchers would use them and combine them differently to model fuels. The reviewer added that continuing to build that palette was very important. A reviewer said that the approach was very logical and had no suggestions for improvement except to spend more time on validation. An expert said that surrogates were being developed for gasoline and models were being developed for larger alkyl aromatics.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer responses were generally good. One reviewer said that there was excellent progress in developing and validating the kinetic mechanisms for components that were more representative of components in real fuels (larger aromatics and naphthenes, more lightly branched aromatics). The reviewer added the project had developed correlation between gasoline surrogate AKI's to ignition delay times and sensitivity to slopes of NTC regions. An evaluator stated that the project had validated 3-methyl, 2-5-dimethyl alkane, and alkylated aromatics mechanisms by comparison to experimental data at engine-like pressures and temperatures and that increasing range of hydrocarbon species that are modeled will contribute to improved chemistry models. One commenter opined that progress looked good, but it was difficult to prioritize which molecules were most critical. A reviewer said that this project continued to add compounds to the palette and develop surrogates. A commenter said that the progress on modeling specific chemical reactions of interest was commendable; of special note was the excellent comparison between model and shock tube and rapid compression machine measurements of ignition delay time and temperature. One evaluator commented that the progress had been very good in developing gasoline surrogates, though it had been a little slower in generating improved diesel fuel surrogates. Overall, the reviewer continued, the output of this project has been very good. The reviewer suggested that more validation was necessary as commented in other portions of this evaluation which could accelerate the progress in meeting the objectives of this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers had mixed responses to this question. One reviewer mentioned that there were lots of interactions with universities and national labs to compare their experimental data to Lawrence Livermore National Laboratory (LLNL) model predictions. The reviewer added that industry collaborations seemed to mainly consist of involvement in Coordinating Research Council, advanced vehicle fuel lubricant (AVFL) and Fuels for Advanced Combustion Engines (FACE) projects and semi-annual AEC MOU meetings. The reviewer suggested making the mechanisms available on LLNL website. An evaluator commented that the principal investigators collaborated with many universities to get the data that they needed to support validation of their models. The reviewer continued by saying that the investigators also were very open with sharing those models with engine modelers, so that they could be used to improve engine simulations with chemical kinetics and also directly collaborate with engine modelers to help validate proposed mechanisms. The reviewer felt that the project had done a great job leveraging other funded research to get experimental data. A commenter stated that work was done in collaboration with multiple academic institutions and that modeling and experimental results were well leveraged and consolidated. The reviewer suggested that these could be more effective. The commenter went on to say that the work has characterized the ignition delays of surrogates such as n-heptane, gasoline-like fuels, with added compounds such as n-butyl benzene. The reviewer wondered, as these characterizations were made, what impact the work has made in modeling of combustion in engines. The reviewer was unclear if the authors of the research were tracking how these were being assimilated by the other PIs at the national laboratories. An evaluator said that very good collaboration existed with several organizations. A reviewer noted that this was an ongoing project that has shown tremendous collaboration throughout the years with other national laboratories such as the Sandia Combustion Research Facility, various universities such as Rensselaer Polytechnic Institute, and also with industry researchers who ultimately use developed chemical kinetic mechanisms for evaluating various combustion strategies in their applicable engine products. The reviewer emphasized that there had been great work over the years. A reviewer suggested that DOE should consider combining the three projects at LLNL with the objective of completing efficient combustion modeling that was fully integrated and correlated and that can be integrated into multi-cylinder engine models.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments were generally positive. A commenter stated that extending mechanisms to larger alkanes and larger alkyl aromatics was very important to develop surrogates that were more representative of components in market diesel fuels. An expert stated that because of the good tie-in with engine experiments, the proposed future work was relevant and continues to get input from larger engine combustion and modeling community. A reviewer commented that the investigators continued to build up the palette of compounds. One evaluator said that the project was well-focused, e.g. larger alkyl aromatics, n-alkanes. Another reviewer said that, generally, the proposed future research was excellent. The reviewer suggested finding a way in the upcoming year to initiate more validation of the various mechanisms versus bomb or engine data. The reviewer added that although the latter is not pure due to its non-homogeneities, it is the real world device and could be valuable in assessing the predictability of the various mechanisms either from a bulk temp/pressure space or simulated (CFD) environment.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All but one of the reviewers responded that the resources were sufficient. One reviewer felt resources were insufficient. A reviewer said that the resources seemed sufficient, with no indication to the contrary. One evaluator said that it appeared that this project was sufficiently funded for completing the work included in the presentation, adding that additional validation would be very helpful to the industry, but who and how it was paid for was another story.

2012 DOE Vehicle Technologies KIVA-Development: David Carrington (Los Alamos National Laboratory) – ace014

Reviewer Sample Size

This project was reviewed by twelve reviewers.

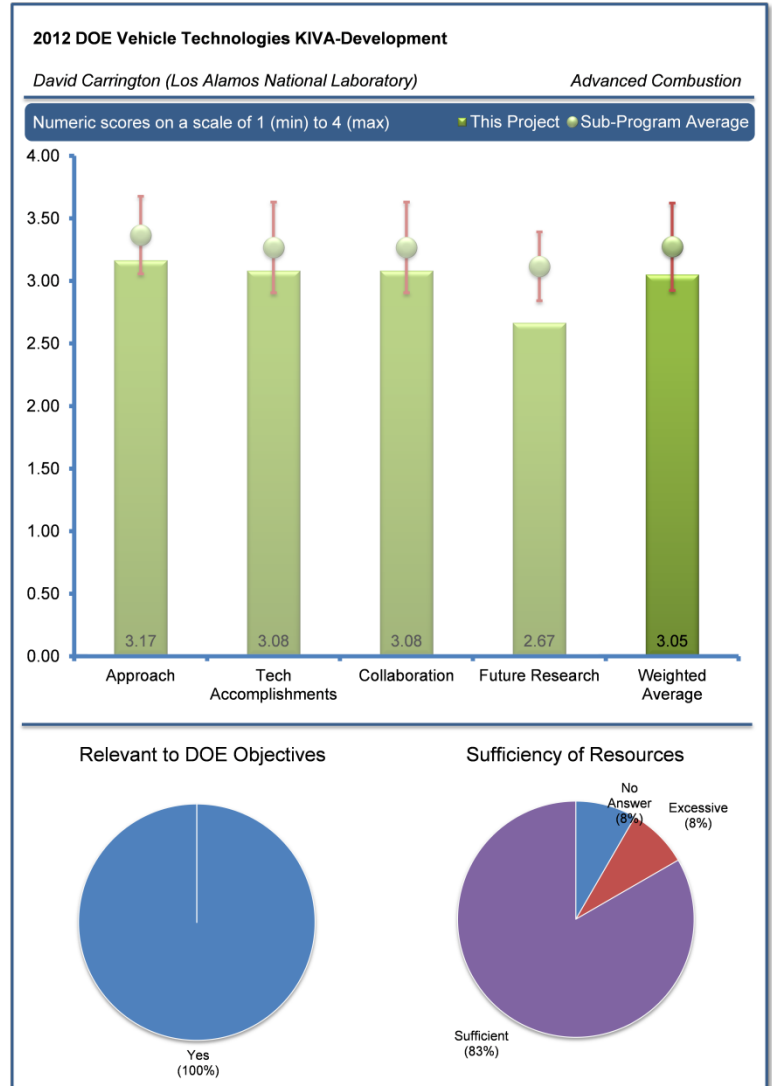
Question 1: Does this project support the overall DOE objectives? Why or why not?

The comments were generally positive. A reviewer commented that this KIVA modeling/simulation work should speed up time to develop and deploy of advanced combustion engines, which would have lower emissions, better fuel economy which would reduce fuel/petroleum consumption. A separate reviewer said that KIVA has long been the standard for combustion modeling and needed to continue to evolve. One commenter noted that the KIVA code was widely used in the industry for modeling advanced high-efficiency engine development, adding that the list of licensees presented was impressive and proved the usefulness of the code. An evaluator noted that this project targeted development of robust and modular (highly desired characteristic) algorithms and easier and quicker grid generation to enable high efficiency. One reviewer said that this project was indirectly linked to meeting DOE petroleum displacement goals by eventually providing an upgrade combustion code for piston engines to engine developers/researchers for exploring advanced combustion strategies such as LTC, premixed charge compression engine (PCCI), or HCCI. An evaluator said

that the development of modeling capability and flexibility was important for optimizing engines; however, with the emergence and popularity of commercial codes like CONVERGE, the role of next generation of KIVA for engine simulation was not well defined, which brought into question the potential for impact on the DOE goals. This evaluator suggested that it should be clearly communicated whether the finite element method (FEM) method provided a significant improvement over existing codes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were mixed. One reviewer said that the approach seemed reasonable. Another reviewer said the approach was outstanding. Another reviewer believed that the work was aimed at developing robust and accurate (more predictive was emphasized) numerical simulation codes, focusing on understanding the physics and optimized discretization of the problem. The commenter went on to say that the effort was accompanied by validation and verification. One commenter said the project aimed to reduce time for advanced combustion and engine development, without compromising accuracy. A reviewer stated that the upgrade of the KIVA code approach by the PI had been methodical and carefully considered during the last two years. The reviewer saw that one area of worry was validation against experimental data from an engine or bomb, adding that this was a key step in determining how well the new algorithms were working compared to the old algorithms. One evaluator said that the work was aimed at developing robust and accurate (more predictive is emphasized) numerical simulation codes, focusing on understanding the physics, and optimized discretization of the problem. This reviewer added that the effort was accompanied by



validation and verification. Another commenter opined that, with robust and accurate commercial codes with fast grid generation available, the need for development of new software code architecture was not clear. The same reviewer suggested that the benefits of KIVA-4 beyond CONVERGE needed to be identified. This reviewer added that this should not just be a competitor code, but something that would ultimately find its way into codes like CONVERGE. The evaluator said that it would be useful to reviewers for the presentation to show the basic approach of model development and what the challenges were. The reviewer would have liked to be told how the projects approach changed over the years and why it was the same or if it had changed. The reviewer was uncertain what data was needed for model validation studies and suggested that more introduction content was needed in the presentation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer responses were mixed. One evaluator said that the quantity of licensees spoke volumes. Another evaluator said that it seemed like good progress, with accomplishments that included: more accurate prediction of combustion chamber wall temperatures; better injection spray model with finite elements; and significant number of KIVA licensees, which the evaluator believed demonstrated value to users. A reviewer said that it was important to have an open source tool that could be used at research institutions and at universities to train new researchers. Another reviewer stated that KIVA-4 was being extended in several ways, including a finite difference approach. The reviewer added that grid generation was also being sped up and spray modeling had been improved. One commenter noted that significant work had been done against the original objectives with validation against a wide variety of test conditions having been done. A reviewer said that the large number of licensees was good. One expert stated that this project was a good analog effort to the ANL project that was focused on a new break-up model development not using KIVA. The reviewer added that progress had been methodical during the last two years, carefully making sure all new algorithms were functioning properly with an overall code context. The reviewer believed that at some point, this new KIVA must be validated against engine or bomb data; and suggested using the x-ray data from Argonne National Laboratory (ANL) or engine/bomb, namely data from Sandia National Laboratories. One reviewer felt that the presenter spent too much time on approach at the expense of detailing the progress made. The reviewer also said that the project was developing fine element methods and conjugate heat transfer methods, but that the estimates of the wall temperatures were unclear. The reviewer wondered if the benchmark was done with engine data/measurements. The reviewer noted that developing work was tied with improved grid generation and that the authors were aware of the importance of rigorous benchmarking methods that were used.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There were mixed responses to the question. A reviewer noted that the only collaborations mentioned were with co-developers at various universities and that there was no mention of interactions with industry users. A reviewer noted that there was a compact team established with clear responsibilities. Another reviewer referenced the collaboration with implementers. An evaluator said that collaborations with many universities existed. A separate reviewer noted that there was good leveraging of universities to accomplish the work, and that a number of licensees existed. One commenter noted that it was impressive to see the licensees as a testimony to the utility of KIVA. This reviewer would have liked to see closer cooperation with LLNL and other laboratories working on combustion modeling so that these developments could be integrated at the earliest opportunity. A commenter stated that there was reasonable collaboration among the PI and a handful of universities with expertise in advanced computational methods and combustion modeling--possibly that this was a good mix for now. The reviewer added that, at some point in time, this project needed collaboration with multiple experimentalists for validating the new KIVA.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter stated that the project was well focused, and that continuous improvements were expected. The reviewer noted that the software appeared to be well accepted by many users. A reviewer said that it was important to identify what of this work was applicable to other CFD platforms and to define mechanisms to offer advancements into those commercial codes. A reviewer believed that the ANL Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence (KH-ACT) model for spray breakup should be incorporated into KIVA. A commenter stated that future plans were not clearly spelled out in the presentation, but that the work

seemed to be continuing on the stated goals. The reviewer suggested that the project needed to show why we needed to do this, and asked if no one in the CFD and finite element analysis (FEA) industry was doing this. One commenter said that, overall, the proposed future research was reasonable, though the PI should consider a significant validation effort for use in piston engines. The reviewer believed that validation against simple flames was not adequate enough. Another reviewer asked when this could be terminated. The same reviewer believed that this project was overlapping private industry work. This reviewer said that while there were a lot of licenses, it did not mean usage; and added that the reviewer had a license, but all the users do not want to use it. Instead, opined this reviewer, the users use a commercial code, because the users can get support when the users have a problem.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Nine reviewers indicated sufficient financial resources were available, while one reviewer indicated that financial resources were excessive. One reviewer commented that the resources seemed sufficient. Another reviewer who stated that resources were sufficient commented if this project cannot make a connection to improvement of commercial codes.

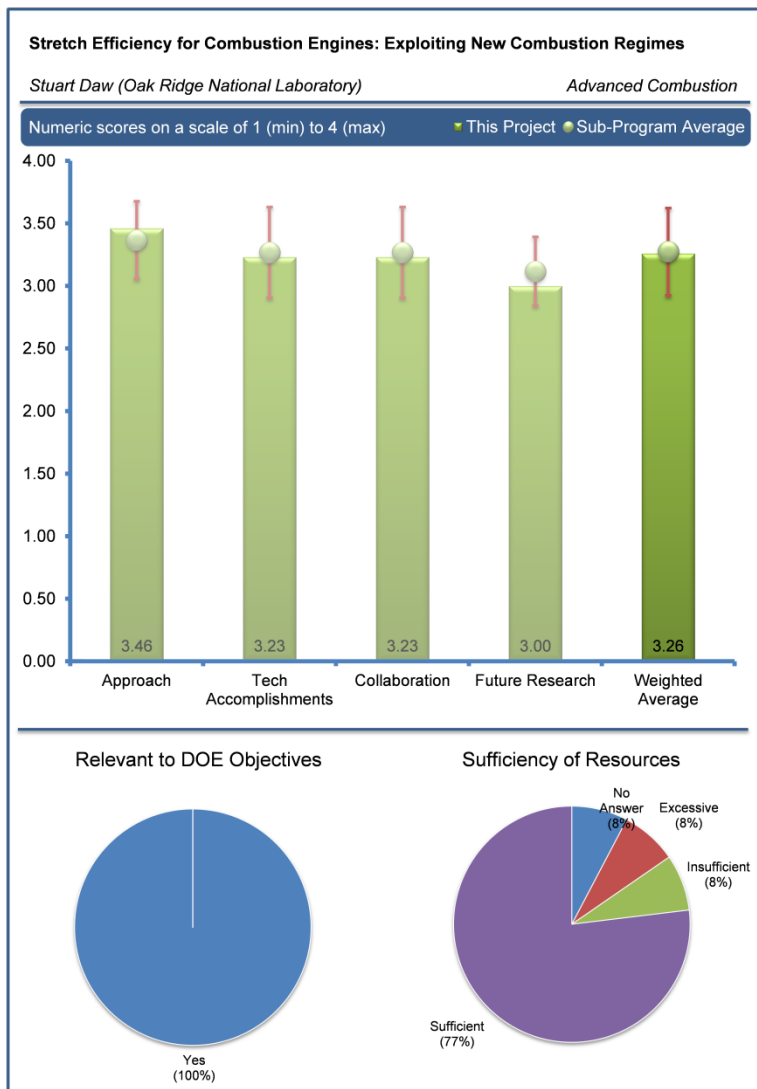
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Stuart Daw (Oak Ridge National Laboratory) – ace015

Reviewer Sample Size

This project was reviewed by thirteen reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The comments were generally positive. A commenter said that it was excellent to see very advanced thinking, adding that this was needed as the limits of conventional engines were approached. An evaluator stated that finding ways to improve engine efficiency reduced demand for fuel/petroleum. A commenter said the project was working to increase internal combustion engine (ICE) efficiency via major combustion and architecture changes while seeking near 60% brake thermal efficiency (BTE). One of the reviewers commented that this project represented a critical long-term approach to explore the potential efficiency gains in ICEs, looking beyond near-term and mid-term technology advances. A reviewer said that this project directly supported the goals of higher efficiency. Another reviewer said that the project was pursuing high efficiency. One commenter stated that the project could achieve breakthrough improvements in engine efficiency by investigating some novel approaches, or, it could result in a mechanical curiosity producing some interesting chemistry results. The reviewer ended by saying that, in any case, something about engines would be learned and was therefore relevant.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were somewhat mixed. A reviewer opined that these novel approaches with analysis and experimental results were exactly what should be done at national laboratories. An evaluator noted that this was a very inventive and creative approach to understanding the potential gains with waste heat recovery, continuing by saying that the models developed based on the data from prototype hardware perhaps would lead the way to understanding where next-generation improvements may lie. A separate reviewer commented that the project's approach of taking a step back and thinking about fundamentals and designing experiments to improve fundamental understanding was useful. One expert stated that this was clearly a high risk, stretch objective type of project; the type of project the DOE should fund. One commenter said that, for this kind of work, the methods were well done. One reviewer listed the following attributes of the project: targeting theoretical and practical limits for engines; looking to promising advanced architectures; and relying on analysis-modeling with experiments and thermochemical recuperation (TCR), which required proper use of the syngas from the reformer. An evaluator greatly appreciated that this program was looking for potential gains in areas that were outside the box, and specifically noted that studying the potential for TCR is of high interest. The reviewer suggested that it would be good to add a couple areas of investigation in the future; specifically, it would be helpful to

understand why TCR could be of benefit; if it was related to the rate of combustion, evaporation of the fuel, location of the combustion event, etc. The reviewer assumed the energy content of the fuel could not be changed (basic thermodynamics), but a good explanation for a logical reason of why it could be of benefit would be helpful. In addition, the reviewer added, some significant cycle simulation modeling (GT-Power, WAVE, etc.) of the six-stroke engine would also give good insight to the potential benefit/penalty of that effort, although certainly the impact of in-cylinder reforming would not be seen. The reviewer concluded by repeating that the project had an outstanding approach to investigating unique opportunities for fuel economy benefit. A commenter said that the potential of the ability to store energy through fuel reforming should be presented and the barriers to realizing this potential defined. The reviewer added that, it was not clear that onboard reforming would improve thermal efficiency, particularly in the context of a six-stroke cycle. One reviewer wondered if it would be a better approach to first complete a thermodynamic analysis of all possible architectures before, picking a couple of the most promising, and then conducting experiments to verify the analysis. Another evaluator would like to see more efficiency modeling results showing what could be expected if these different cycles had to be run on one cylinder, or have a cylinder run backwards.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses were mixed to this question. An evaluator said that the six--stroke hydraulic valve actuation (HVA) experiments with alternative fuels was an extremely well-targeted experiment. A commenter noted that, although the output was mainly theoretical with some experimental verification, that this was precisely what was needed. One expert said there had been good progress understanding the process for reforming. A reviewer said that the fabrication and testing of the prototype hardware represented an important accomplishment, adding that how this data would be characterized would be critical to establishing the long-range reference value of the work. An evaluator stated that it seemed like the researchers had made reasonable progress on exploring several thermocuperative reforming concepts theoretically and experimentally and also fuel properties such as molar expansion ratio. The reviewer added that there were interesting results on exhaust temperatures from combustion of iso-octane, ethanol, and methanol. One commenter noted that the first step to making a better engine was making a different engine, and that some different concepts were definitely being investigated. The reviewer added that it would be very interesting to see if the concepts turned out to be better. A reviewer listed the following project attributes: thermodynamic modeling study – showed that no one fuel was best, reforming experiments, one embodiment uses EGR + fuel, n-cylinder with dedicated EGR cylinder running rich, regenerative air preheating and TCR (RAPTR), experiments performed with a six-stroke cycle on a SCTE with variable valve actuation (VVA), suppression of exhaust temperatures seen with added fuel on off-stroke event. The reviewer was uncertain how the H_2 compared with dedicated EGR. The reviewer noted that no analyses was shown in this presentation for the merits of these concepts, suggesting that at least a first level analysis should be done to justify merits and direction. One evaluator commented that the discovery of the countering effect of fuel specific heat ratio on the Molar Expansion Ratio was very interesting and important. The reviewer suggested that the third bullet at the bottom of slide number 13 needed to be simplified. The reviewer wondered if the higher compression ratio enabled by H_2 , in reality, would not result in an increase in NO_x . The commenter suggested that the fourth bullet on Slide 14 also needed further explanation, wondering if the 5% increase in efficiency was based on an analysis conducted by the Gas Technology Institute (GTI), and if so, what was that published work and could it be referenced. The same commenter noted that the injection of fuel into the recompressed exhaust gases experiment should be related to the negative-valve-overlap (NVO) experiments being done by Dick Steeper at SNL, where acetylene was being injected into the recompressed exhaust and effects in the main combustion were being observed. This reviewer noted that the SNL work was focused on HCCI combustion and wondered if these two projects could learn from each other.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

An evaluator noted a good-sized list of collaborators were named, which was composed of industry and universities. A separate reviewer stated that there was a good connection to other projects on efficiency as well as industry and university partners. One commenter stated that the level of collaboration was appropriate, given the long-range focus. The reviewer would have liked to see greater collaboration with system modeling, such that the experimental data may be used to project the ultimate potential for the technology. Another reviewer said that it would be good to open this up to a wider audience, suggesting that a symposium on TCR and very high efficiency concepts might be worthwhile. The reviewer added that it was good that this project was connected to the complete engine program. An evaluator suggested that discussions could be had with project ace006 for mutual benefit. A

commenter urged the project to continue collaboration with Dean Edwards' project. A reviewer believed that this group would work with the other teams at ORNL on simulation and engine testing, but was not clear how some of the partners collaborated, such as Reaction Design, GTI or Cummins.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer said that the plans seemed reasonable. A separate reviewer suggested that continued understanding of fuel effects may be useful. One reviewer agreed with the future plans, but cautioned that the hardware study should not distract from the overall goals of demonstrating the potential of the technology. The commenter added that the project was focused on the long-term, and therefore the implementation of such a technology may ultimately be much different than it would be with today's hardware features and limitations. The reviewer continued by saying that the emphasis of the testing should be to validate system modeling, so that the results could be generally applied 10 years down the road. A reviewer asserted that the work needed to be focused more on how to accomplish its implementation. One commenter said that more upfront thermodynamic analyses should be done first. An evaluator suggested that there would be a benefit to modifying the plan moving forward to fundamentally explain and show why TCR had the potential to be of benefit as opposed to other alternative fuels.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Ten reviewers responded that the resources were sufficient; one felt the resources were excessive and another reviewer said the resources were insufficient. One reviewer commented that the resources were sufficient for this type of long-range development. Another reviewer said that the resources seemed sufficient to accomplish plans. A separate reviewer felt that the project needed more resources.

High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Scott Curran (Oak Ridge National Laboratory) – ace016

Reviewer Sample Size

This project was reviewed by thirteen reviewers.

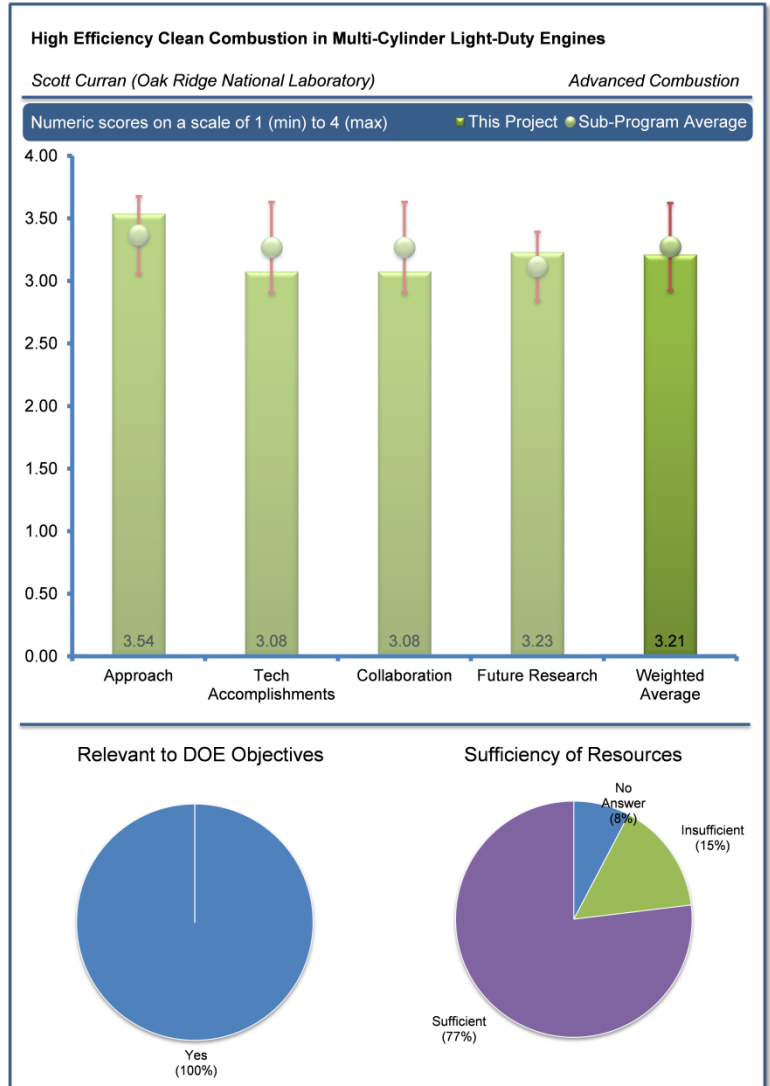
Question 1: Does this project support the overall DOE objectives? Why or why not?

According to the first reviewer, reactivity controlled compression ignition (RCCI) represented a potentially important technology for light-duty engines. The second reviewer noted that this project had a direct impact on DOE's goals by addressing the promise of RCCI combustion for improving the gross and net thermal efficiency of CI engines through utilization of a multi-cylinder research engine. According to the third reviewer, advancing LTC was important for improving thermal efficiency while meeting emissions, and demonstration of those modes on a multi-cylinder engine was a key for demonstrating that DOE goals were being met. The fourth reviewer noted that expanding testing of advanced combustion technologies from single cylinder engines to multicylinder engines with aftertreatment systems enabled a more accurate assessment of potential benefits of these technologies to improve engine efficiencies and reduce fuel/petroleum requirements. The reviewer noted that the project also included biofuels in testing. The fifth reviewer noted that the project addressed barriers to meet engine efficiency goals, focused on RCCI on a multi-cylinder engine, and aimed to reduce emissions to T2B2 and improve efficiency.

For the sixth reviewer, multi-cylinder assessment of LTC needed more emphasis to establish the real potential and issues. The final reviewer noted that the project was exploring higher efficiency operating conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed feedback on the project's approach. The first reviewer noted a good approach with common speed and load points and fuel and strategy comparisons for alternative pistons. The second reviewer commented how the project was addressing practical implementation of HECC by using a systems approach was good, and the project directly addressed goals and roadblocks. The third reviewer noted an excellent approach of working with single cylinder researchers and modelers to extend work at ORNL to multicylinder engines. The fourth reviewer posited that the approach of multi-cylinder testing of proposed advanced concepts heretofore only demonstrated on single cylinder engines was a much needed one. This reviewer indicated that this project made a big step towards exposing real-world challenges. Another evaluator stated that this project was sharply focused on assessing RCCI combustion in comparison to conventional diesel combustion in a practical engine for ultimately showing the merits of advanced combustion modes on engine efficiency. This reviewer continued that the approach addressed key challenges with engine hardware associated with HECC over the years. Further, the reviewer indicated that it has included piston modifications when necessary, aftertreatment modifications when necessary, and development of flexible engine system for



assessing various HECC approach. This reviewer commented that the project has a very good approach. The sixth reviewer observed that the project combined close coupled modeling and testing, and integrated aftertreatment to advanced combustion models. The seventh reviewer noted that the main focus appeared to be RCCI; however, regarding RCCI this reviewer had concerns about the combustion noise. The reviewer noted that coupling multi-cylinder engine data for engine mapping with full system models to project cycle emissions and fuel was sensible. The eighth reviewer perceived that targets were well established with a focus on real vehicle requirements. Still, it was unclear to this reviewer if the control could be accomplished in a real-world environment. The ninth reviewer commented that the project was focused appropriately on both the efficiency and emission, and aftertreatment issues. For this reviewer, still some work appeared to be needed in defining the goals for engine-out emissions, particularly NO_x . The final reviewer observed that the results were good on NO_x , efficiency and PM. The reviewer suggested that the project needed to explain further what would be done about the UHC and CO at these low exhaust temperatures. This reviewer perceived this as a significant barrier.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress, and also offered suggestions. The first reviewer found that the initial results were very encouraging, and that the focus on emissions from LTC was long overdue. This reviewer felt the initial mapping to date was pointing toward good progress. The second reviewer commented that many issues have been identified and addressed. The third reviewer found that this project has yielded practical results and subsequently has explored engine system modifications for further understanding the validity of various HECC approaches. In particular, the contributions on understanding the limits of RCCI combustion in multi-cylinder engine have been of great value to the engine research community and future results with modified pistons should also be of great value. The fourth reviewer perceived that the project demonstrated that RCCI operation in multi-cylinder engine could cover most of the LD drive cycle with peak efficiency slightly higher than conventional diesel combustion. This reviewer indicated the project showed that NO_x emissions could meet Tier 2, Bin 5 NO_x levels without NO_x aftertreatment, but not Tier 2 Bin 2. HC and CO emissions were much higher in RCCI than conventional diesel combustion and HC emissions were different. The fifth reviewer noted that it was good work to map RCCI on the multi-cylinder engine; however, that the operating range demonstrated was fairly small and while it may benefit the FTP cycle, emissions on US06 would still be dominated by conventional combustion. The evaluator cautioned that the MPRR limited used was unrealistically high for the engine in this study, and noted that the maximum thermal efficiency was not increased beyond the stock engine. This evaluator continued that it was at lower load and ultra-low PM and NO_x emissions, but that the noise level was very high. This reviewer would like to know what would be the thermal efficiency and emissions if the MPRR were allowed to increase to 10 bar/deg. This reviewer noted that showing the thermal efficiency difference between diesel and RCCI was needed, and complimented that the project has done a good job in identifying potential barriers for RCCI based on multi-cylinder results, such as exhaust temperature. The sixth reviewer remarked that engine efficiency comparison to standard diesel engine looked like there was no advantage for RCCI. The reviewer suggested a need to compare to SI gasoline engines for efficiency comparison, or to show the emissions advantage of RCCI at the same time as efficiency. This reviewer noted that low maximum load was a severe limitation and would like to know what could be done to increase the maximum load. The seventh reviewer observed that the project began at single point optimization; extended to multiple speeds and loads; continued to introduce fuel effects; included modified RCCI piston with lower CR in its research; and that the work examined catalysts under RCCI conditions. This reviewer noted that the program captured clear boundaries with imposed MPR and CO ppm levels, and noted impressive BTE numbers, showing advantages over baseline, though results were shown without EGR. The reviewer indicated that the authors could do a better effort to explain the BTE changes, and noted that the reported differences may be due to a poor matching of the turbo system. Another reviewer commented that an expected increase in indicated and net thermal efficiencies due to decreased heat transfer with the lower CR modified RCCI piston did not result. The reviewer would like to know the explanation for that. This reviewer also indicated that for a load of 8.8 bar BMEP, Slides 10 and 11 showed a clear increase in brake thermal efficiency going from conventional diesel combustion to RCCI E85 or RCCI gasoline combustion. This reviewer felt that some of the benefits came from a reduction of ring friction due to the reduction in CR with the new RCCI piston. However, as this reviewer found, in Slide 12, for loads less than eight bar BMEP, there was no clear indication that RCCI combustion offered higher brake thermal efficiency. Further, this reviewer indicated that this was also seen in the BTE bar chart on Slide 14. The reviewer would like to know the reason for this result. This reviewer also stated that in this context, the sub bullet Higher BTE overall with RCCI in Slide 14 was confusing. This

reviewer questioned whether the BTE with RCCI depended on the percentage of gasoline. This same reviewer also commented that the percentage of gasoline decreased with load according to Slide 16 and questioned whether this was the reason for the decreased RCCI BTE performance at lighter loads. The final reviewer would like to know how this technology behaved under cold start conditions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responding reviewers remarked on the range of collaborators. The first reviewer remarked that a good team had been assembled. The second reviewer commented that there were good collaboration with the University of Wisconsin (UW) to implement RCCI and to investigate new combustion chamber, and that connection to CLEERS and others was useful for this project. The third reviewer noted that collaborators included several OEMs, including GM, Chrysler, MECA, Borg Warner; national laboratories; and universities. The fourth reviewer observed that very good collaboration with all relevant partners existed. The fifth reviewer commended that throughout the years, the various PIs' close work with GM, UW, and sub-system suppliers had been very good, with the only missing element being a stronger linkage with advanced combustion work at SNL. The sixth reviewer recommended that collaboration with ANL RCCI program should be included, and possibly with HCCI work at SNL (e.g., John Dec) in defining emissions targets for LTC aftertreatment systems. This reviewer suggested seeking deeper collaboration with OEMs where appropriate. The final reviewer questioned what the actual collaboration activity was.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, the proposed future research was logical, and one possible consideration was to explore a means to utilize the large concentration of UHC in a positive manner or a means to reduce UHC with post injection or a non-standard valve timing strategy. This reviewer indicated, however, that these were just thoughts at this point in time. The second reviewer perceived that plans seemed reasonable. The third reviewer remarked that looking at the effect on aftertreatment and potential A/T solutions was important. According to the fourth reviewer, given the focus on emissions and aftertreatment for light-duty engines, next steps should include greater consideration of emissions test cycles, including more aggressive transient cycles such as the US06, as well as cold start emissions leading to catalyst light-off. Another reviewer suggested detailed FMEP breakdowns that account for injection pump and mechanical friction effects. The sixth reviewer observed that future hardware was delineated, including LP EGR, 2-stage TC. The seventh reviewer noted that future objectives were on target but would be difficult. The final reviewer thought that the project needed to explain if there was an answer needed for the UHC and CO. This reviewer would like to know if NO_x aftertreatment was still needed. If so, the reviewer wondered if diesel, gas, and DEF were needed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer thought resources were insufficient. This reviewer noted that based on the hardware cost for this continual effort, this project could use a little more support for any additional subsystem needs. Ten reviewers thought that the funding was sufficient. According to one commenting reviewer, the resources appeared sufficient for the upcoming year, although the scope could be broadened to address more LTC aftertreatment challenges. Another reviewer remarked that the resources seemed sufficient.

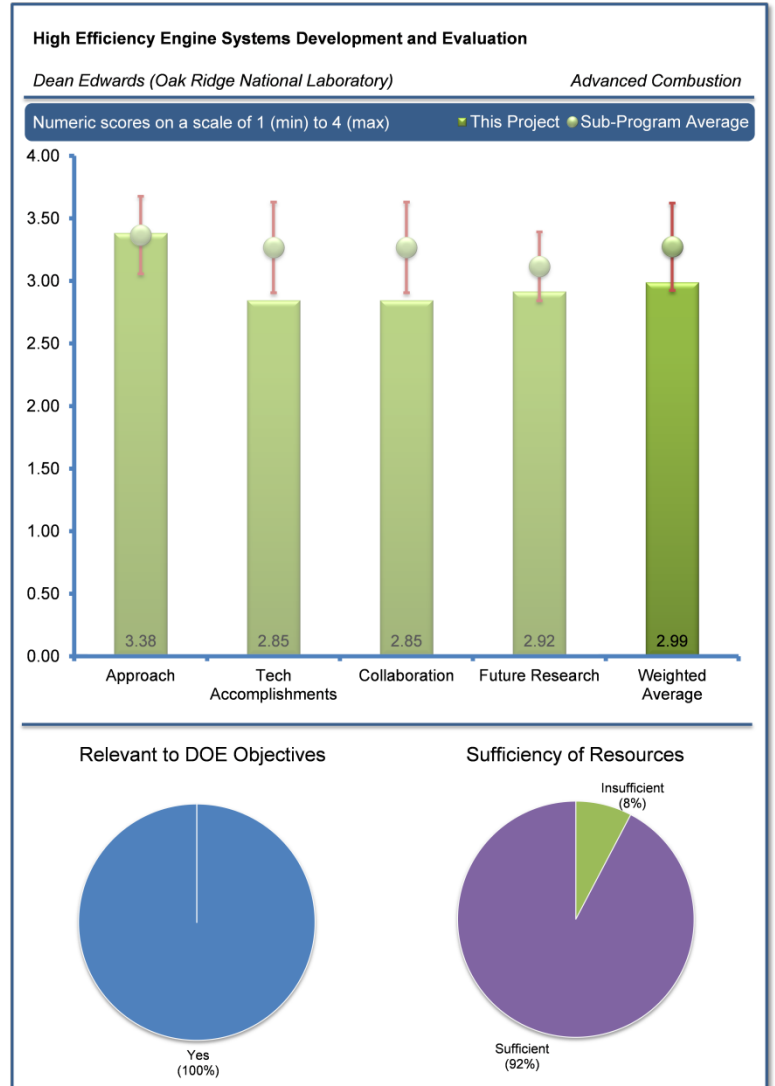
High Efficiency Engine Systems Development and Evaluation: Dean Edwards (Oak Ridge National Laboratory) – ace017

Reviewer Sample Size

This project was reviewed by thirteen reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers found that the project supported DOE’s objectives. The first reviewer noted that this project held great importance for establishing future goals for the ACEC program. The second reviewer noted that the project directly addressed efficiency barriers. The third reviewer commented that the key project goal of determining maximum efficiency of ICEs and identifying methods for achievement would lead to higher fuel economy, reduced need for fuel and/or petroleum. The fourth reviewer saw excellent work to determine potential areas of improvement. Another reviewer perceived that this project had good relevance given that the goal was to quantify where there was potential to improve engine brake efficiency. The sixth reviewer thought the project was important work as part of the goal setting process to ensure that engine efficiency goals were meaningful and realistic. According to the seventh reviewer, the project addressed a comprehensive thermodynamic analysis to meet maximum engine efficiency goals. Another reviewer remarked that this was a good fundamental first and second law investigation of where engine efficiency loss came from and what actions could be used to improve it. According to the final reviewer, the project was working on higher efficiency.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally perceived that the approach had value, and also provided suggestions for future work. The first reviewer remarked that this study identified loss pathways via a second law of thermodynamics analysis. This person thought it would stand the test of time. The second reviewer noted that looking at fundamentals of combustion processes seemed reasonable. According to the third reviewer, the project sought to limit energy losses comprehensively, within the secondary constraints of cost and emissions. This reviewer saw the effort as analysis driven, specifically by the first and second laws of thermodynamics. The fourth reviewer noted the approach to understand loss mechanisms. The fifth reviewer thought that the approach was valuable in providing guidance to future programs; employing more detailed models of projected future engine geometries and features may affect the analysis, and should be incorporated. The sixth reviewer remarked that it was very important to analyze where gains could be made but that it was also necessary to set realistic targets based on technology to be utilized. For the seventh reviewer, leverage of a first and second law analysis was a good approach for a low-cost, up front investigation of various pathways to improve efficiency. The reviewer liked that the analysis was conducted at both a low load and peak efficiency point. The reviewer remarked that there may be a need for greater collaboration with the industry in order to solidify assumptions around how efficient

waste heat recovery worked. The eighth reviewer complimented that this project did a good job of identifying potential loss reductions, but felt that the project did not get enough into the potential methods of recovering these losses. This reviewer understood that that was a much bigger job. Another reviewer liked the idea of using thermodynamics to isolate efficiency improvements. This person noted the need to apply some rigor to the inputting assumptions. The final reviewer commented that doing this type of analysis to isolate where the saved energy goes was definitely valuable and that engine modeling was a good starting point. This reviewer then indicated that at some point in the near future, it was possible that this approach should be opened up to understand what could be done to influence some of these tradeoffs. For example, this reviewer indicated, if the cylinder is insulated, most of the saved energy goes out of the exhaust instead of to piston work. This reviewer questioned whether modeling could be used to try and come up with strategies to alter the amount of energy that goes out of the exhaust instead of to piston work. Further, the reviewer explained that this was something to consider in the future that would separate this project from similar modeling efforts that were constantly being performed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to the first reviewer, the approach had been applied to two light-duty cases, one diesel and the other gasoline. This reviewer felt the results and conclusions looked very reasonable, and were pointing to areas of focus for increasing engine efficiency. The second reviewer remarked that it was very good to see a complete look at the entire system. According to the third reviewer, the presenter did a good job of showing the different results for the light load versus the full load cases, as this sometimes gets lost. The fourth reviewer was complimentary of the very nice summary of engine inefficiency sources. Parametric studies to understand sensitivity of assumptions was good. For the fifth reviewer, there has been some good progress made and this type of modeling was always interesting. The sixth reviewer thought that the project was on track for excellent results. This reviewer was awaiting assessment of multiple engines, including CDC, RCCI, and SI-dilute, at several conditions. This reviewer noted that the accounting in the turbo pumping and waste heat recovery losses might be presented in an alternate format. For example, that the engine system pumping losses should or could include pumping losses. This reviewer also emphasized boundaries. Another reviewer noted that the project identified some strategies to improve thermal efficiency. The eighth reviewer found that some of the findings seemed obvious, i.e., reduced friction and pumping losses, but that the project's efforts to determine the biggest impact areas for improvement of engine efficiency should be very beneficial. For the ninth reviewer, the modeling provided useful insight; however, it did not yet appear to incorporate important engine features and combustion strategies that may affect the outcome of the analysis. The final reviewer observed that the effort recognized this was a comprehensive approach; an adequate example was given dependency on Fuel-Air ratio and the distribution of energy in ideal expansion work, thermal exhaust, irreversibility. This reviewer commented that general guidelines were given regarding friction, maximize in-cylinder pressures, lean, full expansion, lower in-cylinder temperatures, and efficient WHR. The reviewer noted that advanced technologies or methods were presented, e.g., high efficiency turbomachinery, and heat loss mechanisms, and that the project focused on a light-duty diesel GM 1.9L. This reviewer commented that the stretch goals given, were maybe a bit optimistic, but a good start.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed responses regarding collaboration. The first reviewer noted that ACEC participation captured multiple labs and OEM partners. The second reviewer remarked that the closer collaboration with OEMs would be important to gaining access to improved models, which would ultimately aid in setting relevant technical performance goals. The third reviewer observed that the main collaboration appeared to be through the ACEC. This reviewer noted that engagement and discussion to get a consensus on what different technologies would offer in terms of energy extraction or to get ideas on possible avenues to explore would be useful. Another reviewer observed only a general description, extensive interaction with industry, university, and national laboratory partners. The project provided supporting analysis for understanding efficiency potential of ICEs to U.S. DRIVE and the ACEC Tech Team. The fifth reviewer commented that it would be good if this program could clearly partner with a couple of engine efficiency improvement programs to feed more data into the modeling effort. The sixth reviewer found it difficult to assess the degree of collaboration, although a statement was made of extensive interaction with industry, university, and national laboratory partners. This reviewer suggested that listing specific partner names would be helpful for reviewers to better assess the

level of collaboration and coordination. The final reviewer remarked that there did not seem to be much collaboration in the program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, the plans to continue this work seemed worthwhile. The second reviewer remarked that it included a good piece of work to set future directions. This reviewer suggested focusing on the RCCI work presented in ACE016 – multi-cylinder work. For a third reviewer, the future research goals were fairly broad and loosely defined. This reviewer felt further collaboration with industry would help to focus the work and make it more fruitful. The fourth reviewer suggested that brainstorming with a panel on ideas to explore for improved efficiency using this analysis might open possibilities. The final reviewer would like to see a proposal on how to firm-up the engineering assumptions on recovery and redistribution factors.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer perceived that resources were insufficient. This reviewer commented that more could be spent on identifying ways to use the lost energy and modeling those solutions. The remaining reviewers found that resources were sufficient. One commenting reviewer remarked that the resources were sufficient at this point, though more could be spent on obtaining improved model inputs. Another commenting reviewer noted that the resources were acceptable given that this was a modeling-only project. This reviewer stated that obviously resources would need to be reconfigured if any engine testing was to be done, although the engine data might be better done via collaboration with other programs that were currently looking at improved brake thermal efficiency.

A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines: Margaret Wooldridge (University of Michigan) – ace019

Reviewer Sample Size

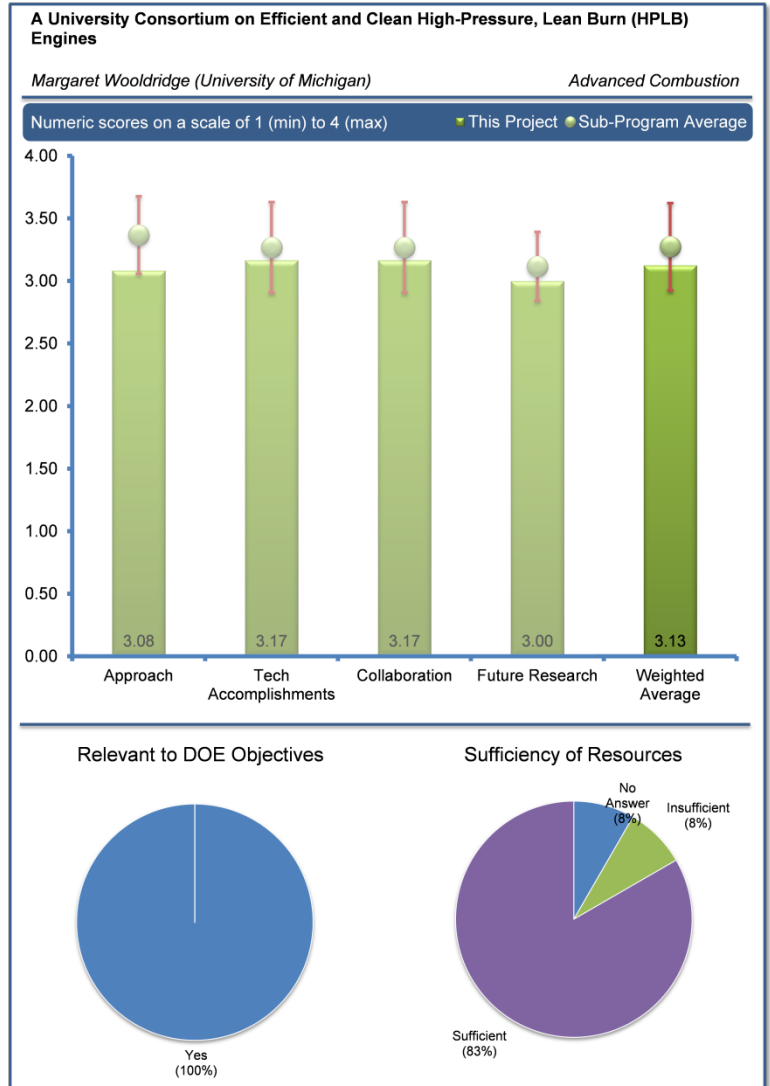
This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that the project’s focus was on improving fuel economy which if successful would lead to direct reduction in fuel/petroleum needs. The second reviewer commented that improving efficiency of gasoline engines was critical, because this was the technology that was likely to have the easiest path of penetration in the U.S. The third reviewer found that this project was clearly focused on methods to improve fuel economy of IC engines. The fourth reviewer commented good focus on improving engine efficiency. The fifth reviewer noted that the project was focusing on SACI, between SI and HCCI, and sought to demonstrate 45% peak efficiency. The final reviewer noted the pursuit of higher efficiency

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed responses. The first reviewer noted that the project possessed well-aligned objectives for dilute high pressure combustion. This reviewer observed a well-presented and organized plan by four tasks. The second reviewer noted that the project explored dilute, high pressure combustion and fuel properties. The project focused on analytical tools, stratification, multi-mode combustion, novel fuel properties. The third reviewer thought that including lean and dilute combustion in the portfolio was critical. This reviewer saw a good mix of modeling and experiment. The reviewer remarked that the connection between them through a final cycle projection was good, but that the connection between the various pieces of the project was not entirely clear. The reviewer commented that there was a lot of great work, but that connecting different research techniques to deepen the understanding would be useful. The fourth reviewer commented that clearly this program was going into good detail in a number of very interesting areas. This reviewer identified that one thing that might be missing was how the project down-selected to the single best approach (e.g., ESC), but perhaps that fell back to the industry partners. According to the fifth reviewer, various elements appeared to be disparate or non-integrated and did not necessarily support each other or have synergies that came together in order to achieve the program goal of improved fuel economy. Another reviewer commented good breadth, and considered the project very useful if eventually integrated. However, this reviewer did not see the vision to achieve that. The seventh reviewer noted that although there was a huge amount of work being done, it was not clear how it tied together. This reviewer also noted that it was not clear if there was any focus on shifting between operating modes. The eighth reviewer would like to know how the various aspects of this research were tied together. The ninth reviewer remarked that the approach seemed to have a shot-gun flavor to it; the link between the tasks on Slide 5 was not clear. The final reviewer questioned what NTC meant and pointed out that it was never documented in the presentation.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that a huge amount of data and improved understanding has been accomplished. The second reviewer noticed good progress on a broad range of projects. The third reviewer found that there was clearly a lot of good technical progress in a variety of areas and noted that the combination of results from modeling, engine testing, optical testing, etc., helped build the fundamental understanding of some of these unique combustion modes. The fourth reviewer observed some good results in SACI mode. This reviewer desired that the project share more information on what conditions were needed and what conditions the project was running at. Another reviewer suggested considering the impact of aftertreatment on efficiency and drive cycle fuel economy. The sixth reviewer noted that the individual technical accomplishments were good. However, this reviewer felt it was unclear how it contributed towards a cohesive understanding of engine efficiency improvements. This reviewer noted that most of the numbers for fuel economy gains were from model estimates, which were nice to start out with but needed to be tempered with solid engine performance and emissions results. The seventh reviewer commented that GT Power results helped identify some efficiency targets, but the combustion model looked over-simplified, specifically with knock at high loads. In addition, this reviewer commented that FE modeling showed a large displacement HCCI engine (3.3L) with moderate economy. This reviewer suggested including the option of an advanced SI TC, or SACI engine with part load HCCI. This reviewer continued that fuel properties work with HCCI showed a fairly small window. The reviewer inquired whether the work could have also correlated with higher load or SI conditions. The eighth reviewer observed that Task 1 involved GT Power model completed on an engine with six case studies including combustion modes detailing increased efficiency, while Task 2 studied the benefits of stratification, including thermal and composition. This reviewer would like to know how Tasks 1 and 2 related to each other and inquired about what the implication of the model using H₂-air mixture was. In addition, this reviewer noted that stratification of RCM data was then presented with gasoline fuel. The reviewer observed that Task 3 focused on multi-mode, and Task 4 focused on fuel properties, specifically ethanol effects and octane number. This reviewer indicated that ignition studies attempted to understand prediction of emissions. This reviewer commented that in general, lots of work was completed, but it was unclear how Tasks 2-4 got incorporated into Task 1 in cycle simulation. The final reviewer remarked that some claimed accomplishments seemed known in the industry for some time, such as the desirability of engine downsizing and boosting.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally observed broad collaboration. The first reviewer noted wide participation. The second reviewer said broad collaboration with other universities, national laboratories and the industry. The third reviewer observed good collaboration with other universities and industrial partners. The reviewer stated that this program seemed to have a good team in place with a good variety of participants. The fourth reviewer noted that project collaboration was very broad and diverse. This reviewer noted that the level of integration or coordination was unclear. To this reviewer, it seemed like there were uncoordinated or minimally-coordinated individual efforts. The fifth reviewer noted that the collaboration between project partners, including UM, MIT, and UCB was not clear, and each seemed to have worked on their own areas. This reviewer noted that there was some apparent collaboration with the industry. According to the sixth reviewer, wide collaborations were shown, but it appeared that the integration of the many tasks could be better integrated or illustrated in the materials provided. The final reviewer suggested that links between all the partners should be clarified based on a clearer vision of the integrated approach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Responding reviewers noted that the project was ending this year. The first reviewer believed that continuing this work was clearly warranted. The reviewer stated that it would help if the future areas to be studied were a bit clearer with some thought given to how these different combustion regimes could all come together. The second reviewer noted that work would be completed this year. The final reviewer commented that with the program ending this year, it was not clear how the work would be tied together.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer thought that resources were insufficient. The remaining reviewers found that resources were sufficient, with one reviewer commenting that it was not applicable because the program is ending this year.

Optimization of Advanced Diesel Engine Combustion Strategies: Rolf Reitz (University of Wisconsin) – ace020

Reviewer Sample Size

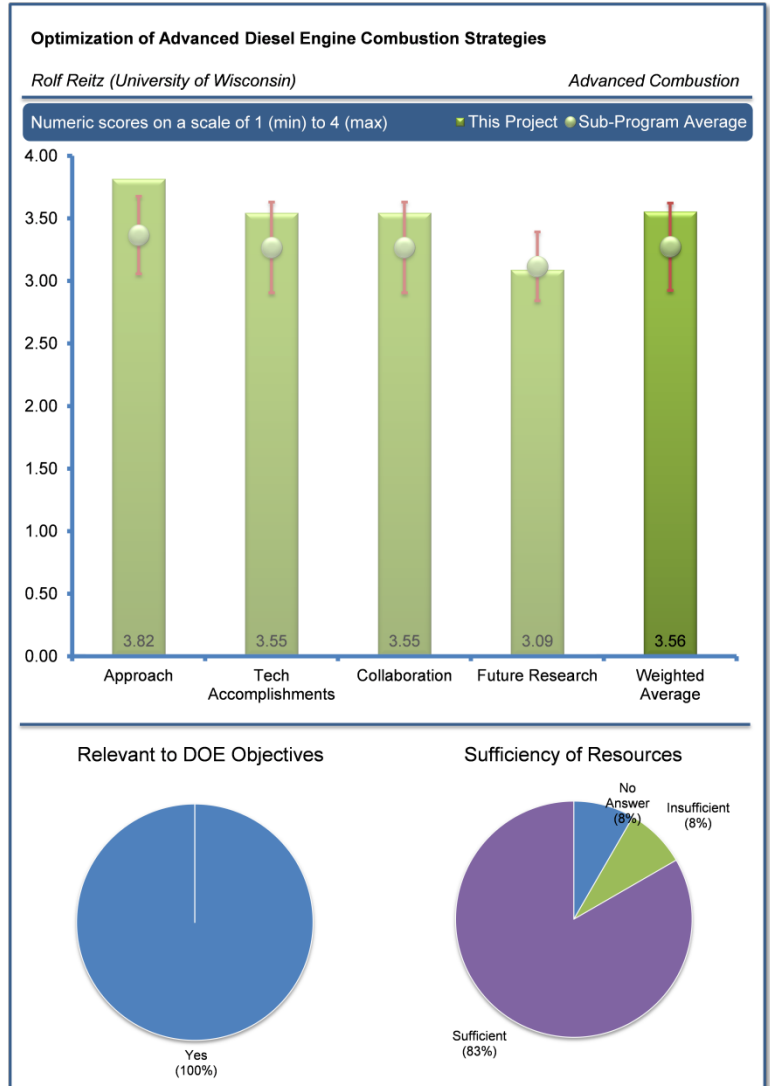
This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally found that the project supported DOE objectives. The first reviewer commented that reducing fuel consumption in-cylinder while also reducing the fueling penalty for aftertreatment systems was important for meeting the objective of petroleum displacement in both the heavy-duty and light-duty sectors. The second reviewer found that this pioneering work was excellent with real potential for improved efficiency. The third reviewer thought that this project was probably the best demonstrated engine efficiency of all the projects. The fourth reviewer stated that the focus on improving engine efficiency/fuel economy supported DOE goals of reduced petroleum usage. The final reviewer observed that the project focused on high efficiency engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Generally, reviewers perceived that the approach was effective. The first reviewer observed a very good approach of using metal and optical engine experiments, modeling and simulation, and surrogate fuels chemistry model development to accomplish goals. This reviewer noted that the project had an interesting approach of using both a more-reactive and less-reactive fuel. The key issue was whether the two fuel tanks could gain traction with OEMs and driving customers. The second reviewer commented that the experimental and computational efforts complemented those of key DOE laboratory programs, and continued to uniquely provide invaluable support. According to the third reviewer, the project developed methods to optimize in-cylinder combustion, and the project was very comprehensive while at the same time the team was notably innovative. Another reviewer commented that the approach continued to keep the scope of the project under control and limited to advanced engine combustion concepts; this helped to ensure efficient usage of resources and good progress. The fifth reviewer remarked that this program was clearly looking at a wide variety of engine systems in order to find potential improvement compared to today's engines. Some of these areas were more interesting and had more potential than others, but to this reviewer, to have the overall program look at a wide range of areas was outstanding. The sixth reviewer observed that the project had showed methods of how to make dual-fueled engines work. The final reviewer stated that although the work was very well done, that there needed to be more focus on gas pumping requirements and more realistic assessment of losses from GIE to BTE.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Many reviewers observed good progress. The first reviewer observed exceptional experimental and modeling coupling. The second reviewer commented that the program provided comprehensive support to many aspects of the DOE programs. The progress in each area was outstanding. The third reviewer noted that the project had made a number of significant accomplishments that provided potential options for achieving goals of improved fuel economy and lower emissions. Specific accomplishments the reviewer noted included the concept of changing fuel reactivity as driving conditions warranted, modeling work to identify optimal injection strategies, and development of surrogate for CRC FACE diesel fuel No.1. The fourth reviewer observed excellent progress and significant accomplishments in pushing the envelope and challenging engine developers around the world. Another reviewer noted that modeling and engine diagnostic work continued to focus on combustion issues raised and observed in metal engine. The sixth reviewer observed that Task 1 addressed optimization of combustion chamber and sprays with CFD with natural gas and gasoline mixed each with diesel, and that the work was accompanied with modeling combustion control and mode switching. This reviewer would like to know whether hardware was available to benchmark models, VVA, and multi-shot injections. The reviewer noted that the work also considered injection pressure and fuel strategies, and that experimental work extended to LD engines. The reviewer observed that Task 2 consisted of optical engine investigation of multiple fuels, and the work was accompanied by investigation of soot formation and impact of flame lift-off. This reviewer inquired whether the conditions were comparable to those of Task 1. The reviewer observed that Task 3 was considering multi-mode combustion and reduced mechanisms -- the work included spray and fuel film for SCR, turbulence mixing measurements, and the project executed crank angle measurements of species and temperature. The reviewer observed that Task 4 consisted of transient work. The final reviewer noted a large suite of research projects, but would have liked to know how the research projects tied together in a system to deliver efficiency for a LD or heavy-duty (HD) application.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed strong collaborations. The first reviewer noted that the level of collaboration was exemplary and unique. The second reviewer observed wide collaborations, and noted that the scope of work was very impressive. According to the third reviewer, it was good to have a strong industry consortium behind this work. The fourth reviewer noted that a large cross section of the industry had input into this program. The fifth reviewer observed collaborations with GM, Woodward, and ORNL, plus the DERC network. Another reviewer noted that the project showed some good results and shared these with others in the industry and in research. The final reviewer commented that while most of the work was being done by UW, the project obtained wide and solid input from the diesel engine consortium.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed comments on the proposed future research. According to the first reviewer, DOE and UW deserved much credit in appropriately defining the scope of the cooperative efforts in so many areas. Each area was producing valuable results. The second reviewer thought that the plans seemed reasonable to achieve goals of the program, which is scheduled to end this year. The third reviewer remarked that no specific details were given. The fourth reviewer suggested that a multi-cylinder demonstration and an actual BTE versus GIE comparison were needed. The fifth reviewer suggested that the effect of heat transfer in a large-bore heavy duty engine versus a small-bore light duty engine should be presented at a future review so that reviewers may better understand the difference between the two. The final reviewer noted that the future plan of increasing the CR to 18.6 seemed to counter the surface/volume and friction trends. This reviewer inquired whether the project expected improvement on a brake basis.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One responding reviewer thought that the resources were insufficient. The remaining reviewers found that resources were sufficient. One reviewer commented that resources seemed sufficient to complete the program, which was scheduled to be completed by year end. According to this reviewer, this work was worth continuing, and the reviewer hoped that this work would receive a new phase of DOE funding.

Flex Fuel Optimized SI and HCCI Engine: Gouming Zhu (Michigan State University) – ace021

Reviewer Sample Size

This project was reviewed by eleven reviewers.

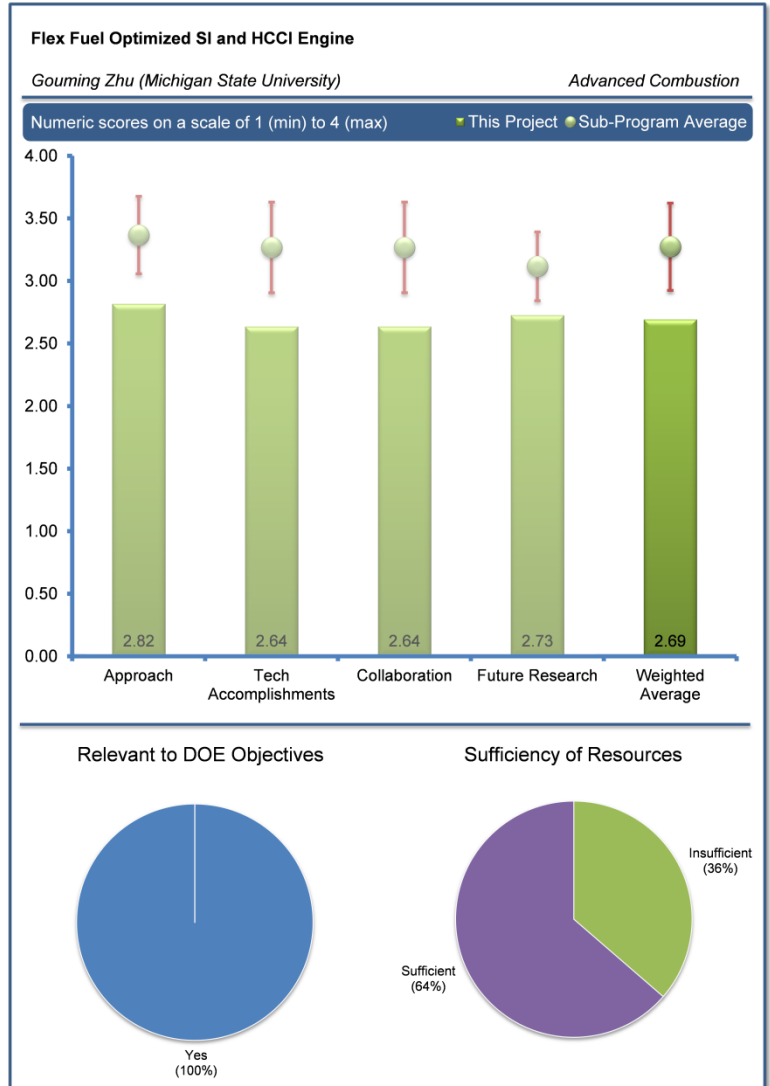
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that Homogeneous Charge Compression Ignition (HCCI) combustion has the potential to provide significant gains in fuel efficiency; however controlling the combustion process is a big challenge. This person added that this project aims to provide knowledge and understanding of the control of Spark Ignition (SI) to HCCI combustion mode transition. Another reviewer believed that the development of a cost-effective HCCI/SI approach would be a valuable contribution to light-duty engine technology. The next reviewer to respond suggested that the project should demonstrate an SI and HCCI dual-mode combustion engine (multi-cylinder) that is commercially viable, for a blend of gasoline and E85. The next commenter stated that the transition from HCCI mode to SI mode will be necessary as long as HCCI BMEP is limited. Another commentator felt that both concepts, E-85 fuel and advanced combustion part-time HCCI engines, support the DOE goal of using less petroleum. The following commentator believed that the control of advanced combustion modes like HCCI is a significant barrier to implementation. These modes offer

the potential to reduce fuel consumption, added the reviewer. Another reviewer agreed with the project as it addressed that another barrier to implementation includes cost effective controls for LTC. The last reviewer to respond felt that there still remains a lot of interest in HCCI engines and it is well known that HCCI can only be used at lower Brake Mean Effective Pressure (BMEP) levels. The reviewer added that a program is needed to study the transition effects between HCCI and other combustion modes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter to respond stated that the developed transient control algorithm relies on the VVT system and that tests would be done in optical and metal engines. Another reviewer believed that the path for future control systems lies in model based control. Leverage of a HIL environment is an effective way to develop control strategies, added the reviewer. This person questioned whether the HCCI engine would be ready to execute transient maneuvers, as well as complete the task at hand. Another reviewer felt that the approach seemed reasonable. The next reviewer to respond believed that this project needed to work on demonstrating how some of the advanced combustion ideas would actually be used. Most of these combustion scheme ideas are neat, but lack the necessary controls concepts to really enable them to be used in the future, added the commenter. The following commentator liked this project. This person felt that, by using hardware in the modeling, the optical and multi-cylinder development effectively includes appropriate noise factors that demonstrate mode transitions. This person also added that, in regards to the execution, the project may have taken on too large a task in building up all of the various pieces (optical, multi-



cylinder, controls hardware, controls software). The reviewer believed that with the large task at hand, the project may not be able to spend sufficient time addressing the key deliverable of a control strategy for SI and HCCI mode transitions. This person also questioned if the results were going to be combustion system specific and asked how the project would establish transparency or transportability to other architectures. The following commenter stated that it is difficult working with simulation without verification of a full HCCI engine. The next reviewer felt that it was unclear if the initial plan is to use pressure or ion sensing to feedback the SI to HCCI transitions. Another reviewer added that the approach to addressing the controls challenges seemed sound. The next commenter expressed the concern that excessive time spent on hardware development leads to insufficient time to address the core objectives of the program. This person added that more time would be needed to produce sufficient details on the nature of the combustion during the transients, such that the salient control issues could be identified and explored. Additionally, this reviewer added that it appeared that the present approach for the combustion mode transition would lead to significant emission concerns (especially HC), and yet this reviewer saw no solution proposed, such as air injection or some other approach. The last reviewer to respond said that it appeared that the approach was diluted from the stated goal of managing the transition to and from HCCI mode and conventional combustion. This person also thought that it appeared that this program had become the development of an HCCI engine and was not actually studying what was initially intended. This would indicate a poor initial assessment of available HCCI engines, added the reviewer. This person then explained that while managing the transition, a number of items should have been studied closely such as the torque resolved per firing event to detect torsional issues; the rates of pressure rise in-cylinder to check for potential mechanical issues; as well as the heat release data to evaluate the combustion performance during the transition. This reviewer was unsure why there was a need for an optical access engine since none of the items on the objectives during the transition required visual observation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent observed that progress made to date included Task 1 – a finalized mode transition control which was validated with HIL; Task 2 – completed electrical VVT control, showing a 25 degree phasing within three engine cycles; and Task 3 – good progress appeared to be taking place with the metal engine build which included an engine controller. The reviewer added that, despite the delay, the hardware and controls were ready for an in depth development of the transition algorithms. With respect to the reviewer's opinion about the progress being made on Task 1, this person believed that it is necessary to detect knock if the author stated that the control relied on cylinder pressure feedback for the five-cycle transition. The reviewer stated that knock sensors were common in production engines and could respond on a 1-cycle base. The next reviewer to respond felt that the electric variable valve timing (VVT) performance was quite slow, even with low viscosity oil. This person wondered if it would be possible to obtain a faster unit. The reviewer also questioned what the tradeoff for controlled SI-HCCI transitions with VCT rate and accuracy would be. This reviewer added that a delta lambda value of 0.25 seemed like a very wide range and questioned what factors would prevent tighter control. Being mostly a control project, the hardware effort to launch a HCCI engine has apparently consumed a lot of time and resources. Another commenter stated that the slow progress may suggest that perhaps the scope was defined too broadly, since the basic nature of the combustion control has not been adequately explicated to make a significant contribution toward moving this technology closer to implementation. The following person listed the accomplishments to date as development of transition controller, method to regulate air/fuel ratio, construction and integration of an electrical VVT system to optical and multi-cylinder engines, and demonstration of the rich-to-lean SI transition in optical engine. With these accomplishments listed, this reviewer observed that the project team still needed to build a metal engine and test the control system with the very limited time the project had left. One commenter felt that the schedule seemed to be slipping. Another reviewer questioned whether there would be sufficient time spent on the actual combustion aspects of the project since there has been progress made in building the hardware. The following reviewer commented that the controls software seemed to have progressed well. This person also observed that this project is nearing the end of the project lifetime and was unsure if there would be a properly operating metal engine running so that the control system could be tested and validated and improved upon. The six-month extension to the project would certainly help in this area, added the commenter. Another reviewer added that there was good progress being made on building and developing an HCCI engine. Although the actual progress and data of managing the transition in and out of HCCI mode is somewhat lacking, the project has developed some interesting results, said the reviewer. The following commenter felt that there was good progress being made on the control strategy development and validation, but noticed that this was all on HIL simulation. This person also observed that progress was made on acquiring hardware, but the timeline

required to complete demonstration may be difficult if the HCCI on the engine proves difficult to calibrate. The last reviewer to respond said that the theoretical results look positive but is unsure that the project will deliver a full engine.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback and in particular had comments regarding the collaboration with Chrysler. The first reviewer observed that two of the several partners named in the presentation were Chrysler and Ricardo. Another expert stated that there was a partnership with Chrysler for system design and technology transfer, but that did not seem to be well thought out. It was unclear to this reviewer that Chrysler was committed to getting an HCCI engine to Michigan State in a timely fashion so that they can further develop and demonstrate their control strategy. The following commenter added that Chrysler was a later partner to the program. This person continued to explain that Chrysler is not known to have an HCCI engine program, and added that the expertise they could bring to this project was uncertain. Since this project was originally conceived as a controls project, this reviewer felt that attention should have been focused on having a partner or collaborator on the project that had the ability to either supply the HCCI engine hardware or the know-how. Another reviewer felt it appeared that the input from the Original Equipment Manufacturer (OEM) was not as valuable as it should have been, particularly in providing necessary hardware for the experimental work. Another reviewer to respond felt that the ability to get a HCCI metal multi-cylinder engine seemed to be limiting progress. A reviewer said that the work could use a bit more involvement from the industry. The final commentator felt that closer collaboration with an Original Equipment Manufacturer (OEM), beyond just supplying hardware, could have improved the approach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed responses on proposed future research. The first reviewer stated that the upcoming task will include a move to start completing the metal engine work. The second reviewer expressed uncertainty whether the plans to complete the building of the metal engine, the integration of controls system, and the testing could be completed based on the current schedule. Another reviewer remarked that the plan looked good, but seemed late in the program. The fourth commenter stated that at this point in the project, time is the enemy, and explained that it appears the project objectives would not be met due to time constraints. Another reviewer added that there are significant concerns about whether it would be possible to calibrate the engine in SI and HCCI modes as well as develop a transient calibration where one could prove mode switching works. The final reviewer advised that the project should keep their focus on getting the metal HCCI engine operational as soon as possible. Then, the focus should be on understanding the issues involved in controlling the transition from SI combustion to HCCI combustion, which is the research issue in question and what is of value to industry.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers felt that funding was insufficient, while seven reviewers felt that the project resources were sufficient. The first reviewer commented that more resources were needed and better hardware would be beneficial to the project team. The following reviewer thought that the current project suffers from inadequate recognition of the degree of difficulty in pursuing the approach taken. The final reviewer stated that the scope of this project was too large for the given funding level. The last commenter to respond assumed that a project extension to first-quarter 2013 was for a sufficient period of time to complete milestones.

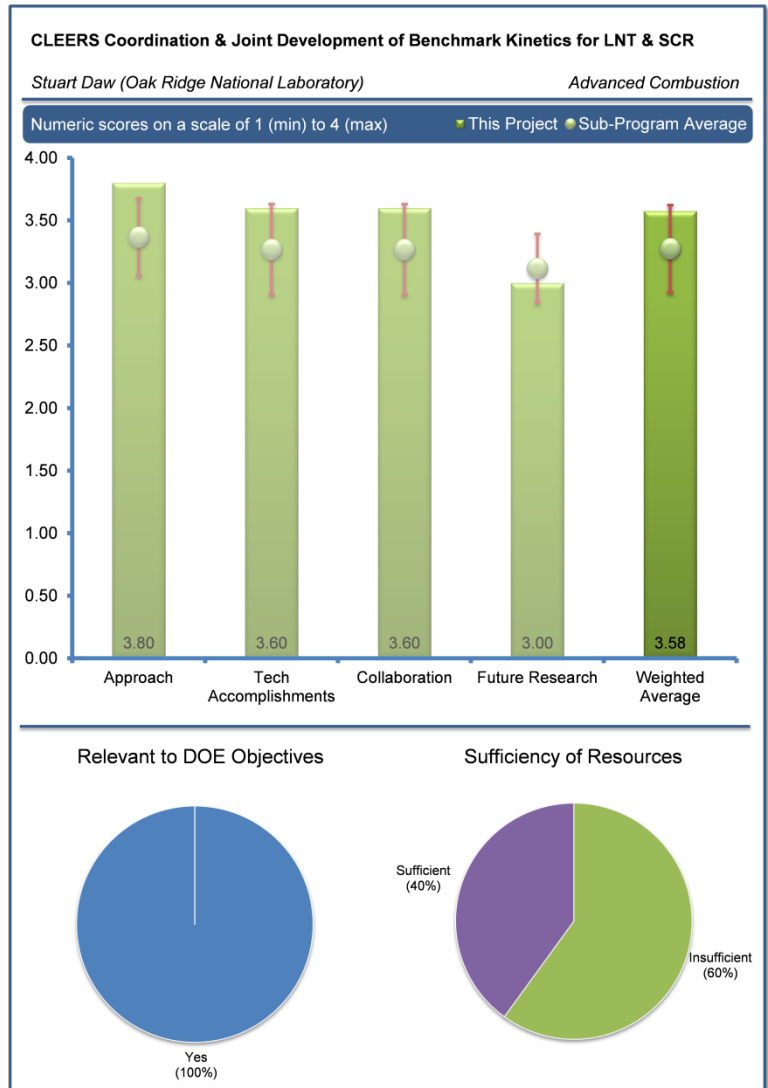
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR:
Stuart Daw (Oak Ridge National Laboratory)
– ace022

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond felt that this project is aligned well with DOE objectives. The effort strives to improve the long term performance of NO_x aftertreatment devices, added the reviewer. This person also believed that as the tradeoff between NO_x and fuel economy is critical, the project supports DOE goals of reduced petroleum displacement. The following commenter stated that the Cross-Cut Lean Exhaust Emissions Reduction Simulations (CLEERS) activities have been very successful for last several years in addressing a number of aftertreatment aspects for fuel efficient advanced combustion technologies. The following reviewer agreed that this work primarily focused on exhaust gas aftertreatment. This reviewer noted that required emission mandates have traditionally reduced fuel economy; however, as the understanding of aftertreatment technology has increased, the efficiency of the devices has increased significantly. This person continued that say that the work completed by Oak Ridge National Lab (ORNL) has increased the basic knowledge of actual production devices. The reviewer added that the CLEERS coordination is a model for bringing industry, national laboratories and academia together. This reviewer noted that the CLEERS workshop has at least one imitator in Europe, and since imitation is highest form of a compliment, to this reviewer that is a strong recommendation for the activity. The last reviewer to respond expressed that the major goal of any emissions control project is to minimize the use of energy to control criteria pollutants. This project provides focus for a wide range of technologies, so its benefit is spread over a set of engine families, added the reviewer. This person believes that the data and models are more likely to be used since they are wide-ranging results are readily available.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that CLEERS is the benchmark for collaborative research. The second commentator to respond stated that the results of this project would be very useful if the team used industrial application catalysts. Additionally the focus on N₂O is a look-ahead approach that gives the work long-term value, added the commentator. The following panelist felt that the approach of this project was unique from the point of view of building of an aftertreatment community. In contrast with the breadth of interaction in the Cooperative Research and Development Agreement (CRADA) or other two-partner projects, these projects bring together people in many ways, through the monthly web talks and through the databases that are available, expressed the commenter. One reviewer observed that CLEERS covered experimental simulation/modeling and made progress in forming

diversified groups participation/contribution in lean exhaust emissions research areas. This person suggested changing the acronym not to limit on simulation; e.g. Cross-cut Lean Exhaust Emissions Reduction System or System technologies. The last commenter to respond said that the work appears to have good communication and collaboration activities. However, it was unclear to this reviewer how OEMs ultimately benefit from some of the work. For example, the hydrothermal aging study suggested that NO_x reduction was relatively robust to aging; that is a strong learning. But, it is not clear to this reviewer as to how the fundamental knowledge of NH_3 storage and its sensitivity to aging would lead to better robustness or better fuel economy. The reviewer felt that connection did not seem to get made.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer could clearly see a change in selectivity of Selective Catalytic Reduction (SCR) catalysts for NH_3 oxidation. This person mentioned that the Lean NO_x Trap (LNT) had focused on N_2O selectivity and that more nitrates stored lead to more N_2O . One reviewer felt that there was strong progress being made especially with respect to the hydrothermal aging study. The next reviewer suggested that the project should continue working on low temperature catalysis. The following commentator observed that ORNL coordinated the 15th CLEERS workshop well as usual, but suggested that they could have generated a more interesting discussion at the meeting if there were more invited talks from industry side (such as OEMs including heavy duty, catalyst suppliers, and etc.). CLEERS has made a good step on providing vehicle engine out data, added the reviewer. This person continued, saying that the recent BMW lean GDI vehicle data would help a wide range of research groups to better understand the real world conditions they are faced with. The reviewer added that, with regard to benchmarking exercise, the database needed some improvement with more frequent updates and well-defined conditions for all diesel oxidation catalyst (DOC), SCR, and LNT technologies. For oxidation catalysts, it would be difficult to standardize the performance level due to high platinum group metal (PGM) dependency on their performance, added the reviewer. This person then suggested that one possible option would be to have a normalized PGM activity database for oxidation catalysts. The last commentator felt that nothing in the work was earth-shattering. This person explained, unfortunately that it is not for lack of good investigative technique; it simply means that ORNL is validating prior aftertreatment studies.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw good collaboration. One reviewer felt that it was clear that there is good collaboration on this effort with a structured communication rhythm. Another commenter stated that ORNL interacts with both the domestic and international community and that the CLEERS workshop has become a high choice meeting for the international community. ORNL provides data to a wide range of institutions including national labs, industrial partners and both domestic and international academic institutions, added the reviewer. The following commentator mentioned that ORNL has been working with a wide range of groups including OEMs and other national labs. Although we are learning more interaction and technical information exchange between ORNL and Pacific Northwest National Laboratory (PNNL), this reviewer suggests that it would create more synergy if both labs work together on other components such as LNT and oxidation catalysts development. The final reviewer to respond believed that some of the key features of the this program include the collaboration between ORNL and PNNL, the collaboration with suppliers to provide catalysts, and the collaboration with universities and national labs in developing data and models that describe the various means of NO_x and particulate control in lean exhaust.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer believed that there are many directions for this program to go. The following commenter mentioned that some of the future work had been covered and already reported by other groups such as PNNL. This person suggested that it would have been nice if the future direction was coordinated with PNNL at least under CLEERS coordination. ORNL has excellent resources in mechanistic study as well as integrated system research, while PNNL's strength lies in fundamental and material-based research, added the reviewer. Another reviewer stated that the project has developed an enhanced mechanism to share data and modeling information with the pre-propriety. This reviewer also stated that the presentation did not provide a clear reason for why the low temperature DOC surface modification should have been completed at the National Laboratories compared with having

that work done at suppliers. The final reviewer to respond felt that the future work did not seem clear from the either communication or the presentation slide. This person suggested that they would have preferred to see more deliberate statements of future activities based upon what was learned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two of the five reviewers to respond felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. Three reviewers found resources to be insufficient, and two reviewers found resources to be sufficient. One reviewer commented that ORNL has been doing the CLEERS workshop and benchmarking exercise on top of technical research on LNT/SCR/OC. It seemed that more resources are needed to achieve a more frequent and systematic benchmarking study so that they can provide valuable up-to-date information to the CLEERS work groups and partners for advanced technology development, added the reviewer. A second reviewer observed that ORNL received most of the funding due to the level of accomplishment. This person suggested that increasing funding is not necessary. Another reviewer stated that the program seemed to be reasonably funded and resourced. The final commenter did not see a large need for further resources since doing so would create a major influx of work.

CLEERS Aftertreatment Modeling and Analysis: George Muntean (Pacific Northwest National Laboratory) – ace023

Reviewer Sample Size

This project was reviewed by six reviewers.

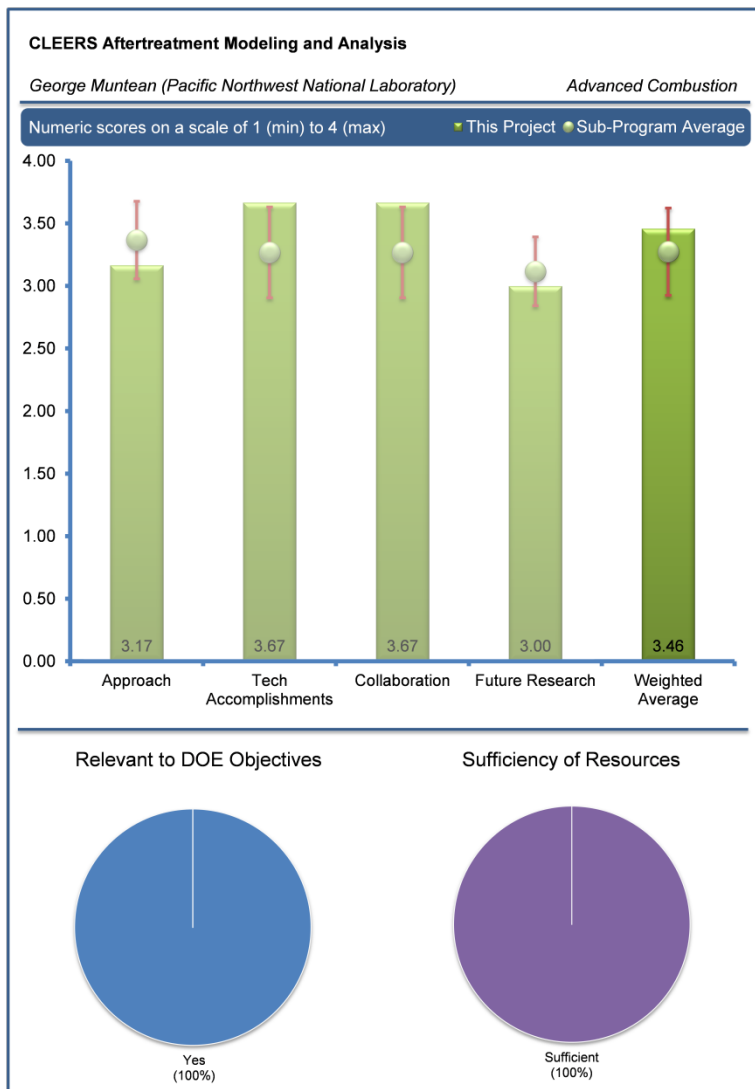
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that there was a good alignment with the DOE goals of reduced petroleum usage. This person felt that the team clearly communicated that what was learned would be used to help develop aging parameters for model-based control in order to develop a clear linkage to overall engine operation and fuel consumption. The following commentator stated that, through CLEERS, this project helps ensure that new ultra-high efficiency engines continue to meet emission requirements. Collaborative development of models to support lean-burn engine aftertreatment designs is a cost-effective approach, especially since the models and the resulting data are being shared, added the reviewer. The next commenter to respond believed that the CLEERS activity has been well coordinated for the overall DOE objectives, and that this project is one of few sources that promote development of improved modeling tools for aftertreatment systems. A different reviewer stated that this project also related to low temperature activity of components, which may be of particular importance and concern as the team goes forward. The project will help maintain a better focus on

projects that deal with future OEM needs by having this initial work validated through individual projects with OEMs (CRADAs), stated the reviewer. The commenter mentioned that the work covered includes a number of different components (SCR, LNT, and DPF) which have relevance to both diesel and lean gasoline strategies. The last reviewer to comment insisted that understanding how lean aftertreatment devices work is critical since they lead to higher fuel economy powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked about the appropriate shift to investigation of NSR materials for use in lean-gasoline applications. This reviewer noted that close collaboration with industry, universities, and national laboratories strengthens the approach. Another reviewer stated that the technical approach seemed reasonable. The third reviewer stated that PNNL's approach on the CLEERS activities was good in a way that all projects were linked to CRADAs. This person continued, saying that this suggested that they had better approach to bring science to solutions to the table. The actual implication might be limited because most projects stay in the fundamental stage of research, added the reviewer. The commenter gave an example and said that PNNL developed unique kinetic models for SCR, but it was not clear how they were going to validate their model for real-world applications. Another example is that PNNL is very strong in material characterization and their approach is perfect for understanding the existing problems, but they are not clear on how to approach the solution, added the reviewer. The next commentator felt that the work was focused on characterizing the current state of the art components such as Cu-Chabazite (SCR),



but also novel Mg and K-based LNT. Benchmarking Cu-CHA catalysts from suppliers other than BASF, added the reviewer, would also be desirable to benchmark technology and performance. This person felt that there may be more relevant alternatives to improve LNT performance other than K/Mg addition. The final commenter to respond felt that CLEERS was good for sharing of pre-competitive ideas and that industry involvement kept the focus more realistic. This person added that a barrier exists with proprietary data sharing, and that will always be an issue for a group like CLEERS. The apparent overlap with the industry makes CRADAs appear to be well managed, mentioned the commentator.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses. One respondent felt that good progress had been made in all three project areas (i.e., SCR, NSR, and DPF). Overall CLEERS data sharing through a public website is excellent, added the reviewer. Another reviewer stated that the project team continued with strong progress. The following commentator stated that the PNNL group had made great progress in the development of the SCR model, the state-of-art SCR thermal durability study, and its characterization. This person added that the NSR (LNT) and DPF work needed a little bit more improvement in their work scope. In the U.S. market, LNT does not seem to be a viable solution for lean-burn engine applications, not because of just high temperature performance, but because of low-temperature performance and its low sulfur-tolerance, observed the reviewer. The commenter suggested that for new NSR materials, all the requirements needed to be satisfied. The reviewer also recommended including NO_x reduction data from a commercially available LNT catalyst to compare to the newly developed NSR material. The next reviewer felt that it was difficult to gauge the technical accomplishments as the material was not appropriately timed and had to be rushed. This person also added that it was clear that the transient SCR model performed very well and seemed like it could be quite impactful to adoption from OEMs. The next reviewer stated that chabazites are now a known quantity and have been available to the automotive industry. This person was wondering what was next for this project team. The reviewer stated that the current work with K-based LNTs was interesting, but added that low temperature activity was lower than Ba. This person questioned whether the Ba formulations could be improved to offer even better low temperature behavior at the same time as destabilizing sulfur components so that De-Sox can proceed at a lower temperature. The reviewer suggested that this would improve performance and fuel economy. Fuel economy must be included in consideration of material more as well as progressively less exhaust energy, added the expert. The final reviewer added that Cu/CHA SCR is not new - it went into production in April 2010 on U.S. diesel trucks. This person found the characterization of existing catalysts not at all interesting. The reviewer added that improvement in understanding their behavior is only interesting if it will lead to improvements in performance and/or a reduction in cost. This reviewer felt that modeling flow reactor data is not so interesting. This reviewer suggested that applying the model to transient data and linking it to Autonomie would be very powerful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that there was good partnering and communication for this project, and also observed many related projects, CRADAs, and collaborations on all three main areas of future emission control. The following commenter observed very strong collaboration with industry, university and national laboratory partners, domestically as well as internationally. Significant publications, presentations, and participation in relevant annual meetings and conferences occurred, added the reviewer. The next person to comment added that PNNL has been working with a wide range of groups including OEMs and other national labs. Although we are learning more interaction and technical information exchange between ORNL and PNNL, it would create more synergy if both labs worked together on other components such as LNT and Oxidation catalysts development, suggested the commenter. Another reviewer felt that the collaborative nature of CLEERS is what the group is all about and that it was especially evident during the annual workshops. The last reviewer to comment stated that partnerships are clear, but because there was a lot of material, it was unclear what role each partner played.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to respond felt that the future work appeared to logically build upon what was learned in the past. The second person to comment remarked that the focus of the project has appropriately shifted from DPF to SCR and that the development and

validation of the SCR aging models was an appropriate future focus area along with the continued work in NSR catalysts and advanced DPF substrate characterizations. The following reviewer mentioned that the CLEERS projects use model catalysts unlike to CRADA, and added that it might have been difficult to work on state-of-art catalyst technologies. This person felt that it would be beneficial to understand state-of-art catalyst formulations that the aggressive benchmarking from in-house developments would provide. The catalyst technology moves quicker than we imagined, and to make the model usable in the industry, we should have a model updated more frequently and validated one step further from lab-scale reactors, added the reviewer. This person suggested that more interaction with engine dynamometer test capable partners should occur. This reviewer added that PNNL was very strong in fundamental research and hoped to see PNNL play a crucial role on the low-temperature aftertreatment technology development. The fourth reviewer to respond stated that the SCR work is of high value, although the direction into SAPO materials may not yield any benefits over the SSZ-13 type catalysts. DPF work is of higher value than LNT, believes the reviewer. This observer recommended a shift in future resources towards filters and soot control. LNT cost is the major barrier and it does not appear to be part of the work, observed the reviewer. The expert concluded by mentioning that K has issues with attacking cordierite substrates and could end up being a showstopper unless K mobility can be reduced. The last panelist to respond felt that most areas of the project were good. The expert added that the team needed to move forward with Chabazite alternatives and suggested that the project team look at improving Ba based LNTs for sulfur resistance. The reviewer concluded that there should be more DPF work, including compliant passive DPFs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six of the reviewers to respond felt that the project resources were sufficient. One of the reviewers felt that the program appeared to be adequately resourced. Another expert stated that this project was well-organized, had attainable objectives, and provided a good return on investment. The following reviewer said that PNNL seemed to have allocated the budget to individual projects in an appropriate way. The next reviewer said that the resource allocation, with a majority on SCR technology, seemed appropriate. This person added that the overall resource level seemed appropriate as well. The final respondent believed that the annual funding was consistent and commensurate with the importance of CLEERS work.

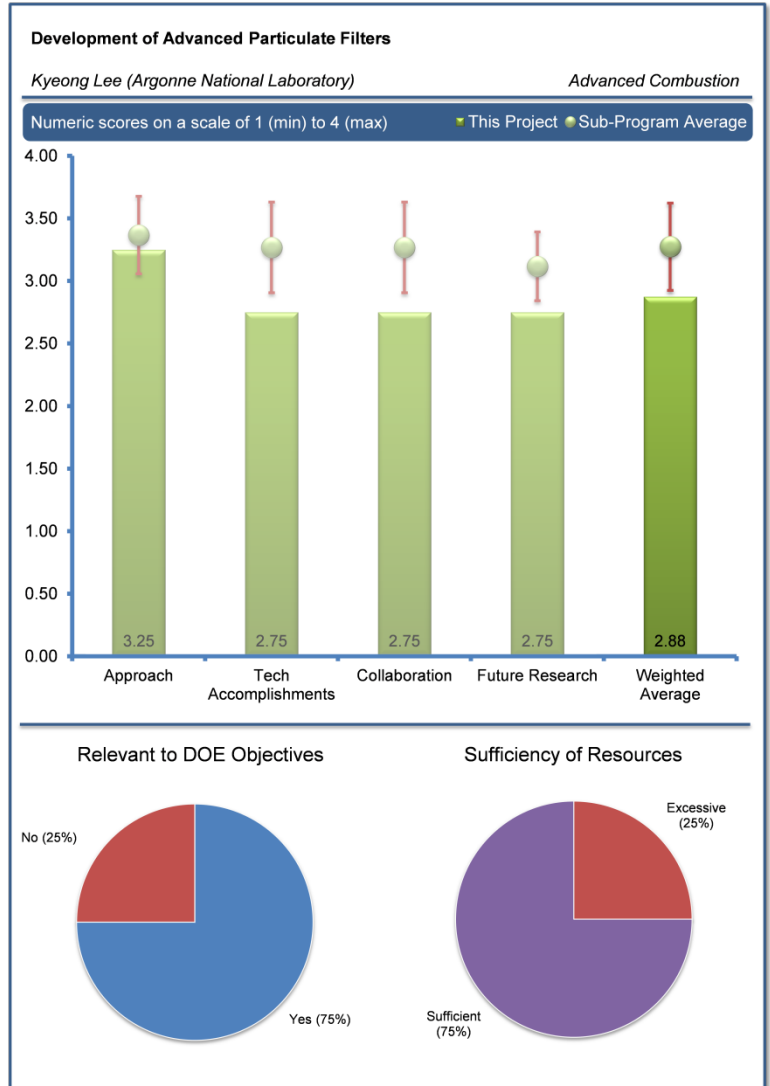
Development of Advanced Particulate Filters: Kyeong Lee (Argonne National Laboratory) – ace024

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond felt that this project appeared to have very clear goals regarding reduced fuel burn. This reviewer added that the additional backpressure of a DPF is a system penalty and regeneration strategies, with low temperature exhaust, could cause an additional loss of system efficiency. Another reviewer understood that a diesel particulate filter is very important in order to develop better regeneration strategies in fuel-efficient lean-burn engines. The commenter stated that regeneration requires extra fuel to burn off soot, and mentioned that the fuel penalty is closely linked to the regeneration strategy. The last reviewer to respond thought that the goals for this project definitely supported the overall DOE objectives of petroleum replacement within the strictures of emission standards. This expert questioned whether this work advanced the DOE objectives and asked if it ever repeated discoveries which had already been published in the open literature. This person also expressed that their view that this work makes no viable contribution to the DOE objectives.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had a range of responses. The first person to respond felt that this program appeared to be very well balanced and had a good technical approach. The reviewer added that the central focus was a GM engine which included a DPF bench top experiment, numerical modeling, and TGA analysis to provide a thorough understanding of what was happening. The next reviewer to respond felt that this group had a unique capability to image the behavior of soot accumulation and oxidation, which allowed a fully integrated approach in monitoring the behavior of soot on the filter under various conditions. Their numerical modeling strengthens the physical behavior of soot on the filter, added the expert. The following commenter stated that some of the data shown in the presentation revisited commonly known information. This person wondered why the oxidation effect of CO₂ would even be under discussion. The expert added that the results shown on Slides 8 and 9 did not seem to be worth the effort, and that for Slide 10, activation energies have been extensively studied by others and published. The reviewer noted that there is no comparison with the prior literature studies. The reviewer referenced that this complaint was made in prior years and has not been very well addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that this program appeared to be very well aligned with OEM needs. This person added that the program also appeared to have provided fundamental data that showed the sensitivity of overall oxidation rates to exhaust gas constituents (i.e., O₂ and NO₂). This data can be used directly by OEMs to help develop a DPF and regenerative strategy, added the reviewer. The reviewer said that the program appears to provide fundamental insight, supported by optical measurements, as to the soot loading and oxidation process. This is clearly insightful and can help drive the design of better DPF substrates, added the reviewer. This person observed that the numerical modeling was well anchored to the data. This person claimed that this was also valuable to the engineering community. The commenter was encouraged to see that a PI can make a firm technical statement regarding the need for catalyzed DPF. Forming a technical opinion is not always easy based upon the fundamental nature of the data collected; however, it is very valuable to the OEMs, stated the reviewer. Another commenter said that they have not seen any new technical accomplishments compared to what was already in the literature. The following reviewer mentioned that soot oxidation enhancement by NO₂ is not new information. The expert added that the kinetic parameter comparison at various temperature regimes that resulted from this work was very useful information. The last reviewer wondered whether this approach and these conclusions could be applied to gasoline direct injection particulates.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer remarked that there seemed to be substantial industrial support for this work. Another person added that, although this research group listed a number of partners for this project, it was not clear what their roles were on the project. This reviewer wondered how much ANL's approach was distinguished from the development of a kinetic model for DPFs done by PNNL. This person stated that it was clear that ANL had a unique capability for the DPF-related research and that there may be a great synergy for both PNNL and ANL if they could find a way to work together on the DPF-related projects. The following reviewer felt that the work being conducted through a CRADA made it difficult to judge collaborations and how the information is disseminated to OEMs outside of the CRADA. The final reviewer to respond stated that the slides spoke of collaboration, but the specific roles the collaborators were not covered, making it unclear as to whether this was a truly collaborative effort. The project very well may have been, but it was unclear to this reviewer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the group's plan on a 2-way DPF was very appropriate as the next step. Another expert said that future work appeared to be laid out well and built upon past efforts. The last responder to comment said that there was no reason for this project to be continued.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of the four reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer felt that the resources available were excessive. The first commenter felt that the budget (\$250,000) seemed to be low based on the scope of project, but thought that the team delivered an excellent amount/quality of work. The next expert to respond stated that the accomplishments over a five-year period appeared to be very good and well-matched to the resources. One respondent believed that it was apparent that there was substantial industrial support for this program. The reviewer preferred for it to become 100%, and mentioned that the DOE should exit supporting this program.

Combination and Integration of DPF-SCR Aftertreatment Technologies: Ken Rappe (Pacific Northwest National Laboratory) – ace025

Reviewer Sample Size

This project was reviewed by six reviewers.

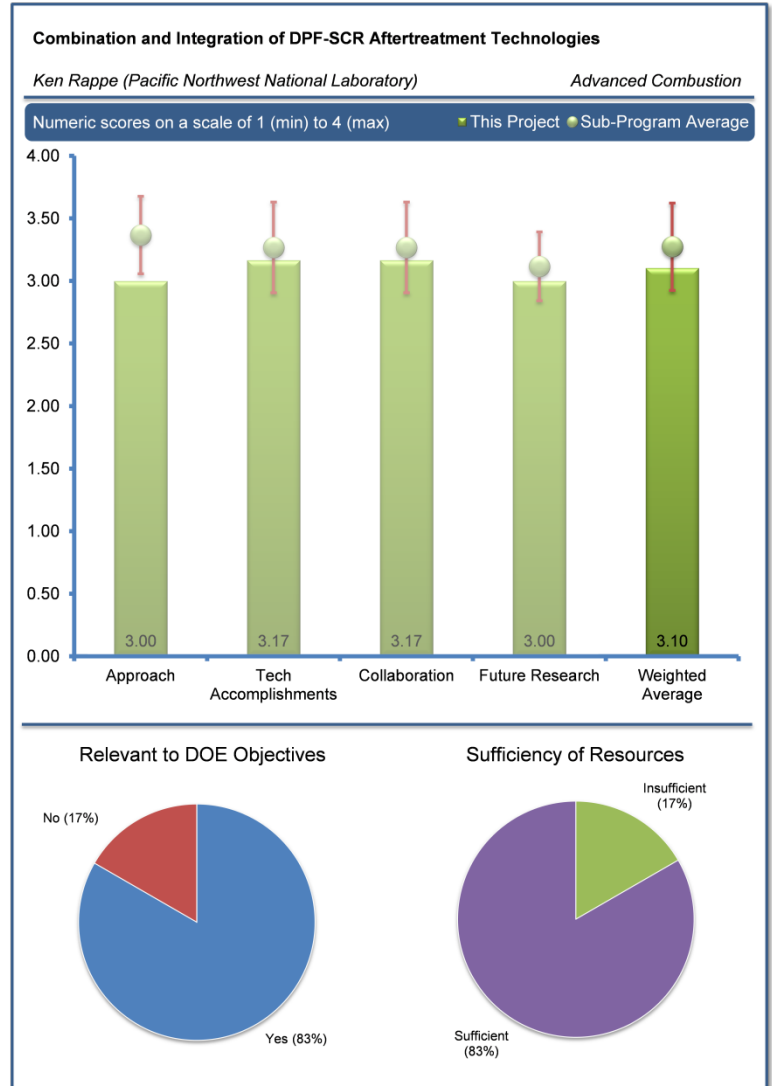
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to comment felt that this project was aligned with DOE goals. This person believed that the adoption of vehicles with lower emissions and lower fuel consumption was going to be well balanced by the overall system cost and complexity. As the program seeks to simplify the overall aftertreatment system via the combination of a DPF and SCR, it is well aligned with the DOE goals of petroleum displacement, added the reviewer. The following commenter felt that it was a good choice in using Urea for SCR and passive soot regeneration for improved fuel economy. This reviewer also felt that this enabled technology for use in LDD and HDD while meeting emissions and fuel economy standards. Another reviewer said that understanding diesel particulate filters is very important in order to develop better regeneration strategies in fuel-efficient lean-burn engines. The next reviewer to respond stated that by integrating DPF and SCR functionalities into a single device, the project has the potential to reduce the negative effects of aftertreatment on diesel engine efficiency. The last reviewer felt that the project did not really support the overall DOE objectives of petroleum displacement. This person added that the combination of SCR and filters, for a more compact aftertreatment system, would enable application in space-constrained applications and could improve fuel economy if the backpressure is less than the system with separate components. The expert stated that in order to get a high NO_x conversion, a relatively high washcoat would be needed to increase backpressure, thus reducing fuel economy. The SCR reaction will compete with passive soot oxidation through removal of NO₂ that may result in more forced regenerations and a lower fuel economy and will be application specific to understand if there are any advantages to DOE, added the reviewer.

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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed comments on the approach; some reviewers offered suggestions. The first reviewer felt that the technical approach was sound. This reviewer observed that it began with learning at the small scale and eventually pushed the technology to engine testing. The second reviewer mentioned that this is highly evolving field of work and the approach was appropriate as it was guided by the project partners, DAF and PACCAR. The third reviewer felt that the project adequately addressed the technical barrier of pressure drop and mentioned that they used NO₂ as a soot oxidation pathway. There has been a lot of work in this area already, added the reviewer. The reviewer continued, mentioning that there is a need to be able to balance the SCR's need for NO₂ as well as a use for it for soot oxidation. The reviewer added that PI has not looked at biodiesel blends, which will be more



important in future fuel stocks and the effect on a DPF/SCR component (during regeneration). Going forward, that will be a concern related to NO₂ oxidation, the reviewer added. The observer felt that due to the composition of biodiesel, there would be differences in the soot morphology and that it might be beneficial to know the NO₂/O₂ reaction pathways. The fourth reviewer believed that there have been a lot of interests to understand a c-DPF system in industry. The expert added that there is limited information on how the accumulated soot layer affects NO_x efficiency over SCR catalysts as well as pressure drop. Having a catalyst supplier (BASF) in the project approach is very good for ensuring that the catalyzed filter was prepared in very duplicable manner, added the commenter. The final reviewer to respond felt that the close cooperation with substrate and coating suppliers gave this project a higher value than in the past, but the goal of retaining passive soot oxidation may not be possible depending on the balance of NO_x versus soot control. Reliance on NO₂ can be expensive if a high Pt catalyst is needed upstream, and Cu itself is a poor NO oxidizer, mentioned the reviewer.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first responder felt that good progress had been made on the modeling of wall-scale transport effects. Another reviewer stated that the work was very interesting. The reviewer observed that important learning has been gained which suggests where the SCR should be physically located (upstream or downstream of the DPF), and that the overall catalyst amount would have significant impacts in the overall pressure drop of the system, which is one of the key barriers. It is unclear from this work whether milestones have been met on schedule, added the reviewer. The reviewer stated that, despite the actual milestones seeming reasonable, it appears that a significant amount of work must happen in the last part of this fiscal year. A third reviewer felt that the cost reduction opportunities were not adequately addressed. The fourth commenter believed that the project required more characterization of fuel blends to be useful for future vehicles and wondered how the project would benchmark BASF technology to other suppliers for reference. The next panelist felt that project focus was on the right things for HDD application, primarily the compromise between NO_x reduction and soot oxidation. The panelist added that the speed of progress has improved, but is still slow. The final reviewer observed that soot oxidation behavior as a function of SCR washcoating was not very clear, and mentioned that it would need a little bit more systematic study to look at the NO₂ effect. This reviewer noted, for example, that the NO₂ ratio was compared between 0.33 and 0.5 when there was 90 g/L of SCR washcoat. The reviewer stated that the team then compared 0.5 vs. 0.65 when the catalyst washcoat was 150 g/L (not 90 g/L). The reviewer wondered how the project can be sure that there was no change in NO₂ effect between 90 and 150 g/L of SCR washcoat.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed good collaboration with a range of collaborators. The first commenter to respond felt that the work appeared to be very collaborative in nature in terms of OEM and substrate manufacturer and catalyst supplier organizations. Another expert felt that there was good collaboration with a truck and an engine manufacturer as well as a university and several industry aftertreatment partners. Collaboration roles are well defined and match partner core competencies, added the reviewer. Another reviewer reiterated that supplier involvement is critical to this project. The following commenter liked how the project partnered with experts in all areas; OEM, university, catalyst supplier, and filter supplier. This perfect team has a great potential to elucidate a lot of information on the evolving c-DPF technology, and their findings will make a big impact on the next generation SCR systems for both LD and HD applications, stated the commentator. The final reviewer to respond mentioned that this project would benefit from looking beyond current sources of material for newer innovations in filter material; however, even more recent innovations such as ACM filters have also been widely studied.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to comment felt that the PI is correctly widening substrate investigation beyond Corning cordierite, such as ACM, which has been investigated by Johnson Matthey and PNNL. The reviewer believed the results would be useful. The reviewer also mentioned that it would be of interest to find SCR formulation that are able to accommodate active components into the pore structure so that higher loaded formulations would not be needed. The second commenter to respond reiterated that many OEMs are interested in c-DPF for their lean-burn engines because the catalyzed filter provides a number of benefits; however there

are unknown issues such as NO_x efficiency, pressure drop, and so on. This person added that this project has a right direction and scope of the research to contribute to improving the c-DPF technology, and with success their findings will make a big impact on the next generation SCR systems for both LD and HD applications. A third reviewer observed that appropriate future work included passive and active soot oxidation in full-scale engine tests. Another reviewer felt that a 650°C aging temperature seemed low for a system that would have to eventually be regenerated in an active manner. This person also felt that the reducing aftertreatment cost reductions were not clearly addressed, especially in light of tuning an upstream DOC for higher NO₂. The reviewer concluded that backpressure reduction is needed and was not properly addressed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that the budget seemed to be insufficient. Five reviewers felt that the project resources were sufficient. A respondent agreed that the overall funding seemed appropriate with the 50:50 cost share. This reviewer observed that the project team received \$3.2 million over four years, with \$875,000 received from DOE in each of the past three years, meaning that \$725,000 from DOE is left in the last (fourth) year. The reviewer stated that this is consistent with full-scale engine testing starting now. The second reviewer to respond stated that just over half of the DOE funding share has been received over the first three out of four years of the project. The reviewer was unclear if that is the indication of progress or if it is in-line with anticipated project spending. The final reviewer to respond mentioned that the project ends in 2012 and was not sure on future funding. If so, the project should incorporate looking at biodiesel blends as well, added the expert.

Enhanced High Temperature Performance of NO_x Storage/Reduction (NSR) Materials: Chuck Peden (Pacific Northwest National Laboratory) – ace026

Reviewer Sample Size

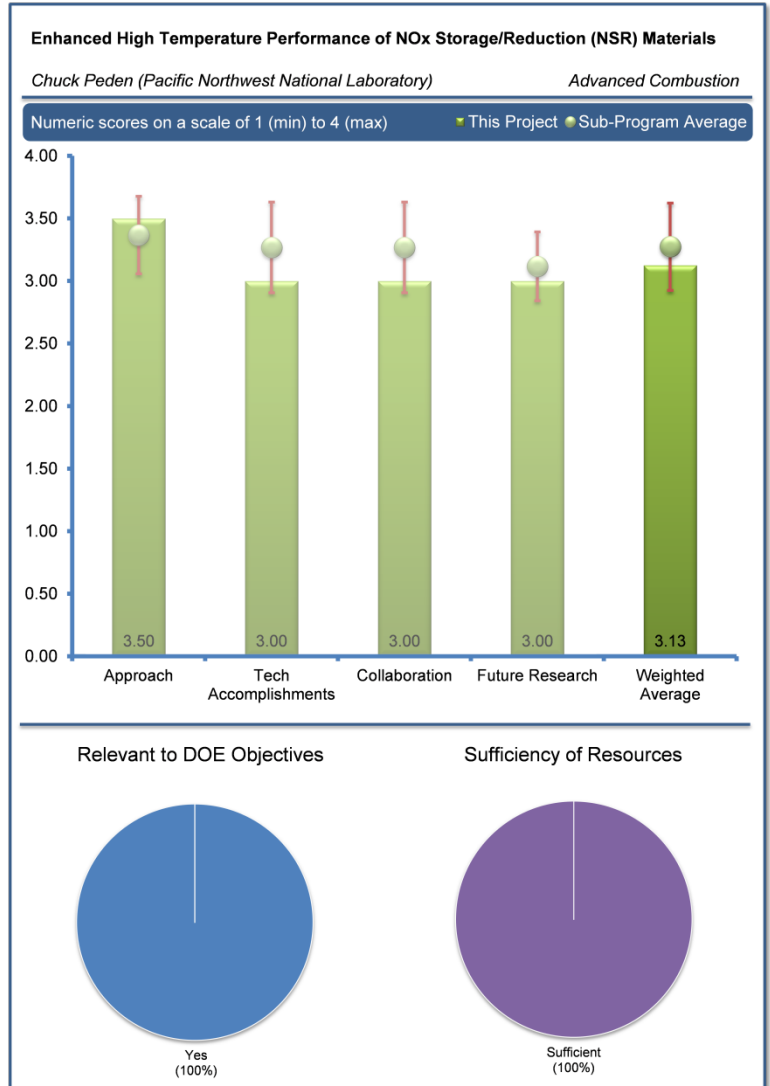
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer mentioned that high temperature lean NO_x aftertreatment will enable light-duty lean-burn engine technology to improve fuel economy. Another reviewer stated that potassium-loaded NSR catalysts are being more extensively explored by catalyst suppliers. The reviewer added that future catalyst will most likely be a combination Ba-K catalyst. This work isolates the response of the potassium with both an alumina support and magnesium aluminate support, mentioned the reviewer. This person also added that these technology improvements can make NSR catalysts more commonly used on a production vehicle. The final reviewer to respond stated that the focus of this program is on mitigation of NO_x emissions, not on petroleum displacement. Specifically, the objective is to evaluate the performance and stability of NSR catalysts for high temperature operation and minimize the amount of precious metals without compromising performance and stability, added the reviewer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commentator to respond stated that PNNL is primarily characterizing the performance of NSR catalysts with a focus on different supports on activity and the deactivation mechanisms relevant at high temperatures. This person observed that Cummins will provide performance testing of NO_x systems; yet representative results were not included in this presentation. The panelist added that Johnson Matthey is synthesizing the catalysts and characterizing them in engine dynamometer tests. Results from Johnson Matthey testing's were not included, yet should be in future presentations to at least compare to the model systems studied at PNNL (K/Pt/Al₂O₃ and K/Pt/MgAlO_x), suggested the reviewer. The expert mentioned that the characterization work done at PNNL and their approach for assessing the role of the support and aging on the model catalysts is reasonable. Interestingly, as the authors noted, the results were not entirely intuitive (such as the high NO_x uptake in the aged and reduced 10K-Pt-MG30 sample) and should be further explored, added the commenter. The following reviewer noticed that the approach leverages a wide range of prior work from PNNL. Nothing new was introduced in this project, added the expert. The reviewer mentioned that this was not necessarily a negative thing since it was evident that a clear indication that potassium is a viable NO_x storage material. Unfortunately, no results on sulfur poisoning were presented, mentioned the expert. This person also added that potassium is known to be very sensitive to sulfur. The last reviewer stated that the effects of high temperatures on precious metals had been looked at by others, and questioned why the team is repeating this. The expert understood that new storage materials were going to



be researched, but mentioned that PGM is not new. The reviewer suggested trying to make sure that the PGM experiments are related to the new storage elements.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer found that the activity of the 10% potassium-supported catalyst to be quite unexpected. The expert believed that this has the potential of being a major technological accomplishment and hopes that it is supported by future work. The reviewer added that the poor NO_x uptake after aging was not a good sign for this to be a major technological accomplishment. The magnesium-supported activity does give some added hope that this is a viable technology, added the expert. The following reviewer noted interesting observations on the performance of Al₂O₃ and MgAl₂O₄ supported catalysts (as noted their high NO_x uptake), yet the reason for the high activity following aging and reduction for the NG supports was not apparent. The expert also stated that the improved stability with the MG samples was also demonstrated in the TEM images. The final reviewer was unsure how higher K loadings would help the technology and wanted to understand it better. The reviewer also expressed concern that K has been shown to migrate into cordierite at high temperatures, 650°C and up. This would be a problem when DPF regeneration or DeSO_x is performed, added the reviewer. This person also mentioned that K has been shown to be more difficult to desulfate, and further reported 700°C and up to really get it reduced.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback on collaboration. One reviewer felt that the collaborations and interactions with others on this project were very strong and well thought out. Another reviewer felt that PNNL had done a nice job characterizing the model catalysts. The expert added that the technical contributions of the other partners was not really discussed or highlighted in this talk and that it would have been nice to learn more about the performance of the Johnson Matthey catalyst. The expert thought that this could have been done without revealing any proprietary information on its composition or synthesis technique. The last reviewer to respond felt that this presentation showed very little collaborative activity.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer remarked that continuing the evaluation of this discovery is a primary focus of future plans. This reviewer strongly agreed with this approach. A second reviewer to comment suggested that as emission regulations come down, it would important to make sure that low temperature catalyst performance is also enhanced. The expert stated that the experiments seem to start at 250°C, and suggested that it would be nice to see how these new catalysts perform at lower temperatures. Testing down to as low as 150 °C would be good, added the reviewer. The last reviewer to respond mentioned that this program ends in September 2012. According to this expert, a preliminary list of future work activities was presented, including further characterization of the MG and alumina supports and continued characterization of the Johnson Matthey catalysts. This seemed reasonable to this reviewer, but the project would need a more detailed plan if funding for three additional years is requested.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six of the reviewers to respond felt that the project resources were sufficient. The first reviewer to respond believed that the funding appeared to be sufficient. A second reviewer said that it appeared that the resources are adequate. The third expert mentioned that this work was supported through a CRADA and also through the CLEERS program. This reviewer stated that the reviewer was not involved in the CLEERS program and suggested that it would have been nice to know what fundamental work was being done in the CLEERS program and how it compliments this work.

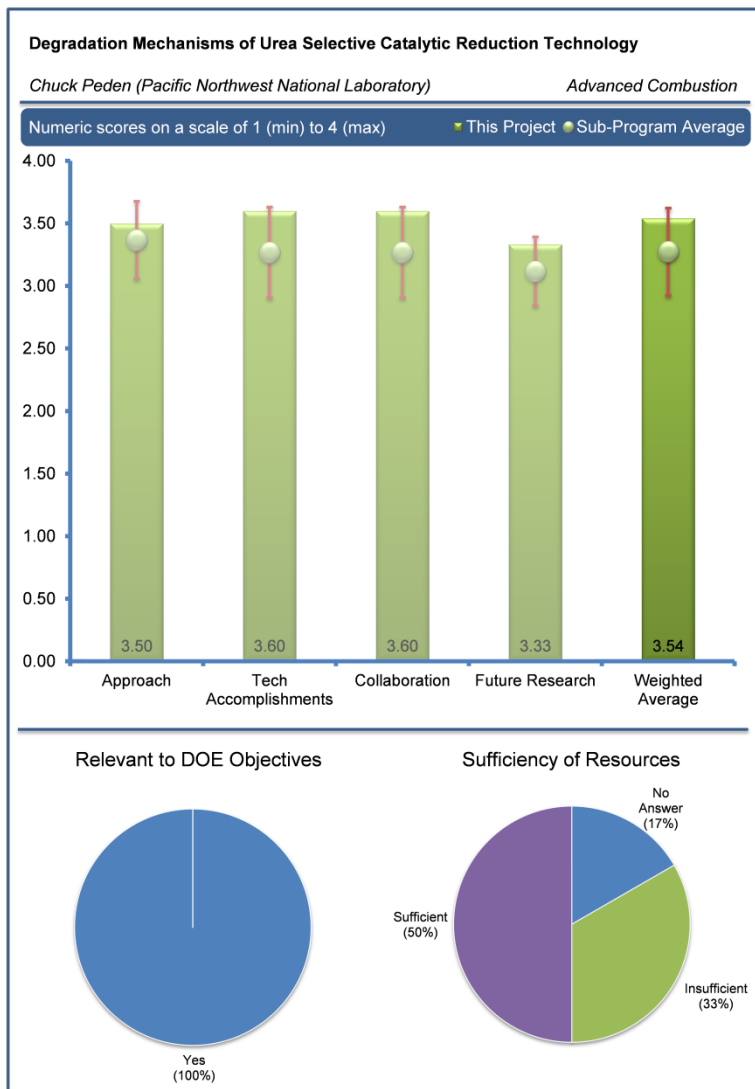
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology: Chuck Peden (Pacific Northwest National Laboratory) – ace027

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer agreed that the project supports the overall DOE objectives, and that the PI's work with GM on a diesel urea SCR system is relevant and important to the industry as a way of achieving emissions standards without sacrificing a significant fuel penalty. A second commenter stated that the focus of this program was on understanding the deactivation mechanisms responsible for urea SCR and DOC catalysts and to validate a rapid laboratory aging protocol for assessing the deactivation of the catalysts used to mimic real-world vehicle test data. This person also mentioned that the focus has been on characterization of the catalysts' performance, not directly on emissions reduction. The next reviewer agreed that this project supported the overall DOE objective of petroleum displacement through a better understanding of deactivation mechanisms in commercial SCR and DOC catalysts, enabling compliance of high-efficiency lean-burn engines with emissions standards over the vehicle life. The last reviewer to respond stated that lean aftertreatment enables higher efficiency lean burn engines, which is a reason why catalyst durability is crucial.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent felt that this was a highly focused project with well-established and achievable results, and that the team has very good direction and management. The following commentator stated that the project is utilizing PNNL's core capabilities in catalysis expertise and IIC testing facilities. This reviewer noted good delineation of tasks between PNNL and GM leveraging each other's expertise. This project helped GM commercialize DOC/SCR system in 2011, added the reviewer. Another commentator explained that PNNL is working with GM to characterize their DOC and urea SCR catalysts in an effort to better understand the deactivation mechanisms and validate the rapid aging lab tests to ensure that these can be used to accurately assess the catalysts' long-term performance in a vehicle environment. This expert added that PNNL has applied their suite of tools to support catalyst characterization and aims to help better understand the deactivation mechanisms for loss of catalyst activity to extend the lifetimes of the catalysts tested (and provided by GM). A different reviewer stated that DOC testing for HC activity was done with only propylene. The activity would be better tested with a broader spectrum of HC that are present in diesel exhaust, reiterated the reviewer. This person continued, stating that the light off characteristics will change, that DOC is an exotherm generator and that the testing did not include that condition which further stresses the catalyst. The last commentator felt that the close collaboration with OEMs helped to properly scope project and develop relevant objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that the project had been completed within the given DOE budget, on schedule, and had achieved its three main objectives. Another expert reiterated that many aspects of the objectives were achieved for this project. The reviewer stated that both the correlation of lab aging with vehicle aging for the SCR and the characterization of the aging mechanism are technically important topics. This person suggested that it would be interesting to know more on the abrupt deactivation mechanism for the SCR as seen in XRD. With respect to the DOC, progress was made on the deactivation mechanism defined by bench and analytical work, added the reviewer. This person mentioned that some elements, though, were not investigated due to time. The reviewer explained that the Pt/Pd particle structure, and surface versus bulk composition, would have been of interest to know in terms of activity and performance. The next reviewer to respond noted that PNNL had applied their suite of catalyst characterization tools to better understand the deactivation mechanisms for SCR and DOC catalysts. The results for SCR catalysts highlighted the importance of agglomeration of the catalyst particles, while sintering and soot accumulation were shown to be issues with DOC catalysts, added the reviewer. This person also suggested that it would be useful to have more information on the catalyst (primary particle size) without infringing on proprietary information. The reviewer also suggested that it would be useful to know more about the 135,000 mile vehicle test protocol since there would be a lot of variability depending on the test procedure. Another reviewer thought that it was very nice work to see the chabazite zeolite falling apart and that the project had enough data to get a NTE temperature. The last respondent to comment thought that there was good understanding of the dominant aging mechanism of diesel catalysts – time at temperature. Testing in a reactor gives some indication of aging level, but the definitive test would be on vehicle, added the expert.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers cited good collaboration, particularly with GM and PNNL. The first reviewer agreed that close cooperation between PNNL and GM was evident. Another respondent observed that there was very good collaboration between PNNL, Cummins, and GM. This person believed that the project was well-structured to achieve SCR aging results that were useful for vehicle applications. The expert added that there was a very good comparison between laboratory bench work and vehicle aging to achieve correlation of SCR performance, as well as for the DOC that GM is now using as a lab aging protocol to represent vehicle in-use data. The reviewer noted that goals were well-defined and achievable within the timeframe. The third reviewer commented that there has been good collaboration with GM throughout the project. The final reviewer reiterated that PNNL appeared to have a good relationship with GM and is essentially subsidizing their research and development with DOE funding.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that the project is completed. The expert added that some ideas were proposed for a new project, such as chemical poisoning effects, and that vehicle level results with aged catalysts is needed. Another commentator mentioned that the PIs have achieved the main objective of this work and that there was no extension of work required. An aging protocol was developed as a result of this work and the mechanism by which the SCR and DOC deactivate as a function of time, added the reviewer. The last reviewer to comment said that no future research was proposed as project has been completed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found that resources are insufficient. Three reviewers felt that the project resources were sufficient. The first reviewer remarked that the lack of time and funds required a highly focused project because funding was lower than what should have been allocated. A large amount of data was obtained for the time and resources allocated to this project, added the reviewer. This person concluded by saying that this project was a very good return on investment. A second reviewer felt that the resources seemed sufficient. The following expert stated that the project was successfully completed with allocated funding.

Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels: John Johnson (Michigan Technological University) – ace028

Reviewer Sample Size

This project was reviewed by six reviewers.

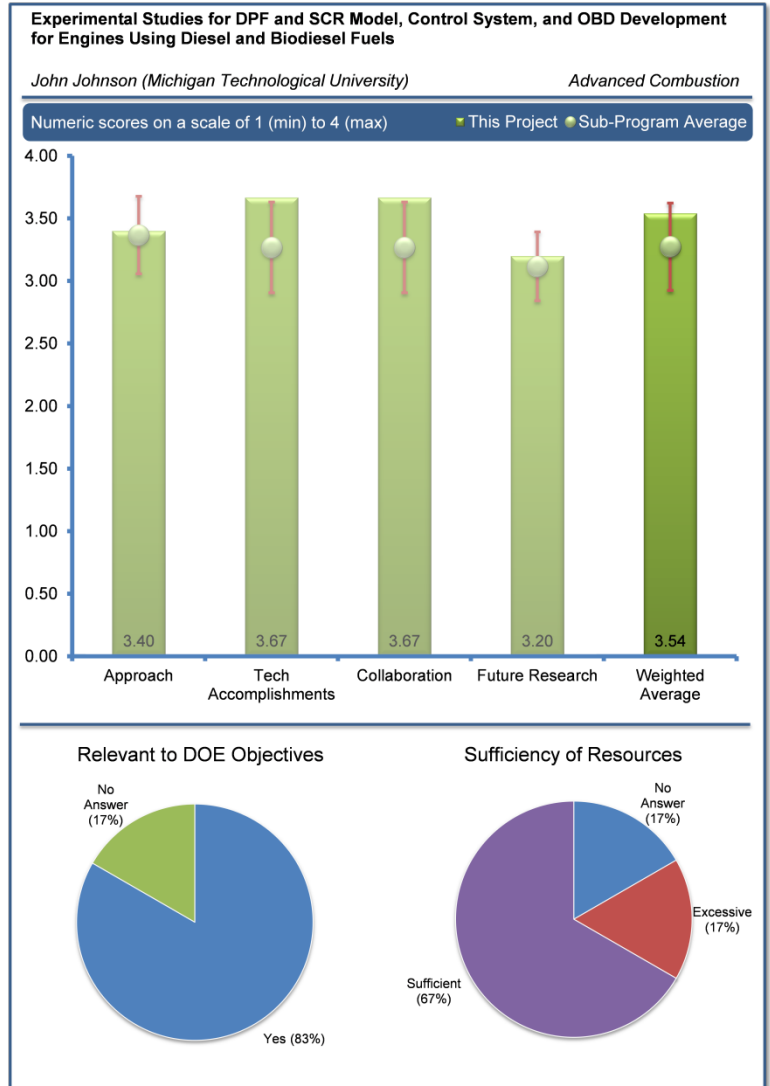
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the overall objective was to develop aftertreatment technologies for emissions reduction while minimizing the penalty associated with using these systems. This expert observed that the objective-specific approaches that had been detailed in the presentation included: the kinetic studies on the oxidation rate as a function of the operating parameters; the acquisition of test data for different operating conditions; the performing of reactor studies in well controlled conditions to evaluate storage in SCR samples; and the development and calibration tuning for the associated models. This person continued to explain that the emphasis of this project was the development of control strategies for these aftertreatment devices. Another reviewer stated that this project was working on new models for SCR and DPF for controls with and without biodiesel fuels, which was believed to help develop technology faster. The expert added that diesels would provide improvements in fuel economy and CO₂

emissions. The third respondent to comment stated that the program intended to develop a computer model and control scheme that incorporated feedback from various transducers and submodels to be able to determine the state of an integrated aftertreatment system, thereby optimizing the fuel dosing for DPF regeneration. This reviewer believed that, if the scheme works as intended, the project may potentially reduce fuel consumption in engines used for transportation applications. This person explained that additional benefits may accrue by reducing inefficiencies resulting from high backpressures from loaded DPFs. The final respondent that commented believed that the approach to developing the control strategy with all the hardware in the loop was great. This person added that this would directly connect the basic simulation work with the integrated control system, making the project unique and very worthwhile.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commentator felt that this was a uniquely integrated project. The reviewer was impressed that the PIs were able to coordinate all the pieces of this project and make them fit together and that the project could not have been done better. Another reviewer said that project appeared to be well organized and had a good suite of collaborators. This person also added that the cycle-based transient dynamometer testing was good. The following commentator stated that a detailed approach (task-level) was presented, and that overall, the program is rather comprehensive – detailed tasks had been reviewed and provided for a well-integrated/comprehensive program. The reviewer was interested in learning more about the models (or optimized model) and their



ability to deal with transients (work planned for this year). The next reviewer to respond thought that the overall impression of the proposed effort was that it was an engineering approach of optimizing the performance of a system by developing submodels for the components. There was no specific novelty to this approach other than the fact that it paved the way for developing control strategies for optimal performance given the fact that various sensors are still under development, added the reviewer. The last commenter to respond wondered if this work enables the aftertreatment architecture to change. This person also asked whether the SCR could be placed in front of the DPF to better represent light-duty systems for faster NO_x light-off. Finally, this reviewer also asked whether the model could be used to construct any type of aftertreatment system and still produce good data.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One of the reviewers stated that the significant accomplishments to date were focused on kinetic studies and the development and calibration of reduced order models with experimental test data. The following reviewer found the progress in stated technical tasks to be adequate. The expert pointed out that it was yet to be demonstrated that this approach had made any progress towards achieving the DOE goal of reduced fuel consumption. Another commentator thought the estimators seemed successful. The next reviewer to comment thought that none of the individual accomplishments were especially noteworthy; however, the ability to make advances as needed was quite impressive. The final commenter to respond stated that the current work was using a Fe Zeolite model calibrated using ORNL reactor data to a Cu Zeolite model using engine data. This person questioned if vanadium could be added to the model.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw good collaboration. The first reviewer felt that there was very good collaboration. This expert wondered if the project has approached any other sensor companies. The following reviewer felt that the integration of the various parties to this project showed a very high degree of collaboration, as well as the fact that John Deere was now beginning to integrate the control system into a prototype system. The next commentator to respond thought that the partnerships seemed well-structured and thought out with involvement from industry, OEMs, academia, and government labs. The last reviewer to comment stated that the net outcome of this effort was that a number of candidate PM sensors get to be evaluated. However, the engagement of the rest of the team members is small, according to this reviewer

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One of the reviewers felt that this project was on track to finish on time. This person added that, occasionally, the milestones have been adjusted to be achievable. That certainly is a measure of a successful project, added the expert. The second reviewer to respond said that, while the tasks recanted in the presentation are appreciable, it would be advisable to direct those efforts to result in an integrated model that would help reduce fuel consumption in an engine. The following commentator stated that a detailed task-level plan forward was highlighted, as was seen by this reviewer as comprehensive. The reviewer was interested in learning more about transient response of the models. The last reviewer to comment wondered what the plan was to help reduce NH₃ slip in the model. This expert also wondered how the project was planning to account for drop to idle DPF regeneration in the model.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of the five reviewers to respond felt that the project resources were sufficient. One reviewer felt that the resources available were excessive. One reviewer thought that this group appeared to be meeting all their milestones. The expert added that they could not see them adding much to their plan without causing chaos. This person mentioned that it seemed there were sufficient resources to accomplish their goals and that no additional resources, in any area, were needed at this point. The following reviewer thought that this is a rather large program with the lion's share going to Michigan Tech. The next commenter to respond saw no issues with the current resources. The last reviewer to comment found the funds allocated to be excessive when considering the magnitude and extent of the testing and modeling work that was involved.

Development of Optimal Catalyst Designs and Operating Strategies for Lean NO_x Reduction in Coupled LNT-SCR Systems: Michael Harold (University of Houston) – ace029

Reviewer Sample Size

This project was reviewed by six reviewers.

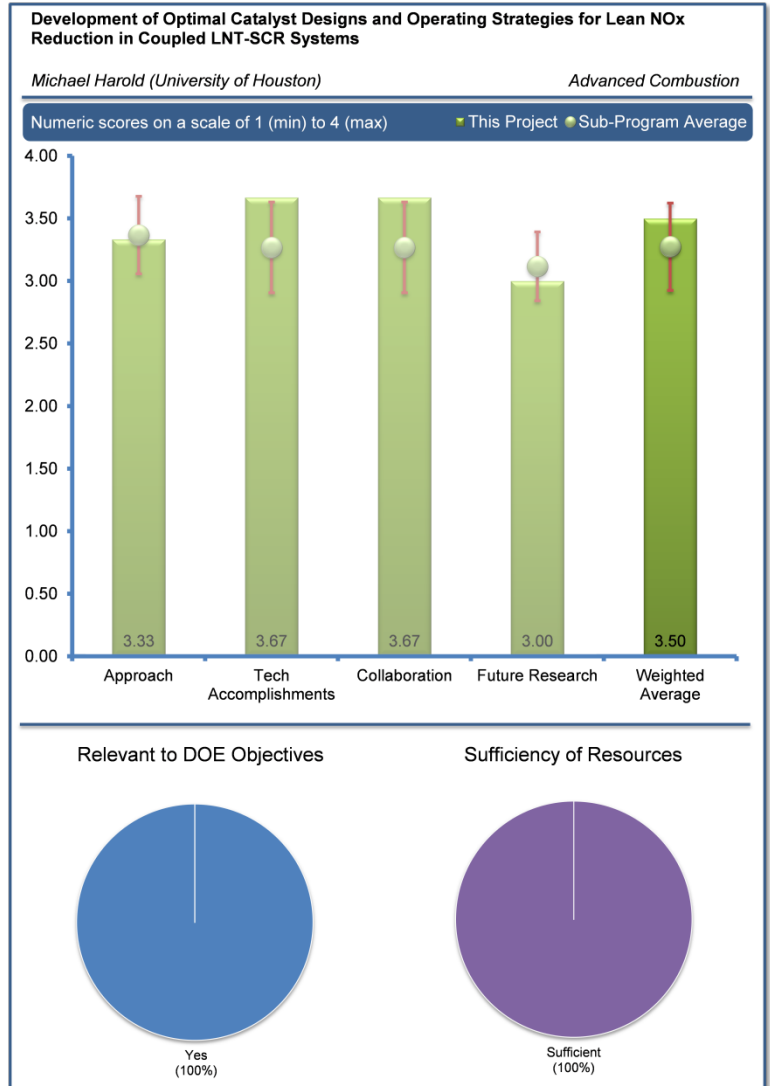
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that this project was relevant to future diesel or lean-burn engines. The expert added that the main concern was how much fuel economy would be saved using LNT technology in front of an SCR to generate NH₃. This person also stated that the deSO_x of the LNT would also impact fuel economy and CO₂ emissions. The following commentator agreed that the project supported DOE objectives, adding that, for light duty vehicles, achieving NO_x emissions standards for lean applications without Urea by employing passive HC regeneration appeared to be a viable pathway. This person felt that an important feature would be to achieve this performance with as little impact on fuel economy as possible. This is an enabling technology to achieve both future emissions and fuel economy standards without the introduction of a second onboard fuel, remarked the commenter. A third reviewer stated that the overall objective of this program was to develop a LNT/SCR system to reduce NO_x

emissions in diesel and lean burn gasoline engines without the need for urea based systems. An additional expert agreed that this project supported the overall DOE objectives of petroleum displacement by the development of LNT/SCR for enabling high-efficiency lean burn gasoline vehicles. Another reviewer commented that this project intended to develop a close-coupled LNT/SCR aftertreatment system that could be an enabler for lean-burn gasoline engines that have substantially higher efficiencies as compared to the traditional stoichiometric engines. The final reviewer to respond added that lean NO_x aftertreatment enables higher fuel economy powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to comment felt that the research team had clearly identified the technical issues and pursued a research effort with a clearly identified pathway. Another commentator believed that the team's approach combined focused experiments that were complemented by models tuned through simulation of experiments to identify optimal LNT/SCR design and operating strategies. The following reviewer added that the approach was very sound and was relevant to the automotive industry. This person mentioned that there were multiple combinations reported in the community now involving the arrangement of the LNT and SCR components to achieve the required emissions results. The expert suggested that the PI should investigate the impact of LNT deSO_x temperatures on those LNT/SCR combinations where the two components are in close contact. Having a HC trap so close to an SCR layer may damage the activity of the SCR from experiencing high temperatures, added the reviewer. This expert



stated that novel Ba based LNT formulations that lower the desulfation temperature would be of interest. This person believed that the investigation of N_2O production by the LNT was very timely since it was a growing concern in the CLEERS community. The next reviewer to comment stated that the approach aimed to understand the mechanisms for NO_x reduction in LNT/SCR catalysts thru experiment and tuned reactor modeling and then optimize the catalyst and that efforts to extend or at least understand the operation at low temperatures and minimize the amount of PGM have been highlighted as principal objectives and challenges. The following expert to comment stated that the application of LNT and SCR have significant barriers including sulfur storage and thermal stability during $deSO_x$. This reviewer noted clearly that the SCR must also survive, but that it was unclear to this reviewer if ZSM-5 is capable of surviving $deSO_x$ conditions. The expert also mentioned that ZSM-5 may also suffer from HC storage in diesel exhaust and could cause damage from the resulting exotherm if it was the top layer of the catalyst and that it was not clear if the layering or zoning approach of LNT and SCR would result in an overall cost savings over LNT. Cost is a major barrier to the use of LNT, mentioned the expert. The last reviewer to respond stated that LNT-SCR systems would work, however, the PGM cost would be a concern. The expert also suggested that they would like to see some details with PGM levels that would be used to meet lower emissions standards.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress; some also offered suggestions. One reviewer stated that good progress had been made on several different tasks and that there was a significant technology transfer through publications, presentations and lectures. The second commentator stated that showing the importance of where and how large the Pt particles are was important in ammonia generation. The expert explained that larger particles further apart reduces LNT conversion, but makes more NH_3 for SCR catalyst. This expert further reported that higher dispersion closer together makes more N_2 , but leaves less NH_3 . The third expert to comment felt that there was very good progress in understanding NH_3 generation mechanisms involving Pt loading and dispersion. The reviewer observed that the team surveyed a wide variety of SCR catalysts for downstream NO_x control while also investigating LNT catalysts. This person added that the results on lean rich control strategies were very good. The fourth commentator observed that the technical work had led to a greater understanding of how LNT and SCR can work together. Cost may still be a major issue to the implementation of this technology, especially with multiple washcoat layers, added the reviewer. This person also felt that the durability was also a major concern and not clearly addressed, most notably the effect of $deSO_x$. The fifth expert to respond thought this was a very productive research group. This person added that both modeling and experimental data was obtained for the LNT validation. The expert observed that the tuning of the model showed very good agreement with one another. For the SCR, a dual layer and dual-zone catalyst systems were also explored in an effort broaden the operating range of the catalyst, added the expert. For the LNT/SCR catalyst work, interesting results were obtained using ceria (suppressing Pt migration from the SCR layer to the LNT layer). This reviewer did not completely understand the physics for why this occurred, and felt that it seemed to be a promising approach as it may enable more NO_x storage at lower temperatures. The sixth reviewer felt that the progress on individual technical goals was outstanding. The expert suggested that, after the individual issues are adequately addressed, efforts ought to be directed in determining the system overall performance. These are however scheduled for the coming year, mentioned the reviewer. The last reviewer to comment felt that the rich cycling of the LNT only contained H_2 , which was unrealistic with a real engine. H_2 only will enhance low temperature performance of the LNT, but when CO is added it inhibits the low temperature performance, stated the expert. This person suggested that additional exhaust gas constituents should be added to make it more realistic.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first commentator to respond said that there was excellent coordination and collaboration with four other partners in this project to achieve meaningful results. This person observed that there was very good use of facilities and assets. The following reviewer stated that there was very good collaboration with the University of Kentucky (UK), ORNL, BASF and Ford, leveraging each partners core capabilities. The next expert agreed and stated that the researchers have adequately leveraged the technical expertise developed in-house and elsewhere. The next reviewer said that it seemed like a complementary group of academics, researchers at DOE labs and industry. This person added that DOE labs performed primarily characterization and experimental measurements, the academics performed both modeling and experiments, BASF provided the catalysts and related expertise, and that Ford provided the application and integration of the technology pending successful results from the study. The final

commenter to respond stated that the numerous partners appeared to be well-managed and include university, national lab, supplier and industry. The reviewer commented clear separation of tasks and responsibility. The last reviewer to respond saw no issues with the collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first expert to comment felt that the project was nearly complete. Another reviewer added that the project was very good. The following commenter noticed that, according to the schedule in the presentation, a significant number of activities remain to be completed and added that the project seemed on track for completion by the end of FY 2012. Another reviewer suggested adding some characterization work on the effect of regeneration of the LNT to understand the effect on the downstream SCR. The last reviewer to respond felt that there was a need to look at HC mixtures in the feedstock. This person suggested that biofuels should be considered in future work. The expert added that higher temperatures should be looked at for aging the SCR if the LNT was going to be used to generate heat for a downstream DPF regeneration.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six reviewers to respond felt that the project resources were sufficient. One reviewer felt that this project was an appropriate R&D topic and was well organized and showed a good use of resources. The second reviewer to respond felt that this project was a good return on investment. Even if this effort was not to result in a successful product, the knowledge base developed is invaluable; however, the progress trajectory indicates substantial progress, added the commenter. The third commentator to respond felt that the project appeared to be coming in right on budget and complimented the project, indicating that a good job was done. The fourth reviewer said they saw no issues with the project. The fifth expert stated that this project had a significant budget but included work from five different partners. The last reviewer to respond added that this project is roughly \$2.2 million, \$687,000 of which is going to Mike Harold group and partners. This reviewer wondered if the difference is distributed among the other partners, and would like to know how so. This was unclear to the reviewer. This reviewer trusts that the level of effort of the other partners would be commensurate with their activities and contribution to the program.

Three-Dimensional Composite Nanostructures for Lean NO_x Emission Control: Puxian Gao (University of Connecticut) – ace030

Reviewer Sample Size

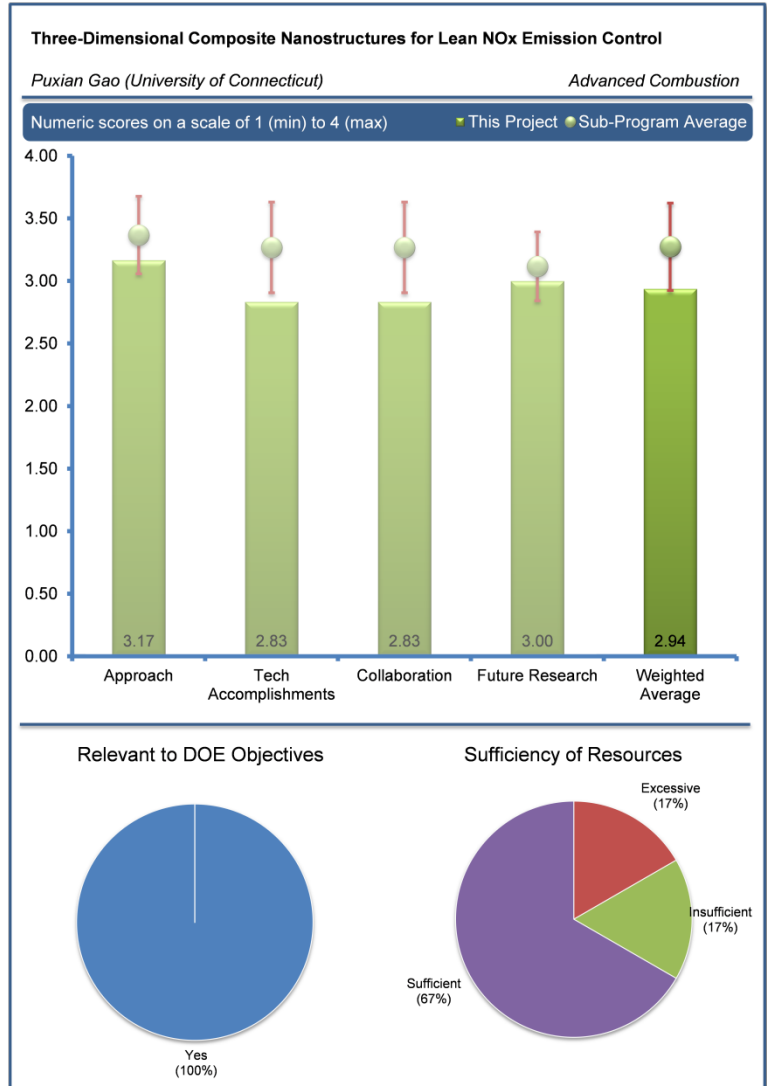
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that the technology pursued here, if successful, could be an enabler for lean-burn gasoline engines that potentially have 20-30% more efficiency as compared to the traditional gasoline engine. This expert added that, as a result, the effort pursued here confirms to the overall DOE goals of energy and fuel savings. The second reviewer to respond stated that the goal of this project was to reduce the cost of the aftertreatment system by reducing or eliminating the precious metal in the catalytic converter. The next commentator mentioned that new catalyst development for low-temperature lean NO_x control was crucial to meet future emission targets with advanced combustion system for high efficiency. The next reviewer added that lean NO_x control is very important and by reducing the usage of Pt-group metal catalysts, these technologies are enabled for the long term. The final commentator to respond reiterated that the overall goal of the program was to develop new catalysts for NO_x reduction with small Pt loadings (synthesis, characterization and testing) and assess their thermal stability. This expert added that the program included a modeling effort using DFT to understand catalyst behavior. This person mentioned that this work relates to undesirable emissions reduction, but was not directly related to petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commentator explained that the effort pursued here evaluated the feasibility of 3D nanostructures for surface enhancement and thereby improving the performance of LNTs. This being a novel technology, the effort is more exploratory; however, the novel materials were tested per the traditional yardsticks for catalyst materials (hydrothermal stability, NO_x conversion efficiency, sulfur poisoning, etc.), added the reviewer. The second respondent to comment added that this approach used nanostructure synthesis techniques to discover a new catalytic active material, which could reduce NO_x to N₂ under automotive conditions. This expert added that this active material has to survive high temperature, sulfur poisoning and have a sufficiently high conversion activity. The reviewer thought that the PI was creatively using nano synthesis techniques to investigate these types of materials and mentioned that it appeared so far that none of the metal oxides or the perovskites were catalytically active. The reviewer added that it seemed as if the project had evolved into an attempt to generate highly dispersed platinum in a highly exposed structure. Effectively this is what the catalyst suppliers have tried to do since the early 1970s. The reviewer was not aware if this approach duplicated any approaches that were employed by the suppliers and consequently believed that gave it high value. The reactor data



ostensibly looked better than what was shared last year; however, there is still some question whether the reactor studies are fully vetted, mentioned the reviewer. This person suggested a more experienced reactor professional be brought in to evaluate the reactor setup and perhaps help educate both the PI and his students on the pitfalls that can occur in reactor measurements. The next reviewer reiterated that the approach had been to synthesize nanowire catalyst arrays using vapor phase and liquid phase techniques (sol-gel and sputtering); to characterize the catalysts using transmission electron microscopy (TEM), x-ray diffraction (XRD), etc.; and to evaluate their activity, stability, and ability to be regenerated. This reviewer stated that representative images of nano-array catalysts were shown, observing that they had a high surface area; albeit the surface area was not quantified. In terms of thermal stability, images of the catalyst were shown before hydrothermal treatment showing what appeared to be a loss of surface area after treatment, added the expert. The reviewer continued, suggesting that it would be useful to show the degradation of the catalyst activity before and after treatment and/or as a function of time for a prescribed set of reactor parameters. The reviewer also added that Sol-gel processed catalysts were shown to be more active than sputtered catalysts, yet no explanation was given about why or how these catalysts are more/less active. This expert felt that, regarding the modeling work, focusing on O coverage on the catalyst was a step in the right direction. The reviewer suggested that it would be helpful to model the work that was more closely/directly tied to the high surface area catalysts developed in the program and create a direct comparison between modeling and experimental results. Another reviewer felt that the approach was on target and addressed important aspects of development/optimization of these types of catalysts. This expert wondered whether it would be good to consider adding catalyst evaluation beyond bench level and asked how the catalyst would respond/survive with real engine-out exhaust. The last reviewer to respond stated that the University of Connecticut research group had a unique approach in nanostructured material synthesis for thermally stable automotive catalysts. The expert added that their approach included synthesis, characterization, and evaluation of new types of oxide-based catalysts. In concluding, the expert noticed that they did not make an effort in benchmarking commercial catalysts in their experimental design, which according to the reviewer is the most important step in developing new materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers saw good progress, and also offered suggestions. The first reviewer to respond said that it appeared to be on track and addressed barriers to this technology. This person added that the catalyst was still active after hydrothermal stability with same conversion efficiency and that LSCO reduces light-off temperature. CO conversion efficiency is still low compared to addition of Pt, but directionally is a big improvement, added the reviewer. The following commentator added that the project had produced a nanowire material which is hydrothermally stable at 500°C in steam and that this was a worthwhile accomplishment. The expert suggested that it would be helpful if the hydrothermal aging was done at temperatures around 700-800 °C, adding that this would be a more challenging condition. The low-temperature CO light-off is encouraging. If low temperature CO light-off that can be retained over a long aging cycle, this would be a good accomplishment, stated the reviewer. This person felt that it seemed as if the material had a decent sulfur tolerance but added there was activity loss with increasing sulfur poisoning. The reviewer suggested that it would be helpful if the possibility of de-sulfurization could be explored. The following reviewer stated that novel surface modifications (3-D growth of nanostructures) on typical catalyst substrates were demonstrated. The expert continued, saying that after platinum deposition, the performance of these materials for use as lean NO_x traps were evaluated. In such an evaluation, the traditional measures of performance are NO_x conversion efficiency, hydrothermal stability, sulfur poisoning, etc.; all of which were used for this performance evaluation, mentioned the reviewer. This reviewer concluded with the observation that the scope of this effort, while supportive of DOE goals, did not include performance testing using real engine exhaust. The next commentator observed that this research group achieved a very unique nanostructured (nanowire) metal oxide support material in monolithic substrates, but felt that the project failed to report basic bulk properties of the newly designed material such as the Brunauer, Emmett, and Teller (BET) surface area. Having thermally stable high surface area support in automotive catalysis is important as the surface area determines the dispersion (surface density) of Pt particles, added the expert. This person continued to explain that the researchers employed 500°C for their hydrothermal durability test, and mentioned that in the real world application, the catalyst had to be stable after hydrothermal aging at 700°C or higher. This reviewer observed that in their activity measurement, the catalyst showed 16% of NO to NO₂ conversion over ZnO/LSCO at room temperature, and that it decreases to roughly 13% at 200°C. For the case of Pt/LSCO/ZnO/CH, this reviewer reported that the catalyst showed 30% of conversion at 25°C, and then decreased to 20% at 200°C. At roughly 450°C, continued the same reviewer, it showed about 55% conversion, which was higher than its equilibrium level ($X_{eq}NO$ to NO₂ equals 35%). The expert felt that the new material had shown some interesting behavior

and believed that the results needed major revision. The reviewer strongly recommended the PI to read others' published work. The last commentator to respond suggested that the team continue to pursue means to lower the catalysis temperature.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the technical expertise of the partnering institutions was leveraged adequately. The second commenter to respond added that the collaboration seemed reasonable but the commenter was not clear on how everyone was contributing. The next reviewer believed that there was a good list of collaborators, but added that the talk did not give any evidence that there was much direct interaction with the collaborators. This person encouraged establishing collaborations with other OEMs in order to guide and scope future research. The following expert stated that the DOE partner, Brookhaven National Laboratory (BNL), provided synchrotron facilities for characterization of the catalysts, yet it was not clear to the reviewer what technical contributions all of the partners had made to the program. This expert added that HRI provided the samples and substrates, United Technologies Research Center (UTRC) provided the characterization facilities, and that Corning provided the catalysts. This person suggested that adding a more detailed slide showing the role and responsibilities of each partner would be helpful. The last reviewer to respond noted that there were many collaboration partners listed in the presentation, and felt that it was hard to understand why there were such poor experimental conditions (e.g., aging conditions, activity measurements, etc.). For example, the Umicore catalyst should have provided a typical aging requirement for real world automotive applications, added the reviewer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to comment felt that continuing the 3-D nano-wire development work seemed to be quite worthwhile. The expert continued stating that the PI has been quite responsive to the AMR reviewer comments. This person added that the DFT Monte Carlo simulations did not seem to add anything to the project, and was unsure why it was continuing. The second reviewer to comment suggested that, while the proposed future research was adequate, it would be beneficial if the following two could be evaluated: determine the performance of these surfaces in real engine exhaust, and long-term stability of the performance of these modified substrate materials. The following reviewer stated that future work included continuation of the MO doping study on nanowire arrays and evaluating their performance for NO_x storage/ reduction, S poisoning and PM filtering. If this reviewer could make a suggestion, the reviewer would suggest that the modeling work should be more closely tied to the experimental program and that ideally the model would be used to eventually guide experimental work such as dopant selection, etc. Another reviewer felt that the investigation of other deactivation such as sulfur poisoning is very appropriate in the development of automotive catalysts. This person felt that it was hard to understand what the theoretical calculations could provide in terms of the oxygen dynamics and suggest that a more detailed plan needs to be provided. The last reviewer to respond felt that some of the future plans read as if they were the same as what was just done. The expert added that it was hard to tell with any detail as to what was next and why.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of the six reviewers to respond felt that the project resources were sufficient. One reviewer felt that the resources available were excessive. One reviewer thought that the project needed a more traditional automotive catalyst evaluation partner to ensure that the reactor work is correct and effective. Another reviewer observed that the project received roughly \$1.5 million for three and a half years.

Cummins/ORNL-FEERC CRADA: NO_x Control & Measurement Technology for Heavy-Duty Diesel Engines: Bill Partridge (Oak Ridge National Laboratory) – ace032

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

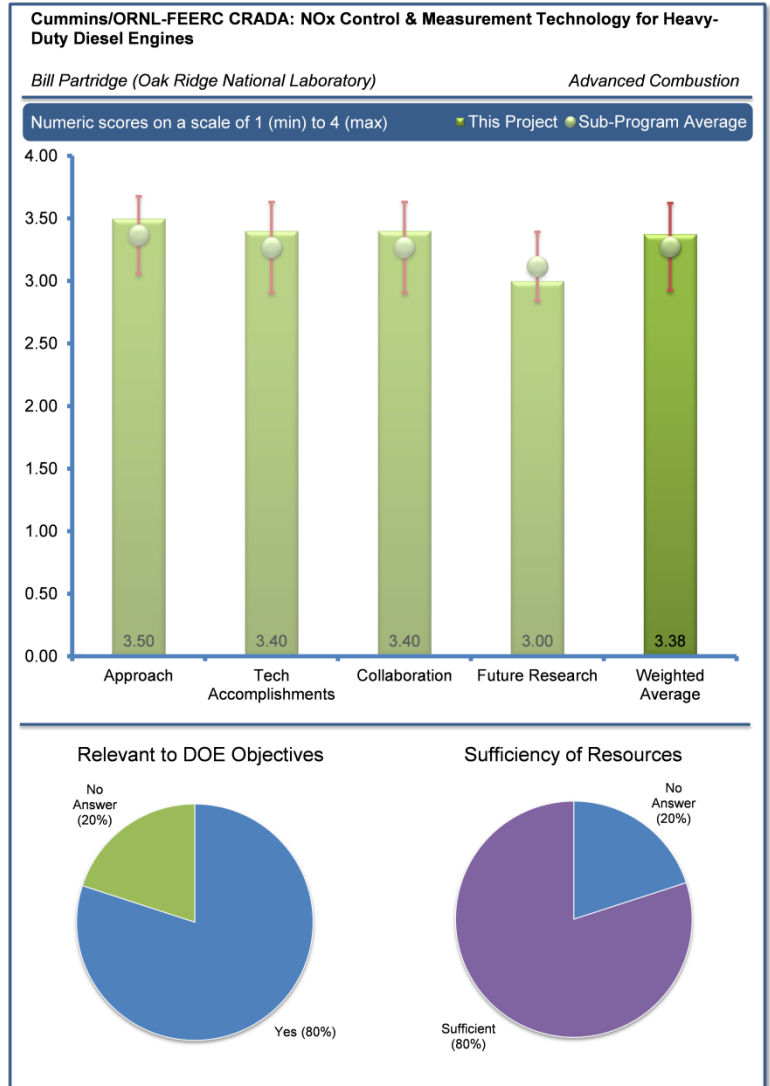
One reviewer noted that this work was one of few projects that were investigating state-of-the-art NH₃-SCR catalysts and supported the DOE objectives very well. The second reviewer to respond stated that the talk explained that the effort was trying to align with time-accurate assessment of the state of the catalyst at a local level. This increased understanding would enable better catalyst control and have the potential for lower cost, lower emissions, lower and fuel burn vehicles to get adopted, added the reviewer. The last commenter to respond stated that the work from this group was known to produce first class instrumentation for the evaluation of the effectiveness of catalytic converters.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter to respond felt that the technical approach was reasonable. The expert added that there was a good balance of work between Oak Ridge developing catalyst knowledge and assessment and diagnostic tools with the OEM performing the system integration. The following expert stated that this project was focusing on transient (dynamic) SCR performance from one of new SCR technologies, and mentioned that the results would provide information for the development of aftertreatment system control strategy. The last reviewer to respond felt that there were a number of ways to characterize the spatial status of the SCR catalyst, and that this was one of them. It contributes to the overall understanding of the SCR process and is not overwhelmingly new or special, added the reviewer.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally observed good progress. The first expert to respond saw strong technical accomplishments in the project. The reviewer found the data regarding the axial location of catalyst activity as a function of temperature to be very interesting and relevant to understanding the instantaneous state of the catalyst. The concept of total/dynamic/unused capacity is a powerful one and can be leveraged for catalyst control, added the reviewer. The following commentator mentioned that the ORNL team employed the popular four-step protocol to measure multiple features of the state-of-the-art Cu-based SCR technologies. The expert also stated that the features included NO_x conversion, NH₃ oxidation, and NH₃ storage capacity. Currently, there are two types of Cu-SCR being used in production; SSZ-13 and SAPO-34, added the reviewer. This person also stated that the Cummins commercial SCR catalyst is SAPO-34 catalyst, and mentioned that it is known to behave much differently from SSZ-13 Cu-SCR



catalysts especially for high-temperature performance and NH_3 storage capacity wise. The team has made very good progress toward objectives, added the commentator. The following reviewer expressed that the spatial measurements from this group have been groundbreaking. This person added that this is an extension of that good work and that it was evolutionary, not revolutionary. The final reviewer to respond observed that the project used SpaciMS to see how conversions occur as a function of temperature. The expert did not see ammonia oxidation. The reviewer commented that in the place that the entire NO is removed, it is called SCR zone. Further, this reviewer remarked that total capacity equals dynamic capacity. The reviewer concluded by stating that conversion inflection is not a well-defined concept in this talk.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One expert felt that the collaborative efforts were strong. This person added that they need to be done in a way that the parts of the program connect between Chalmers, Milano, and Prague, in particular, to comment on similar issues. The second reviewer reiterated that the ORNL researchers have teamed up with world leading research groups in aftertreatment technologies such as Chalmers University and Politecnico Di Milano. It is well coordinated; however it would have been perfect if the team partnered with a catalyst supplier who may be more familiar with the intrinsic properties of the SCR technology, suggested the commentator. According to the third reviewer, there seems to be several partners working on this effort; however, the actual role of each partner relative to the work that was presented was not very clear. The fourth expert found that the collaborations do not seem to be well coordinated. This reviewer believed that the collaborating groups were good. This person added that they believed this will be a positive; however, they did not see anything earth shattering here. The fifth reviewer to respond encouraged further collaboration with other OEMs to guide and scope any future research.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commentator to respond stated that the future work appeared to logically build up on what was learned in the past. Another reviewer said that this work is on track and observed nothing unusual. The third reviewer mentioned that, unlike SSZ-13, it is known that SAPO-34 suffers from low-temperature deactivation. The expert suggested that the unique NH_3 storage behavior needs to be looked into as well as how its capacity changes as a function of aging conditions. The expert mentioned that the SCR technology moves quicker than we would imagine, and that the current Cummins commercial SCR catalyst may not be the same for the next generation SCR technology; therefore, it would be nice to have catalyst suppliers involved and be advised from them in terms of future directions, suggested the reviewer.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four of the reviewers to respond felt that the project resources were sufficient. One reviewer mentioned that this project would be finishing in about four months and that the funding was appropriate. Another reviewer stated that the budget seemed to be well allocated for this CRADA.

Emissions Control for Lean Gasoline Engines: Todd Toops (Oak Ridge National Laboratory) – ace033

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

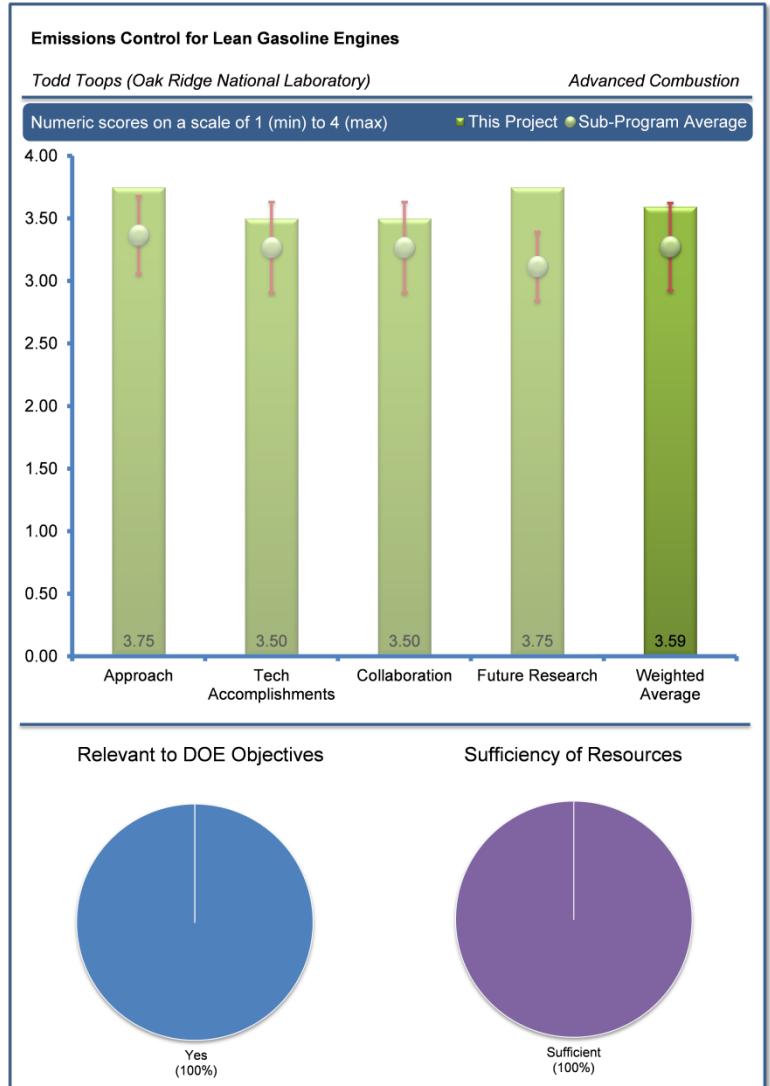
Four reviewers commented. All agreed, some emphatically, that this project supported DOE’s overall objective. One said that this work fully supported the overall DOE objectives of technology development for highly efficient, lean-burn engines and aftertreatment system. Another said that this program was extremely relevant to DOE goals. A strong case was made that lean-burn gasoline was an enabler for petroleum displacement, but that U.S. emissions compliance was currently a barrier. The last two reviewers said that lean emission control could result in significant fuel savings from gasoline vehicles and that the project was especially supportive of DOE objectives in light of the new focus on lean and dilute gasoline combustion.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The approach to the project work was approved by all reviewers. According to one reviewer, this project directly addressed the state-of-the-art in lean-burn gasoline aftertreatment technology that had been in commercial use in the European market and evaluated its performance for U.S. passenger car application. With this approach, continued this reviewer, the project would provide the technology gap of the lean NO_x trap (LNT)-based aftertreatment system and suggest the elements for which focus would be needed to improve its performance for future emission-compliant systems. Finally, another reviewer affirmed that the project was tackling the cost issue head on as cost was the most significant barrier to enabling lean emission controls. The third reviewer generally approved the approach of using vehicles and bench testing, but questioned the ability to develop an aftermarket set of controls (Drivven, Inc.) that would also capture other necessary attributes such as drive-ability. The last reviewer said that the technical approach seemed very sound and noted that lean-burn engines have been obtained from OEM and were being fully characterized. The reviewer concluded by mentioning that several different implementations with respect to aftertreatment were being considered and evaluated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers indicated their approval of the technical accomplishments and in some cases offered suggestions for continuing research. One reviewer said that the biggest step the ORNL team had made was the full control of the BMW engine hardware and controller so that the engine could operate in various modes. This was critical for aftertreatment control with multiple aftertreatment devices, especially for the passive ammonia (NH₃) selective catalytic reduction (SCR) system. In parallel, the



researchers carried out catalyst evaluations in lab-scale reactors under various engine-out exhaust conditions given by actual engine dynamometer results. This parallel approach helped researchers understand the system and technical barriers, and the quick turnaround feedback from lab reactors provided the next step in engine dynamometer tests. Another reviewer highlighted the nice understanding of catalyst behaviors achieved so far. The reviewer also thought that the reactor studies were nice, but cautioned that the vehicle work would be essential to this project. The third reviewer wondered how the impact of transients on the performance of the aftertreatment system could be assessed. The last reviewer noted strong technical accomplishments, and pointed out that engines were obtained and data collected on the impact on emissions of lean/rich durations.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers gave the project strong marks in this category. One person observed great partners covering the gamut of OEM, catalyst supplier, university, and a national lab and affirmed that the collaboration appeared to be well-coordinated. The second project evaluator concurred, saying that the program appeared to have a series of partners with active collaborations apparently supported by structured communication (monthly telephone conversations, visiting grad student, etc.). The third person urged for continued OEM collaboration to scope and guide the research. Finally, the fourth reviewer said that although the level of the participation could vary, this project formed a good team that included OEM, catalyst supplier, and universities. However, this reviewer went on that it would have been better if the team included an institution specializing in catalyst characterization. The reviewer noted that the nature of this catalyst work demanded an understanding of why the catalyst behaved differently under differing conditions, aging levels, platinum group metal (PGM) level, and oxygen storage capacity (OSC). Therefore, some basic material characterization would aid in the understanding of the system.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Three reviewers endorsed the future research plans of this project. One described the future work as being very well planned, but suggested that something the project team might want to consider was investigating the effect of sulfur on NH_3 generation over three-way catalysts and lean NO_x traps. Another reviewer recommended setting a platinum equivalence goal to allow comparisons to stoichiometric gasoline three-way catalyst systems to know what the gap was. The last reviewer said that the future work appeared to build in a logical way from past technical work and findings.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers deemed resources to be sufficient. Only one offered further comment, saying that the budget seemed to be well-arranged for FY 2012.

Advanced Boost System Development for Diesel HCCI/LTC Application: Harold Sun (Ford Motor Company) – ace037

Reviewer Sample Size

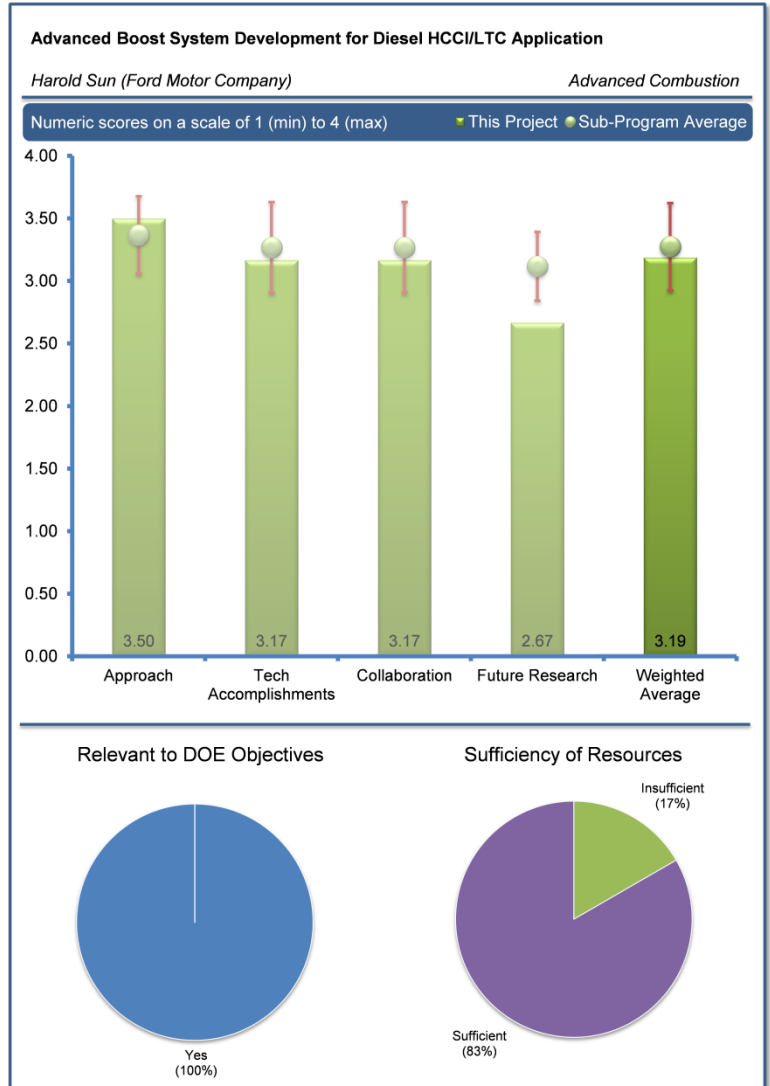
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five reviewers were in general agreement that the focus of this project was relevant to DOE petroleum displacement objectives, albeit indirectly in most cases. One reviewer said better turbocharging would improve fuel economy, though it was not a very large impact by itself. It was a necessary enabler for high-dilution combustion systems which could yield larger gains. The second person concurred, calling boosting equipment a critical enabler for prime paths for engine efficiency like boosting and downsizing. The technology was also critical for more advanced, high-efficiency combustion methods like PPC and RCCI. This reviewer found that it was surprising that there was not more DOE investment overall in air-handling technology. The third reviewer predicted that surprisingly large improvements in turbocharger efficiency achieved in this project should yield useful improvements in many engines. Another reviewer concurred in the assessments of the first two, saying that new turbo technology was needed for low-temperature combustion (LTC) regimes that were needed to meet the DOE objectives. As the available energy in the exhaust is reduced with LTC, the demands placed on the turbocharger system change dramatically. This advanced boosting system addressed this specific barrier, targeting a 15-20% extension of the operating range of the turbo. In a similar vein, the last reviewer described this project as addressing turbocharger systems which were an important engine component to enable boost and achieve higher fuel efficiency and thus petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

General approval of the work approach was expressed by all reviewers. One said that the approach focused on broad-range turbocharger improvements coupled with on-engine test and demonstration was a good way to target this development program. The reviewer indicated that it would be nice to see something that indicated how this program could integrate with some of the DOE programs (ORNL HECC, ANL LTC, SNL HCCI, etc.), as those programs could make use of similar turbocharging technology. Citing a comprehensive team of OEM, turbo suppliers, universities and others, the second reviewer termed the approach well-focused. If there was a shortcoming, this reviewer said, it may be that the improvement goals were too conservative. The reviewer suggested focusing on longer-range engine plans. In the view of another reviewer, the project represented a nice combination of analytical and experimental work and good leveraging of an expert supplier and academia to support the work. A reviewer termed the approach integrated, using extensive simulation, followed up with experimental validation. This reviewer, while declining to comment on the arbitrary surface and ruled surface impeller designs as being outside of the reviewer's expertise,



called the active casing treatment logical and innovative. Offering no specific comment on the merits of the approach, the last reviewer described it as attempting to optimize the turbocharger component of the engine to achieve greater fuel efficiency while still managing emissions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers praised the project's technical accomplishments. One noted that achieving significant gains in turbo efficiency was challenging, in view of which the demonstrated improvements were impressive. The new technologies that had been introduced through this program were working well to achieve the project objectives. The project had demonstrated and validated improved operation, in the view of another reviewer, who cited the innovation of active casing treatment in particular. This reviewer believed that the technology appeared to be transferrable to other engines, a step that might be facilitated with three turbo manufacturers on team. This reviewer was unclear on what outcomes were achieved by NREC and Wayne State. The third reviewer commenting said simply excellent progress, although somewhat longer timing than planned. Echoing the comment of the second reviewer, another reviewer singled out the active turbo casing treatment as a very innovative concept to open/close surge/choke slots and noted the excellent results of its use. The medium-duty (MD) performance, this reviewer continued, met or exceeded the goals of a 30% range improvement and a 3% improvement in brake-specific fuel consumption (BSFC). Engine demonstration of the MD turbo was completed, but the LD (light-duty) remained to be completed. The final reviewer said that the authors did an excellent job of optimizing the turbocharger component. This reviewer continued that reductions in fuel consumption were measured and NO_x and PM (particulate matter, or smoke) emissions were comparable between old and new turbo design. The reviewer suggested that it would be nice to observe the fuel economy benefit from a vehicle with an engine using this technology. This reviewer also noted the very nice technical work describing shock wave changes from impeller design. Attention was called however, to the fact that with the new DOE goal of Tier 2 Bin 2 emissions, that the Tier 2 Bin 5 emissions goal of this project lagged current goals. The reviewer added that more NO_x and PM emission reductions were needed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

While generally approving the degree of collaboration in the project, reviewers offered two specific qualifications to their remarks. The first reviewer's comment was typical: It appeared the collaborations were working well. However, it was difficult to tell how much each partner was bringing to the program based on the presentation. Likewise, the second reviewer's comment was that the team was comprehensive, but that the contributions of NREC and Wayne State were not conspicuous in the presentation. The reviewer offered that the inclusion of three turbo companies was a very positive feature of project. Unqualified approval was expressed by the third reviewer, who said that the combination of consultants and academics with significant internal work was very strong. The fourth reviewer returned to the qualified approval theme in noting that the turbo suppliers chose not to have their names publicized. This reviewer would have considered rating this higher, suspecting that these suppliers were probably contributing heavily to the success of this project. However, since the presenter was unable to elaborate on their involvement, the reviewer did not feel justified in assuming that the success had been because of good collaboration. The last reviewer deemed the collaboration with Wayne State University to have been fruitful and supportive of the project design objectives.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers' comments on the proposed future project work were positive; two reviewers recommended that consideration be given in that work to specific questions. One reviewer thought that the proposed work looked like it would permit achievement of the final project goals, but remarked that there did not appear to be any significant barriers remaining in the program. The second reviewer observed a good plan to finish the program. The third applauded the planned Tier 2 Bin 5 goal engine demonstration, calling it good, but wished to see some effort put into determining if this design was manufactureable, or into identifying obstacles to commercialization of the concept. Another reviewer also suggested that such a revision to the planned future work, recommending that it consider the overall manufacturability and cost of new configuration and confirming that the casing treatment was not susceptible to fouling in low-pressure (LP) exhaust gas recirculation (EGR) systems. The last reviewer

wondered if sufficient time would be available for the completion of this project, as it appeared to have lagged from the original schedule.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six reviewers considered project resources sufficient; three submitted further comments. Two noted the delay that had occurred in the project schedule. One said that while there seemed to have been sufficient resources through the program, the time delay was due to product plan changes in Ford and not any lack of funding. The second agreed, noting that the time delay, caused by a change in engine platform, was significant, but that it did not appear that more funds would have prevented the delay. The reviewer remarked that the team deserved credit for seeing the project through to completion with the no-cost extension. The third reviewer felt that the overall funding had been modest over a long period. With the project now complete, this reviewer felt further comments were not very relevant.

Advanced Collaborative Emissions Study (ACES): Dan Greenbaum (Health Effects Institute) – ace044

Reviewer Sample Size

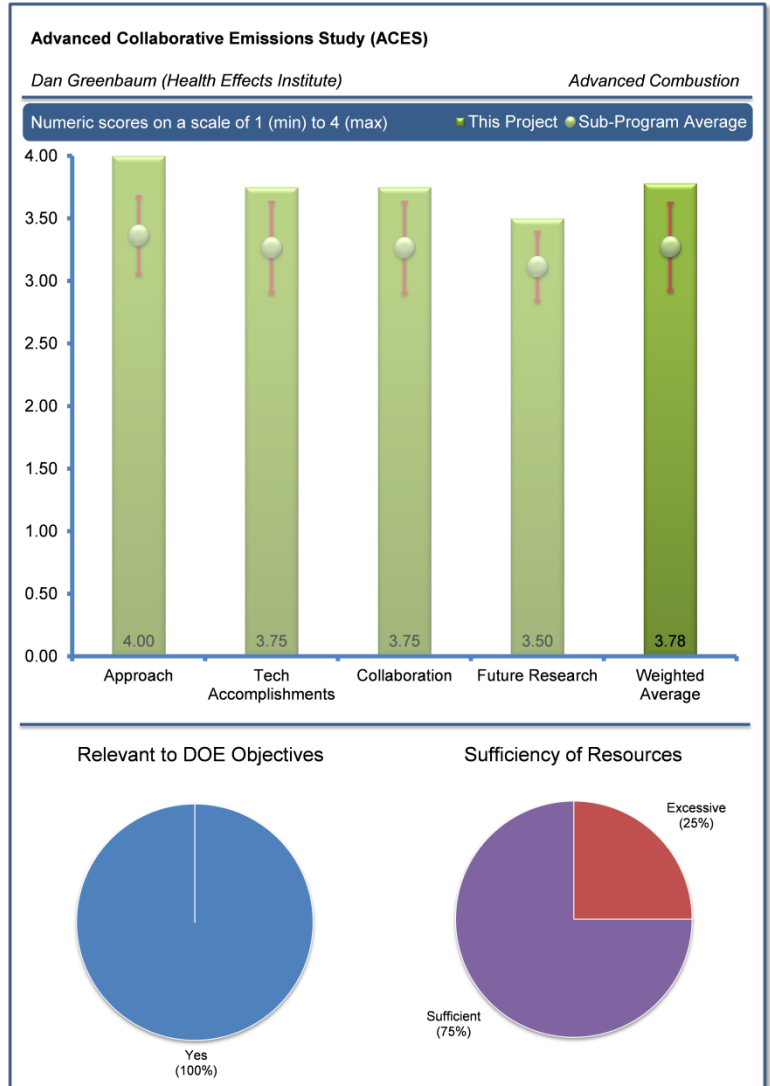
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While all four reviewers expressed approval of the project, one reviewer addressed this question directly, saying that this project supported the overall DOE objectives of petroleum displacement indirectly, as it investigated potential negative health impacts associated with the new generation of efficient, heavy-duty diesel engine technologies with modern aftertreatment solutions. Other reviewers' comments were more generally addressed to the importance of such work as this project advanced in areas other than petroleum displacement. One such reviewer opined that quantifying the health effects of particulate emissions and NO_x exposure was important to identifying the necessity of more stringent emission standards. The other two comments were in a similar vein, one reviewer noted that particulates created as a by-product of diesel and lean gasoline combustion processes had been a health concern for some time. Much progress had been made in reducing these emission products to levels below current standards. This project was a very good verification study validating the progress in aftertreatment technology which should influence the setting of standards by regulatory agencies. The final comment was that it was important to make sure future engine efficiencies did not cause health issues and this study confirmed it.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers clearly endorsed the technical approach to this project's work. One evaluator noted that the approach was an ongoing project whose approach has been vetted over the years and could think of no better way to determine these effects. The second person called it a very good approach, building on previous phases of work with 2007 diesel engine technology. The third agreed, saying that the experiments were thought out and executed very well and gave a good understanding of how newer diesel engine technologies performed with respect to tailpipe emissions as related to health issues. Calling lifetime studies very important to understanding the cumulative effects of exposure on human health, the fourth reviewer said that this work strongly supported the position that new diesel aftertreatment technology was capable of significantly reducing particulate and NO_x to levels considered not carcinogenic to human health.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers praised the technical accomplishments of this project and appeared to consider them quite significant. One reviewer expressed the belief that this project had very effectively shown that the mandated level of particulate emissions was so small as to have a negligible effect compared to other environmental sources of pollution. Another reviewer lauded very good lifetime studies of HDD (heavy-duty diesels) noting the implications of the work for light-duty diesels (LDD). In this reviewer's opinion, it appeared these LDDs would not be sources of named carcinogens, and that as of now, no studies were planned for LDDs on this scale, as these were considered too expensive. Good progress had been made to date, in the view of the third commenter, who felt that the work would potentially have large implications for how the health impacts of emissions from the new diesel engines were viewed worldwide. The last comment expressed the reviewer's belief that the health effects shown with newer diesel technologies was some great work which proved that newer diesel engine technologies did not impact health issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers rated the collaboration and coordination exhibited in this project was good to excellent. While noting that the majority of the work was done in-house, one reviewer praised the advisory board as first rate and, assuming that the board had had an effect on the oversight of the project, judged the coordination with other institutions to be very high. The second reviewer cited the good coordination of assets and collaboration with testing labs, while another praised excellent collaboration with relevant stakeholders including the U.S. Environmental Protection Agency (EPA), Engine Manufacturers Association (EMA), the Coordinating Research Council (CRC), the California Air Resources Board (CARB) and the American Petroleum Institute (API). Finally, the fourth reviewer cited good collaboration with the heavy-duty engine manufacturers and others involved.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer (of four) said that the proposed future research followed a proven approach that was implemented for 2007 engine emissions exposure. The second gave the authors of this report major credit for completing a phase of a project and knowing when enough was enough, i.e., for indicating that the project - no longer saw a need to do very expensive testing. A key result of near-future work, the third reviewer predicted, would most likely show that the new-technology diesel engines were not the source of human carcinogens (NO₂ or particles). This was extremely important evidence to communicate to regulatory agencies, the reviewer said. Noting that the project work was complete except for final reports, the fourth reviewer expressed a desire to see light-duty diesel engine testing in the future with different aftertreatment systems.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers deemed resources to have been sufficient. One termed them excessive. Two of the three reviewers offered brief comments that simply affirmed their assessments of resource sufficiency. One noted that health impacts studies of this type were very expensive and therefore co-funding from partners was very beneficial. The dissenting reviewer acknowledged that while multi-year project, lifetime studies were very expensive to conduct, it was nevertheless unclear whether the testing conducted required the degree of funding used or if less testing could have achieved the objective.

Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications: Clay Maranville (Ford Motor Company) – ace047

Reviewer Sample Size

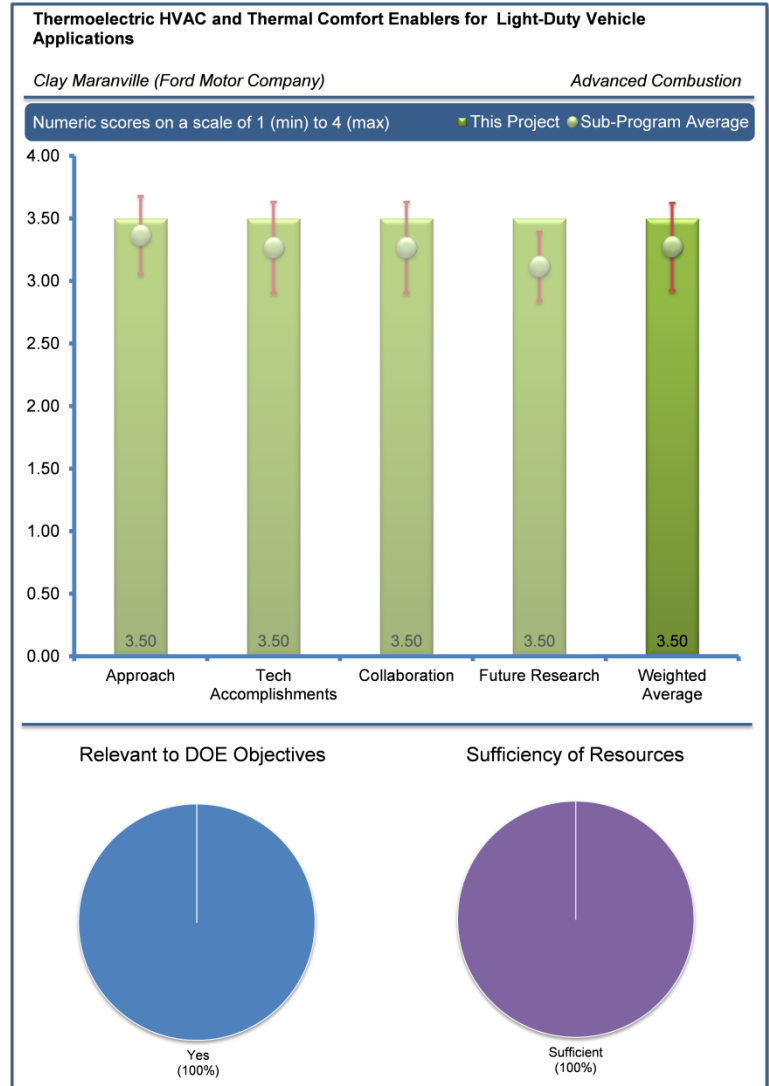
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers were unanimous in the view that this project supported the DOE petroleum displacement goals. Two reviewers offered succinct comments to that effect, one saying yes, thermoelectric (TE) devices had many advantages over traditional heating and cooling options. The key was the materials and engineering design. This project was addressing these issues. The other agreed that this project did support the DOE mission to improve fuel efficiency by the integration of TE into an automotive platform. The other two reviewers commented at greater length. One explained that the project aimed to develop TE heating, ventilation and air-conditioning (HVAC) modules to reduce the load on the alternator, and thus improve fuel efficiency. In this respect the project was consistent with the DOE goals. The goal of this program was to reduce by 30% the fuel used to maintain HVAC systems. Finally, the fourth reviewer said that the program run by Ford offered one path to reduced fuel usage and petroleum displacement by developing alternative automotive cooling technology. If successful, there were two major ways fuel consumption would be reduced. First, this reviewer explained, vapor compression cooling systems on current cars can be removed, reducing the belt-drive mechanical load on the engine. Secondly, continued this reviewer, the zonal climate control eliminated the waste inherent in cooling sections of the cabin that do not contribute to passenger comfort. The effort by Ford appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Here again, one reviewer commented directly and briefly on the merits of the work approach, saying that the project had been well-designed and that the technical approaches were aimed at solving the critical issues for the scale-up of thermoelectric devices. The approach consisted of the following: system design; CAE, thermal comfort models and control strategy; TE materials and device design; and prototype build and testing. TE device development includes impurity doping of commercial BiTe to improve ZT and thermal interface materials [Ohio State University (OSU)]. Work appeared promising but was still in development. OSU investigators are experts in the field. The comfort models and optimization appeared to have made some progress with simulations and mannequin data and identifying some promising architectures. The final system design, including heat exchangers, prototype build and test appeared all to be left for the last year. The third reviewer noted that much of the effort concerned modeling to predict system performance, which was good. More on this, the reviewer said, especially to draw a link between system components and fuel efficiency would be extremely valuable. The reviewer noted that the project included bench evaluation



testing and materials development with an academic partner. The PI was coordinating a range of tasks including test protocols, CAE and comfort models to determine optimal heating and cooling node locations, and validating performance in a demonstration vehicle. The fourth reviewer noted Ford's development of a mannequin-based test bed that provided very useful raw data upon which an effective solution could be designed and engineered. While much of the presentation did not provide hard numerical benchmarks (most of the plots had no labeled axes), it was explained that the design of the system was so complex over a given real-world drive cycle that hard numerical figures could be somewhat misleading. While COP (coefficient of performance) values are informative and valuable for design, in an actual car the delta-T may change significantly over the course of driving (through a tunnel, in the shade of a tree, in hot sunlight, etc.). This reviewer confirmed understanding that the numerical benchmarks, while having been met in a lab, do not necessarily translate to real-world automotive comfort. Acknowledging that the term, passenger comfort, was almost impossible to quantify, this reviewer considered that it was clear from the plots that comfort would easily be achieved.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers offered concise comments, both favorable, on the project's technical accomplishments and progress. One said Ford and their teaming partners had achieved significant progress and appeared on track to succeed in meeting all of the objectives. The COP metric appeared already to be in-hand in their lab tests. The other reviewer noted that the overall technical approaches were targeting the most difficult issues. On the materials side, however, it was unclear to this person how the ZT improvement was made and the quantitative values were hard to judge without the vertical scale. The third reviewer's comments were notably more detailed, citing specific technical improvements, but without rating their significance. The reviewer noted that the project was roughly two-thirds of the way into its three-year program, with the major barriers appearing to be the cost of the system relative to its performance, scaling it up from the lab and the challenge of packaging the TE system in the allowable design space. Specific goals included reducing compressor energy demand by the third and achieving a high COP for the TE device. Accomplishments included: TE device design, comfort modeling, control of HVAC (multiple points) in a transient environment, and advanced TE development. No component fabrication, cost analysis or systems testing had been done yet; these were slated for the next year. TE device accomplishments included design of liquid side heat exchanger (HX); optimization of fins on the HX air side; and a 25% improvement in p-type TE. Comfort models and matching performance of distributed systems to the overall HVAC system had been performed. Differentials between the two had been small. Model integration work with NREL has used mannequin testing (both virtual and physical) and feedback between the two. The reviewer felt that the presentation did not address how close an approach to the desired metrics was achieved; the approach appeared to be based on trying to effect improvements at different levels with the hope that performance gains relative to cost could be justified. However, at this stage it appeared to be a desired goal, and that no data in this regard were presented. Thus, it was difficult for the reviewer to assess if any of the gains at individual level would translate to a meaningful gain in the system performance. The last reviewer felt that the PI appeared to have met the Phase 2 Go/No-Go decision points for chamber testing, prototype evaluation, packaging studies, etc. This reviewer reported the following accomplishments: development of an apparatus to evaluate thermal properties using IR cameras and thermistors to quantify heat flux through the samples; modeling to determine an optimal TE element size and required number of elements; and fin optimization studies and dielectric system selection, all for TE device optimization. The same reviewer also pointed out that a liquid heat exchanger has also been designed and fabricated (though the details seemed a bit vague as described in the presentation). The reviewer summarized that the materials development effort resulted in a 25% increase of ZT over commercially available Bi_2Te_3 (the long-term use of this material is a bit uncertain), but explained that the lack of numbers on the ZT plot was curious.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers entered clear and succinct comments expressing their estimation of the degree of collaboration and coordination evident in the project, and two commented at much greater length and with less directness. The first reviewer called the collaborative effort good, with academic and industrial partners for testing and evaluation. The reviewer pointed out that the team included Ford as the prime contractor, Visteon, NREL, Amerigon, ZT plus and OSU. The second person said that this project had assembled an excellent team to complete the material and device development tasks. The third reviewer's comments, while more detailed, made clear a positive view of the value of project collaborators' capabilities. The reviewer noted that Ford had teamed

with leading institutions and smaller thermoelectric specialty companies with unique capabilities for success. For example, BSST/Amerigon was already the world's largest suppliers for thermoelectric sub-assemblies for automobiles and they were already a DOE performer and well-suited for full production. The Ohio State partner was well-regarded as a world leader in developing new research and approaches to independently improve the dimensionless thermoelectric figure of merit. The comments of the fourth reviewer, for all their length, pertained more to technical accomplishments and planned future work. The reviewer listed the project collaborators and the areas of their respective contributions, noting Ohio State University (improved BiTe and others), Visteon (HVAC), Amerigon (TE materials), ZT plus (scaling TE) and NREL (systems integration), but offered no assessment of the degree or effectiveness of their collaboration in the project. Progress in the materials development, comfort modeling and systems integration were presented. However, this reviewer went on, that there still seemed to be issues to be addressed e.g., n-type TE doping optimization, systems control and design, discrepancy between virtual and physical mannequin data, etc. Scale-up issues were not clearly addressed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer commented that future plans appeared to be well-aligned with DOE objectives of reducing overall demand by developing technologies that did not require petroleum-based fuels. This reviewer explained that thermoelectric cooling was purely electrically driven refrigeration that reduced mechanical load on the belt-driven engine, and would improve fuel efficiency. Noting that the system design, prototype build and testing were all still pending, another reviewer expressed the view that a lot of work had been left for the final year of the project. The third reviewer listed the remaining activities: a proof-of-principle TE unit design, build, test and model. This reviewer also noted that a thermal comfort model would be used in a sensitivity study and that additional work on system component design would be included, with a test vehicle delivered to DOE in 2013. This reviewer strongly recommended that the system-level model be expanded to allow linking the results to fuel economy. It was unclear, in this reviewer's opinion, if this could be done with the model as it currently existed, as it would require considering aspects related to effects that play into engine load: alternator, aerodynamic drag, rolling and component friction, etc. If this could be done, the results would help guide where future resources should be directed. For example, it would make little sense to study a problem with little promise for impact on fuel economy if that sub-problem were predicted to have little or no influence on fuel economy.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers found the project resources to be sufficient. Two people provided additional comments. One evaluator termed the budget expenditures to be commensurate with the industrial nature of this project. The project costs were comparatively high but that was the nature of Ford's budget structure. This reviewer expressed hope that Ford was investing significantly in this technology, which at present seemed to be about 50% of total costs. Eventually, Ford would need to be weaned off this government subsidy and develop TE systems to the point where they were self-sustaining to the company's product line. The other reviewer discerned no requests for more funding, and since the contractor was engaged in a funds-match with DOE, saw neither a need for additional funding nor excessive funding.

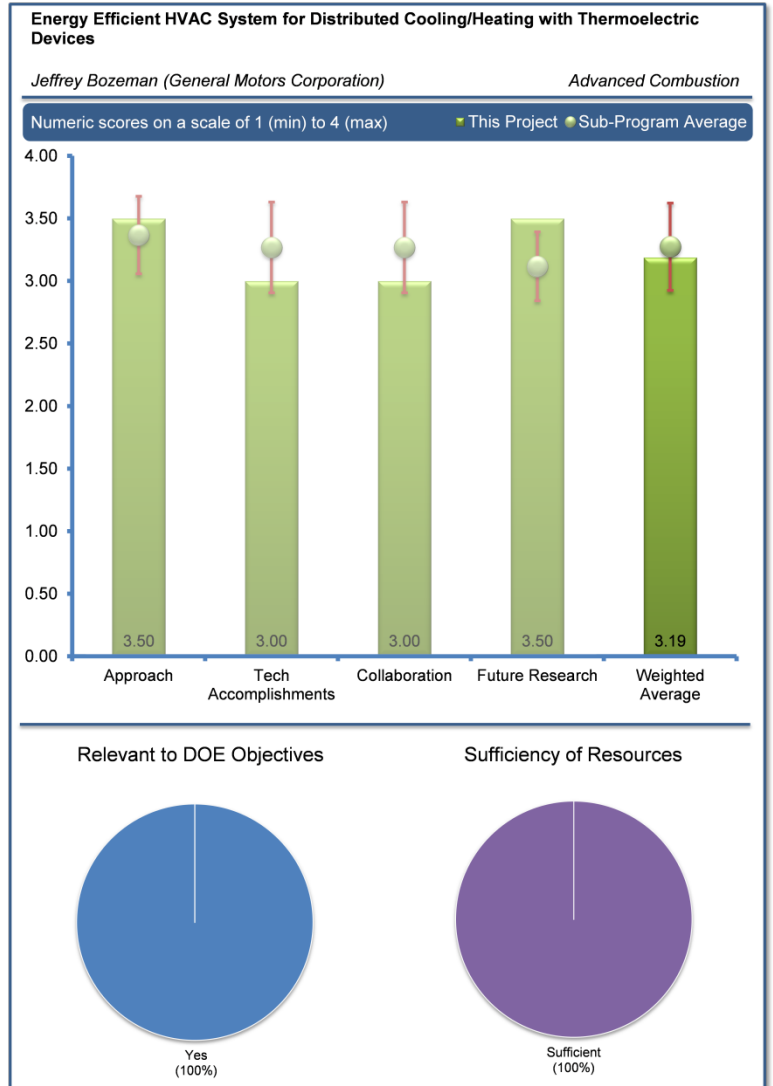
Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices: Jeffrey Bozeman (General Motors) – ace048

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer asserted that the project supports the main goal was reducing energy usage by 30% and it supported the overall DOE objectives for petroleum displacement. In the view of the second reviewer, the General Motors (GM) program was well-aligned with the overall DOE objective for new technologies to reduce fuel demand and cut overall petroleum usage. Eliminating the conventional belt-driven air-conditioning compressor's mechanical load on the engine would improve overall fuel efficiency. Also, for future all-electric vehicles, thermoelectric cooling would be the method of choice because it was an all solid-state electrical cooling technology. The third reviewer who commented said the project appeared to focus on an improved HVAC system to improve fuel efficiency, with emphasis on comfort modeling, and system design and integration. The TE work, however, was not a big focus for this project. The one-third energy savings could apparently be achieved through an optimized distributed HVAC systems modeling. This was where the focus of the work had been, and this was supportive of the DOE goals. The last reviewer concurred, saying that the primary goal of the project was to reduce the energy used for vehicle heating and cooling, with a secondary goal of developing a new TE material for engine waste heat; thus these broad objectives were relevant to DOE's objectives.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer opinions on the approach to the project work were mixed; some reviewers approved of some aspects while others elicited suggestions for improvement. Fairly typical were the comments of a reviewer who described the project as comprising a number of tasks, including developing a thermal comfort model for distributed heating and cooling; an exploratory effort concerning development of prototype HVAC components (based on bench and demonstration vehicles); integration of HVAC components into a demo vehicle, and developing a new TE generator. The comfort modeling effort, the reviewer said, was important, and other components of the DOE program were pursuing apparently similar efforts, suggesting that DOE might better coordinate overlapping system-level model development (e.g., Ford's apparently similar effort). Better coordination among overlapping tasks would be preferred. The second reviewer described that the GM project was focused on overall system design and integration of TE materials into the vehicles, calling the selected vehicle platforms and technical approaches well-planned. The zonal control and design were based on the low efficiency of thermoelectric devices. The reviewer cautioned that if it was unable to replace the current air-conditioning (A/C) system, addition of TE cooling/heating may not be cost-effective, especially in

extremely hot or cold climates. The third reviewer observed that GM's effort had approached the work by designing a mannequin test bed to qualitatively and semi-quantitatively analyze the cooling performance of their designed system. While passenger comfort appeared to be an impossible-to-define quantity, their mannequin test bed could give important design and performance testing. The last commenter was similar and stated that the overall approach appeared to design a distributed HVAC system and to optimize the system design with a thermal comfort model to seek COP improvements to achieve the desired fuel efficiency gains. The TE elements would provide the distributed heating/cooling units. The system design and comfort model with a specific TE selected have been implemented for a chosen vehicle to demonstrate COP and performance gains, this reviewer said, but offered no explicit assessment of the merits of the approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers were prone to enumerating project accomplishments without offering explicit opinions on their value. One reviewer noted the primary project goals of a 30% reduction of fuel use attributable to HVAC (DOE goal) and the development of TE with high COPs. Milestones cited included the development of a passenger comfort model (UCB), control systems to integrate control of TE components (Intrepid), and comfort system installation (Faurecia). This reviewer reported that the five project tasks included the following: applied research on thermal comfort model; prototype HVAC components; COP evaluation; integration into vehicle and testing; and TE research and integration. The reviewer observed that the chosen vehicle was a Buick LaCrosse with a belt-driven compressor, adding that it is desired to equip it with an electrically-driven compressor. The project focus, the reviewer said, appeared to be much more on HVAC and comfort modeling and that it was not clear what improvements to the TE system design would be developed and implemented. The technical accomplishments cited by the reviewer included improvements in thermal comfort model subject to tunnel test data and PC-based CAE tool with virtual mannequins that was used to understand physiological impacts of HVAC design. The emphasis was on understanding the effects of different parameters on skin temperatures. Marlow's TE heat exchanger (a dense plate-fin design) showed a COP of 1.7. Overall, the effort showed progress on several fronts, but that work on a commercial system remained. The second reviewer commented in a like vein, observing that accomplishments were reported for the comfort model, identification of a final set of HVAC locations, initial design concept of a fin and plate heat exchanger, incorporation of recently published data about sweat distribution on human body into the physiology portion of the comfort model, specify control strategy, development of waste heat recovery modules. However, this reviewer offered no assessment of the significance or value of these accomplishments. The third reviewer said that the hard metrics that have been laid out by DOE to the contractor seemed to include common thermodynamic quantities including the COP (coefficient of performance), and GM appeared to be capable of meeting that metric. The reviewer asserted that their mannequin system was providing excellent feedback data. The last reviewer explicitly addressed potential improvements to the work approach, noting that while it had made significant progress in overcoming the identified barriers, several areas needed more attention. The first area was materials and device reliability because TE coolers could fail under thermal-mechanical cycling, so it was important to identify the design limitations on temperatures and stress levels and obtain data on the performance of the TE devices. The second area was high-performance materials because the HVAC application demanded the best-performing TE materials. The cost associated with performance must be understood and a pathway to reduce cost after the demonstration phase must be identified.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

In the view of one expert, this project had assembled an excellent team to focus on the research tasks. In the opinion of another, collaborations appeared extensive, including nine partners from the industry, national laboratories, and academia. However, this reviewer felt that the coordination of such a large team was not especially well-described in the presentation. A similar comment was submitted by the third reviewer who saw no mention of what the actual activities and accomplishments of the teaming partners were. For example, UNLV was specified by name, but it was unclear to the reviewer what would not have happened had the university not been part of the program. UNLV was identified as providing materials modeling support, but the reviewer did not recall seeing any materials modeling results. The last reviewer's comment partially echoed this observation, and this reviewer acknowledged that partners included UC Berkeley on thermal comfort modeling, and Delphi Systems and UNLV on TE materials where Delphi was doing the TE component design. The reviewer added that Marlow was responsible for TE module development, but to this reviewer, it was not clear that all partners had been actively engaged, with GM and Berkeley playing major roles.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer termed the proposed future work clear and very promising in completing the project. The second reviewer felt GM to be well-positioned to succeed on this program and to have excellent plans. While believing success to be extremely likely, however, this reviewer would have liked to have a risk analysis, and to know if there were mitigation plans in case problems arose. The third reviewer noted that future work included completion of Phase 2 tasks, climatic tunnel testing (including Go/No-Go points), a look back at liquid cooling, testing and evaluation of final components, and vehicle integration (for Phase 3). This reviewer speculated that a greater degree of specificity in the future tasks might better crystallize the team's way forward. The last reviewer cited a number of remaining future efforts including vehicle build and instrumentation; commercializing and testing new components, and vehicle level testing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers agreed that the project resources were sufficient. Three people provided supplementary comments. One said that based on information in the presentation, it seemed difficult to determine if the resources were adequate or inadequate. Accordingly, this reviewer indicated a belief that resources were sufficient (rather than excessive or insufficient), and encouraged the contractor to have that direct conversation with DOE. Another reviewer said that the project had been using the appropriate resources and reaching stated milestones timely. Finally, the third reviewer termed resources commensurate with the industrial scale of the project and said that the funding appeared adequate.

Neutron Imaging of Advanced Engine Technologies: Todd Toops (Oak Ridge National Laboratory) – ace052

Reviewer Sample Size

This project was reviewed by twelve reviewers.

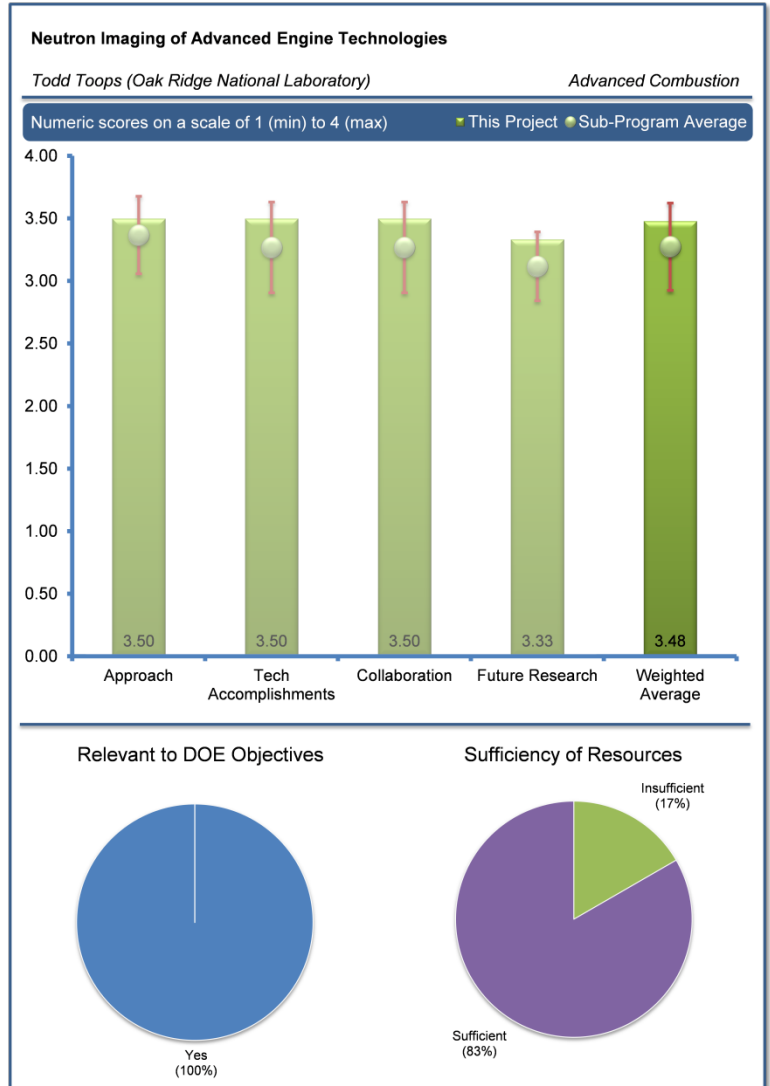
Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the eight reviewer comments addressed this question directly or by implication. The most directly relevant comment was that some aspects of this project directly supported petroleum displacement, such as its focus on improving diesel particulate filter (DPF) regeneration to minimize fuel consumption. Another reviewer said that, although not directly related to efficiency, the technique showed promise to help with problems that restricted engine advancements. The third offered a comment in a similar vein, saying that the project contributed to a better understanding of aftertreatment devices, which was important so that high-efficiency engines can still meet emissions requirements. The fourth comment was that the project was developing a new technique for looking at diesel technologies to understand and improve them. This would potentially translate into higher-efficiency diesel engines. The project contributed to a fundamental understanding of devices needed for high-efficiency engines, said the fifth reviewer. The remaining three comments described the project’s aims but offered no opinion on its relevance to DOE goals. One person

commented that the project concerned non-destructive and non-invasive imaging techniques to study DPFs, EGR coolers, and diesel fuel injections. The second evaluator offered essentially the same information, and stated that the project included non-destructive imaging of EGR coolers, DPFs, injectors. The last reviewer echoed the preceding two people’s comments, describing the project focus as a unique, nondestructive and powerful technique for evaluating and diagnosing the performance of a number of advanced engine sub-systems like particulate filters, EGR cooler fouling or fuel injector performance.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three of the five submitted reviewer comments expressed keen interest in the work that was the focus of this project and generally approved the approach to its development. One reviewer thought that the project had some great potential uses and that the approach to developing the tool and selecting applications for it was appropriate. In addition to the tool itself, the reviewer was gratified that the visualization tools were also being developed because that would make this a complete package. Another reviewer urged continued development of the usefulness of the technique, including quantitative metrics. The non-destructive technique was very valuable, in the estimation of this reviewer. The third agreed, saying that it appeared that neutron imaging was a potentially useful tool, providing a non-destructive technique for evaluating components such as filters. The fourth termed it a unique non-destructive technique to understand soot deposition on a DPF to enhance modeling and understanding of durability



issues. The last of the five commenters simply stated provide a complete analysis of hardware performance without destroying them.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Nine reviewers commented on the accomplishments and progress achieved in this project, with generally very positive opinions. One person called the progress on this program outstanding and described that this tool was being applied to areas that were of direct interest to a wide cross-section of the diesel industry, and that the progress and demonstration were going extremely well. The second reviewer said that the work done so far to demonstrate the usefulness, as well as the limitations, of the technique was exactly what was needed to understand its power. The results presented left no doubt to this reviewer as to the power of the technique. The improvement in resolution, the generation of quantitative results and the animations all constituted very good progress, in the view of the third reviewer. There had been good progress developing the technique for both DPFs and injectors, said another, who cited interesting results on partial DPF regeneration and interpretation of the results. One reviewer termed the presentation an excellent demonstration of neutron imaging's potential. This reviewer felt that it would be good to focus on injection, since DPF regeneration had been largely solved with minimal fuel use in most engines using selective catalytic reduction (SCR) for NO_x control and DPF regeneration was not required in low-temperature combustion (LTC) engines. Another reviewer noted that the project met the first milestone – demonstrating that filter images could be obtained which distinguish between particles and walls – and was on target to meet the second milestone. Also speaking to the quality of the images obtained, another evaluator spoke of incredible pictures of the soot loading in a DPF and averred that there was nothing else like it. The next step, in this reviewer's opinion, would be to learn if it was possible to get down to the individual DPF cell wall and show the pores and the soot in them. This would be helpful in understanding the newer, higher-porosity DPF materials that were entering the market. Another reviewer cited the project's improved visualization tools and its identification of particular loading images such as tomography profiles on actual DPF units. The project also investigated how particulate profiles changed during regeneration and provided insightful comments on packing densities as the initial loading changed. The tool seemed an excellent technique to leverage for filter performance and future developments, the reviewer said, urging that work begin on injectors. The last reviewer asked what subsequent learning resulted from DPF imaging (injection strategy versus efficiency, and etc.).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers were explicit in their positive assessment of collaboration in this project. One observed that there were a number of collaborators and that the interaction appeared to be quite fruitful. The second agreed, noting several key collaborations existed that have enabled the successful evaluation of the technique to date. Other reviewers (two) noted that samples had been obtained from several OEMs and that the researchers were working with several universities. The last reviewer cited complete sample from DOE's Office of Basic Energy Sciences (BES), academic institutions and industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The plan to develop visualization tools is excellent, said one reviewer, and will help make the data that much more understandable. This person added that there are certainly a number of items that could be studied in DPFs and injectors and those plans of study should be considered carefully, but that was outside the current project's scope, which appeared to be the development and demonstration of the imaging tool. Said the second reviewer, this was a powerful technique, and one of the next areas it should be applied to was visualizing flow and cavitation inside the nozzle of high-pressure, direct-injection fuel injectors. The third reviewer commented that the injector tests would be interesting. Speaking more generally, another reviewer said it would be exciting to see further results from this unique approach. The plan was deemed reasonable by one reviewer and the fifth observed that the research team would continue to use this unique approach on DPFs, incorporating ash-laden and catalyzed samples, and on injectors.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Comments were received by twelve reviewers, of which 10 deemed resources to be sufficient, and the remaining two reviewers dissented and termed them insufficient. Only one of the latter offered further comment, expressing the belief that more could be done with more funding.

Collaborative Combustion Research with BES: Steve Ciatti (Argonne National Laboratory) – ace054

Reviewer Sample Size

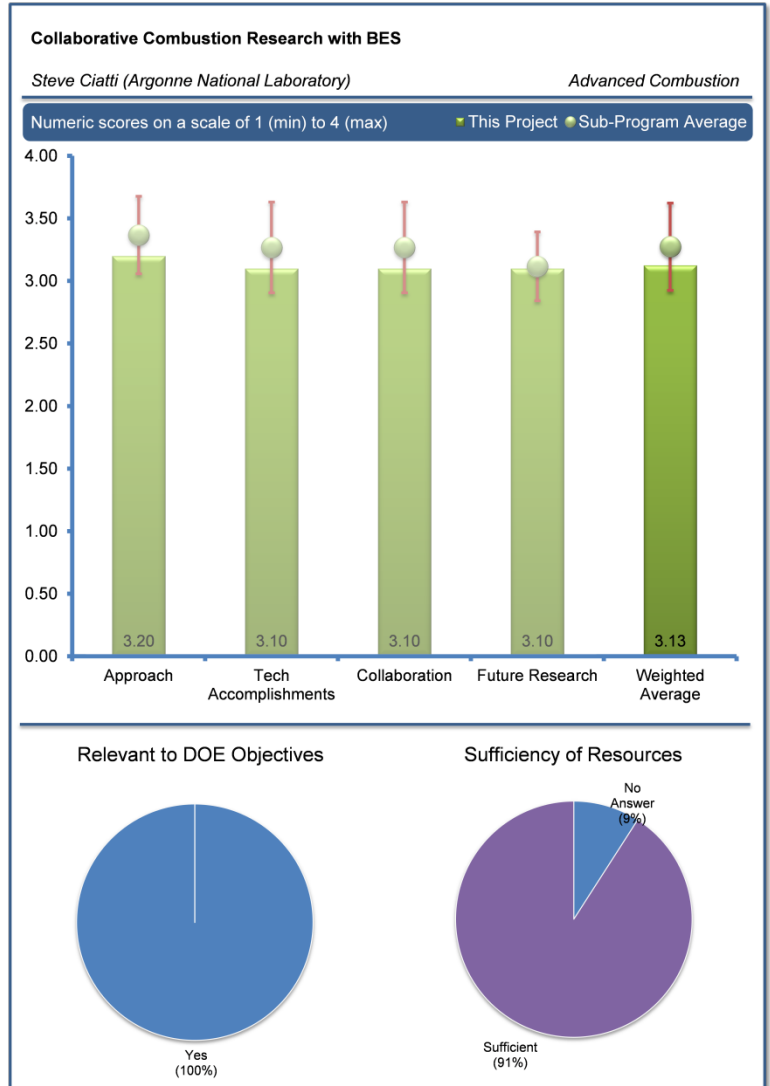
This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While only one of the five reviewers who commented spoke directly to this question, all seemed generally to consider the research worth pursuing. The one directly relevant comment was that, in general, fundamental combustion data from rapid compression machines (RCMs) should help to optimize high-efficiency, advanced combustion systems that should reduce fuel/petroleum usage. The second reviewer said that the project supported the DOE objectives through improved understanding of chemical mechanisms of autoignition. A similar comment from another reviewer was that to realize control of LTC, there was a need for better understanding of fuel combustion characteristics. The fourth reviewer agreed, saying that getting data on a rapid compression machine was a key component of kinetic mechanisms validation. These mechanisms were used in detailed computational fluid dynamics (CFD) models used to optimize engines for higher efficiency and low emissions. The last reviewer called this important collaborative combustion research with the BES office which addressed fundamental knowledge of advanced engine combustion regimes. The same reviewer further observed that this research supported the development of chemical mechanisms. This reviewer, however, was unsure if this work was unique or how it compared with other facilities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

There was a distinct division of opinion on this question among the seven reviewers, with some deeming it useful and complementary to similar work being pursued elsewhere and others suspecting it to be unnecessarily duplicative. Typical of the former was the reviewer who called this project a great application of experimental tools (RCM) to develop an improved fuel property database. Another said that the project provided complementary capability to other organizations doing similar work with capability to support testing of high boiling-point fuels and high pressures. Yet the third reviewer appeared to agree, noting that the team was providing a new RMC. It appeared that it would coordinate with other teams from the DOE. Marking the transition between the differing opinions, one reviewer wondered how the approach complemented or replicated other work in the field. Two reviewers' comments expressed doubts about the uniqueness of the work. One evaluator observed that the installation and use of RCMs to study fuels ignition, including in the negative temperature coefficient (NTC) region, had been done by several other organizations (including University of Michigan, MIT, and Stanford University). Stanford had also developed the capability to volatilize/evaporate components in diesel fuel. So it was important not to reinvent the wheel, both in terms of setting up instrumentation capabilities and with regard to the fuels studied. Quite a bit of work had been done on fuels and fuel components



by others. The next reviewer clearly agreed with this assessment, saying that this program seemed very much like the other rapid compression testing devices, so it was not clear what was unique about this. The reviewer added that it seemed the desire was to fill some gaps in the data, but it was not clear that this was what was actually being done. The reviewer also thought that there should be more priority given to testing with gasoline and diesel, as the other fuels are largely just a science project. The final comment suggested a modification to the approach, the reviewer opining that the obstacles to obtaining useful data from the RCM appeared to have been adequately addressed. The reviewer concluded by stating that a more focused approach to addressing specific issues was needed, otherwise, this would become a solution in search of a problem.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three reviewers cited good progress and expressed general approval of the accomplishments in this project to date. One said that there had been good progress getting the experiments set up and validated and in starting to get results to help generate data to validate Lawrence Livermore National Laboratory's (LLNL) surrogate models. It looked to this person that there was a lot of detailed work developing the RCM. The second commenter noted many good results with fuel data and in advancing RCM techniques. In the opinion of the third reviewer, development of the RCM had scientific value, provided that sufficient collaboration existed to fully interpret the data generated. The progress and improvements with the RCM to date demonstrated that it could in the future be a productive apparatus for improving the understanding of certain aspects of chemical kinetics. Another reviewer agreed that clearly there was progress made and data were taken. This reviewer expressed full understanding that there were challenges with the hardware and sampling system, but still felt that the actual amount of data taken was small. The fifth reviewer observed that there seemed to be significant scatter in the RCM data taken so far and asked what steps could be taken to reduce the scatter and experimental uncertainty in the data. The last two reviewers recounted the specific accomplishments described in the presentation. One expert noted that the research team had tested iso-octane and a four-component surrogate in the newly constructed RCM hardware; tested a very rapid sampling valve which was unsuccessful and had been replaced with a sample dump tank. The evaluator described that the researchers had helped develop high-aerosol fuel adaptation for an RCM and that the work shifted to control-oriented models for chemical ignition prediction and aimed to evaluate existing ignition delay correlations on a homogeneous-charge compression-ignition (HCCI) engine platform. The last reviewer simply observed that the team had finished setup of the RCM and had started to take data with it.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Three out of four reviewers specifically mentioned project collaboration with academia and two of them drew attention to collaboration with a national laboratory. One commenter said that the main collaborators included universities (Akron, Marquette, and Wisconsin) and LLNL. The second respondent cited extensive interactions with LLNL and three universities who were each providing separate assistance on analysis and experimental techniques. The third person praised the good connection to other universities doing similar work as well as LLNL and others who would use the data to validate kinetic mechanisms. The last reviewer endorsed the collaboration with Lawrence Livermore Laboratory, but also called for greater collaboration with other national labs, particularly LLNL and Sandia National Laboratories (SNL), so that these results could be used most effectively for modeling purposes.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers offered clear suggestions for the direction of future research. One said that the project team's plans seemed reasonable, but again, the project needed to ensure the focus was on fuel formulations and components that have not already been tested by others (unless this is absolutely necessary for calibrating equipment). In the view of the second commenter, the plan needed to show clearly how studying these various alternative fuels helped build a better database, as that was somewhat lacking. What exactly would it help calibrate, and equally, why was low priority being given to the fuels that engines actually burn, as this was what was most often required in real-life models against engine testing. The third reviewer felt that the emphasis should be on integrating this work with modeling efforts, to provide feedback into the test program. Another reviewer said that the proposed candidates for future work supported future development and refinement of diesel and biodiesel surrogates. The last reviewer again

cited the proposed future work mentioned in the presentation, and described that the team would do the following: continue to improve the RCM, seeking to extend its operating regime (not specified); expand the fuel matrix including real gasoline, a diesel surrogate based on n-dodecane and m-xylene, and a biodiesel surrogate based on methyl decanoate; and continue the development of aerosol fueling capability.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All ten reviewers termed project resources sufficient. Only two offered amplifying comments, one saying resources appeared sufficient to support a fundamental study of this type, the other merely affirming that resources seemed sufficient.

Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials: Chuck Peden (Pacific Northwest National Laboratory) – ace055

Reviewer Sample Size

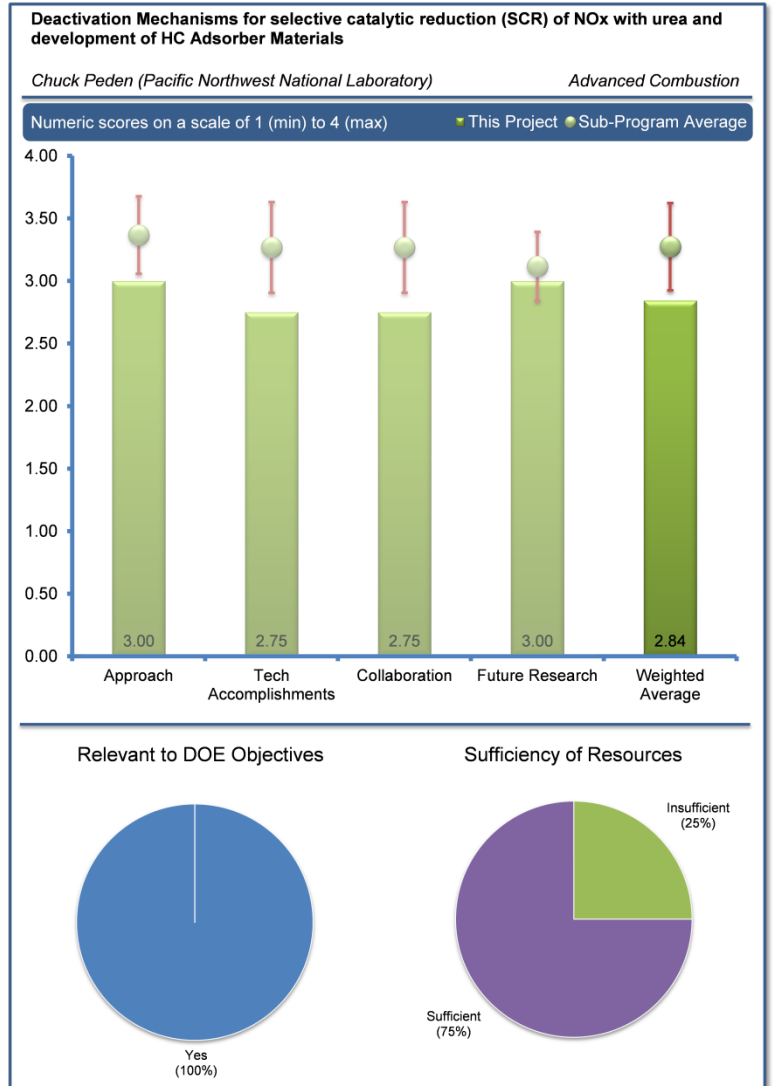
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers appeared to believe that this project was well worth pursuing but only one explicitly addressed its relevance to petroleum displacement. Two others did so by implication. The first person said that SCR and hydrocarbon (HC) traps were key technologies to facilitate fuel economy improvement in internal combustion engines, and that this project addressed challenging aspects of protocols for rapid aging of SCR and the performance of HC adsorber materials. The second reviewer agreed, noting that both SCR and HC adsorber catalysts would help reduce emissions and SCR would enable lean-burn engines. The third reviewer observed a very relevant program, adoption of high-efficiency diesel engines relied on robust, cost-effective NO_x aftertreatment devices, and that the deactivation and poisoning of these devices is critical to successful implementation of these devices in the marketplace. The last reviewer pronounced both aspects of this project as relevant to reducing the life-cycle costs of clean, high-efficiency vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the technical approach seemed sound, with the OEM providing new and aged catalysts while PNNL did the detailed characterization. This reviewer noted that the project consisted of two phases (i.e., SCR aging and HC adsorber performance assessment). The second reviewer described the approaches to both phases effective. This reviewer described that in the SCR aging portion of the work, the approach successfully identified and addressed the key technical barriers of sulfur poisoning and deactivation mechanisms, using appropriate methods to assess these losses. In the HC adsorber performance assessment portion of the work, performance parameters were well established and technical barriers effectively identified. Technical barriers for HC adsorber performance relative to zeolite type (variations in pore size and shape, acidity, and Si/Al ratios), the effects of added metals and/or other exchangeable cations were the main targets along with deactivation methods. The third reviewer cautioned that the project work was outside his areas of expertise and noted that reporting two different projects in a single presentation somewhat complicated evaluation of the projects. The reviewer nonetheless observed that understanding aging mechanisms helped designers avoid and/or mitigate those mechanisms and realistic aging protocols substantially lower total testing time and cost. The reviewer noted that the team was also investigating fundamental understanding of HC trap mechanisms. The final reviewer offered the comment that the experimental feed gas used in the HC adsorber work seemed to be well-designed



and asked if the research team had thought about aging catalysts to full useful life (FUL) on the vehicle instead of just to 50,000 miles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All four reviewers were impressed by the technical accomplishments and progress achieved in this project and were intrigued by some of the same findings. One person cited the recognition that sulfur trioxide (SO₃) had a greater effect on catalyst poisoning than the more abundant sulfur dioxide (SO₂) was a significant result, showing the importance of developing system-level understanding. The second reviewer agreed, saying that there had been good progress and technical accomplishments in both phases of the project. The SCR aging portion accomplishments, this reviewer said, were handled thoroughly with very clear, strong results concerning the effects of sulfur poisoning. Echoing the first reviewer's comment about the relative effects of SO₃ and SO₂, this reviewer further noted items including the ability to remove SO₃ with catalyst heating strategies, the greater activity loss at the front of the catalyst, and the source of activity loss and its probable causes. The more complex and interesting aspect, the reviewer felt, and which is critical to the dissemination of this work to other manufacturers, is the specific methods and degree to which this research allowed the SCR aging process to be reduced. The presenter, however, identified this as work done by Ford, which unfortunately limited the universal value of the work. The published work showed the protocol recommendations; however, the presented work and questions did not address this point. The reviewer thought the HC adsorber portion of the project also showed significant accomplishment, with the establishment of clear assessment parameters, set-up of the reactor and initial tests of ethanol adsorption and desorption. Agreeing with these comments, the third reviewer said that progress on the SCR work was very good and wished to see more progress on the HC adsorber work in the future. The fourth reviewer cited strong technical accomplishments overall. The same reviewer opined that understanding the mechanism of sulfur poisoning was important and the studies on SO₂ versus SO₃ seemed critical given the diesel oxidation catalyst (DOC). It was unclear to this person why these sulfur oxides effects were not shown. Secondly, it was very interesting to this reviewer that the aged SCR was largely deactivated in the front end due to changes in the copper, and not so much due to carbon or phosphorus. However, the reviewer acknowledged that there did not appear to be any insight offered as to why the copper aged differently at the front of the substrate than at the rear, which led to the reviewer asking what the root cause may be.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers lauded collaboration on this project. One called it good collaboration, calling Ford Motor Company a strong partner, with clear, published results. While observing that this project appeared to have fewer partners than other programs, the second reviewer also noted that, unlike some of the other programs, the collaboration seemed very deep and well-coordinated. The two other reviewers joined in making the observation that there was not a catalyst company involved in this work. The reviewer felt this would help to resolve any issues found and implement in future technologies, so suggested working with a catalyst manufacturer in the future. Seconding this, the other reviewer suggested that a catalyst supplier could be a worthwhile addition to the team. That reviewer also noted the presence on the team of a major automotive OEM (Ford).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Future activities appeared reasonable, given that the projects were nearing completion, said one reviewer. The second deemed the proposed future work good to fair both phases of the project, especially the SCR aging work, as it was sound and nearly complete, with models being evaluated against actual dynamometer test results. The HC adsorber had limited/fair plans for future work, with the claim of limited funding. For HC trap, the specific focus was limited to studies aimed at identifying ways to improve ethanol retention (and the potential for metals and exchangeable cations zeolite pore structure). The final reviewer commented that the HC-trap future plans seemed a little unclear and lacking specificity. The reviewer also wondered what exactly the deliverables were.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three respondents deemed resources to be sufficient, while another respondent found resources to be insufficient. One respondent said the SCR catalyst work was done well with a limited budget. The HC trap work was by researchers to be underfunded in light of the large array of work ahead. The reviewer felt that this claim was not well substantiated and required additional support, which the reviewer anticipated. Another respondent felt that not enough resources had come from the PNNL side and questioned whether resources were sufficient to complete the work in the time left for the project.

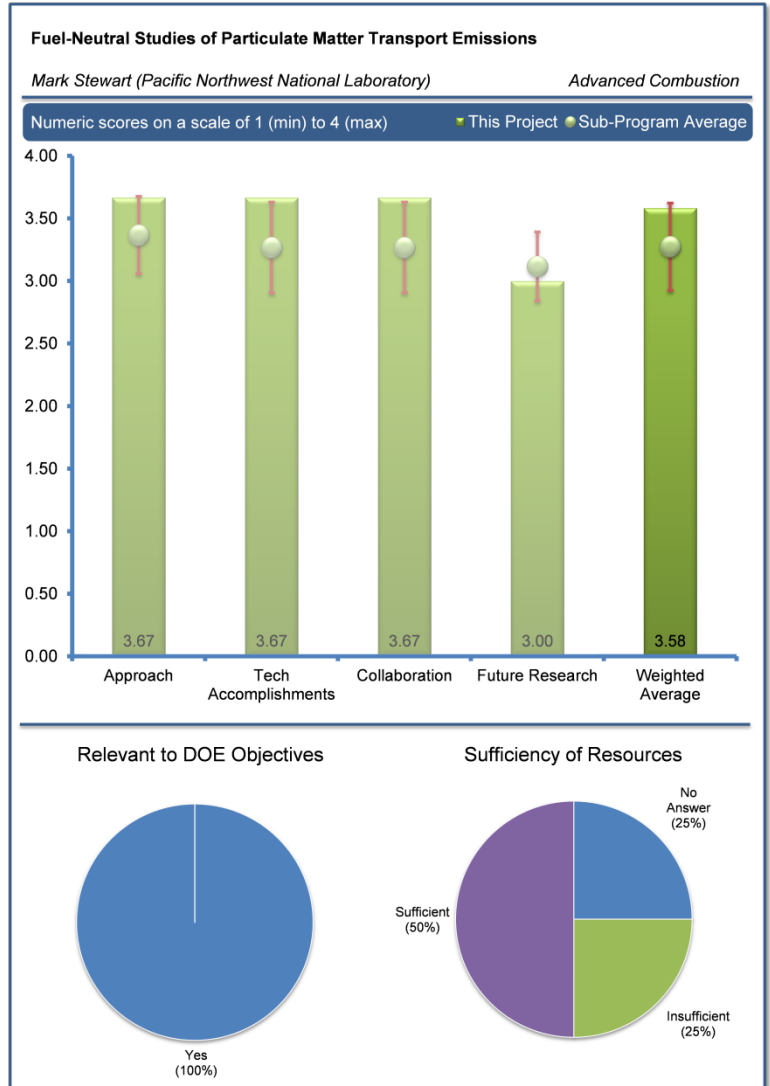
Fuel-Neutral Studies of Particulate Matter Transport Emissions: Mark Stewart (Pacific Northwest National Laboratory) – ace056

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All three reviewers appeared to consider this work important, but the only reviewer who explicitly addressed the matter of petroleum displacement noted that its focus was not directly on displacing petroleum, although a few ethanol fuel blends were tested to get a sense of the differences in soot morphology. The reviewer went on to describe the project as focusing on particulate emissions (particle size distribution, aggregate shape, average particle size, etc.) from next-generation engines. Particulates produced using a few different fuel blends (e.g., E20) and engine operating conditions were considered to get a sense of primary particle sizes, fractal dimensions, size of agglomerates, etc. Modeling efforts for filtration were also conducted and select results were reported. The second reviewer speculated that the project’s relevance could increase pending California Air Resources Board LEV III and EPA Tier 3 emissions regulations and a potential move to regulation of particulate emissions by particle number versus the current particulate mass regulation. The reviewer also mentioned that the focus on gasoline direct injection (GDI) was important for U.S. market versus diesel particulates. The final reviewer commented that this work was an extensive effort to characterize soot from gasoline-fueled engines. The reviewer reported that there was substantial concern that filtration would be needed for high-efficiency gasoline engines. Since gasoline engines made up a very large proportion of the consumer vehicle fleet, resolution of the need for filtration and definition of the filtration characteristics was a very large barrier to future gasoline engine development.



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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Calling it a coordinated approach of measurement and modeling, one reviewer said the approach appeared to utilize all tools to evaluate the character of gasoline soot. In addition, it was evaluating the soot emissions from all three types of future consumer gasoline engines. Another person urged the project team to consider adding engine temperature (especially combustion chamber temperature) to the test plan, pointing out that most particulate matter (PM) was generated during the first 500 seconds of engine operation on a GDI engine. The third reviewer observed that the work focus to date had been on spark-ignition, direct-injection (SIDI) engines, on the assumption that those would play an important role in efficiency improvement; a recent focus on gasoline direct-injection compression-ignition (GDICI) and reactivity-controlled, compression-ignition (RCCI) engines had followed suit. This reviewer called for additional justification in the form of evidence to suggest that these new engines would displace current internal combustion (IC) engines. The reviewer added that the presentation had been gratifyingly informative concerning the soot/particle characterization and unit collector modeling, and that it would be helpful to strengthen the tie between the

experimental characterization work and modeling work. The reviewer concluded by mentioning that the characterization work provided some sense about the average particle size, and perhaps could be used to guide the filtration design work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Noting that the number density, volatile fraction and morphology of the soot particles were examined, a reviewer called this the most comprehensive study presently available. Another person described the project as significant work on characterizing primary particle size and morphology of soot agglomerates for SIDI operation and praised it as nice work, overall. Improvements suggested by this reviewer included the development of a comprehensive understanding for a broader range of operating conditions and closer tie between the characterization work and modeling effort. The reviewer further noted that tunneling electron microscopy (TEM) of particulates for gasoline and diesel had been done, that gas could be more reactive and that ethanol blends produced far fewer particulates. Other project findings mentioned by this reviewer included that the shape and number of particles changed depending on fuel-air ratio, rich or lean, and that the data were providing a better fit to models.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Observing that the direct funding for this project was relatively low, one reviewer said that the investigators have nonetheless very effectively leveraged results from several very well-respected research institutions to gather a comprehensive view of the gasoline soot. The combination of OEMs, university, and national laboratories was good in the view of the second reviewer. The final comment was that the primary collaboration was really between PNNL and the University of Wisconsin (UW). The reviewer did acknowledge that Pennsylvania State University provided analysis and imaging of the particulates and GM seemed to have provided financial support for the UW engine research.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Both reviewers commenting offered suggestions for future research in this project. One observed that the current future plans did not seem to emphasize the filtration efficiency for these gasoline-generated particles using the innovative, membrane-coated soot filters. Noting that it may simply have been unclear from the slide if these membrane-coated filters were being evaluated or if the end of funding in 2012 precluded a more extensive study of these filters, the reviewer expressed a strong desire to see these filters included in the future of this work. The second reviewer's suggestion was that the results be extended to a broader range of operating conditions and that a more fundamental understanding be developed of how the particle size/morphology depended on engine type/fuel type/operating conditions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The one reviewer (of three commenting) who deemed project resources to be insufficient, noted that this work was apparently scheduled to end in FY 2012, a fact the reviewer deplored, saying that the work was sorely needed to allow engine manufacturers the technology to control soot from gasoline-fueled vehicles. The only comment made by either of the reviewers who considered resources to be sufficient was that the resources seemed sufficient.

Cummins Super Truck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: David Koeberlein (Cummins) – ace057

Reviewer Sample Size

This project was reviewed by eight reviewers.

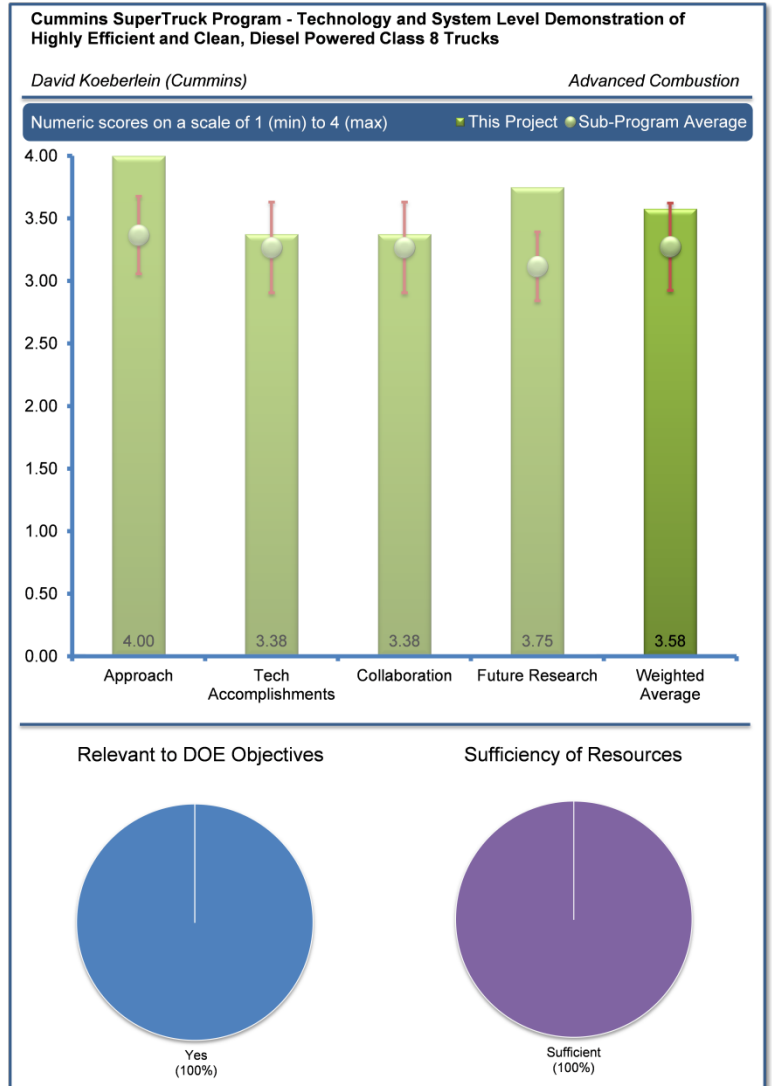
Question 1: Does this project support the overall DOE objectives? Why or why not?

While not all eight reviewers directed their comments explicitly to the matter of petroleum displacement, most did so at least indirectly and all seemed to agree on the merits of the project. One reviewer said this project supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 Tractors) and provided potential for near-term reductions in fuel use in these applications. Two other reviewers commented, respectively, that major efficiency improvements in highway trucks would reduce energy use significantly, and that the project objectives were clearly in line with energy reduction and security. The fourth commenter noted that the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. This reviewer was inclined to classify not using petroleum as equivalent to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere. The fifth reviewer praised the very solid presentation overall and deemed the project to support the overall objectives of petroleum displacement, but felt it might be extended. Stating that Cummins was the only company that has not considered downsizing as the project approached the efficiency goals, the reviewer expressed the opinion that if Cummins could meet the goals with technology that was excellent, but Cummins could then exceed the goal with additional, simpler strategies such as downsizing. One reviewer called engine thermal efficiency improvement the most critical element of this program in meeting the overall DOE objectives. Another evaluator said that the value was an approach which used an untested technology; in this case it was the solid oxide fuel cell. The last reviewer noted that the project met the American Recovery and Reinvestment Act (ARRA) and DOE Vehicle Technologies Multi-Year Program Plan goals.

The fifth reviewer praised the very solid presentation overall and deemed the project to support the overall objectives of petroleum displacement, but felt it might be extended. Stating that Cummins was the only company that has not considered downsizing as the project approached the efficiency goals, the reviewer expressed the opinion that if Cummins could meet the goals with technology that was excellent, but Cummins could then exceed the goal with additional, simpler strategies such as downsizing. One reviewer called engine thermal efficiency improvement the most critical element of this program in meeting the overall DOE objectives. Another evaluator said that the value was an approach which used an untested technology; in this case it was the solid oxide fuel cell. The last reviewer noted that the project met the American Recovery and Reinvestment Act (ARRA) and DOE Vehicle Technologies Multi-Year Program Plan goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All reviewers endorsed the work approach, with several noting its sharp focus and its concentration on engine and powertrain optimization. One reviewer noted that this project had demonstrated 49.3% engine efficiency, which the reviewer believed was the best demonstrated to date. In the view of another reviewer, Cummins had done a good job identifying and categorizing the different losses of the engine and powertrain. Because of their business, their emphasis was on improving the efficiency of the engine and powertrain system. The reviewer felt that the project team's estimates of the potential improvements achievable by addressing each of these losses are reasonable, but unfortunately, because of the nature of the program, technical details of the



approaches being used were not presented. The commenter added that the review must accept that the researchers are competent and doing good work. The reviewer felt that the approach that the researchers were following was sound and that the presenter did a nice job reporting on their answer to the question of whether a non-EGR engine with increased aftertreatment or one using EGR and less intense aftertreatment gave a preferred answer. The researchers were staying with EGR. Downsizing and higher BMEP will play an important role in the project work. It is an integrated effort with collaboration among many participants. The third reviewer called the project sharply focused indeed, well integrated and covered the bases. This appeared to be a solid analytical and experimental technology selection program, said one reviewer. Although the presentation was very short and thus could not say too much, some data was shown to indicate real work and solid results. The overall approach was very strong (as expected) on engine approaches, observed another reviewer, who also noted that there was good definition of barriers and approach, and authoritative descriptions. The approach to EGR and brake thermal efficiency (BTE) was logical and analytical. The approach seemed a very strong and engine-centered one, which was expected. The reviewer commented that these contributions would make the whole SuperTruck program of DOE more productive. Partially echoing these comments, a reviewer described the work as highly focused on technical barriers for engine/powertrain efficiency: EGR, automatic transmission, waste heat recovery, downsizing, friction, combustion chamber design, and fuel injectors. The project was very sharply focused on goals with reasonable technology decisions, another reviewer said, calling it the best of the program. The last reviewer noted that the program included many advanced technologies that could mitigate the overall program risks and that the road map was very well-defined.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that this project showed outstanding performance for the very challenging goal of 50% brake thermal efficiency (BTE). The project was currently at 49.3% and had well integrated engine systems which had potential for near-term production, including an integrated waste heat recovery (WHR) system. According to the principal investigator (PI), the map at which the high efficiency could be achieved had been significantly widened, which was excellent. The research team had exceeded the freight efficiency goal of 50% by 10% (i.e., reached 60%). This assessment was largely echoed by the second reviewer who called the presented results impressive, noting that the team claimed a demonstrated 49.3% BTE in 2012 and expressed confidence that by addressing the remaining issues, such as a compression ratio (CR) increase, combustion chamber shape optimization and specific injector calibration, the 50% BTE would be achieved. The same reviewer indicated that the researchers would not pursue hybridization. The project anticipated including waste heat recovery, which the researchers felt they were uniquely qualified to do, and would enable meeting the ultimate target of 55% BTE. Two other reviewers commented on similar lines. One person said that the small amount of data shown indicated very solid progress toward these very difficult goals and was impressed by test results from the waste heat recovery (WHR) system. The second commenter noted the very impressive progress at 49.3% BTE now, and called this result the best of the four programs. This reviewer praised the description of gains achieved, predicting that the team would exceed goals and be well on the way to 55% total. The reviewer welcomed the open presentation the research team made welcome. A reviewer noted that the project was on target and ahead of schedule in some aspects, another that the team seemed to be doing well with emissions, but observed that because there was very little discussion of the solid oxide fuel cell (SOFC) it was difficult to know where that was in development. Yet another reviewer called attention to the demonstration of 49.3% BTE with engine, aftertreatment (AT), waste heat recovery (WHR) (analysis shows optimization would move it to just over the 50% mark), reduction in pumping and friction losses. Finally, the last of the eight reviewers seconded several colleagues' comments, and called the demonstration of an interim milestone for 50% BTE an amazing accomplishment.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Some evaluators offered suggestions for additional collaboration or changes to the relationships among them, but reviewers were united in their approval of the collaboration and coordination within the sizable group of cooperating companies and institutions. One reviewer said that through Cummins Inc. and Peterbilt Motors, many different organizations were included in the work. From the information presented, it appeared that the project had a good collaborative effort. Another person agreed substantially, noting a nice list of who was doing what and a good set of collaborators. Cummins had a history of working well with long-term collaborators, including suppliers and universities, and this program built on that. The third reviewer's comment was similar, noting a nice breakout of collaborators, with clear definition of engine and vehicle partners. The challenge, this reviewer said, would be integration rather than throwing it over the fence. Also, there was a risk that full optimization of the interplay between

the engine and vehicle might not be realized. That was not altogether bad, as more would be required from each, and integration could be learned from others. The project was quite engine-centered, but there was very impressive collaboration with right team members. The fourth reviewer also noted the long list of supplier, university, national lab and OEM contributors. The project's bottom-line results were well integrated and appeared commercially productive, substantiated effective integration of suppliers', universities', and lab's efforts. The project team, in the words of the fifth reviewer, was solid, diversified and integrated. This reviewer, however, regarded the SOFC auxiliary power unit (APU) as a weak part of the plan and recommended that the team pursue other options as soon as possible, considering integrated options in contrast to a separate APU. The collaborations were well described, said a reviewer, noting that the work with Purdue University seemed to be very mature. Acknowledging the participation of Modine, VanDyne, ONRL, and Purdue University, another reviewer opined that more university involvement would be an improvement. The last reviewer offered the following comment: actively involve partners into the program with tangible deliverables.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All reviewers voiced strong endorsement of the proposed future work. One said that the road map which was laid out and their current accomplishments led one to believe that the project would be successful. In a similar vein, another reviewer described future plans as well laid out and would likely be achieved ahead of schedule. Reiterating gratitude for the team's open presentation, the reviewer said future programs were right in line with what should be done. The third reviewer saw a solid plan to integrate the selected technologies and looked forward to seeing the results next time. The fourth reviewer noted clearly presented next steps which included the final integration and vehicle demonstration of developed technology. Very good, the reviewer added; the project was on target, on plan. The project seemed to be on track, said a fifth person, it was reported in a manner that provided confidence that the project would achieve or exceed their objective. The future work was very well-defined toward the final program goals, according to the sixth of the eight reviewers. Future work was actually excellent, said another reviewer, who referred to an earlier comment urging a revised approach to the APU development and an end to work on the solid oxide fuel cell APU. The future work seemed to be pretty standard milestone description, said the last reviewer, finding nothing exciting there.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The eight reviewers all termed project resources sufficient. Four offered supplementary comments, one noting that to achieve such significant goals in a short time required large-scale funding. Cummins and other manufacturers were supporting essentially matching funds, so the research was highly likely to yield productive, real-world results in future designs. Foreseeing that the project team would likely exceed its goals, another reviewer concluded that resources were certainly adequate. This seemed like a good investment and well worth the expenditure, the reviewer said. The third reviewer termed resources solid funding for this major program. The last reviewer said simply that the funding resources seemed to be sufficient.

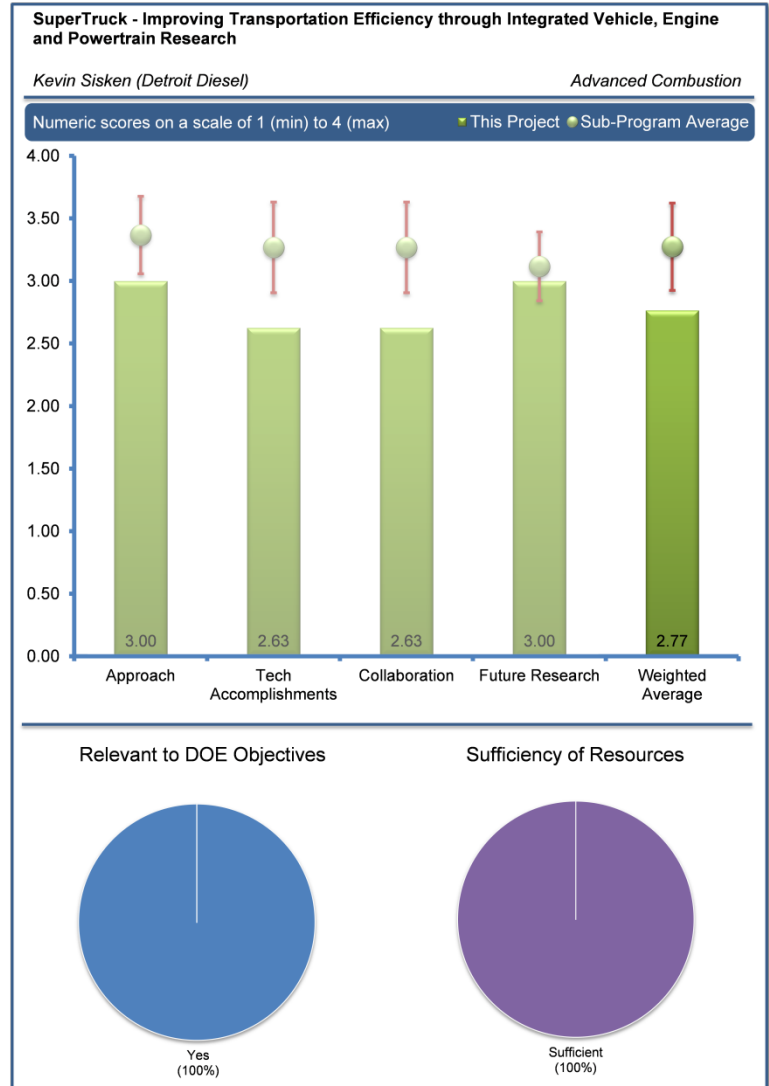
Supertruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research: Kevin Sisken (Detroit Diesel) – ace058

Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the six reviewers who offered comments stated explicitly that this project supported DOE's goals. One said it supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. Three others weighed in with similar observations, one saying that major efficiency gains in highway trucks would make a big impact on energy use. Certainly this project was in line with meeting DOE's goal of reducing fuel consumption and energy security, another affirmed. The third of these reviewers said that improving engine thermal efficiency was one of the most effective ways to support overall DOE objectives. The fifth reviewer observed that the objective and goals of the Super Truck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum, in the judgment of this reviewer, was equivalent to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere. The last reviewer did not directly address the subject of DOE's overarching goal, but praised Detroit Diesel for doing a great job of analyzing the various contributions to fuel economy for heavy-duty trucks.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers were generally quite positive in their assessments of the approach to the work of this project, although some discerned specific weaknesses and offered suggestions for addressing them. The first reviewer observed that the research team was going step by step through each of the possible engine systems and making state-of-the-art technology improvements. The reviewer stated that their approach was the interactive one which was most likely to be successful. The reviewer concluded by mentioning that the project had not identified any technology as being infeasible. The second reviewer was among those who approved the work approach but saw a shortcoming in it. The reviewer called it a good program, predicted that it would be successful, and described that the researchers were pursuing downsizing with an increased CR. The project team, continued the same reviewer, was also aggressively pursuing reduced friction and gas exchange improvements. The reviewer agreed that all of these would give improvements. This person felt that one of the unique aspects of the project team's program was the real-time engine control using global positioning system (GPS) information which would interface with the hybrid powertrain. This was really good, the reviewer said, foreseeing that it would lead to significant reductions in fuel consumption. However, the reviewer saw no efforts in combustion improvement and felt that an important component of improvement was not being addressed. Expressing confidence

that the research team would meet the 50% BTE goal, the reviewer added that the project would have been rated outstanding if combustion improvement were also being sought. The third reviewer thought the approach seemed quite good, noting that the presentation covered only the powertrain and not the vehicle part, so the reviewer had to assume that the two lined up well. The commenter stated that powertrain part shown here was good. It would be easier to judge more completely if more detail were presented, but the short presentation probably precluded that, concluded this reviewer. Another evaluator asserted that the researchers had a good approach, who noted that the work was focused on technical barriers to engine/powertrain efficiency, listing EGR decrease, waste heat recovery, engine downsizing, higher compression ratio, reduced friction and parasitic loads. A weakness this reviewer felt was not well addressed was the increased NO_x production in the base engine and the assumption that aftertreatment could take it up without penalty. The fifth reviewer approved the good step-by-step plan to reach 50% BTE and the logic of the order in which subsequent steps would be taken, noting that modeling suggested engine downsizing, followed by work on EGR, then air handling, and finally adding compression ratio and parasitics reduction later. The reviewer agreed that waste heat recovery (WHR) was logically approached last. However, the reviewer stated that counting on a new lubricating oil for most parasitics reduction seemed expensive and risky, but made sense if it was valid for others. It was reasonable, the reviewer felt, to wait in the wings to see how others progressed on WHR. Some unique features of the project seemed risky to this reviewer (fluid). Other aspects of the work seemed incremental to the work of others. This reviewer pointed out that predictive controls were a major contribution and seemed unique and valuable. Achieving 48% BTE from the engine seemed reasonable and the 2% balance from others was expected. However, this reviewer found that the project's movement toward 55% BTE seemed poorly thought out and wanted to have more information, questioning whether these technologies lined up with 55%. The sixth reviewer said it would be challenging to achieve 50% thermal efficiency from the current 46% in two years. The reviewer asserted that the program should have more options or technology road maps at this stage to show various technology potential to achieve the 50% BTE goal. The last two reviewers' comments were remarkably similar. One commenter observed that integration of the building blocks was planned for late in the program, and added that some level of integration testing, virtually or in the dynamometer lab, should be ongoing. Separate engine and vehicle development, the last reviewer said, seemed likely to lead to challenges and that better integration here would be warranted.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Four of the eight reviewers who provided comments on this project spoke positively of its accomplishments and progress, although some expressed reservations regarding some aspects of the work. One person said that progress was good; 46% BTE had been demonstrated, and the project's road map to getting to 50% was credible. According to the project road map, the researchers will use WHR to get to 50%. From the presented information, there was reason to be confident that the researchers would succeed. Another agreed substantially, saying the evidence so far indicated the researchers would be successful. This reviewer cited waste heat recovery and route prediction as the most challenging aspects of the proposed work. Solid progress on several difficult technologies was the assessment of the third reviewer, who was pleased to see some real data even in such a short presentation. The fourth reviewer complimented a good description of accomplishments, citing impressive progress on aftertreatment, air handling, engine mapping and firming calibration and predictive capabilities which were described as unique. Achieving 46.2%, this reviewer said, was well on the path. The project represented very impressive work on all aspects of the program. Subsequent reviewers, while generally positive in their estimation of the project's progress, also noted potential shortcomings. One said good performance for the very challenging goal of 50% brake thermal efficiency noting that the team's results currently stood at 46.2%, with plans to optimize a prototype waste heat recovery system and other components. The reviewer noted that a weakness appeared to be the level of productive hardware and claimed thermal efficiency performance gains at the expense of NO_x, which may not be realizable in production, as SCR system cost or performance penalty may offset such gains. Another possible weakness cited by this reviewer was that the milestone of 50% freight efficiency was not addressed in this presentation, being deferred by PI to another presentation on the project. A reviewer expressed the view that 46% thermal efficiency was low at this stage of the project, considering the program road map and the limited time remaining. More detailed commentary on aspects of the project was offered by a reviewer who cited specific slides in the presentation. With respect to Slide 5, the reviewer said much of the reported testing (done and planned) could be avoided if high-fidelity simulation was used. This would save much money and time; ditto for Slide 6. Obviously, the reviewer opined, reduced engine size would reduce its motoring parasitics. Further, higher BMEP at road load would compromise any hoped-for improvements in fired engine parasitic losses, and would have additional

deleterious effects. This was engine-engineering ABCs, had been researched for decades and had been the subject of many Ph.D. theses. The engine tests in Slide 11 confirmed what had been known all along. Although currently and historically fashionable, engine downsizing may not be desirable. The reviewer discerned a bright spot in the Detroit program in its controls approach. Returning to the presentation, the reviewer cited Slide 11, saying it repeated tried-and-true pursuits and testing, and gets the same results. The MIT consortium was approved by the reviewer, but also called a rehash of similar work there over the last 40 years. The reviewer said a search of the literature of a decade starting in the late 1970's would surface work similar, albeit even more sophisticated, to the ongoing engine parasitic reduction pursuits at Detroit Diesel and elsewhere. This reviewer referenced work done at MIT, UM, Georgia Tech, and by Japanese researchers. The documents of the DOE's ECUT program of this period would yield similar results. The last reviewer cited the considerable amount of controls work (i.e., neural network to calibrate) yielded the accomplishment of good predictions for transient events, and reported that the 46% goal was met.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers' comments on this aspect of the work indicated general approval of the breadth of the collaboration, but expressed reservations concerning the actual degree of involvement. One reviewer said that the project's collaborative effort was good. The project worked with two national labs, one university, and a company and it appeared the effort was coordinated and each participant had specific tasks. Another felt the researchers were working with their collaborators in a supplier mode, which appeared to be working. However, there was not much evidence of feedback from the suppliers having an appreciable effect on the project trajectory. This reviewer speculated that this impression may have resulted from the brevity (20 minutes) of the presentation. The third reviewer said that there seemed to be a good team, although most of the work appeared to be in house. Perhaps, the reviewer speculated, there were a number of suppliers involved who were not documented here. The next reviewer sounded a contrary note, sensing weak collaboration, but allowing that this might be an incorrect impression. It seemed to this person that Daimler was doing everything. Others had a small role, but this was not all that bad, except that it did not permit for widespread dissemination of knowledge acquired with public money. Internal coordination toward meeting the goal was nonetheless expected to be excellent. The fifth reviewer noted a fair list of collaborating partners – MIT, national labs, and DOE – but felt that, for commercial production systems, there seemed to be a weakness in that only limited production supplier organizations had been identified. The Principal Investigator (PI) asked the audience to recognize the inherent support of the German parent company, but no material support was substantiated. The PI also pointed to the strong attention to detail in the use of funds. The complicated master powertrain controller system was developed by parent company Daimler Trucks AG, based in Stuttgart, Germany. The following reviewer echoed this observation, calling the collaboration a bit parochial. Limited partnership with ORNL on WHR and with Atkinson on controls was cited, but the reviewer agreed that the involvement in the project of Stuttgart should have been explained and details provided as to what was being done there versus here in the United States. The last two reviewers' comments were brief, one noting the collaboration of Oak Ridge National Laboratory (ORNL), MIT and Atkinson but wished for more university involvement. The other said simply that various partners seemed to be involved in this program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers expressed general confidence in the proposed future research, but noted the challenging nature of the work remaining to be done and the relatively short time that remains in which to accomplish it. One thought there seemed to be a solid plan, assuming the powertrain/vehicle interfacing was done as well as the part presented here. Another reviewer noted that the team was close to meeting the project target and has stayed pretty much on trajectory. Another expressed a high level of confidence that the project would achieve 48% engine-out and get at least 25 from WHR. The reviewer noted that there had been no comment on a proposed pathway to 55% BTE. The approach to laying out a trajectory to achieving 55% BTE was not very well-defined in the opinion of one reviewer, who interpreted the approach as being: the project would achieve 50% and then see where improvements could be made to reach 55%. The fifth reviewer noted a good understanding of future obstacles and the approach that was laid out. This reviewer felt that there was some room available for misses, but not much. The project was well laid-out and the work seemed to be focused on high-risk areas. More thought should be given to the 55% BTE goal and the long-term roadmap, but tools were in place. The sixth reviewer noted that the project was now in its second year and weaknesses identified so far were that the SCR

system was not capable and the waste heat recovery system was still in optimization. Thus, there was the risk that many additional gains were planned to be achieved by complex and time-consuming friction reduction and combustion development. The seventh reviewer briefly sounded the same cautionary note, saying that the technology menu seemed to be thin considering the aggressive goals and the current achievement of 46.2% BTE. The final reviewer simply referred to comments made in the previous section, in which criticisms were directed at specific slides in this presentation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The eight reviewers unanimously agreed that resources were sufficient in this project. Five of the reviewers offered further comments. One said that the mix of DOE funds and industrial funds was not quite clear from the presentation, which left the reviewer with the impression that DDC's investment greatly exceeded the DOE investment, leading the reviewer to conclude that resources were sufficient. The second reviewer saw solid funding for a major program. Funding seemed about right and goals were being met, said a third evaluator. Non-project help from Stuttgart assures success and adequate resources. The fourth reviewer noted that to achieve such significant goals in a short time required large-scale funding. Detroit Diesel was on track, but there were some concerns about production-ready subsystems and components from the project based on their current maturity of development. The last reviewer identified the uniqueness of the project as the support of people and resources (especially for WHR) and predictive controls.

Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Dennis Jadin (Navistar International Corp.) – ace059

Reviewer Sample Size

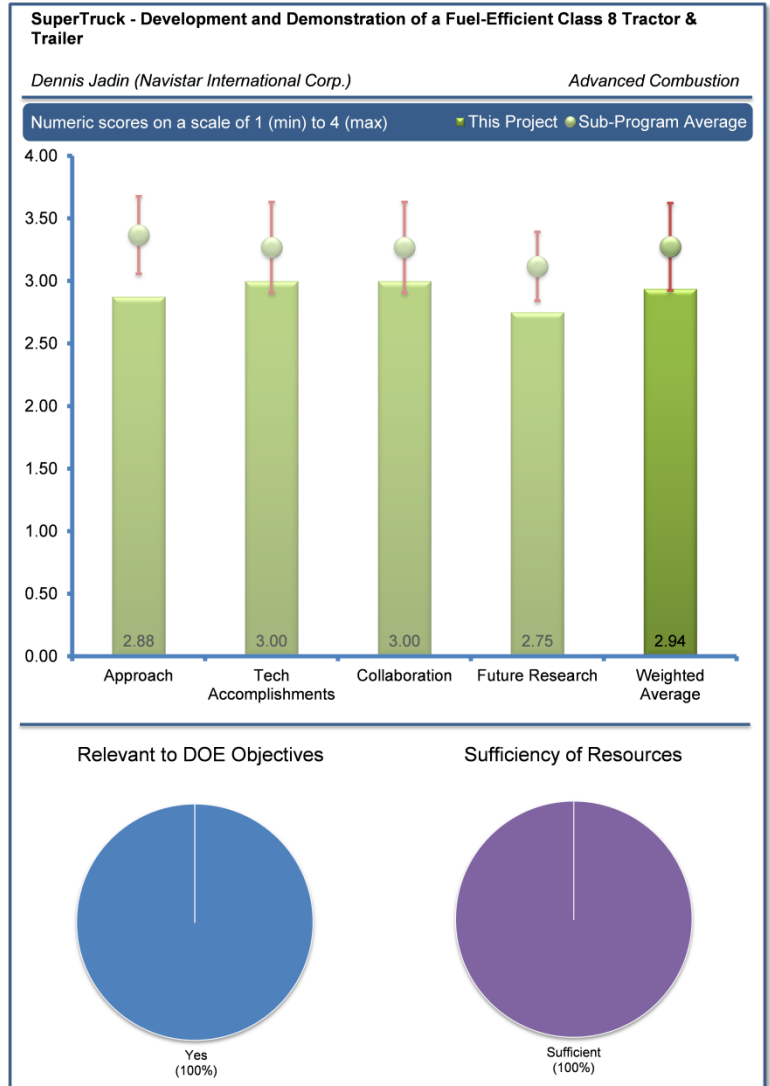
This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the six commenting reviewers agreed that this project supported the DOE objective of petroleum displacement. The sixth did not address that question explicitly, but observed that the value of these competitive projects was that each had a different focus. This project, as far as the reviewer could determine, emphasized reactivity-controlled, compression-ignition (RCCI) combustion technology. The first of the other five reviewers said the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum was equivalent, in this reviewer's opinion, to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere. The second of the five said major improvement in truck efficiency would save significant energy use. Another concurred that the DOE Program goals were right in line with this project. This project, in the view of another reviewer, supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. The last reviewer observed that engine thermal efficiency improvement undertaken in the program was one of the key deliverables of the DOE program.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers seemed to be in two minds concerning the approach to this work. The reviewers recognized and applauded its uniqueness, but foresaw critical technical challenges to be overcome. One said that using an advanced engine technology was definitely an alternative, but was not convinced that the computational fluid dynamics (CFD) calculations provided value. This reviewer strongly approved the payback analysis and cited the planned reduction of the waste heat recovery complexity as a potentially significant accomplishment if the BTE goal could be reached without it. The reviewer said that most of the SuperTruck projects presented to that point had seemed to be throwing everything at the ultimate objective. This project showed a rational evaluation. The second reviewer noted that Navistar was not as far into their program as two of the other teams, said the project seemed to be pursuing an approach of minimizing the need for sophisticated aftertreatment systems that minimized engine-out NO_x emissions so that the project could minimize NO_x aftertreatment system complexity. The reviewer felt that a persuasive technical foundation for this approach had not been presented, but considered the approach unique. Other teams, the reviewer said, were looking for synergistic combinations of combustion modifications and aftertreatment system performance, that was,



employing much more of a systems optimization approach and wondered if Navistar had assessed the trade-offs of letting the in-cylinder emissions increase and relying on the capabilities of the improved aftertreatment systems. As they stated, it was a system challenge. They are placing tremendous emphasis on improved combustion, which is good, but may be over-constraining themselves with simplified aftertreatment. The third reviewer was less concerned about such considerations, calling the program plan excellent, pragmatic and realistic. On a peripheral matter, the reviewer noted that for the second year, the presenter was shown as Dennis Jadin, while in fact the person who led the engine sub-program was William de Ojeda. This should be corrected, the reviewer said, ethically and professionally. Dennis was the SuperTruck program manager, but did not need to have his name on the engine section; see the similar presentations of others. This reviewer made three additional minor observations, calling the presentation style excellent, citing Slide 8 as an exemplary tech program tracking chart and urging all SuperTruck contractors and others to construct their program reporting in like fashion. The reviewer praised the presentation as having substance and value, which was good for DOE and its stakeholders. Another reviewer, while citing the difficulty of judging well on such a short presentation, said a strong set of technologies had been considered by the project team. It was unclear to this reviewer exactly how the set was defined and how the downselection was being done. It appeared, the reviewer said, that Navistar was relying more on advanced combustion concepts than other SuperTruck teams. These were very sensitive to fuel properties and would require sophisticated systems to control combustion in the presence of fuel variability. The reviewer surmised that while this may be included it was not mentioned in this presentation. The fourth reviewer called new approaches to the overall DOE program a good idea and agreed that keeping deNO_x on the table but moving to low-NO_x, high-efficiency engines was challenging but pushed the envelope. The reviewer cited a nice approach to components and payback period, and expressed hope that the new program shifts would pay off. RCCI seemed a very high risk, the reviewer felt, for a minimal return and the approach to achieving 55% BTE seemed weak. In a similar vein, the fifth reviewer commented that the plan's strength was that it included virtually all important elements which could be listed to reach the goal of 50% BTE and the path toward 55% BTE, including waste heat recovery, combustion and friction reduction. Additionally, the approach considered the value equation through payback analysis and presented this, which was a great benchmark. The weakness, on the other hand, seemed to be the plan to incorporate every possible option and potential pathway (e.g., the addition of RCCI, PCCI). This posed complexity risk and the possibility the system would become unwieldy and difficult to manage to successful completion as focus and resources became scattered. The next reviewer also discerned technical risk in the approach, noting that the main plan was hybridization, which was risky. This reviewer noted that Navistar was the first company to mention the true sticking point of any new technology (i.e., customer acceptance) and bestowed kudos to Navistar for realizing that it did not matter how great the engine was if no one would buy it. The reviewer also cited the best matching between in-cylinder combustion and aftertreatment and observed that the plan did not relax engine-out emissions to improve efficiency. The reviewer observed only mention of cost/payback consideration. The reviewer indicated that last year's reviewer comments on payback were taken, and then further reported re-evaluation and down-selection to derive an updated plan. However, continued this reviewer, the plan for RCCI seemed unreasonable. The same reviewer pointed out that the efficiency numbers quoted come from a single point, and for a technology that was notoriously hard to control; this seemed very unrealistic, opined this reviewer. The last reviewer found it unclear whether the baseline engine was based on an SCR solution or EGR solution. It would be extremely challenging to achieve the program 50% BTE goal with the EGR solution approach while maintaining 2010 emissions levels, in this reviewer's opinion. Integrated aftertreatment and engine should be one of the critical areas for improvement. Slide 7 failed to mention any contribution from the aftertreatment system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer comments again reflected the tension between recognition of high technical risk and the possibility of significant payoffs from the incorporation of uncommercialized technologies. One reviewer said that the work the project team had done so far was very good and explained that the project team was earlier into the program than two of the other teams. Therefore, observed this reviewer, much of the project work was still at the component, bench, and simulation level. The evaluation work the researchers did on WHR systems was good. The project was pushing technical boundaries with their injection systems and working with Bosch in a nice collaboration. The project's demonstration of 46.5% BTE on the dynamometer resulting from improved combustion and turbocompounding was good. The researchers were pursuing exciting new technologies like RCCI, the reviewer noted, which was anticipated to be challenging for them to achieve the load and speed range of their applications, but indeed they were pushing the envelope. The second reviewer was of like mind, noting good performance for the very challenging goal of 50%

brake thermal efficiency. Current result was 46.5% BTE and the research team had begun to integrate engine systems with the potential for near-term production, including a waste heat recovery system. One reviewer described that a weakness and risk was that progress had been slower than planned and the team had taken on a long list of technologies. The project's accomplishments were limited, but were progressing, said the third reviewer, who expressed appreciation for the open descriptions, and noted that the parasitics had been met. BTE seemed behind but was nonetheless on track at 46%. Variable valve actuation (VVA) seemed integral but was slow. Air handling progress was good. The fourth reviewer felt that the fuel reactivity studies of this program complemented the Sandia National Laboratories (SNL), UWM, and ORNL work. It had the potential to produce higher-value, disruptive technology results and was worthy of DOE support via the SuperTruck program or separately. The reviewer mused about a team led by competent engine representatives (ORNL or Navistar) spearheading such a relatively large program, and involving SNL, Argonne National Laboratory (ANL) and UWM, but did not recommend any of those three organizations to lead such a team. The reviewer asserted that the controls piece was critical, but there was not much reporting on it. The same reviewer also mentioned that Navistar could benefit from an increased focus on controls. This was especially critical in probing the VVA and fuel reactivity areas; otherwise, a great discovery (or discoveries) may be missed. The Detroit Diesel controls part of the SuperTruck may provide a clue. ORNL, but not other laboratories, have some competence in this area too. So does UWM, focused here on combustion. This project had a lower demonstrated engine efficiency than the other programs, a reviewer noted, finding it hard to separate what analytical from experimental data in some of the slides. The reviewer said it appeared individual parts had been tested and the benefits combined analytically to predict future program results. Other teams seemed to have more of their systems put together with actual test data to support their status. The last two reviewers noted, respectively, that this team had hit 45% BTE with engine alone, without compounding and friction numbers, and that jumping from the current 46.5% BTE to 50% in two year is a big step, especially while maintaining 2010 emissions at 0.2 g/bhp-hr NO_x level.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments continued to be equivocal in this section of the review. One reviewer said that the project had identified and established collaborations with good partners: Bosch, Federal Mogul, and ANL. The second reviewer expressed that the project team apparently was working with Argonne, but that it did not seem to be an intensive collaboration and that very few other collaborations were mentioned. Work within the partnership was needed and going well, said the third reviewer; all parties seemed committed and coordinated. This reviewer observed a well-managed project. The next reviewer noted little mention of collaboration other than a listing of a small number of partners on an early slide. This reviewer found it unclear what the collaborators were doing, for instance, whether Bosch was a development partner in control and combustion, or just providing fuel system parts. The ANL/Wisconsin collaboration was not defined, the reviewer said, presuming it to be related to RCCI, but left wondering what that effort was doing, what part Navistar was counting on, and who was doing what. The fifth reviewer cited as a strength of the project the engagement of some suppliers (Bosch, Federal Mogul, Behr), and one national laboratory. With the long list of technologies to model, integrate, and test, the reviewer said, the weakness was a short list of collaborators. Additional suppliers and universities might strengthen the team's ability to deliver all of what was promised. It may be that there were other collaborators, but these were not mentioned in the presentation. The sixth reviewer also noted the collaboration of Behr, Federal Mogul (friction), Bosch (high pressure injection), ANL, and the Engine Research (ERC). The last collaborator, in spite of its co-location and association with the University of Wisconsin, was not a true university partner, in this reviewer's opinion. Another reviewer said a good team of collaborators was on board, and felt that close (or closer) involvement by Navistar and perhaps UWM, in the ongoing testing at ANL was warranted. This should cover hands-on involvement in the execution of the test plan, quality of data acquisition, raw data processing, etc. The last reviewer said it seemed that all key partners were involved in the program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers continued to be in two minds about the proposed future direction of this research. One found the description of the future work to be somewhat limited, consisting mostly of milestones. While expressing hope that the team would meet their efficiency targets, the reviewer felt that the future plans did not show a clear path to success. The second reviewer's assessment was that the team had over-constrained themselves by imposing the limit of a simple aftertreatment system. This reviewer suggested the team at least analyze the efficiency gains that would result from assuming aftertreatment capabilities equal to those

of in-use systems and determining what the optimal engine performance would be if that level of emissions were allowed to leave the cylinder to be handled by the aftertreatment system. This reviewer, too, found the proposed trajectory to reach 55% BTE target to be unclear. In the opinion of the third reviewer, the future plans were not explicitly identified. The reviewer was left in doubt as to how the combustion system would be selected, whether there would be aftertreatment and, if so, what kind would be used. VVA was to be added, but no strategy of analysis was presented to say what that term meant in practice or what basis there was for expecting the results shown in the plan. Weaknesses in the proposed work were being addressed, one reviewer said, and while there were many challenges, the plan seemed doable. However there was a big gap in the approach to 55% BTE. The strength was a solid plan of attack, said the fifth reviewer. There were separate efforts planned for engine friction reduction, the prototype Rankine cycle WHR system and PCCI/RCCI engines. The weakness lied in the timing delays and the risk that the already large scope may continue to grow and become untenable or result in further delays and cost overruns. A reviewer suggested that further serious consideration be given to whether RCCI was a viable technology. Another was unconvinced of how dual-fuel engines could help the program achieve the 55% goal in a multi-cylinder configuration, considering this concept suffered from a huge pumping loss and substantial pressure rise during initial heat release.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All eight reviewers deemed project resources to be sufficient. Five of them offered further comment. Again, said one, it was difficult to extract how the funds were directed; however, Navistar has billed DOE for about \$13 million so far, or about three times what DDC billed. Conceding that knowing how to judge was difficult or impossible, the reviewer ventured that Navistar may not be as far along as DDC. The second reviewer said simply that this was well funded for a major project. The third comment was that project funding may be a little low given the challenges, but project was well-managed. To achieve such significant goals in a short time, said the fourth reviewer, required large-scale funding. Due to fund matching requirements and the structure of the project for specific goals, Navistar research was highly likely to yield some productive, real-world results in future designs. Commercialization of new combustion regimes may put pressure on the budget and it surely would on the timing of the work. The last reviewer commented that resources may not be sufficient if the program was focusing on a baseline engine with an in-cylinder EGR solution.

SuperTruck Initiative for Maximum Utilized Loading in the United States: Pascal Amar (Volvo) – ace060

Reviewer Sample Size

This project was reviewed by eight reviewers.

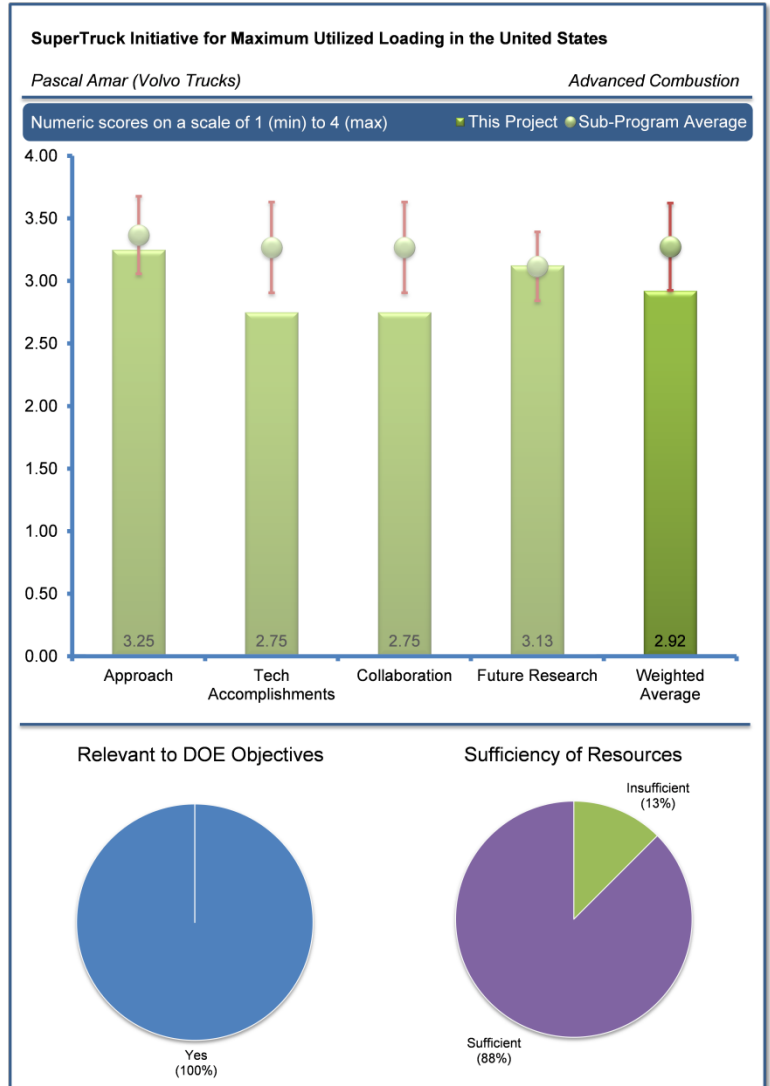
Question 1: Does this project support the overall DOE objectives? Why or why not?

With the exception of one reviewer who did not address the question directly, the reviewers were in agreement that this project supported the DOE objective. One said that the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum was equivalent to displacing it, and perhaps better, because petroleum not used was an increment of carbon not emitted to the atmosphere. The second agreed that major improvement in highway truck efficiency would impact energy use strongly. Likewise, the third stated that clearly, improving freight fuel efficiency was in the best interests of the nation's energy strategy. The technologies listed had a good chance of attaining the stated goals of 50% and then 55% BTE. The fourth reviewer concurred, saying that this project supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. This project addressed the objective of petroleum displacement by increasing energy efficiency through lightweighting and systems integration (including aftertreatment and WHR). It supported petroleum displacement through improved efficiency was the conclusion of one reviewer. Another considered that improving thermal efficiency was one of the key overall DOE objectives. The last reviewer remarked that this was part of the heavy-duty improvement in fuel economy, but saw nothing unique about this project and found it interesting that the PI did not choose to make the presentation.

It supported petroleum displacement through improved efficiency was the conclusion of one reviewer. Another considered that improving thermal efficiency was one of the key overall DOE objectives. The last reviewer remarked that this was part of the heavy-duty improvement in fuel economy, but saw nothing unique about this project and found it interesting that the PI did not choose to make the presentation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers were hampered somewhat in their evaluation of the work approach in this project by the fact that it was recently begun. One reviewer noted the fact, remarking that Volvo was still very early into their program, so the presentation mostly focused on explaining their capabilities and articulating their approach to achieving the goals. The project had a very balanced and comprehensive plan. As expected, their plan addresses both engine and vehicle improvements and their road map carried to 55% BTE. The second reviewer concurred, saying that the plan appeared to be methodical and systematic. The reviewer would have rated the project higher if more substantive information had been provided to justify an outstanding rating. The third reviewer found it hard to judge based on such a short presentation and with so little actual technical content. This reviewer felt that the presentation implicitly asked reviewers to assume the research team really had useful technologies that ought to work. The next reviewer thought it was unclear that the combustion simulation would add much to the field, given the other models out there. However, if it was a specific tool for the project, this was acceptable. The reviewer also liked the idea of staged development on



individual technologies, starting with the 50% BTE goal, and then refining it for 55%. The chassis design approach was valid, the reviewer said, and thought the integrated approach of all aspects of the truck a key attribute. The use of accepted technologies and approaches to achieve the objective improvements was deemed to be a strength of the approach by a reviewer. For the 50% BTE target, the approach was typical, i.e., assess waste heat recovery, combustion, air handling, aftertreatment, driveline in a test cell. For 55% BTE, evaluate PCCI and RCCI, alternative cycles, simulation tool, fuels optimization, demonstrate in simulation and single-cylinder scoping. A weakness of the approach was that the modeling and single-cylinder work for advanced combustion modes (PCCI and RCCI) was not on the critical path and there was no mention of the value proposition for technologies (payback and cost per percent of improvement). The sixth reviewer termed the approach logical, and stated that using the second objective to drive the first seemed well thought out to actually accomplish the goals of the first objective. The approach was unique in that it built an entire system, not just engines and thus resulted in an integrated product. But in the view of the seventh reviewer, the road map was not very well-defined, with different technologies. At this stage, the incremental efficiency improvements based on some of the key technologies should be analytically defined. The reviewer felt that Slide 10 (i.e., Strategy for 50% BTE Powertrain Demonstration) was confusing. It showed that combustion had the greatest impact on BTE improvement, higher than WHR. The final reviewer reiterated an earlier comment, finding nothing special in this project compared with the competitors. There was no clear indication that the CFD work was bringing much to the table.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

In this category, too, reviewers noted the difficulty of rating a project's progress and accomplishment so soon after its inception. Because the project was so early into the program, one reviewer said, it was difficult to rate progress. The researchers had a believable plan in place, the reviewer acknowledged and after viewing the presentation felt that their chances of success were high. The project was already demonstrating efficiency improvement in their early tests. The second reviewer said that the project could have been rated higher if more substantive information had been provided to justify such a rating. This reviewer complimented the presentation style, saying it got the message across with ease. Slide 5 and similar ones gave a top view of the program and allowed reasonable tracking of it, continued the same reviewer, who also suggested that listing the acronyms would have been helpful. This reviewer also mentioned that some slides presented good information, though these were scarce, while other slides were merely a weather report and should offer more substance in the future. The reviewer found it hard to see how \$4-5 million had been effectively utilized to result in technical accomplishments and progress. The next reviewer to comment also found it hard to judge, since no data were presented in any quantitative way to allow a judgment. A graph showed apparent progress but it did not seem connected to presented data. The fourth reviewer, on the other hand, saw impressive progress toward 2016, given the limited time in play. The project was now in a stabilization period for debugging and would enter another rapid growth period. This reviewer did not see much on WHR except sweet spots, or much data on other sub-projects, and so found it difficult to assess progress. The reviewer deemed 45% BTE to be about right for this stage of the project. Rating the strengths and weaknesses of the project, the fifth reviewer noted in the first category the fact that engines had been built and tested with prototype combustion, air handling, fuel injection, and EATS as an integrated unit. Among the weaknesses, the reviewer included a lack of clarity in the presentation materials as to actual BTE achievement. A 10% increment over a baseline value was all that was shown, the reviewer said, implying a masking of results to date. Results may be better than indicated, but little data about hardware results was presented. The fact that the PI did not attend the review to present such a large-budget project also was a concern to this reviewer. The sixth reviewer discerned excellent progress, the team meeting all goals, and on track to meet the next set. The seventh reviewer found that Slide 18 (i.e., Milestone Update) was vague and lacked any tangible number. It was hard to believe, this reviewer said, that the next goal could immediately jump to 55% BTE without any intermediate milestones. The last reviewer failed to note anything special from the presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers commented positively on the selection of collaborating institutions in this project, although there were some reservations expressed concerning the amount of work done by the principal contractor. For example, one reviewer saw indications of collaborations with Ricardo and Penn State; however, this reviewer said, this seemed to be an in-house Volvo activity. The second reviewer commented simply that the researchers had established a good team of principal and collaborative participants. The third reviewer agreed in part, saying that it was a good team of collaborators but also limited because much of the teaming was

an in-house work. The reviewer asked what the level of effort distribution among teams and collaborators was. It seemed that small pieces (WHR and combustion studies) were thrown over the wall to Ricardo and PSU. The reviewer wanted to know in the future if there was more and what portions of the work were done in the United States and what was done in Sweden. In the view of the third commenter, there appeared to be a good set of suppliers and co-researchers, but without more information on who was doing what and how decisions were made, it was hard to judge fully. The fourth reviewer expressed approval of the idea of bringing some new partners into the fold, citing UCLA, Penn State University, and Grote. These were good organizations, the reviewer said, and it was good for DOE to develop multiple sites of expertise and it appeared that the parties were working together. Citing as project strengths the university partners in the California system and Pennsylvania State, another reviewer went on to identify a weakness in the limited supplier involvement in combustion and hardware integration. Ricardo was an excellent engineering systems partner, but had not been a viable production supplier. Production-level collaboration was relatively weak for such a large project (on the Rankine cycle WHR system, etc.). If it was desired to keep suppliers confidential, the reviewer said, more results and accomplishments were needed to compensate for the omission of supplier collaborators. Some collaboration existed, said another reviewer, citing Ricardo and two university partners with fairly specific roles that coordinate into overall project. Partners did not seem to be full participants, but did seem to be well-coordinated. The final reviewer comment was that all key partners seemed to have been involved.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer opinions on this question were mixed. One reviewer felt that this project seemed to be far behind the curve compared to the competitors and saw no clear indication of a way to catch up. On the other hand, the second reviewer, who found this category difficult to rate, nonetheless expressed intuitive confidence that the project team would succeed. The project team has done a nice job partitioning where gains would come from as the project moves forward and have identified the challenges that must be met. Downsizing and downspeeding would be major components of future improvement, and the researchers have the entire vehicle to work with. This reviewer thought that the project team had a clear focus on where their effort needed to be focused and hoped this would hold true as the project progressed in the program. The list of proposed future tasks was very good, according to a reviewer, but more substance would have to have been presented to score the project higher. Also noting that little detail had been provided, another reviewer still felt there was a solid plan to carry forward. The project was entering a critical timeframe of optimization and testing, in the opinion of one reviewer, something entirely reasonable and expected. The sixth reviewer said that the plans for the future were good and followed the general schedule which was provided. The seventh reviewer noted an excellent plan/pathway to an integrated solution. The final reviewer, however, considered the statement on the future work vague and said more detailed future technologies should be described.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All but one of the eight reviewers termed project resources sufficient. The dissenting opinion held them to be insufficient. Four supplementary comments were provided by members of the seven-reviewer majority. One person merely noted that this was a large program with significant funding while another reviewer pointed out that it appeared to be well-staffed and progress was being made and that the right parties were in place. To achieve such significant goals in a short time, the third reviewer observed, required large-scale funding and that Volvo was matching funds and many of the technologies fit in the advanced technology portfolio plan for a Class 8 truck manufacturer. The same reviewer observed nothing special here. The reviewer who thought resources insufficient noted that the project had started late with the half the funding compared to other competitors. The goals were too aggressive, this reviewer felt, for the time frame mentioned.

**ATP-LD; Cummins Next Generation Tier 2
Bin 2 Diesel Engine: Michael Ruth
(Cummins) – ace061**

Reviewer Sample Size

This project was reviewed by five reviewers.

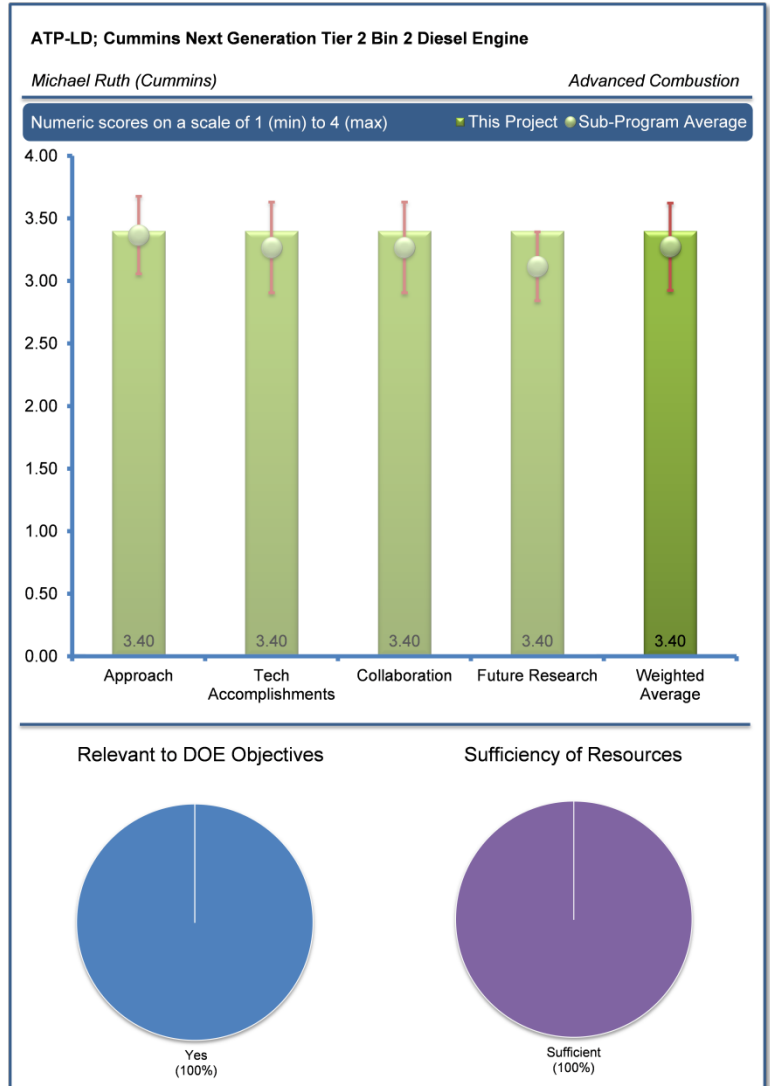
Question 1: Does this project support the overall DOE objectives? Why or why not?

The five reviewers who addressed this question largely agreed that the project supported DOE’s petroleum displacement goal. One reviewer, noting that the project targeted a 40% increase in fuel economy for the half-ton pick-up truck, observed that such vehicles enjoyed a large market share and account for a significant share of fleet fuel consumption. This made them the most logical target for getting significant fuel economy gains. The second reviewer’s comment was similar. A large improvement in light-duty and medium-duty (LD/MD) truck applications would lead directly to fuel savings, opined this reviewer. The same reviewer explained that the program was designed to contain costs and meet other program requirements increased the likelihood of increased diesel use in North America. Likewise, the third reviewer noted that a fuel economy increase in light trucks and SUVs of 40% would reduce U.S. oil consumption by 1.5 million barrels a day (bbl/day). The fourth reviewer’s comment was more general, namely that improving engine thermal efficiency and vehicle fuel economy was the key to the overall DOE program objective. The last reviewer did not make the connection

between project goals and the DOE objective, merely observing that the project entailed engine design to achieve 40% FE benefit with Tier 2, Bin 2 vehicle standards.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most of the comments indicated approval of the project work approach. One reviewer called it a very strong approach based on extensive previous work. According to this reviewer, the project team was apparently employing mixed-mode combustion with HCCI, but not full time. This reviewer noted a stretch SCR NO_x conversion target had been set and a good selection of collaboration partners were contributing important parts of the approach. This reviewer also indicated that Cummins has a good history of working on projects with DOE and collaborators and leveraging the results; this skill showed in this program. The second reviewer identified project strengths as the choice of an aluminum diesel engine, PCCI combustion, passive NO_x adsorber, and direct ammonia injection systems. Although technically challenging, this reviewer felt these represented an excellent approach to achieving aggressive goals. A very logical approach, said the third reviewer, with excellent leveraging of previous DOE-funded work. A reviewer observed that the team did not appear to be developing any breakthrough technologies, but were implementing all logical technologies for achieving good fuel economy on a light-duty truck. This reviewer said some of the engineering steps would be challenging, but appeared achievable. Finally, the fifth reviewer agreed that the goal of a 40% improvement over baseline seemed to be aggressive with the approach taken. The reviewer felt the technology road map seemed to rely more on



aftertreatment improvement and a new engine design with a focus more on weight reduction. This reviewer was unsure how much fuel economy would improve with a 140 pound weight reduction.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers' remarks on the project's technical accomplishments were generally positive, although some reviewers tempered their comments by noting the brevity of the presentation and its consequent lack of detail. One reviewer noted very nice results so far. In spite of its brevity, this reviewer believed this presentation managed to communicate a picture of major progress in basic engine design. In addition, this reviewer noted that the difficult tasks were clearly identified and good progress has been made against them. The NH₃ supply seemed to work well, this reviewer said, and asked if there had been an initial effort to determine whether the California Air Resources Board (CARB) and EPA would approve the system. The reviewer called the cold NO_x trap innovative and expressed the desire to hear more about it in the future. The strength of this project, in the view of another reviewer, was having an operating engine with aluminum block and very good initial results for emissions and the potential to achieve 40% fuel economy improvement. This was seen by this reviewer as an extremely challenging task which has been achieved in a very timely manner. According to this reviewer, the weakness was the limited discussion of power targets relating to vehicle performance and cost/value estimates. The performance metric presented for the cylinder block material was a good start, but standard torque and power curves (power and torque versus RPM) would be more appropriate, in this reviewer's opinion. The third reviewer considered that accomplishments appeared to be in line with overall program timing, but found it difficult to track specific progress on hardware given the minimal detail provided. This reviewer indicated there was good progress on the aftertreatment side and an impressive weight reduction, though this was unsurprising given the change from traditional cast iron to aluminum. The fourth reviewer said that the project had already demonstrated the capacity to exceed projections and expressed very positive feelings about the likelihood of its achieving project objectives. The last reviewer discerned more progress on aftertreatment improvement and tailpipe emissions, but less on fuel economy. Still though, the reviewer said, the overall progress is outstanding.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Again citing the shortage of detailed information in some cases, reviewers approved the degree of collaboration and the selection of partners. One reviewer said collaboration appeared to be very good, though there was not much detail on how integrated the partners were into the day-to-day program work, but the project was addressing challenges through good partnerships. The second reviewer observed that there was apparently good collaboration with suppliers like Johnson Matthey, customer Nissan, and others, but found it hard to fully evaluate the collaboration after such a short presentation. The third reviewer felt the strength of the project was having a good lineup of partners for emission work and engine design: Johnson Matthey, Nissan, and Rose-Hulman for controls, as well as a national lab for materials. This reviewer felt the results show apparent synergy, but a weakness may be controls and power, as limited discussion in these areas may show a need for additional university or engineering consulting. The last point was also mentioned in the comment of a reviewer who noted project partners Nissan, Johnson Matthey, Rose-Hulman and ORNL, but felt more university involvement seemed warranted. The final reviewer's comment was that it seemed the program involved all key partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The proposed future work plans met with the reviewers' approval. One called them appropriate for a development program. Another noted that the open issues seemed to have been clearly identified with good work plans aimed at resolving them. The third reviewer noted the strength of the plans in getting to vehicle testing in 2012, indicating that this was the most effective way to compare performance when making powertrain size reductions, transmission changes and aftertreatment system changes. According to this reviewer, there was no mention of value analysis, however. Detailed costs were not necessary, but some idea of potential relative to the baseline was worth considering for this reviewer. At a minimum, this reviewer continued, it should demonstrate that this was a better choice over a hybrid or other options. The project appeared on track to exceed targets, said a reviewer. Another noted that focus appeared to be more on aftertreatment improvement and the bet was put on the forthcoming new engine for achievement of the final goal, but that significant development was still needed on the engine, which would take

time and resources to accomplish. This reviewer also noted that it appeared achieving the aggressive fuel economy goals while maintaining Tier 2 Bin 2 emissions was a high-risk undertaking.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers deemed project resources to be sufficient. One observed further that resources appeared to be appropriately deployed for the program. The second reviewer called this a well-funded project with a large team doing a lot of work. A high level of funding is justified for this aggressive goal, said the third reviewer, however, this architecture must continue to be evaluated as a top contender for best value for achieving fuel economy benefit.

A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency: Ron Reese (Chrysler) – ace062

Reviewer Sample Size

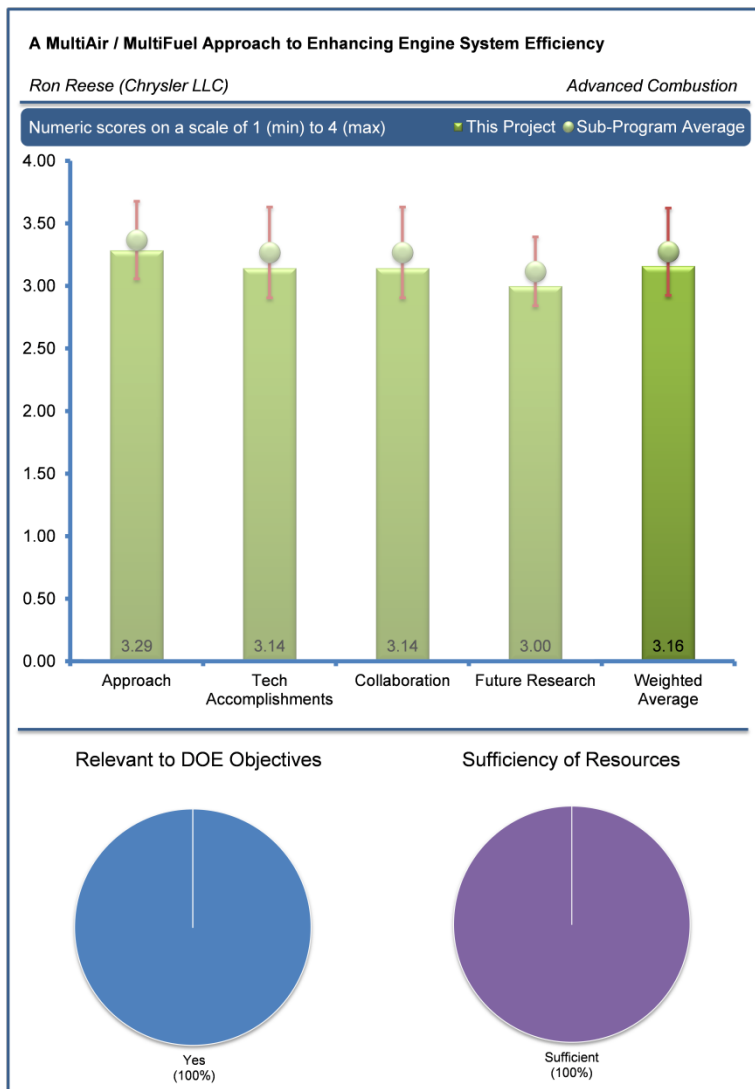
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the targeted 25% improvement in fuel economy was a significant improvement and well aligned with DOE's goals. The second reviewer mentioned that the research supported efficiency improvements in main-stream engines and vehicles. The third commenter indicated large gains in fuel efficiency at moderate cost would have a large leverage on the LD vehicle fleet. The fourth reviewer noted clear support objectives with goals to demonstrate a 25% improvement in combined City FTP and highway fuel economy for a minivan, meet Tier2 Bin 2 emissions, and accelerate the development of highly efficient engine and powertrain systems. The final reviewer explained that this project addressed the fuel efficiency challenges of larger SUVs (minivan to be specific) which were driven by a large portion of the U.S. population. Even small improvements in the fuel economy of these vehicles would achieve significant petroleum displacement/ reduction.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the stoichiometric approach made excellent sense for more rapid deployment to the market. This reviewer felt the overall program plan was very good, with suitable decision points for revisiting hardware designs. The second reviewer reported that there were many ideas and technologies stacked up here, with a number of engine approaches built on HEDGE. This reviewer noted that the engine appeared to be expected to bring 45% of the 25% improvement, which was (only) 11.25% net improvement from quite a bit of added engine content. The reviewer noted that the comprehensive team was good. The same reviewer suggested to keep the baseline engine performance documented so that the improvement was clear in the future. The third respondent observed a good approach, but pointed out that many technologies were selected with apparently little or no previous data to assure that it would work. This reviewer noted that although the selected system seemed reasonable, several key improvements were needed. The reviewer questioned if the CARB/EPA agreed to dual fuel systems, and reported that stoichiometric operation avoided the need for lean NO_x aftertreatment. The fourth respondent expressed that the strengths were the consideration of list of technologies which had been vetted to prioritize and provide an incremental benefit. This reviewer indicated that the weakness was the potential cost of some technologies, such as crankshaft balancing scheme and that the performance of the downsized engine must be identified in part to ensure value. The fifth reviewer described that the approach encompassed many aspects of the engine system, which was good as multiple fuel efficiency improvements could be additive to achieve impact. The same reviewer described the balance of engine and system R&D and collaboration matrix as good. The dual approach of DMP and multiple sparks was logical as the DMP approach may have market challenges, according to this reviewer.



This reviewer inquired about the value of the DMP if it was only used at high loads. The commenter noted that multiple spark locations were of potential interest in enabling advanced combustion, and that this project was uniquely addressing that approach. The sixth reviewer indicated that the approach was to downsize and boost, but was not considering stoichiometric approach. The reviewer stated that this is really confusing because that seemed like low-hanging fruit. The reviewer appreciated the distinction between RCCI and Dual Fuel (HEDGE) – and noted that this puts Chrysler way ahead of HD companies that have more fanciful ideas. Also, the reviewer appreciated that Chrysler appropriately credited development partners (SwRI). The seventh reviewer felt that the use of stoichiometric combustion and TWC was safe but not terribly innovative. The reviewer commented that it was good to see dual fuel (DMP) considered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter indicated that the parallel ignition system approach was very good; that it would permit both low-risk/moderate reward and high-risk/high reward paths. According to this reviewer, it appeared that good progress had been made on many fronts to develop advanced technology components and integrate them all into operating engines. The second reviewer agreed with good progress on building and installing research engines and computational tools. This reviewer stated that progress was evident in the remainder of controls and vehicle systems. The third reviewer explained that there seemed to be good progress, although it was hard to judge due to the short presentation time and the blinded results plots. The reviewer questioned if the damper system actually had been able to remove lug limit issues. The fourth reviewer noted that the strengths were available prototype engines with consideration for multiple fueling schemes and thorough modeling assessment, MATLAB Simulink models and GTPower models of control system and EGR, as well as control architecture definition. The reviewer added that the data on dual fuel and single fuel indicating some progress was also very good. The fifth respondent observed that the benefits from the system components make sense; crankshaft damping and nine-speed transmission were good and when added together provided significant fuel savings. The progress on DMP and the multiple spark approaches were good according to this reviewer; however, it was unclear whether the DMP approach would be worth it as operation was limited; only high loads and multimode control may be problematic. This reviewer felt the multiple spark approach was showing good fuel efficiency and stability. The final reviewer stated that the project was behind schedule already--no cost extension and that there were go/no-go plans set for June for major decisions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first commenter felt it was unclear if the supplier partners were true partners or simply component/technology suppliers. The reviewer felt that the work with OSU was promising and a good use of the capabilities of the university. In addition, the reviewer added that the fundamental work at ANL looked promising for providing some more fundamental insight into the combustion systems, especially the dual-fuel system. The second reviewer observed a well-defined team roles and listed suppliers, universities, and national labs. The third commenter reported a limited selection of partners, but that the partners seemed to be solid. Historically, explained this commenter, DOE supported engine testing at ORNL and basic combustion research at SNL; ANL seemed to be getting into the business but the reviewer was not sure if these would have been the reviewer's first choice. The reviewer noted that the project team does have good strength in injector spray research. The fourth respondent noted that the strength was a good mix of suppliers that could implement the technology, national labs, and universities. The reviewer suggested a potential need to add support or split activity for dual fuel concept with base engine platform. The fifth respondent noted good collaboration with Delphi on the ion sense technology. The reviewer also stated that it was not clear what the magnitude of the impact would be, but it was apparent that the technology has been characterized well. It was also not clear to this reviewer what was being learned from the modeling efforts. The final respondent listed ANL, Bosch, and OSU, and stated that more university involvement was warranted.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the remaining work was significant, but all appeared achievable based on the results to date and the overall program scope. The second commenter acknowledged that the plans as presented were acceptable, but were not very

detailed, and that calibration was expected to be big challenge. The third commenter observed a solid plan and noted that the down-select of ignition concept would be very important. The fourth commenter described that the strength was zeroing in and prioritization of a path with milestone decisions for effective results. The reviewer pointed out that a weakness in the presented material was the lack of detail in the timeline, and consideration of value analysis for concepts. The reviewer indicated that it appeared that there were still too many options to engineer and integrate that were not part of the critical path to meet the near-term production objectives. The reviewer added that the dual fuel concept may be extra credit at this time. The final respondent indicated that it was a good idea to move to down-select between DMP and multiple spark approaches at this point.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the commenters agreed that resources were sufficient. The first respondent stated that the funding supported a significant program with lots of work and real stretch in the technologies chosen. The second reviewer reported that a high level of funding was justified for this aggressive goal with continued diligence to consider technologies that have good value and could be implemented in the near-term of three to five years. This reviewer further remarked to scope for funding and timing. The third commenter indicated that the largest budget of all projects was reviewed in this session, and that it was good to see a 50/50 cost-share.

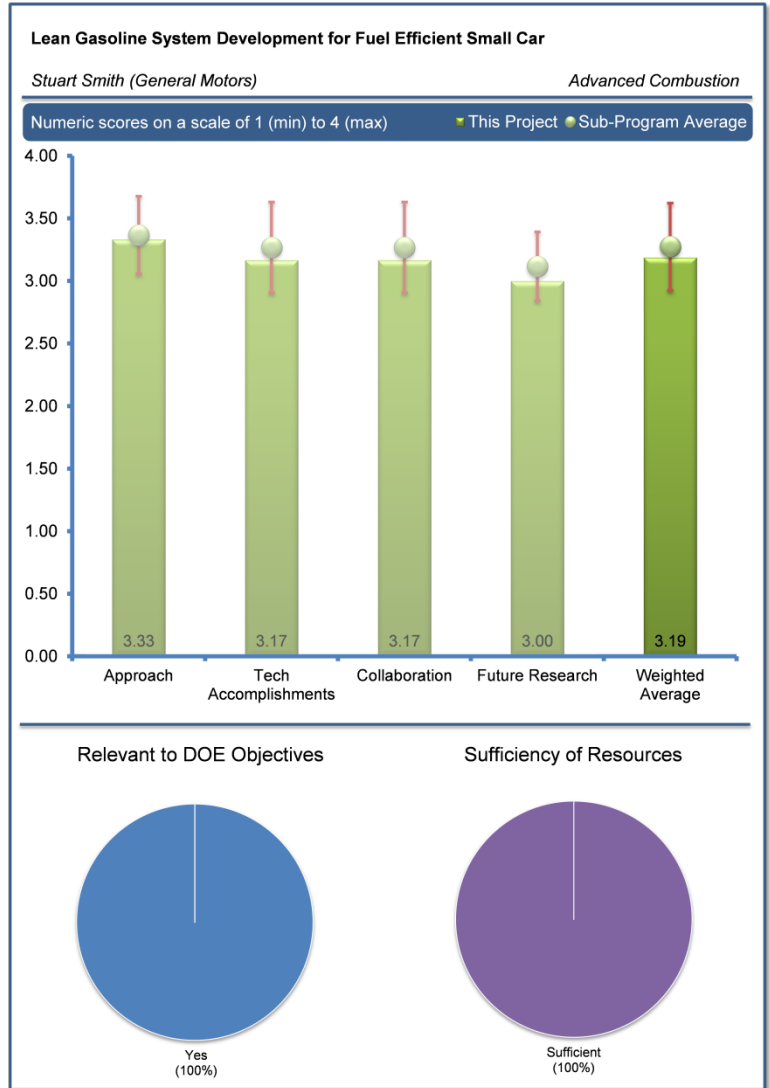
Lean Gasoline System Development for Fuel Efficient Small Car: Stuart Smith (General Motors) – ace063

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project targeted development of a more efficient engine applicable to a multitude of future vehicle platforms. The reviewer applauded tackling lean-burn as a possible leap in technology. The second commenter indicated that major improvements in fuel economy would impact the U.S. LD fleet fuel use in an important way. The third reviewer noted that the target of 25% improvement in fuel economy for LDVs is in line with DOE's objectives. The fourth respondent reported a clear support of objectives with a goal to demonstrate a 25% improvement in combined City FTP and highway fuel economy in a mid-sized sedan, meet Tier2 Bin 2 emissions, and accelerate the development of highly efficient engine and powertrain systems. The fifth respondent described that this project addressed improving the fuel efficiency of the passenger car market in the United States. The reviewer concluded that the technological approach being pursued is widely applicable to that market and therefore has potential for high impact.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent affirmed a well-defined combustion and emission control approach on relatively high-risk approach with higher efficiency return. The second reviewer stated that a variety of technologies were considered. The reviewer noted that not much evidence of why concepts were chosen or an analysis to assure concepts worked together was provided (at least in this presentation). A lot of effort had been expended on the wrong engine - naturally aspirated and different displacement. There was a lot of published data that showed boosting changes in the cylinder environment strongly, so the solutions developed at naturally-aspirated conditions may not be right for the boosted concept. The third reviewer stated that the approach was sound, employing a combination of technologies to reach the 25% fuel economy improvement. This reviewer indicated that the combustion and aftertreatment approaches were using a balanced combination of CFD simulation and laboratory validation to develop the dilute combustion and aftertreatment systems. The fourth respondent indicated that the strengths of approach were a clear critical path and limited the number of technical risks. The reviewer added that the start/stop is becoming mature, downsizing strategy with turbo was mainstream, and advanced dilute combustion was also moderate risk. Lean, dilute aftertreatment was most significant risk in approach, according to this reviewer. This reviewer also noted a simplified approach for other elements frees bandwidth to be considered, and that an additional strength was the clear timing plan. The reviewer identified that a weakness was consideration for driver response with a downsized engine. According to this reviewer, this was a historical issue which needed to be clearly placed on a technical challenge list and addressed. The fifth reviewer remarked that the approach was good as progress could be

achieved in phases as the engine becomes downsized and that the technological approaches of interest were added to the system. This reviewer went on to note that the approach built on existing engine technology and transitioned well to the newer technology. The reviewer concluded that it was good to see nice attention to the emission challenges via passive SCR.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One respondent emphasized good progress on controls, combustion/ignition, and aftertreatment. This reviewer felt there was a lot of work remaining for one more year. The second reviewer indicated that some good results were shown, but that it was hard to judge well on such short presentations. Another reviewer remarked that much of the data shown for the naturally aspirated engine may not be relevant to the boosted engine. This reviewer indicated that the lean aftertreatment would be challenging; not much was shown to assure that it has worked so far. The third respondent criticized that the technology demonstrated in Phase 1 needed improvement at higher load conditions, and that the needed improvement appeared to come from the stratified/boosted operation. The reviewer observed good progress and noted that the chart on Page 10 in the handout was in error. This reviewer indicated that the closely spaced injections have increased the range of lean operation. This reviewer noted that the higher ignition energy improvement in EGR limits looked very good, but questioned if the level of energy that was used to demonstrate this was feasible. The third respondent also commented that it was unclear as to whether adequate progress was made with the aftertreatment development. The commenter said that the obstacles were clearly identified, but asked if the move to active SCR, with passive at light loads was possible (i.e., what the low temperature efficiency was, if there were long-term efficiency concerns). The fourth reviewer reported that the strengths were the demonstrated fuel economy benefits at steady state of 10-20% and the preliminary results on the novel aftertreatment system called passive SCR, which produced ammonia. The same reviewer added that the active SCR backup was a strength that eliminated technical risk. The reviewer identified that a weakness was that no cycle fuel economy numbers were provided or projections/data for vehicle performance expectation and cost risk of poor consumer acceptance of active SCR system for lean operation. The reviewer added that a value analysis was needed for the technologies to insure a proper path. The final commenter felt that at this stage in the project, positive results were being shown for both fuel efficiency and emissions. The reviewer commended good attention to the driving map and identification of opportunities for fuel savings (by load/speed). The reviewer concluded that the Phase 2 findings of 90% lean operation capability over the FTP and highway cycles showed good promise for high impact

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that this part of presentation could have used more detail on exactly what the other team members had contributed. The second reviewer observed that solid suppliers were chosen for interaction. This reviewer felt that it was not clear how much was in-house versus suppliers. The third respondent observed that these collaborations were better than what GM had typically shown in previous DOE projects. The reviewer observed well-regarded partners in their areas of expertise. The reviewer also commented that it would have been helpful if the presentation could have made it more clear what the level of involvement that each had. The fourth reviewer noted that the strength was a good core team for combustion: Ricardo Fuel System and Bosch and Umicore for aftertreatment. The reviewer then pointed out that the project's weakness was that a high risk passive SCR system optimization may need additional support and benefit from national lab involvement or consideration of other suppliers to develop solutions. The final respondent mentioned good collaboration with suppliers, but no mention was made of university or national laboratory collaboration. The final reviewer asked if the project would benefit from collaboration with universities and/or national laboratories.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer emphasized that the future project path was acceptable and noted that hopefully there would be enough time for good vehicle calibration. The second commenter felt that the aftertreatment development needed to be integral with engine development and calibration. The reviewer added that development needed to move to the boosted engine and review system impacts. The third commenter stated that future activities looked good. The fourth respondent asserted that the strength was that the future work followed the strong plan with achievements shown already. According to this reviewer, a weakness was that the

communicated level of detail in the future work relative to technical challenges and risks could be improved (for example, how to address the consideration and the combination SCR active and passive system did not appear to be the most cost-effective solution and that the data was not provided). The reviewer added that it may be worthwhile to consider focusing on a decision gate to use SCR passive only or SCR active only but not both, unless the cost/value data can support both systems. The fifth respondent highlighted that it would be interesting to see performance once moved to a 1.4-liter system.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

There was unanimous agreement from the reviewers that resources were sufficient. The first respondent commented that the program was well-funded and supported large efforts. The second respondent indicated a good level of funding for an aggressive goal. The third reviewer felt that it was good to see a 50/50 cost share. The final respondent stated that the resources seemed barely sufficient for a lean-burn system and full vehicle demonstration.

Gasoline Ultra Fuel Efficient Vehicle: Keith Confer (Delphi Automotive Systems) – ace064

Reviewer Sample Size

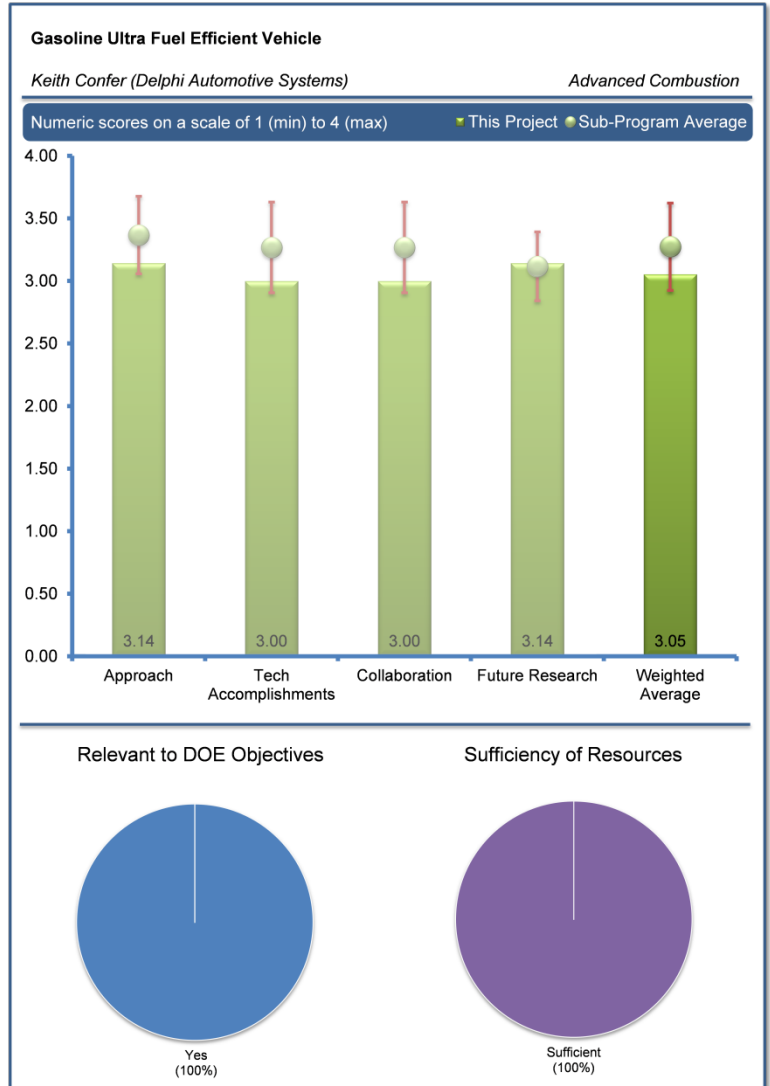
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent stated that the fuel economy improvement target was appropriate for supporting DOE objectives. The second commenter mentioned that it investigated a wide range of technologies to improve vehicle fuel economy, with major focus on a most-of-the-time lean-burn engine. The third reviewer noted that large fuel economy gains in LD vehicles would save lots of petroleum. The fourth respondent indicated that the project aimed to demonstrate a 30% improvement in fuel economy from a current baseline vehicle, and that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. The fifth reviewer mentioned that this project addressed improving the fuel efficiency of gasoline-powered passenger cars which dominates the U.S. LDV fleet; so, it does support DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent reported that the vehicle-level tasks were interesting, but were not particularly advanced technologies. To this reviewer, many of the tasks appeared to be minor refinements on already deployed technologies. On the other hand, this reviewer noted, the advanced combustion tasks appeared to be too much of a stretch for successful vehicle implementation in the timeline of the program. The second reviewer mentioned that the kitchen sink approach to friction reduction was fair for a demonstration, but that the features like roller bearings on crankshafts was an old idea and had been historically rejected for cost and durability issues. This reviewer asked what was new this time, and indicated that the engine valve control did not appear to be stretch technology. This reviewer noted that the GDCI approach was good in pushing technology forward, but the reviewers were not shown efficiency and emissions comparisons with DI diesel or GDI. Thus, this reviewer posited that the GDCI apparently needed SI for starting. In addition, this reviewer felt it was unrealistic to assume that the engine would not need aftertreatment. The reviewer noted being surprised that DOE did not challenge that more in the award process. The third commenter observed a good set of candidate technologies and aggressive combustion and engine design goals. This reviewer added that there was a nice set of loss reduction technologies to be evaluated. The fourth respondent stated that a suite of technologies was being employed to reach the targeted fuel economy improvement, and that these were aimed at parasitic (friction) losses, thermal losses, and advanced combustion. The reviewer stated that this project was certainly exploring all of the possible technologies currently available and that it looked like a nice combination of simulation and testing on a single-cylinder optical engine and multiple-cylinder engines. The reviewer indicated that all of this sounded good, but the reviewer criticized how the down-select process would happen from



Phase I to Phase II for all of the features. In addition, the reviewer asked what the evaluation criteria would be for the Go/No-Go phase review process. The fifth reviewer indicated that the approach of GDICI technology was good. The focus on injector technology was very relevant to this approach, according to this reviewer. The reviewer suggested that while the PM measurements were a valuable part of the approach, further demonstration of transient emissions relative to regulation drive cycles should be considered. The sixth respondent felt that the goal of no aftertreatment was probably overly optimistic. The last reviewer noted that the project stopped its original HCCI plan based on mid-term results and indicated that this showed excellent judgment and use of tax payer dollars. This reviewer also observed a 2011 Hyundai Sonata 2.0 L Theta turbo, an 80% new engine, and detailed that GDICI as best of diesel and SI. Referencing GDICI, the reviewer reported the following: high-CR and late multiple injections; gasoline vaporizes and mixes easily at low temperature (mixed enough); and gasoline PCCI (centralized mounted injector, pushing injection pressures down, multiple late injections, continually variable valve train, no classic knock, and diesel type piston).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One respondent felt that it was unclear that a fully calibrated PPC engine could be developed and installed in the vehicle in time for the end of the project. The reviewer felt the Phase 1 progress was good, though there was much lower uncertainty in the success of those technologies. The reviewer expressed concern about the parallel single-cylinder and multi-cylinder development, as changes in the combustion system may require changes in the boosting and other systems for best performance. Aftertreatment concerns also appeared significant with the current combustion approach, according to this reviewer. The second commenter noted that there was a nice achievement in completing the low-parasitics vehicle and was looking forward to the results. The reviewer observed lots of iterations and improvements on fuel injector designs, but that one would think that exercising models would have been sufficient without so many design and build iterations. The reviewer appreciated realistic conclusions on HCCI. The reviewer also noted that it was a little surprising that there was no multi-cylinder data. The reviewer added that there was also no substantive discussion of boosting system requirements. The third commenter remarked that the new engine design and features seemed to be making good progress and noted that a lot of work has been done. This reviewer felt that the presentation was too short to fully present the work done. The fourth commenter pointed out that the demonstrations were on schedule. The reviewer stated that very good progress was shown on extending the operating range of the GDICI mode of operation. The reviewer added that good progress was shown on simulations of spray and combustion, as well as the fuel injector configuration tests to select the best performer. This reviewer applauded the team for evaluating the particle emissions size and distribution. The reviewer noted that this would be an important consideration in the future, and seemed to be overlooked by a lot of the projects. The fifth respondent described that this project showed some excellent technical progress; in particular, the demonstration of lower PM emissions with (injector E) technology was a dramatic improvement in regard to PM emissions from DI gasoline engines. Furthermore, this reviewer indicated fuel efficiency and NO_x emissions were also significantly improved. The last respondent commented on plans for robust controls concerning sensing and changing timing. This reviewer noted a lot of faith was put in fuel injection.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer reported that there appeared to be a good partnership with other OEM/supplier/R&D entities. The second respondent affirmed that the team was complete with the exception of an aftertreatment technology organization. The third reviewer indicated that major suppliers, OEM, and academia were nicely integrated. The fourth commenter said there were good partnerships developed between academia and the industry. This reviewer assumed that the Hyundai participation was strictly from the North American center. The fifth respondent observed that the partners identified were HATCI, WERC, and Wayne State University; however, that it was unclear what benefits were being attained from these partners in general. The reviewer asserted that perhaps HATCI's benefits would be realized later in the project in vehicle phases. This reviewer questioned whether Wayne State University would model newer combustion techniques if its HCCI modeling work was completed. The reviewer noted that it would be good to see publications coming out of this project and that it was an important aspect of giving back to the public information related to technical accomplishments of this cost-shared program with U.S. taxpayer support. The final respondent noted WERC and HATCHI. This commenter emphasized that university involvement would be very beneficial and noted that WERC was a spin-off consulting group, and not a university partner.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent pointed out that the plans were good, but remained skeptical about the chances for success. The second reviewer noted that simulation was in future plans, but thought that would have been greater as a part of early work. The third commenter indicated this was a solid plan to continue moving forward. The fourth reviewer reported that future work appeared to be on target to reach the fuel economy goal. The reviewer noted that not much detail was given, just mostly general statements with regard to carrying out the Phase 2 plans. The reviewer added that the simulation appeared to play a larger role in Phase 2 than it did in Phase 1, which should help guide the project's decision making process. This reviewer questioned if enough attention was being put into model validation with the single-cylinder optical engine. The reviewer noted that maybe this did occur, but that there was not enough time to highlight this effort for the presentation. The fifth commenter stated that the authors had a logical path forward and were adjusting their vehicle plans accordingly.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated that there were sufficient resources. The first respondent reported that this was a well-funded program supported by a large team working on difficult technical problems. The second respondent expressed that the progress appeared to be appropriate at the current funding level.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Corey Weaver (Ford Motor Company) – ace065

Reviewer Sample Size

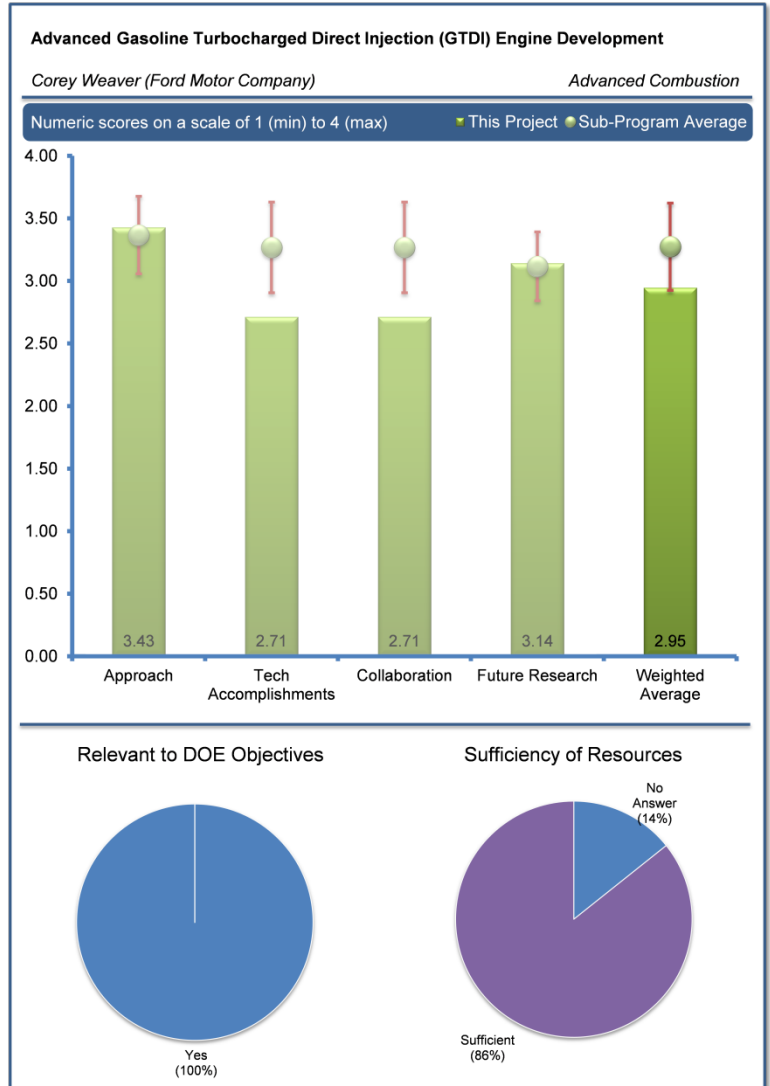
This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent noted that the goal of 25% fuel economy improvement fit with DOE goals. The second respondent affirmed that the project intended to achieve a greater than 25% gain in fuel efficiency of vehicles using main-stream engines (not niche technology). The third reviewer indicated that a larger fuel economy improvement for LD vehicles would save a lot of petroleum. The fourth commenter reinforced that the project aimed to demonstrate a 25% improvement in fuel economy from a current baseline vehicle, and that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. Another commenter agreed that this project addressed gasoline light-duty vehicle fuel economy improvement and, thereby, addressed DOE objectives of petroleum displacement for the U.S. fleet (which is dominated in LDVs by gasoline engines).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One respondent observed a good, progressive program plan with a suitable path from easy-to-implement technologies to higher-risk, higher-reward solutions. The reviewer would have liked to see more detail on how the different technologies would cascade to the MCE and vehicle timelines. The second reviewer affirmed a comprehensive approach of medium-to-high risk technologies, including stretching the current EcoBoost system to higher levels and also looking at lean-burn. The reviewer noted the excellent grasp of benefits and challenges of each step. The reviewer described use of a full VVA system to explore valve timing space as nice. The third respondent mentioned that a solid approach based from EcoBoost with added features for fuel economy improvement, but that nothing in the presentation addressed why lean versus stoichiometric; aftertreatment gets much harder, and what the benefit was. The fourth respondent criticized that the approach section of the presentation was lacking in details, but did become apparent through the accomplishments. This reviewer indicated that the combustion development use of simulation (MESIM) was a good approach, as well as the usage of a single-cylinder engine for initial program guidance. This reviewer further noted that the other components that appeared to be key elements of the overall approach included EGR, a composite intake air intercooler, electronic controlled variable valve timing, pendulum damper/active engine mounts, and aftertreatment. According to this reviewer, the use of the MTU combustion vessel to understand the limits of operation was excellent. The fifth respondent noted that the approach by the authors was solid. The commenter remarked that the approach builds on the Ford EcoBoost product family and thus leads to an achievable technology introduction to marketplace pathway. The commenter noted that the approach is to achieve fuel economy gains via various aspects of the engine system, and that the work is appropriately



addressing many potential opportunities in the system. Another reviewer noted EcoBoost GTDI and listed moderate downsizing, advanced dilute combustion with cooled EGR and advanced ignition, advanced lean combustion, and advanced aftertreatment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One commenter noted a lot of progress on the design and specification tasks. This reviewer emphasized the need to see data from the experimental hardware. The second commenter observed good progress in modeling, single-cylinder work, ignition studies, and multi-cylinder design. The reviewer noted that not much data was shown for SCE work. This reviewer stated that 12 engines and 5 vehicles were being built; with only 18 months left in the contract, the project appeared a bit behind schedule. The third reviewer acknowledged that nice results were shown and that it was hard to say too much in such a short presentation, but what was shown was quite good. The fourth reviewer reported that the accomplishments seemed to be on schedule, according to the timeline provided. This reviewer felt that it did appear that the multi-cylinder engine dynamometer tests may be a bit behind, but did not appear that it would cause significant problems. This reviewer expressed concern that the modeling effort did not continue during the multi-cylinder testing. The reviewer added that if the simulation had been adequately validated with the single-cylinder engine data, that it should be useful to continue to provide guidance and insight on the advanced combustion during multi-cylinder tests. This reviewer noted great use of the MTU combustion vessel. Another respondent felt that this project showed good technical progress in the areas of micro stratified charge, low P EGR, Electric tiVCT, and engine design. However, the reviewer added that more specific information on the different benefits that these technologies gave for various drive cycles was needed. Also, the reviewer noted that the combined drive cycle performance benefits were of interest. The reviewer concluded that it was good to see the approaches being pursued to address the emission control challenges (TWC, LNT+SCR, and etc.).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer highlighted the interesting advanced research at MTU, but felt that it was unclear how those results would feed into the overall program. The second reviewer stated that the project consisted of a small team. The reviewer added that it seemed an ignition system supplier would be needed. The third commenter observed that the presentation did not highlight a lot of collaboration; however, Ford is a large company and can contain much of this work in-house to their benefit, and thus the reviewer did not see this as a problem. The fourth commenter liked the MTU work and interaction, although MTU seemed to be the only organization in collaboration. This reviewer questioned whether the program would benefit from additional partners like an aftertreatment supplier or fuel injection company. The fifth reviewer said that while there did not appear to be a large number of collaborations, the work with MTU did seem to be benefiting the project by providing fundamental insight into the ignition and combustion processes. The last reviewer noticed very little collaboration, but that it was not really needed with an OEM that had all resources in-house. The reviewer concluded that this was somewhat a meaningless criterion for this type of project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter said that the program plans were suitable. The second reviewer observed lots of work left including the MC engines and vehicle calibration, with integration of aftertreatment. This reviewer questioned the integration of the new ignition system. The reviewer noted that this appeared to be a good project overall, and that it was likely to succeed and be commercialized. The third reviewer noted a solid plan to complete the program. Another reviewer stated that the proposed future research looked okay and added that there was not a lot of detail, but that the project seemed to be on target. The final reviewer pointed out that a logical path forward on the project was apparent. The reviewer added that it should be interesting to observe the combination of the engine technologies shown on the vehicle.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers were in agreement and indicated there were sufficient resources. The first respondent stated that the speaker had no respect for the other presenters, reviewers, or audience by going far over his allotted time. The reviewer suggested that the presenter prepare a more appropriate presentation length next year. The second reviewer observed a well-funded program with a large effort making good progress. The third reviewer commented on the overall presentation and that the presenter went way over

time. The final respondent felt this was the largest budget of projects reviewed in this session and that it was good to see a 50/50 cost share.

Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles: Hakan Yilmaz (Robert Bosch) – ace066

Reviewer Sample Size

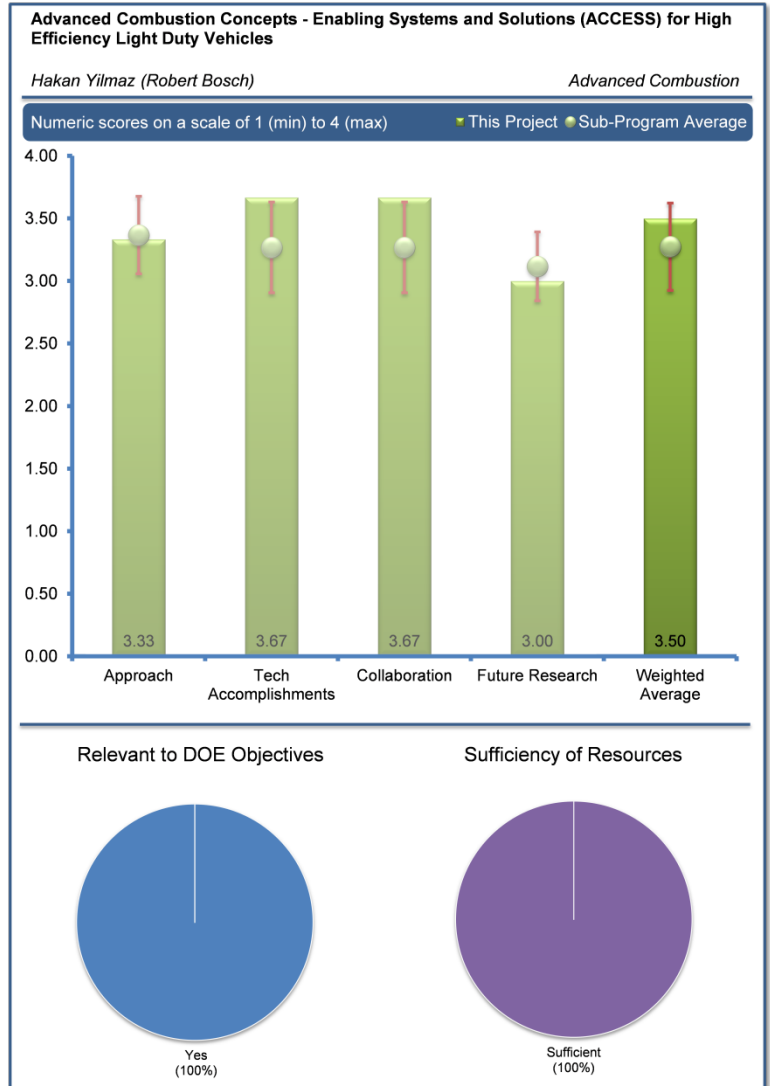
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated that a 25% FE improvement target was suitable. The second commenter reported an aggressive engine development program for higher efficiency and greater than 25% reduction in fuel consumption. The third reviewer reported that the project aimed to demonstrate a 25% improvement in fuel economy from a current baseline vehicle. The reviewer noted that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. The fourth reviewer affirmed that this project addressed DOE goals for energy security and petroleum usage reduction by pursuing advanced combustion concepts that could greatly improve the fuel efficiency of the LDV U.S. fleet.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent said that HCCI would be challenging to implement, but in the context of a multi-mode approach that it would be interesting to see how it turns out. The second respondent reported that the engine development program had a number of innovations and was generally aggressive on combustion and air handling. The reviewer added that it stays with stoichiometric operation and three-way catalyst for most of the operation that lowered risk. The reviewer noted that this program did not include vehicle improvements and questioned vehicle validation. The third respondent stated that the team had taken on a very comprehensive hardware arrangement that would provide many options for future direction. The reviewer indicated that the capability for multi-mode combustion flexibility looked like it had a high probability of success. In addition, this reviewer noted that the system would be capable of multi-fuel operation towards the end of the program, which would provide a good demonstration of the robustness of the approach. Another reviewer reported that the approach for this project was nice in that it combined expertise from a team of universities and industry companies into one common platform for fuel economy improvement and low emissions. This reviewer felt the coordination of all of the activities appeared solid, and the incorporation of various engine components looked thorough. Furthermore, this reviewer continued, the production-suitable (relatively) high capability ECU was a nice aspect of the project especially considering the multitude of controls and sensors that the project addressed. The final respondent pointed out somewhat vague responses regarding questions about aftertreatment plans.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent observed that there were clearly many engines and experiments running. The reviewer noted that it appeared that modeling results were providing useful guidance to hardware design and calibration. The second reviewer observed much progress on simulation and engine experiments running at multiple sites. This reviewer also mentioned that the progress was evident on HCCI controls theory and application. The reviewer noted a good list of publications. The third commenter reported that the engine demonstration of 33% fuel economy improvement with a downsized HCCI engine was significant. This reviewer questioned if a valid comparison was really being made here. The third commenter also questioned if targets had been achieved, or if the HCCI Prototype 1 engine was not a viable solution for production (i.e., controls and transitions) because this was steady state data. The reviewer added that this did not come across clearly in the presentation. This reviewer stated that the combustion modeling effort looked very good, and the use of model-based HCCI control looked to be making significant progress. The fourth respondent observed that the fundamentals of combustion had been studied, and multiple injector technologies had been evaluated. This respondent indicated that boosting with a supercharger and turbocharger demonstrated excellent reductions in BSFC with reasonably low NO_x emissions. This reviewer also felt the controls work was excellent and was extensive (covering cycle-to-cycle variations as well). Further implementation of the engine in transient drive cycles was needed and was of interest, according to this reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent reported that there was an excellent collaborative program with clear definition of roles and with clear technology transfer between the partners. The second reviewer said that the exceptionally strong team seemed well-coordinated. The reviewer noted Bosch representation at most team member sites to assist with hardware and experiments. The third commenter felt that this team had a good mixture of industry and academia members with an excellent definition of their individual roles. This commenter also noted that the vehicle platform to be used and the exact U.S. OEM (one or multiple) support role were not apparent. The team members looked to be well qualified to take on the approach of using extensive feedback and controls of the HCCI mode and transitions, according to this reviewer. Another respondent indicated that there was excellent collaboration in the project and that the various entities appeared to be operating in a nice team atmosphere. The final reviewer noted a very large international team.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the ongoing plans looked good for completing the project on time. The second commenter reported that the future tasks were well-defined for each team member. The third reviewer asserted that everything looked to be on target and looked forward to next year's progress. The final reviewer pointed out that while there was not a lot of detail on the future work, the plan would importantly include evaluation of multi-mode combustion and controls.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the respondents indicated sufficient resources. The first reviewer stated that no apparent lack of resources could be seen. Another reviewer commented on the very large budget. This reviewer offered that it was good to see a 50/50 cost share.

High Fidelity Modeling of Engine Combustion Systems: Sibendu Som (Argonne National Laboratory) – ace075

Reviewer Sample Size

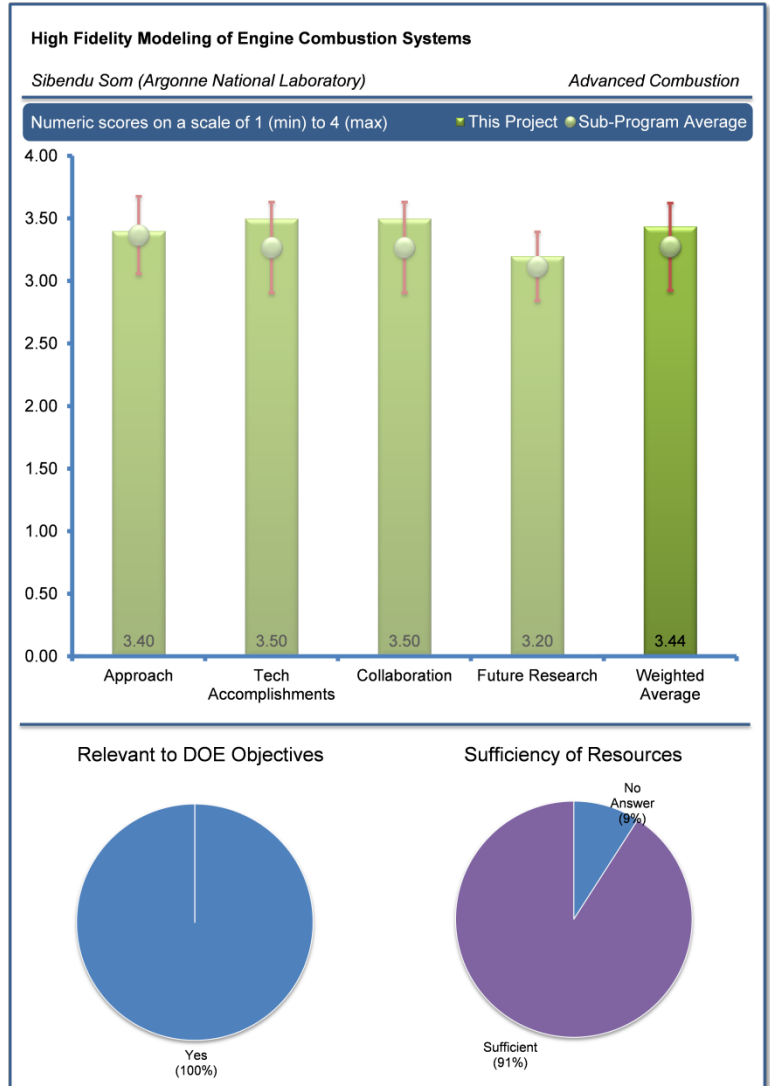
This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted the improved predictive capability of spray and combustion models. The second commenter explained that better simulation and predictive capabilities of fuel spray and combustion should enable the development of engines with lower emissions and better fuel economy which would result in lower requirements for fuel/petroleum. The third reviewer indicated good fundamental work on spray to support improved combustion models. The fourth reviewer emphasized that the linking of spray and combustion simulation with reduced processing time was significant in advancing combustion development. The fifth reviewer affirmed that improving spray modeling was important for predictive simulation tools that would be used to design future engines with greater efficiency and lower emissions. The sixth respondent pointed out that this fundamental spray modeling project was indirectly related to DOE goals by enabling a more precise tool for modeling the break-up process, which ultimately impacted spray formation, ignition delay, and the heat release profile that collectively impacts indicated thermal efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One respondent reported that the approach was focused on several important tasks in fuel spray and combustion modeling. The second respondent commented that the project had just begun. The reviewer indicated that the project would develop spray models particularly looking at the nozzle cavitation and focus on *n*-dodecane + *m*-xylene as a suitable diesel surrogate since it better mimicked diesel cetane characteristics. This reviewer questioned the number of cases studied. The third commenter noted that a clear focus on barriers and methods to improve. The fourth reviewer felt it was not clear what the benefit of dynamic coupling of nozzle flow and spray modeling was beyond the static coupling. To this reviewer, there was some question whether there was a sufficient plan to get nozzle geometry. This commenter questioned if the use of *n*-dodecane and *m*-xylene was enough to capture cetane effects of very diverse fuels in the United States. The fifth respondent questioned if there were synergies with Joe Oefelein's work. The sixth respondent reported that this project could be improved by more validation, since, to date, there has been a little bit of validation, but nothing extensive enough to conclude that the proposed break-up model is a big improvement over existing models. This reviewer felt the same statement could be made for the dodecane diesel fuel surrogate work. The final reviewer explained that this project if focused on understanding and modeling spray atomization and characteristics was a very critical industry need. This reviewer indicated this project aimed to develop spray breakup and spray combustion models that were closer to commercial viability and that could be used by the industry to affect engine design.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent felt that the KH-ACT (Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence) model seemed to do better job of matching x-ray data than the original KH model. The reviewer added that there was also better agreement with lift-off lengths and ignition delay. This reviewer mentioned the successful reduction of the *n*-dodecane mechanism which reduced computational time. The second reviewer noted that the work was developing the KH-ACT breakup model focused on aerodynamics, cavitation, and turbulence, and that the x-ray data was used to validate data. This reviewer noted the simulation of the impact of conicity to limit cavitation, and to identify interesting definitions for ignition delay and flame lift-off length. The third commenter noted that the project was just starting but that the plan looked good. The fourth reviewer reported that the results from the KH-ACT model were very encouraging for qualitatively capturing the effect of internal nozzle flow. The fifth commenter acknowledged very good work proposing and developing what appeared to be an improved break-up model near the injector nozzle orifice. Nevertheless, according to this reviewer, more validation was necessary covering a wider variety of boundary conditions including injection velocity, cylinder pressure/temperature, and nozzle design. The reviewer commented that the initial results were promising for this break-up model and also in reducing a possible diesel fuel surrogate fuel for ignition delay modeling. Another respondent indicated that very good progress had been made in model comparison to experimental data.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted good collaboration – including ECN. The second commenter reported a number of collaborations with industry (Convergent and Caterpillar, with Cummins pending); national labs (SNL and LLNL); and universities (University of Connecticut). The third commenter mentioned that the team was rather complete. This reviewer stated that it would be very helpful to partner with an industrial partner as the one mentioned here to have direct data and realistic conditions to relate to. The fourth reviewer noted that the connection to the ECN was important and added that playing a leadership role in the Spray A modeling for ECN. According to this reviewer, Argonne National Laboratory is the main group who is connected to CONVERGE, which is becoming more popular among OEMs. The reviewer noted that collaboration with OEMs was likely a direct result. The fifth respondent mentioned that this project included good collaboration between the PI, a university, other national labs, and two HD engine development partners. The last respondent stated that very good collaboration existed with several partners. The reviewer added that the possibility of immediately using the model results by industry was greater.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One respondent reported that plans to continue work on nozzle simulation, further mechanism reduction and development of diesel surrogate model, and improving efficiency and scalability of models would build on and add to current accomplishments. The second respondent suggested that the project defined early on the scope of injector nozzle geometry selection. The reviewer noted that this work was necessary to ensure the results were broad enough to have a reliable model that is valid across a range of geometries. The third respondent felt that it would be important to determine how critical the dynamic coupling was relative to static coupling. The fourth respondent found that this was a good plan overall for future research. This reviewer suggested more validation with wide varying spray boundary conditions and also suggested a closer partnership with the two industry partners to aid in the validation of both the spray model and reduced diesel fuel chemical kinetics surrogate. Another reviewer observed that so far only diesel spray was being studied. This commenter suggested that gasoline sprays should be included.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers who responded indicated sufficient resources. One respondent said that resources seemed sufficient. Another respondent stated that the project appeared funded well enough especially given its computational focus. The reviewer added that any additional funding should be used for experimental validation.

Advanced Numerics for High-Fidelity Combustion Simulation: Matthew McNenly (LLNL) – ace076

Reviewer Sample Size

This project was reviewed by ten reviewers.

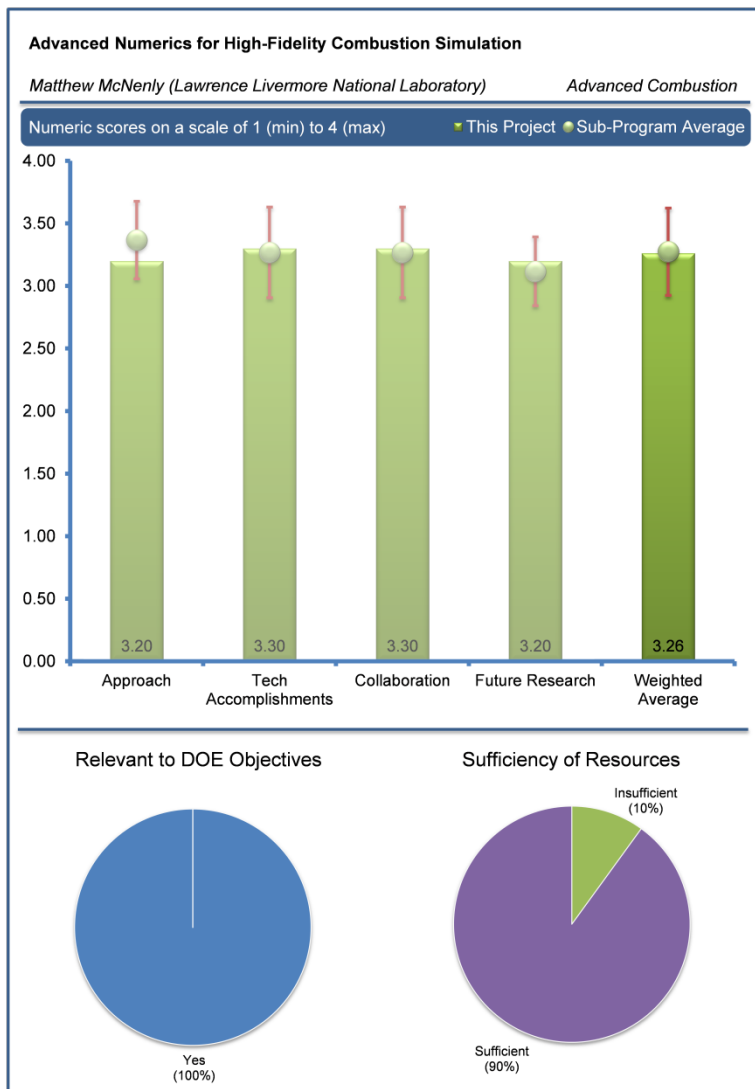
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent noted that the reduction of computational costs to solve detail kinetics in an effort to improve modeling of combustion for supporting design of high efficiency engines would accelerate research. The second commenter indicated that improving computational speed was necessary to allow accelerated development of highly efficient combustion processes. Another reviewer mentioned that CFD tools were essential for combustion system optimization and combustion research, both of which were critical components to increasing efficiency of engines. The reviewer added that increased modeling efficiency without sacrificing fidelity would be essential as models continue to increase in complexity through the use of chemical kinetics and more complex turbulence models. The final respondent emphasized that this project was linked to project ACE012 and was evaluated with the same grading as that project. The reviewer added that it was too difficult to discern the difference between these two projects and that this same grading approach seemed reasonable. This reviewer stated that this project could supply tools that run at reasonable computing times with

decent accuracy for engine developers considering homogeneous combustion modes for gasoline and diesel applications as a means to improve upon today's engines thermal efficiencies at various operating conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer reported that this project has done a good job at identifying the key components that are limiting speed of kinetics modeling and addressing them. While other projects focused on creating models that are faster, this reviewer felt this project recognized that the mathematics and computer architecture may not be optimized for engine problems, and then set out to improve them. Another reviewer felt that the modeling approach was reasonable, but that validation was a concern. The reviewer noted that there appeared to be some level of validation, but it was limited to a few selected operating points. The reviewer added that more validation based on real engines was necessary for continual improvement in the clever multi-zone with chemical kinetics modeling approach. The third reviewer observed that this project bridged the gap between the detailed fundamental chemical kinetic mechanisms and the need for combustion software to model engine combustion by reducing computation cost. Therefore, this reviewer noted that it made use of recent advances in computers and computing methods. The fourth reviewer stated that the team decided to work on new algorithms to speed up CFD calculations (new chemistry integrators, new thermochemistry software and solvers) and that the methods were beyond the expertise of the fourth reviewer and could not be judged.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter stated that this was interesting work on implicit methods to integrate time scales over an engine cycle. This evaluator stated that this work looked into the physical meaning of the Jacobian matrix of the system's set of differential equations to improve the solver proposed here. The second reviewer remarked that the speed of computation without loss of accuracy was quite impressive. The third respondent felt that the improvement in chemistry computation speed was great, and licensing to commercial codes like Converge would have a large impact on industry. Another reviewer noted that the speed up achieved relative to previous computations was very impressive. The reviewer noted that it was now to a point where others could start using it to speed up computations. The fifth respondent affirmed that the reduction in computational times without a loss in accuracy was impressive. At this rate, the reviewer indicated, there is hope that complicated chemistry modeling could be used for the analysis of engine performance data in the not too distant future. The final reviewer noted that there was good progress during the past year with the multi-zone work and that it would be helpful to see more comparison with a larger set of experimental data; also validation was lacking a bit.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer reported extensive interactions with the industry, national labs and universities. Another commenter mentioned that the suite of LLNL projects on combustion simulation had potential to deliver huge gains for modeling combustion. Although there was good collaboration, the reviewer suggested that it would be even better if these were all managed under a single lead to manage resources and priorities. The third reviewer indicated that the plan was to make the new solvers available to the combustion modeling community. In the future, this reviewer noted, it would be important to consider how to provide improvements to the combustion modeling community quickly to maximize the impact of this excellent work. Another commenter reported that this project had strong collaboration historically with other national labs, universities, and certain industry partners. According to this reviewer, it appeared that much progress has been made in the last two years and the multi-zone work in particular has drawn great interest from the research community due to its reduced computational time and apparent accuracy in comparison to CFD at select operating points. The fourth reviewer noted that very good collaboration existed with Convergent Science, GT-Power, Volvo, etc.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent suggested that the project continue to explore strategies for improving efficiency of CFD and chemical simulations. The second reviewer remarked that high fidelity combustion simulation on a desktop PC was a worthy goal. Another reviewer acknowledged that the computational aspects of the planned future work were reasonable, but that validation was really lacking in future plans.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The majority of reviewers indicated sufficient resources. One respondent noted this was an adequately funded modeling project. Another commenter stated that this project could do with more funding which could accelerate the development of computer codes that were within the reach of the industry.

CRADA with Cummins on Characterization and Reduction of Combustion Variations: Bill Partridge (Oak Ridge National Laboratory) – ace077

Reviewer Sample Size

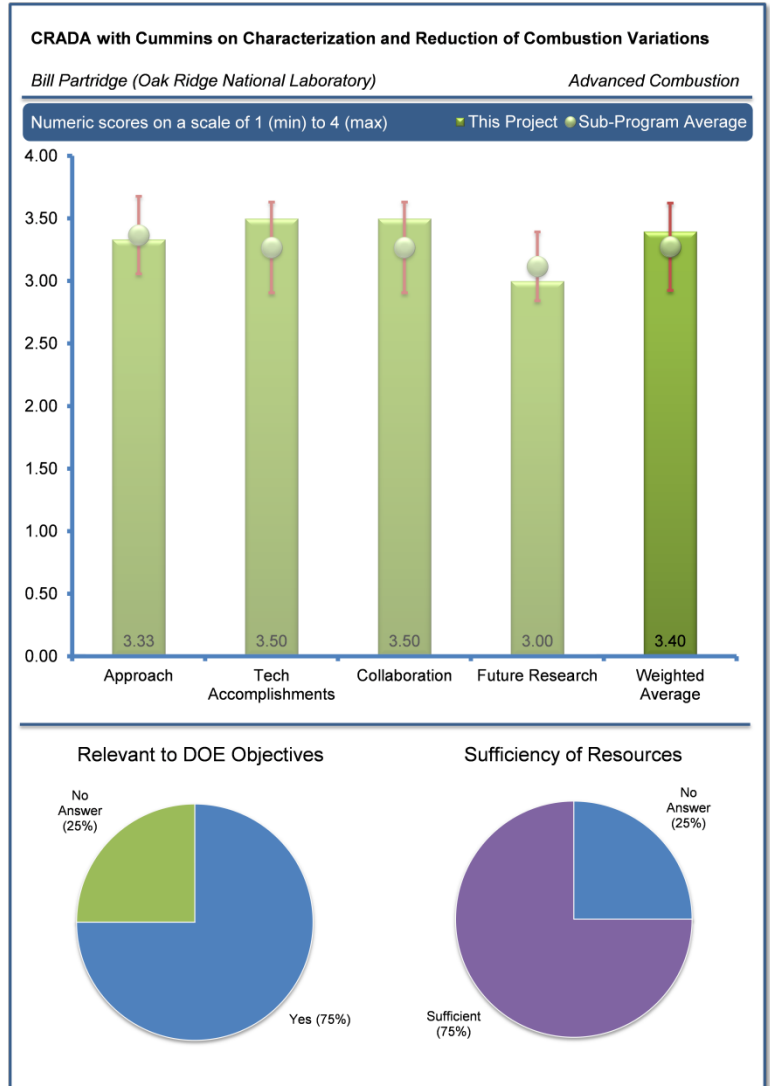
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers were in agreement that this effort supported petroleum displacement objectives. The first respondent remarked that reducing cylinder-to-cylinder mixing variations had always been recognized as necessary to improve both fuel economy and reduce emissions. This reviewer indicated that this instrumental design provided the measurement technology to be able to accomplish this. The second reviewer stated that broadly, the program aimed to develop advanced diagnostics for improved engine design (controls, etc.) for improved efficiency and reduced emissions. As noted by this reviewer, in the past year, the focus had been on the effect of EGR uniformity. Further, this reviewer stated that a new probe for single point measurements was developed and preliminary data was acquired on a representative Cummins engine showing that the EGR fraction varied as a function of spatial location (highest near the wall and lower away from the manifold wall). This reviewer felt these results provided additional information that a single line of sight measurement could not provide. This reviewer acknowledged that this was all very nice experimental work. In general, however, this reviewer indicated it would be helpful to better understand how the data would be used and specifically understand the correlation between the EGR uniformity and the combustion figures-of-merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

There was general consensus regarding the approach. The first reviewer noted that it was a really cool approach to getting in cylinder gas distributions. Another reviewer stated that addressing multi-cylinder robustness issues (cylinder-to-cylinder effects) was good. The final respondent reported interesting results, overall. This reviewer noted that the correlation between the EGR results and the actual combustion performance was not discussed. According to this reviewer, if the sensitivity of the combustion process was shown to be highly dependent on the EGR fraction, it would be a strong case for demonstrating the need for high resolution single point measurements using the new probe and the proposed development of laser-based techniques for even higher accuracy measurements (future plans). The reviewer added that it was not clear that such high accuracy measurements were needed. In addition, the commenter added that there needed to be a stronger tie between the EGR fraction and combustion performance and emissions.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

There were mixed results regarding the project's technical accomplishments and progress. The first reviewer indicated that this was a difficult experimental technique, but that the project seemed to have been quite successful. Another reviewer noted the ability to measure EGR variations across a region of the engine. The reviewer added that now there was a design for a system that could use single point access and that it could run for hours to a day. According to this reviewer, the data can be translated and in one case showed large variation in what went into the cylinder, depending on which cylinder it was relative to EGR input. This reviewer noted that one can see variations in the five millisecond time scale. The third reviewer reported that the value of this project was clearly the diagnostic tools development. The reviewer observed that hardware development (i.e., mixer design) is engine dependent and was not so interesting. This reviewer also reported application to LD gasoline engines as the project team begins to employ cooled EGR. The final commenter emphasized that the key technical accomplishment was to develop a new single point, faster response probe for EGR measurements showing that the EGR fraction was not spatially/temporally uniform. The same commenter recommended clarifying the importance of this effect to further justify the need for high accuracy single point measurements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There was general consensus among reviewers concerning collaboration and coordination efforts. The first respondent noted that there appeared to be a strong relationship to Cummins. There was not clear indication that this device had been used yet at Cummins. The second reviewer reported strong collaboration with Cummins, as Cummins is the partner in this CRADA and no others. The reviewer noted that the work at Cummins was by ORNL people. The third commenter agreed that there were strong collaborations with Cummins.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent noted that the proposed future research seemed to be reasonable. The second reviewer suggested tying the measurements to the combustion performance and emissions to further justify the need for high speed, single point EGR fraction/species concentration measurements.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers indicated that resources were sufficient. One reviewer commented that there was no indication that this project was limited by funding.

Mixed Oxide Catalysts for NO Oxidation: George Muntean (Pacific Northwest National Laboratory) – ace078

Reviewer Sample Size

This project was reviewed by seven reviewers.

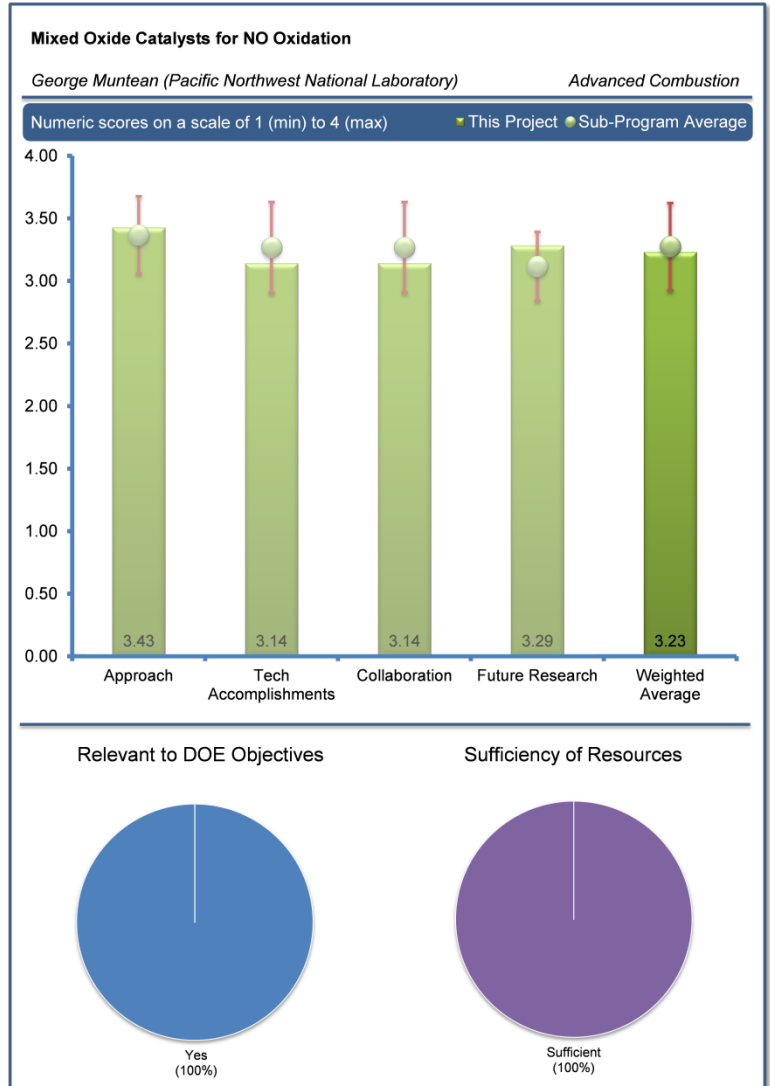
Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that the effective catalysts that require less or no platinum-group metals would help reduce the costs of clean high-efficiency vehicles. The second reviewer reported that understanding both the deactivation mechanisms that impacted the temperature window for SCR reduction performance, and the development of effective HC absorber materials that operate at lower temperature in the presence of water, were important enablers for advanced combustion technologies which left less exhaust energy available for emissions catalysts. According to this reviewer, these technologies, with lower PGM content, showed the potential to achieve mandated emissions standards while employing lean gasoline and diesel combustion strategies. The third respondent noted that reducing LNT costs was an important step to enabling high-efficiency lean-burn engines. Another reviewer affirmed that lean aftertreatment was an enabler for higher fuel economy. The fifth respondent agreed that this project supported the objective of petroleum reduction peripherally through potentially reducing aftertreatment costs for NO_x and offering solutions for low temperature combustion. Strategies for lean operation generally produced more NO_x and advanced combustion techniques like RCCI and PCCI have low exhaust temperatures. The final reviewer indicated that the work just recently began in late 2011 and noted that a clear path forward was outlined with a focus on better understanding of mixed metal oxide substrates and metal doping on NO oxidation. This reviewer noted that the program had both an experimental characterization assessment components with some preliminary work done to better understand NO oxidation on ceria by DFT.

Strategies for lean operation generally produced more NO_x and advanced combustion techniques like RCCI and PCCI have low exhaust temperatures. The final reviewer indicated that the work just recently began in late 2011 and noted that a clear path forward was outlined with a focus on better understanding of mixed metal oxide substrates and metal doping on NO oxidation. This reviewer noted that the program had both an experimental characterization assessment components with some preliminary work done to better understand NO oxidation on ceria by DFT.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent stated that the approach to address the project objectives was fairly sound, but that there appeared to be alternative materials that may be more effective at achieving the intended results. The reviewer noted that work done by others, including Honda, shows that yttria incorporation showed enhanced performance for CO and HC oxidation which could be extended to NO oxidation. The second commenter indicated that there was a clear delineation of tasks between partners. This reviewer identified that a specific focus was on replacing platinum in LNT to reduce cost fluctuations. Another respondent stated that lower cost catalysts were needed; platinum substitution with base metals was favorable for lower cost. In addition, this reviewer felt that the project may benefit from early catalyst supplier involvement. The fourth reviewer reported that the strength was the selection of most likely candidates to replace platinum in catalysts and sound analytical methods. A project weakness identified by the reviewer was that although candidate materials and processes were sound, the approach did not include an



assessment of alternatives or state-of-the-art in the presentation. The fifth commenter indicated that the approach was well-defined. This reviewer noted that catalytic reaction and catalyst characterization tests had begun. This reviewer also indicated that interesting questions were raised pertaining to the underlying mechanism responsible for lower reduction temperatures for MnO_x with CeO_2 , etc. The final commenter stated that the approach was reported as preparing and evaluating potential catalyst formulations. This reviewer questioned how PNNL and GM were selecting and refining the candidates and if it was because the PI worked with manganites in SOFCs as he mentioned during the Q&A. This reviewer felt that the audience questions and comments seemed to indicate a broad appreciation of the work; this reviewer noted that this work was outside the reviewer's areas of expertise, and suggested to evaluate comments accordingly.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that some progress had been made, but that it was still early in the project. The reviewer pointed out the table on Slide 12 where the presenter said that the trend in lattice dimension is down, but what little trend there was not smooth. The second reviewer indicated that durability and sulfur tolerance were not well known and that the project should address durability as an important component to the work. The commenter noted that if the project cannot demonstrate hydrothermal or sulfur regeneration procedures, then this must be addressed. However, according to this reviewer addressing low temperature activity would be an important aspect of future aftertreatment solutions. Another commenter felt that the manganite materials were interesting because they may be more stable to reduction and sulfur-resistant. The reviewer added that the Science article did not use supported materials. The fourth commenter observed that this project had just started in the fourth quarter of 2011, therefore accomplishments were limited, but the approach seemed good. The fifth respondent warned that the test conditions so far seemed like ideal conditions and may not be indicative of vehicle operation. The reviewer added that aging was unclear and that it was also not clear if these materials would survive deSOx. Another respondent mentioned the limited results, but indicated that a project strength was a systematic completion of a plan. The reviewer commented that it was a good indication about the impact of Ceria and use of Mn. The final reviewer highlighted that a number of samples had been formulated by GM and characterizations studies at PNNL have begun. The reviewer added that the preliminary results obtained aimed at improved understanding of the reaction mechanism for NO oxidation on CeO_x , MnO_x , and mixed metal oxides. The reviewer concluded that interesting questions were raised related to the importance of bulk versus surface effects on NO oxidation with the catalysts being evaluated.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There were mixed results among the reviewers regarding the project's collaboration and coordination. The first reviewer stated that PNNL was working with a major automotive OEM (GM) and that a catalyst supplier could be a worthwhile addition to the team. The second commenter felt that GM and PNNL contributions were fairly clear and essential. However, the reviewer perceived that the contribution from Tianjin University was not clear. According to this reviewer, it appeared most of the work had been contributed by the national lab and GM directly. Another respondent also questioned how Tianjin was involved. The fourth reviewer acknowledged that the academic partner is Tianjin University, which has reportedly developed some interesting nanospherical and hollow spherical catalyst materials, yet the contribution to the program was not clear from the presentation, so the reviewer asked for clarification on this point. The fifth reviewer indicated that CRADA with GM was leveraging partners' core capabilities and also hosting a Chinese student from a university that would be providing some new material samples for testing. The sixth respondent reported there was good collaboration with the industry. The final commenter stated for scope and level of funding was good. The reviewer also added that a strength of the collaboration was the connection to an OEM and a national lab. The reviewer concluded that a weakness was identification of catalyst supplier or consortium state-of-the-art.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter reported that not much detail was given regarding future work. The reviewer noted that what was there appeared reasonable. The second reviewer stated that while this was a CRADA, benchmarking of results with other work in this area might benefit the project. In addition, this reviewer noted that the metrics did not seem to be clearly defined in the presentation. The third respondent affirmed that a strength of the proposed future research was to follow the plan. The reviewer

noted that the project was just getting started. The fourth respondent noted that generally, there was good direction for future work, although the contribution of Tianjin University was not well understood. The final reviewer observed that catalyst characterization studies and DFT modeling were proposed. The reviewer added that it would be nice if the DFT calculations could provide new insight into NO oxidation on mixed metal oxides and guide the catalyst synthesis and characterization testing. The reviewer noted this was perhaps premature.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers all agreed that the resources were sufficient. One respondent reported that DOE funding was \$150,000/year for three years with a 50/50 match from GM and that this funding level seemed reasonable for the level of effort discussed. A second reviewer agreed that the funding did not appear to be an issue for achieving the stated goals within the timeframe allotted. The third reviewer asserted that this was a relatively low budget project but seemed to be addressing an important need. The final respondent pointed out that there was a reasonable work scope considering the funding.

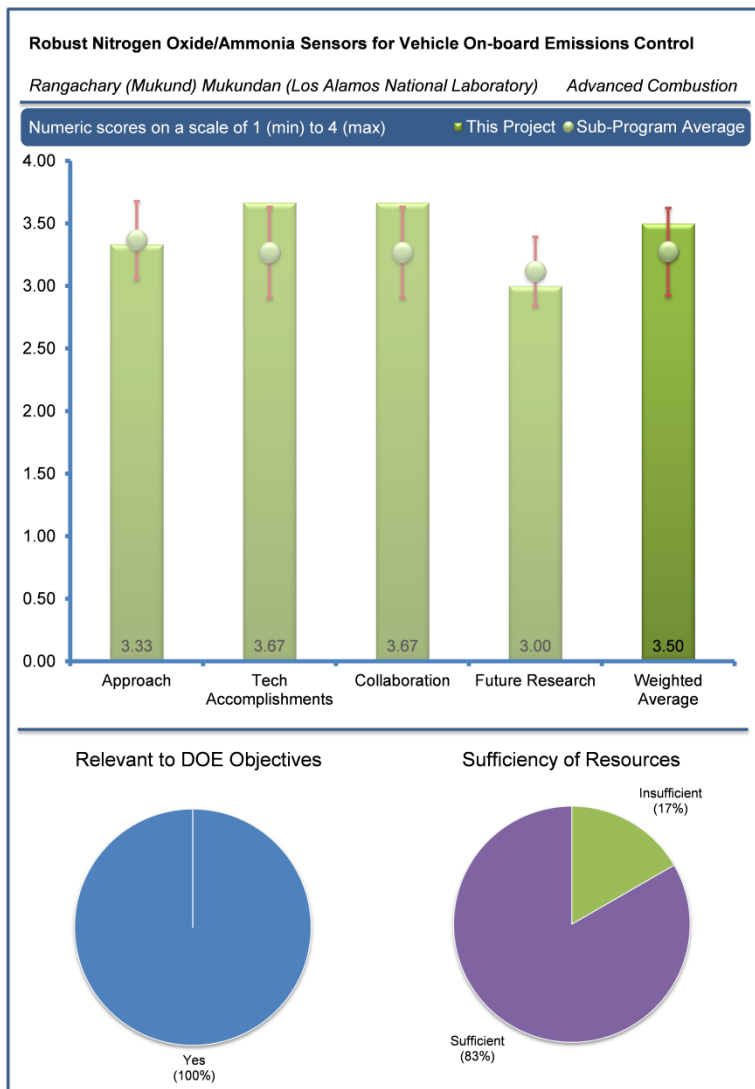
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control: Rangachary Mukundan (Los Alamos National Laboratory) – ace079

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback was positive in this section. The first respondent explained that a NO_x/NH₃ sensor would assist greatly in closed-loop control of urea SCR catalyst, thereby enabling the OEMs to meet emission standards with higher fuel efficiency. The second respondent agreed that the automotive grade sensors for NO_x and ammonia were important for emissions control compliance of high-efficiency engines. Another respondent asserted that these sensors were critical to enable the cost-effective use of emission control systems and to meet OBD requirements. Furthermore, this respondent explained that monitoring the state and activity of a LNT or SCR were essential to a viable NO_x reduction system. The fourth respondent commented that yes, this would enable a diesel or lean-burn engine technology into the market with a lower cost NO_x sensor for control. The fifth respondent remarked that NO_x and NH₃ sensors were essential for future OBD of a lean NO_x emission control system. The sixth respondent encouraged DOE to have more sensor projects in its research portfolio.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments received in this section were generally positive. One of the reviewers stated that focusing on a production-viable solution was good. Another reviewer expressed that this work represented a more novel approach to preserve the reactants until they reached the electrodes so that they have increased sensitivity. The third reviewer observed that this appeared to be an extension of previous work and further opined that the most appealing part of the approach was the attempt to use all of the manufacturing advances for oxygen sensors to make this NO_x/NH₃ sensor more cost efficient. The fourth reviewer offered that the approach seemed acceptable to try a dual sensor for NO_x and NH₃ because the current, commercial NO_x sensor had interference and could not differentiate. This reviewer pointed out that the reduction in platinum usage was attractive, but that the approach needed sharper focus on sensor durability and interferences in real exhaust gas. The fifth reviewer remarked that a very specific approach was presented and followed. The same reviewer suggested that testing in an actual engine exhaust environment would be interesting to see, especially due to the interference shown when multiple gases were present. Another reviewer explained that while this technology seemed to be good for both NO_x and NH₃ with the approach taken, it did not allow for NO and NO₂ measurements. This reviewer queried whether there could be a Phase 1 sensor that would just provide NO_x and NH₃, and a Phase 2

sensor that would provide the ability to measure NO and NO₂. The seventh reviewer reported that a two electrode system was done (i.e., one for NO and NO₂, and one for NH₃).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was generally mixed in this section. The first commenter noted that accomplishing a +/- 5 ppm for both NO_x and NH₃ on the same sensor is a substantial accomplishment. The second commenter opined that good progress had been made on testing in a laboratory setting with different gases to simulate the engine exhaust. This commenter also observed identification of a few issues that would hopefully be investigated in more detail during the proposed follow-on work with Caterpillar. The same commenter added that it had shown good promise to significantly reduce the cost, close to that of the conventional oxygen sensor, given its simplified design compared to the current commercial NO_x sensor technology. Another commenter described progress on the sensor so far as very good and indicated a desire to see results from a full exhaust gas feed. Also, this commenter noted that the stability of the sensor needed to be improved, but the commenter did not see a clear plan of how to do that. The fourth commenter expressed that using sensor material that was not reactive with the gases was useful for increasing the sensitivity of a NO_x detection device. This commenter further explained that diffusion through the porous layer was not reactive, therefore preserving a more accurate accounting of the exhaust feed. In order to meet future emissions standards, added this commenter, accurate detection of low concentrations of NO_x species would be required. However, the reviewer claimed that more work must be performed with more realistic gas feeds to determine the interaction and interferences of other interfering species. This commenter pointed out that distinguishing between NO and NO₂ could not be done without changing the bias on the sensor, but that the response time may be too long to be effective. The same commenter recognized that the measurement of NH₃ would require a separate sensor to also account for interferences with NO_x species. This fourth commenter noted that N₂O was also increasingly important, but not a part of this study, and inquired how this compared to competitive sensors (performance and cost). The fifth commenter stated that NO could not be separated from NO₂ and NH₃. The sixth commenter was unclear regarding the cost reductions achieved, and further remarked that new sensor durability under exhaust gas conditions like repeated filter regenerations were unknown and not presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were positive. One respondent described the collaboration with Caterpillar as promising. Another respondent indicated the interactions with industry sensor producers seemed to be very strong and greatly assisted this project. The third respondent recognized collaboration with ESL, who had expertise in sensor manufacturing for high volume production, which allowed better batch-to-batch reproducibility. This respondent highlighted the partnership with Custom Sensor Solutions (CSS) to stabilize the temperature, because temperature stabilization must be controlled tightly. The fourth respondent observed good collaboration with ESL and CSS for ensuring commercial manufacturability of a potential end product. The final respondent also saw good collaboration with ESL and CSS and inquired who the project team planned to work with to get the sensor to the market.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was somewhat mixed. The first reviewer remarked that the plan going forward looked good with respect to multi-component gas feed and, eventually, engine testing, but pointed out that it was less clear how sensor stability was to be improved. The second reviewer observed this project was very near its end, but noted that future work had been proposed as part of a new project, which would evaluate the NO_x sensor in actual engine exhaust with Caterpillar. The next step when this project ends, as stated by the third reviewer, is to approve a project with Caterpillar to test a sensor at their facility under realistic conditions. However, this reviewer cautioned that interference problems with a mixture of interferents must be resolved. The same reviewer added that the ability to distinguish NO, NO₂, NH₃, and possibly N₂O was required. This reviewer further observed a new proposal to diagnosing the sensor for OBD. The fourth reviewer stated that the project was awaiting funding.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The respondents disagreed regarding the adequacy of project resources. Five respondents indicated that resources were sufficient, while another respondent reported that resources were insufficient. One respondent believed this project should be extended or have a carry-on version, while a second respondent observed that the project had progressed well with the given resources and was very near completion. The third respondent remarked that resources were appropriate, and the final respondent saw no issues with resources.

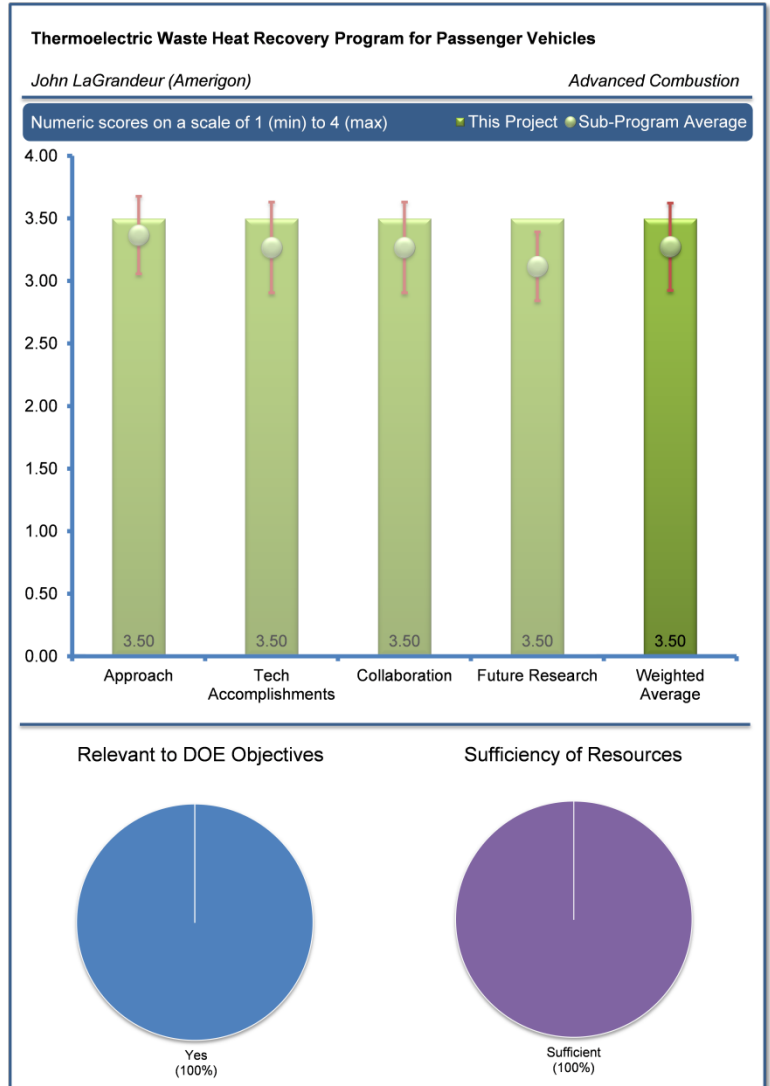
Thermoelectric Waste Heat Recovery Program for Passenger Vehicles: John LaGrandeur (Amerigon) – ace080

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall feedback in this section was positive. One evaluator indicated that development of low cost TE materials and engines was highly relevant to DOE's effort to integrate thermoelectrics in vehicle platforms, and further asserted that the target of achieving high efficiency with TEGs was very relevant. The second evaluator reported that the goal of this 2011 completed project was to achieve a 10% FE improvement, which supported the DOE objective of reducing petroleum consumption. Another evaluator agreed that the fuel economy improvement goal supported the DOE objective of petroleum displacement. The fourth evaluator described that the program run by Amerigon/BSST offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this evaluator, there are two major ways fuel consumption would be reduced: compression cooling system on present cars can be removed such that the belt-driven mechanical load on the engine is reduced; and the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This evaluator concluded that the effort by Amerigon/BSST appeared to be an excellent program with significant merit.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were positive in this section. The first reviewer opined that the Amerigon/BSST approach was the best in the business, and observed the project team adopted a novel device structure that seemed to solve critical issues in TE power generation, such as differential thermal expansion. In earlier work, explained this reviewer, the project team selected device materials that gave reasonable ZT, but gave the most impressive power output, overall. In subsequent work and with higher quality materials, this reviewer opined that these power output values should only be more attractive. The second reviewer remarked that this project has shown the complete process of materials selection, system design, and prototype demonstration of thermoelectric waste heat recovery. Furthermore, this reviewer pointed out that the approaches have been focused on solving the technical barriers. Another reviewer expressed that the task of addressing production costs and manufacturability of the cylindrical TEG developed in past years was relevant to commercial viability, and described the incorporation of half-Heusler materials as good. This reviewer also acknowledged that further development of the cylindrical TEG (e.g., better control of gas through the system to more precisely determine locations for the TEG) and developing strategies for improved manufacturing were appropriate. The same reviewer praised the project team's very good understanding of the challenges of the TEG design, and noted that design

improvements would result in reduction of the overall, physical size. This reviewer concluded that integration of the TEG into Ford and BMW vehicles included developing better atmosphere control through installation of gas ports in the outer shell. The fourth reviewer reported that the phase five objective was to improve the design of the cylindrical TEG and integrate into the BMW and Ford vehicles, and further commented that the prototype was delivered and tested. This reviewer observed that the heat exchanger design was carefully optimized to control TE locations, hermetically sealed enclosure. In Phase 5, added the reviewer, stacked TE designs were made and tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback was generally positive in this section. One of the respondents remarked that Amerigon/BSST showed the largest overall power output, and employed a novel cylindrical design. Additionally, continued this respondent, the materials choice (half-Heusler) and cylindrical design decisions had really paid off. This respondent further opined that the project team was currently leading the pack and was best-in-class. The second respondent observed that the team appeared to have completed the 2011 milestones, including TEG building and testing, dynamometer testing at NREL, delivery of a TEG to BMW and Ford, and completion of system evaluation in BMW and Ford vehicles. The same respondent further reported the following, completed activities: road tests were carried out and TEG power measured; dynamometer tests were carried out on BMW's six-cylinder engine; and independent confirmation of results was accomplished at NREL. Another respondent summarized that an actual prototype TE device was designed, built, and implemented on BMW and Ford automobiles. Further, this third respondent explained that TE material was half-Heusler, crossflow HX, hermetically sealed with stainless tubing to eliminate material degradation. This respondent remarked that the focus was on delivering the prototype and performance testing. Additionally, according to this reviewer pressure transducers monitored the pressure drop in the system, and the bypass valve allowed lower pressure drops to avoid engine performance degradation. Approximately 500 W on a 500°C hot side was achieved in a test bench at Amerigon. The same respondent further described that the BMW test data showed 400-450 W of power at 120-150 km/hr, while Ford Lincoln data showed 250-300 W at about 65 mi/hr. Although this respondent commented that it was not clear what this translated to in terms of fuel efficiency and that work remained to be done to go to the next step, the project was one of the few ones, overall, with encouraging data. The fourth and final respondent stated that the technical accomplishments of the project were impressive, especially the demonstration of power output on Ford and BMW vehicles. However, this respondent noted a few issues remained to be resolved in the area of materials and module design. Referencing the materials area, this respondent pointed out that although half-Heusler was used in the final generator, it was stated that this was not going to be the final material of choice for TE devices. Based on a recent literature report, this respondent suggested that this decision seemed to require a second look. If the properties of the half-Heusler materials could be verified, the same respondent also recommended that it may be worth a second look because there had been a lot of experience built upon this material during the project. Referencing the module design, this final respondent observed that an inappropriate power form was identified in Slide 7. This respondent concluded with an inquiry regarding whether the requirement of serial and parallel combination of TE couples was going to complicate the heat exchanger design and how the new design was going to affect cost.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were positive. The first commenter indicated that Amerigon/BSST have partnered with well-respected experts in the field in academia, as well as in other small business and large business. This commenter further remarked that the project team had a good perspective – that teaming was the path towards successful completion of DOE goals. Another commenter observed that the collaboration between BSST, Ford, BMW, and other team members has been excellent. The third commenter stated that the collaboration with BMW and Ford was very good, and had been essential to the success of the TEG designed ultimately developed. The fourth commenter reported OEM partners were BMW and Ford, and noted that other partners included Faurecia and Visteon, California Institute of Technology (Caltech), Virginia Polytechnic Institute and State University, JPL, and NREL. This commenter explained that Faurecia provided input on the bypass valve and component design, whereas ZT Plus and Caltech provided support in material characterization.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were generally positive. One evaluator expressed that future research (in Waste Heat II) had been planned well, and that based on the experience in Waste Heat I, this team had very promising potential to succeed. The second evaluator stated that Amerigon/BSST have considered and rationalized plans to continue the project team's effort towards making DOE succeed in reducing fuel demand and using available fuel more smartly. Another evaluator reported that future work would include the following: a greater number of smaller TE devices; desired fuel efficiency gain was 5%; and economic analysis. This evaluator opined that it was not clear whether the project team would achieve the 5% improvements with the choices the project team has made in terms of the TEG, which was limited by what was available. The fourth evaluator commented that future work would follow the development of the TEG module, especially the cost of the TEG module. The evaluator noted that the PI mentioned a 5% efficiency gain as a target. It was suggested by this evaluator that details of a how-to-get-from-here-to-there strategy to achieve that benchmark would be very useful to know, as the answer would guide the allocation of the project team's budget. Furthermore, this reviewer encouraged the PI to provide some guidelines regarding the targets that should be emphasized in the project team's future work to achieve this goal.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The respondents agreed that the project resources were sufficient. One of the respondents offered that the resources appeared to be sufficient for the tasks that comprised the project. The second respondent observed this project had utilized sufficient resources from each collaborator, while the third respondent indicated that there was not enough information to determine adequacy of the resources.

Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power: Greg Meisner (General Motors) – ace081

Reviewer Sample Size

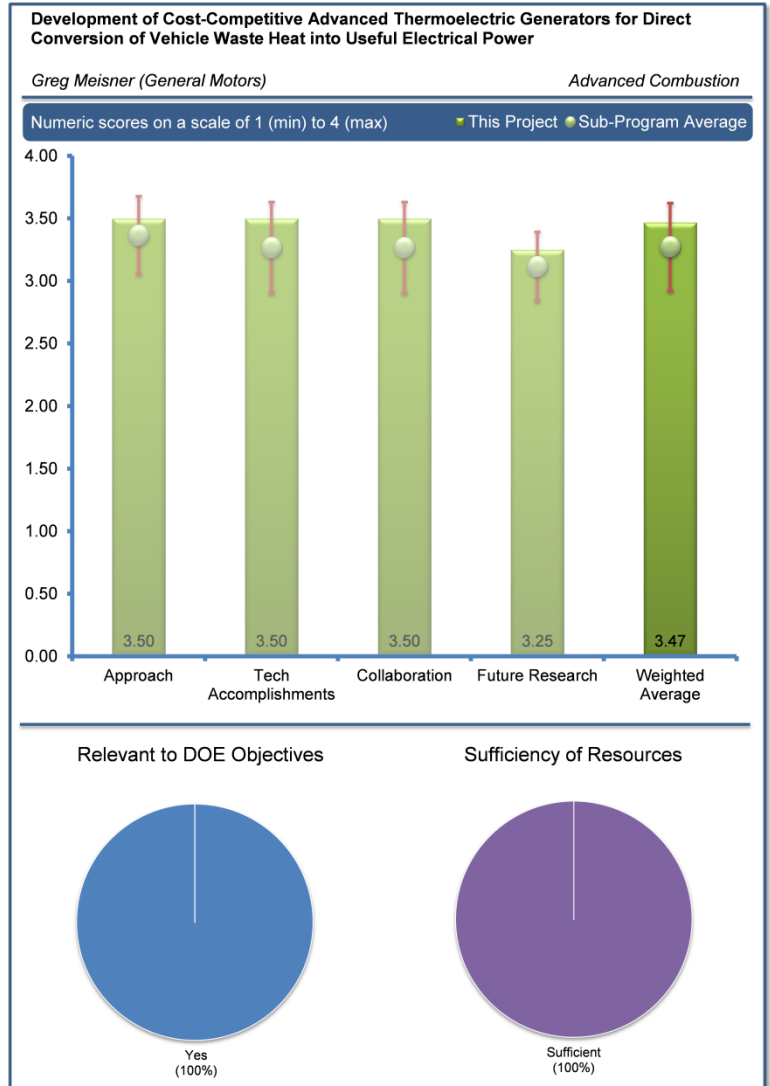
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. The first reviewer explained that integration of a TEG into a commercial vehicle would be a significant accomplishment consistent with DOE's goals of improving fuel economy (through waste heat recovery). Additionally, continued this reviewer, the goal of reducing fuel consumption via waste heat recovery was certainly relevant to DOE, and national interests. The second reviewer reported that the overall goal of the project was to design, incorporate, and test a TEG prototype on a vehicle to demonstrate fuel efficiency improvements by 5%. These project goals are consistent with the DOE requirements, opined this reviewer. The project goal is in good agreement with DOE objectives of petroleum displacement, agreed the third reviewer, who added that thermoelectric devices provide a good alternative to reduce energy and improve engine efficiency. The fourth reviewer expressed that the program run by GM offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this reviewer, there were two major ways fuel consumption would be reduced. First, stated this reviewer, the compression cooling system on present cars could be removed such that the belt-driven mechanical load on the engine was reduced. Secondly, added the same reviewer, the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This reviewer concluded that the effort by GM appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was mixed. One of the evaluators described that the completed project has gone through careful materials research and down-select process, system design, and prototype generator manufacturing and testing. Additionally, continued this evaluator, this exercise was the basis for future development of TE generators. This evaluator further opined that the focus on materials and system design was appropriate and effective. The second evaluator explained that the focus of the work had been on the TEG design, including materials development of skutterudites, heat exchanger design, implementation, and testing. A number of collaborators with GM as the lead were involved, observed this evaluator. The approach has been systematic, and the work has focused on scalability issues, according to this reviewer. However, this reviewer continued, the performance of bulk skutterudite materials has been a challenge, and the two-part design with two, different, TE materials has not been as successful. This evaluator



concluded that the lessons learned would be transitioned to the next phase. The third evaluator acknowledged that there were strengths and weaknesses. This reviewer commented that one strength of the approach was the expertise of the PIs for accomplishing the objectives. The reviewer noted that the PIs had made good materials selection(s) and teamed with experts to make rapid progress. One weakness was in the device (and TEG) design, opined this evaluator. The merit of the planar design, stated this evaluator, was that significant pressure could be applied to make interface thermal resistance negligible. The same evaluator opined that one team member, Marlow, knew this and should be consulted about the magnitudes recommended for their modules. This evaluator inquired whether the exhaust flow through the TEG was serpentine, or laminar and straight. Unless it was a highly proprietary secret, this evaluator asserted that the project team should discuss topics similar to that because they give insight into the mechanical physics of the process. The final evaluator reported that the approach was outlined in 18 tasks ranging from materials integration into TEG components, modeling to compute performance, manufacturing TEG components and scale-up manufacturing processes, and carrying out a detailed production cost. This evaluator noted that the actual approach to achieve the target fuel economy improvement of 5% needed better definition in future work, and further encouraged the PI to provide a detailed roadmap that would also be helpful to the project team to allocate internal resources (e.g., there would be no point to direct resources to tasks that could be shown to have a minimal influence on fuel economy).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed comments were received in this section. One commenter opined that this project has made significant progress. Further, continued this commenter, the critical issues in materials and design have been identified and would need significant improvement in the next phase of the program. Referencing materials, this commenter offered that skutterudite was one of the most promising materials for TE generators. However, according to this reviewer, the performance had not been optimized especially in the p-type materials. This commenter asserted that material stability needed to be studied for long-term usage. Referencing system design, the same commenter expressed that it seemed the current design was not the best choice based on test results, and further noted that improvement in the design should include enough flexibility to accommodate potential issues in the generator. Referencing generator power, this first commenter acknowledged that the reason for very low power output was explained, but pointed out that there seemed to be a missing step in verifying the performance of skutterudite modules. This commenter concluded that if the performance of each module could be specified and verified, the final generator performance would be easier to predict. The second commenter observed that while a lot of work had gone into the design, material scalability, fabrication, and testing, the results in terms of power output were quite discouraging, with maximum output power in the range of 20-35 W. It appeared to this commenter that the design weakness with the use of Pb-Te, the two-part TEG, and the HX design could have been predicted and improved at the outset. This commenter described that the future work, which appeared to be focused on the lessons learned, was promising. The third commenter reported that accomplishments included development and testing of a TEG, a materials development effort concerning skutterudite materials, and incorporation of the materials into a TEG. This commenter described the TEG as a sort of flat structure that contrasted with the BSST design, and suggested that it would be useful to discuss why the design was to be preferred, or vice versa. The accomplishments also included testing and evaluation in a US06 drive cycle series of tests. The same commenter further pointed out that it would be interesting to re-evaluate the TEG design and performance limits benchmarked against the BSST design. This commenter expressed concern in the apparently low performing TEG design that the team had invested considerable resources to develop. At some point, stated this commenter, it would be necessary to have a Go/No-Go point to determine the extent to which further work on developing the project team's TEG module was warranted. The fourth and final commenter remarked that the output power seemed to be somewhat low considering the platform from which the project team was harnessing energy, and that it appeared that the PI was aware it was low. But at a minimum, opined this commenter, the project team should explain its results. The same commenter indicated that low power was acceptable if it was understood in sufficient detail to design a path towards higher output power. If the explanation was that the interface thermal resistance was a limiting factor, added this commenter, then that was valuable information to know for future demonstrations. The commenter expressed that the presentation would be improved if more mechanics, heat flows, and stresses of the TEG were described.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Positive comments were received in this section. The first respondent explained that this project has shown successful collaboration among team members and that the project has been very well coordinated. Another respondent observed that an excellent group of partners were involved, including Marlow and Purdue. The third respondent acknowledged an extensive collaborative team, including groups at GM (R&D, Powertrain, and the Alternative Energy Center) as well as TE industries (Marlow), national laboratories (ORNL, BNL), and academia (e.g., Purdue, MSU). The fourth respondent indicated that the GM team had partnered with well-respected experts in the field. This respondent further noted that the Marlow staff members were leading experts, and that GM has had a long history of success with developing skutterudite materials for TEG applications.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, reviewer comments were positive in this section. One evaluator opined that valuable lessons appeared to have been learned based on the TEG data generated and the vehicle tests, and that a rational path forward had been proposed. Another evaluator explained that the future plan laid out by GM included several thrusts, all of which seemed reasonable. First, continued this evaluator, the project team planned to down-select from two different TEG materials (i.e., skutterudite and bismuth telluride) to just one, which seemed like a simplification that helped both power conditioning and system design. Overall, concluded this evaluator, the project team should be able to significantly exceed the past accomplishments in the future. The third evaluator reported that future work would include continued evaluation in a demonstration vehicle, completion of TEG system analysis, and establishing design targets for the TEG subsystem and associated targets. This evaluator described the identification of issues that do not relate to the materials themselves (e.g., interfaces) as good. The fourth evaluator stated that the proposed research in Waste Heat II was focusing on the issue identified in a previous project. If successful, noted this evaluator, it would bring commercialization of TE generators in vehicles closer to reality.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The respondents agreed that project resources were sufficient. One respondent observed that the resources appeared to be adequate for the tasks proposed. A second respondent asserted that resources were being sufficiently utilized in this project, while a third respondent explained that there was not enough information to determine whether the resources were adequate or inadequate.

Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery: Chris Caylor (GMZ Energy Inc.) – ace082

Reviewer Sample Size

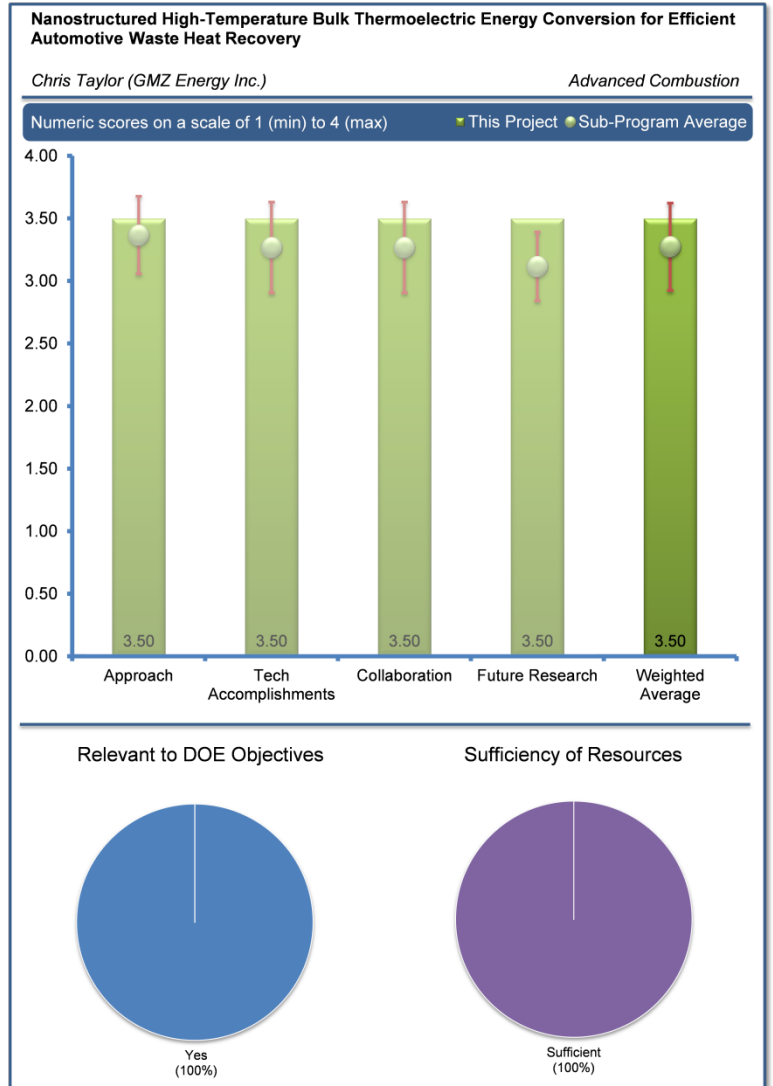
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Positive comments were received in this section. The first evaluator stated this new project focused on the vehicle fuel economy improvement and fully supported the DOE objectives of petroleum displacement. Added a second evaluator, development of efficient and cost-effective materials was relevant to DOE's objectives as success in these efforts would improve the efficiency of TEGs and ultimately, fuel economy. Another evaluator reported that this project was focused on improved TE materials and an improved metallization system for a higher efficiency TEG, and was expected to contribute to improved fuel efficiency. The same evaluator noted that the project was in its early stages of research and is a partnership of GMZ, Boston College, and Bosch. The fourth and final evaluator explained that the program run by GMZ offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this evaluator, there were two major ways fuel consumption would be reduced. First, this evaluator observed that the compression cooling system on present cars could be removed such that the belt-driven mechanical load on the engine was reduced. Secondly, the same evaluator remarked that the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This evaluator concluded that the effort by GMZ appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was generally positive. One of the respondents indicated the technical approaches were appropriate and focused on the critical technical issues. The second respondent opined that GMZ had an excellent approach that leveraged low-risk half-Heusler materials with new, high-efficiency improvements. The project team, observed by this respondent, had selected low-cost variation of half-Heusler alloys for the hot-side stage, and nanostructured bismuth telluride as the colder-side stage. This respondent added that these were excellent choices and offered the overall DOE program an alternative to Skutterudites, which have significant challenges. The same respondent pointed out that the project team teamed with Bosch to help with integration and transition to automotive applications, and have noted the need for a compliant bus technology to mitigate the deleterious effects of differential thermal expansion. The work was new, concluded this respondent. Another respondent acknowledged that the project aimed to demonstrate a robust TEG device that would provide fuel efficiency gains. A system design was developed that combined half-Heusler and BiTe at the higher and lower temperature stages. Half-Heusler was chosen because of greater reliability. The



focus of the proposal, reported this respondent, appeared to be on the nanostructured TE materials. The same respondent added that this work was based on earlier, published results from MIT and Boston College (GMZ is a spin-off company), while the other contribution of the work appeared on the contacts/metallization. This respondent also mentioned that plans for prototype build and testing were parts of future work. The fourth respondent observed the PI noted that the goal was to achieve a five percent fuel efficiency gain. This respondent asserted it was imperative that some sort of analysis be undertaken to assist with determining where resources should be targeted to reach this goal. Without doing this, cautioned this respondent, it could be like shooting in the dark to achieve this goal. The respondent encouraged the PI to develop some sort of system-level modeling to assist in targeting what needed further work to achieve this goal. The respondent also reported that the materials selected were half-Heusler (versus skutterudites), which the PI believes was a higher performance material. The focus on system design, contact metallization, joining, and mechanical strengths of joints, etc., was described by this respondent as appropriate. The same respondent summarized that the TEG design was a two-stage structure comprised of half-Heusler materials in the first stage and Bi_2Te_3 as the low temperature stage. This respondent opined that although the design seemed novel, it also seemed complicated. The respondent recommended that some indication of the difficulty of fabrication and integrity of the interfaces over time would be appropriate to provide in additional presentations. It was reported by the same respondent that the materials were nanostructured, and that the team appeared to have the capability to make these materials in large quantities. This respondent concluded that the Phase 1 effort would focus on TE device performance using a suite of sophisticated instrumentation for characterization.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer comments were generally positive in this section. The first reviewer expressed that this team has shown significant progress and potential to be successful, given the very short duration of the project in FY 2011. Furthermore, continued this reviewer, the materials research based on prior GMZ work has laid a good foundation for the project. This reviewer concluded that it was good to see that this new project was able to use the lessons learned in other DOE projects to catch up quickly. The second reviewer pointed out that the project is relatively new (i.e., about four months along) and anticipated that accomplishments would be more forthcoming in next year's presentation. This reviewer remarked that the PIs have carried out some initial contact metallization studies that showed low contact resistance and good diffusion barriers, and pursued some initial modeling studies using ANSYS. The same reviewer reported that the team plans for a workshop at GMZ in May 2012 to share results among Bosch, GMZ, and BC, and observed that GMZ was building a system-level model of power generation using ANSYS that includes TE output and associated thermo-mechanical stresses. The reviewer further remarked that the team was developing a plan to merge the TE model with a model for the heat exchanger/system multi-scale model. The third reviewer highlighted that this program really had not kicked off, but indicated the project team was already hitting the ground running with some initial results. The fourth reviewer recounted that GMZ would look at both mechanical and thermal testing, and reported that progress included improvement in materials fabrication of half-Heusler, as well as improved contact metallization and power generation. Improved ZT of half-Heusler of both n-type and p-type to 0.6-0.8 has been shown. According to this reviewer, the investigators had also shown that reducing the Hafnium composition by a factor of three did not lead to a definable reduction in ZT. This reviewer also observed system design exploration and modeling with Bosch. Specific system improvements were not clear to this reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, positive feedback in this section was received. One of the evaluators highlighted that the project had assembled an excellent team to carry out the planned tasks. The second evaluator reported that the collaboration included GMZ as the lead, along with Robert Bosch, ORNL, and Boston College. Each component, observed this evaluator, brought excellent expertise in various disciplines, including prototype fabrication, heat exchangers, contacts and integration, materials characterization, and dynamometer testing. Another evaluator opined that the project team had assembled a good team with very high expertise in the relevant areas. This evaluator described Bosch as a known parts supplier and pointed out that MIT and Boston College were experts in TE materials. The same evaluator further noted that Chris Caylor was a nationally known expert in TE materials, devices, and sub-systems for integration. The fourth evaluator recounted that Gang Chen from MIT (consultant) and Zhifeng Ren from Boston College, along with Bosch and ORNL, were all collaborators with GMZ. It was not clear to this evaluator, however, whether scalability and vehicle integration/system design were properly represented.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks in this section were generally positive. The first commenter explained that while most of the work on this program was to be performed in the future, the scope and perspective of the future plans appeared to be excellent. The commenter added that the project team appeared to have identified risk areas, and had planned for mitigation of those risks. If successful, continued this commenter, the half-Heusler approach could be a far more attractive alternative to skutterudite materials. Another commenter reported that most of the future work presented focused on the critical issue for thermoelectric generators. The third commenter stated that the future work, which in reality was the beginning work because the project was so new, included tasks associated with characterization of properties (i.e., ZT), mechanical testing, thermal cycle data, heat exchanger design, and system level modeling. The final commenter observed power generation and mechanical testing of half-Heuslers and bismuth telluride. This commenter also indicated that the project team would conduct planning on the heat exchanger design and system/vehicle model development. At this stage, concluded this commenter, it appeared that GMZ was more focused on the materials development, and in capitalizing on their improved performance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that the project resources were sufficient. One reviewer described the budget allocated to the project as reasonable, and another reviewer remarked that the resources of each participant were being utilized sufficiently. The third reviewer noted that there was not enough information to know the adequacy of resources.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
3D	Three Dimensional
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AFRL	Air Force Research Laboratory
ANL	Argonne National Laboratory
API	American Petroleum Institute
APS	Advanced photon source
AVFL	Advanced vehicle fuel lubricant
BET	Brunauer, Emmett, and Teller
BMEP	Brake Mean Effective Pressure
BNL	Brookhaven National Laboratory
BSFC	Brake-specific fuel consumption
BTE	Brake Thermal Efficiency
CARB	California Air Resources Board
CE	Coulombic Efficiency
CFD	Computational Fluid Dynamics
CIDI	Compression-ignition Direct-injection
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulations
CO	Carbon Monoxide
CO2	Carbon Dioxide
COP	Coefficient of performance
CR	Coefficient of Rolling Resistance
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
DERC	Diesel Engine Research Consortium
DOC	Diesel oxidation catalyst
DOE	Department of Energy
DPF	Diesel particulate filter
ECN	Engine Collaboration Network
EGR	Exhaust Gas Recirculation
EMA	Engine Manufacturers Association
EO	Engine Out
EPA	U.S. Environmental Protection Agency
ERC	Engine Research Center
FACE	Fuels for Advanced Combustion Engines
FE	Finite Element
FEA	Finite Element Analysis
FEM	Finite element method

Acronym	Definition
FMEP	Friction mean effective pressure
FPE	Free-piston engine
FY	Fiscal year
GDI	Gasoline Direct-injected
GM	General Motors Corporation
GMZ	GMZ Energy Inc.
GTI	Gas Technology Institute
H₂	Hydrogen
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy-Duty
HDD	Heavy-duty diesel
HECC	High Efficiency Clean Combustion
HPLB	High-pressure, lean burn
HVAC	Heating, ventilation and air-conditioning
HX	Heat Exchanger
ICE	Internal Combustion Engine
K	Temperature in degrees Kelvin
K	Potassium
KH-ACT	Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence model
LANL	Los Alamos National Laboratory
LD	Light-Duty
LDD	Light-duty diesel
LES	Large Eddy Simulation
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NO _x Trap
LP	Low-pressure
LTC	Low Temperature Combustion
Mg	Magnesium
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
NO_x	Oxides of Nitrogen
NO₂	Nitrogen Dioxide
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAH	Polycyclic Aromatic Hydrocarbon
PCCI	Premixed Charge Compression Ignition

Acronym	Definition
PGM	Platinum group metal
PI	Principal Investigator
PM	Particulate Matter
PMEP	Pumping mean effective pressure
PNNL	Pacific Northwest National Laboratory
PPC	Partially Premixed Combustion
Pt	Platinum
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
R&D	Research and development
SA	Spark assisted
SACI	Spark assisted compression ignition
SCCI	Stratified charge compression-ignition
SCR	Selective Catalytic Reduction
SEI	Solid Electrolyte Interface
SI	Spark-ignition
SIDI	Spark-ignition direct-injection
SNL	Sandia National Laboratory
TCR	Thermochemical Recuperation
TE	Thermoelectric
TEM	Transmission electron microscopy
TGA	Thermogravimetric analysis
UHC	Unburned hydrocarbons
UK	University of Kentucky
UM	University of Michigan
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UTRC	United Technologies Research Center
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
VCT	Variable camshaft timing
VTP	Vehicle Technologies Program
VVA	Variable Valve Actuation
VVT	Variable valve timing
WHR	Waste Heat Recovery
XRD	X-ray diffraction

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5. Fuels and Lubricants Technologies

The Fuels Technology subprogram supports fuels and lubricants R&D to provide vehicle users with cost-competitive options that enable high fuel economy with low emissions, and contribute to petroleum displacement. Transportation fuels are anticipated to be produced from future refinery feedstocks that may increasingly be from non-conventional sources including, but not limited to, heavy crude, oil sands, shale oil, and coal, as well as renewable resources such as biomass, vegetable oils, and waste animal fats. The impact of changes in refinery feedstocks on finished fuels is an area of relatively new concern to engine manufacturers, regulators and users. Advanced engine technologies are more sensitive to variations in fuel composition than were earlier engines, in addition to facing tightening emissions standards. This subprogram consists of two activities: Advanced Petroleum-Based Fuels (APBF); and Non-Petroleum-Based Fuels and Lubricants (NPBFL). The goals are: (1) to enable post-2010 advanced combustion regime engines and emission control systems to be more efficient while meeting future emission standards; and, (2) to reduce reliance on petroleum-based fuels through direct fuel substitution by non-petroleum-based fuels. These activities are undertaken to determine the impacts of fuel and lubricant properties on the efficiency, performance, and emissions of current engines as well as to enable emerging advanced internal combustion engines. These advanced engines operate in low-temperature combustion regimes that are expected to become more prevalent in the marketplace because of their higher efficiency and continually improving emissions performance. These activities are coordinated with and supportive of EPA's fuels and emissions-related activities, as mentioned in their strategic plan.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Fuels for Advanced Combustion Engines	Brad Zigler (National Renewable Energy Laboratory)	5-2	3.33	3.67	3.67	3.00	3.50
Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends	Bob McCormick (National Renewable Energy Laboratory)	5-4	3.33	3.33	3.33	3.00	3.29
Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies	Chuck Mueller (Sandia National Laboratories)	5-6	3.50	3.75	3.75	3.25	3.63
Advanced Lean-Burn DI Spark Ignition Fuels Research	Magnus Sjoberg (Sandia National Laboratories)	5-8	3.00	3.50	3.50	3.00	3.31
Non-Petroleum-Based Fuels: Effects on Emissions Control Technologies	Scott Sluder (Oak Ridge National Laboratory)	5-10	3.00	3.00	3.00	3.00	3.00
Gasoline-like fuel effects on advanced combustion regimes	James Szybist (Oak Ridge National Laboratory)	5-11	3.50	2.50	2.50	3.50	2.88
Chemical Kinetic Modeling of Non-Petroleum Based Fuels	Bill Pitz (Lawrence Livermore National Laboratory)	5-13	3.20	3.40	3.40	3.00	3.30
Lubricants Activities	George Fenske (Argonne National Laboratory)	5-16	3.20	3.00	3.00	3.25	3.08
Overall Average			3.26	3.27	3.27	3.13	3.25

Fuels for Advanced Combustion Engines: Brad Zigler (National Renewable Energy Laboratory) – ft002

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

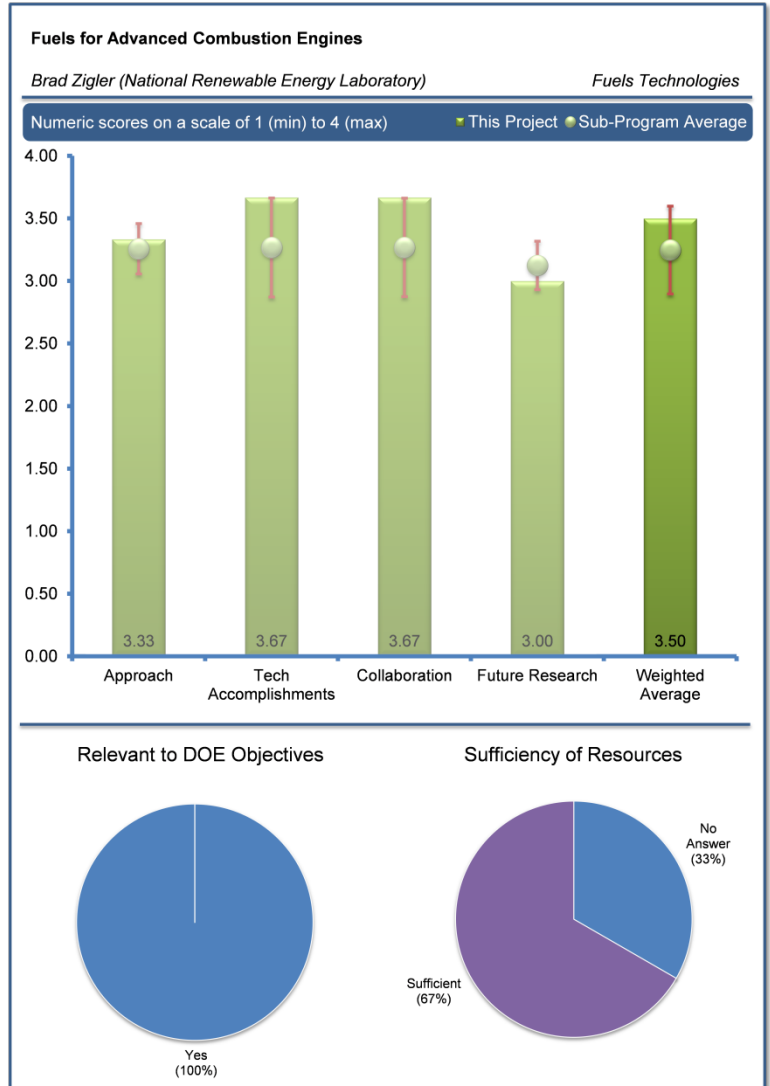
All reviewer feedback was positive. One reviewer stated that there was an extensive matrix of research fuels to be blended, characterized and made available to the research community. Another evaluator said that research characterized a set of surrogate reference fuels to be used as tools for advanced combustion modeling and research. A separate reviewer commented that this is an important collaboration between the Department of Energy (DOE), original equipment manufacturers (OEM) and energy companies, and that developing research fuel sets for advanced combustion processes can result in engine efficiencies.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All reviewer feedback was positive. A reviewer said that the diesel fuels matrix is quite advanced and the gasoline fuels matrix is in progress. A separate evaluator noted that there is such a wide range of possible fuels to consider; a condensed and focused table is needed to help minimize the costs associated with supply of these fuels. One expert commented that improving the fuel economy of light-duty (LD) and heavy-duty (HD) engines is addressed and the project brings together the stakeholders in designing a set of research fuels.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive. One expert said that there had been good progress and that Chevron and Conoco Philips made outstanding contributions in the gasoline fuels analysis. The reviewer added that there were only five fuels commercially available. A separate commenter stated that the creation of the Fuels for Advanced Combustion Engines (FACE) coalition was a major breakthrough in order to get the right level of buy-in. The reviewer added that 5 out of 10 gasoline range fuels are complete in their characterization and that the balance will be studied and reviewed in Fiscal Year (FY) 2012. Then the goal would be to correlate the engine based data against these models. Additionally, the reviewer remarked that the project had reduced the possible number of fuels from 58 to 10 that could provide high value of data to researchers. The final reviewer noted that the FACE activities are progressing well and in a timely fashion, and that the diesel FACE fuel matrix was fully blended and available. The reviewer added that the analytical characterization of diesel fuels has been accomplished, and some studies using the FACE fuel set have started. The same evaluator stated that the gasoline FACE fuels matrix is underway, and AVFL-18 and AVFL-19 are started. The



reviewer did caution that the cost of research fuels is high, and researchers must come up with ways to reduce the cost. The reviewer added that there is a risk that many would not buy the fuels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers all had positive responses to this question. One reviewer mentioned an impressive collaborative work between DOE labs, Canadian labs, and the Coordinating Research Council (CRC). A separate reviewer also noted that there was excellent collaboration with CRC. The third reviewer stated that there was a strong group of both industry as well as academia involved in the support of the project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer suggested that more emphasis on alternative fuels is needed. A separate evaluator suggested that the project should perform additional characterization of other fuel blends and includes the AVFL-19 fuel in the project. That reviewer also suggested the project focus on ways to reduce the cost of fuel on a barrel or gallon basis. Another reviewer noted that the timeline on delivering specific goals, such as engine-based data correlation to specific physical/chemical properties of fuels, was not well defined. The evaluator wondered if we are talking two years or five years. One commenter suggested performing a detailed fuel characterization and encouraging the use of FACE research fuels in the future.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Sufficient resources were observed by two respondents, of which one reviewer stated that the DOE annual operating plans seem to be sufficient. The third reviewer expressed a deep concern about insufficient resources and funding to complete planned activities.

Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends: Bob McCormick (National Renewable Energy Laboratory) – ft003

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the goals and objectives of current and future work were clearly defined and focused. A separate reviewer said that the project supports the baseline requirements for development of drop-in fuels, and supports the United States' ability towards offsetting foreign oil supply for transportation. The reviewer also noted that the presenter was able to strongly articulate how the research connects to practical applications such as diesel fuel replacement with B20 in transit bus applications. A separate reviewer said that the research was necessary to achieve DOE's petroleum displacement goals.

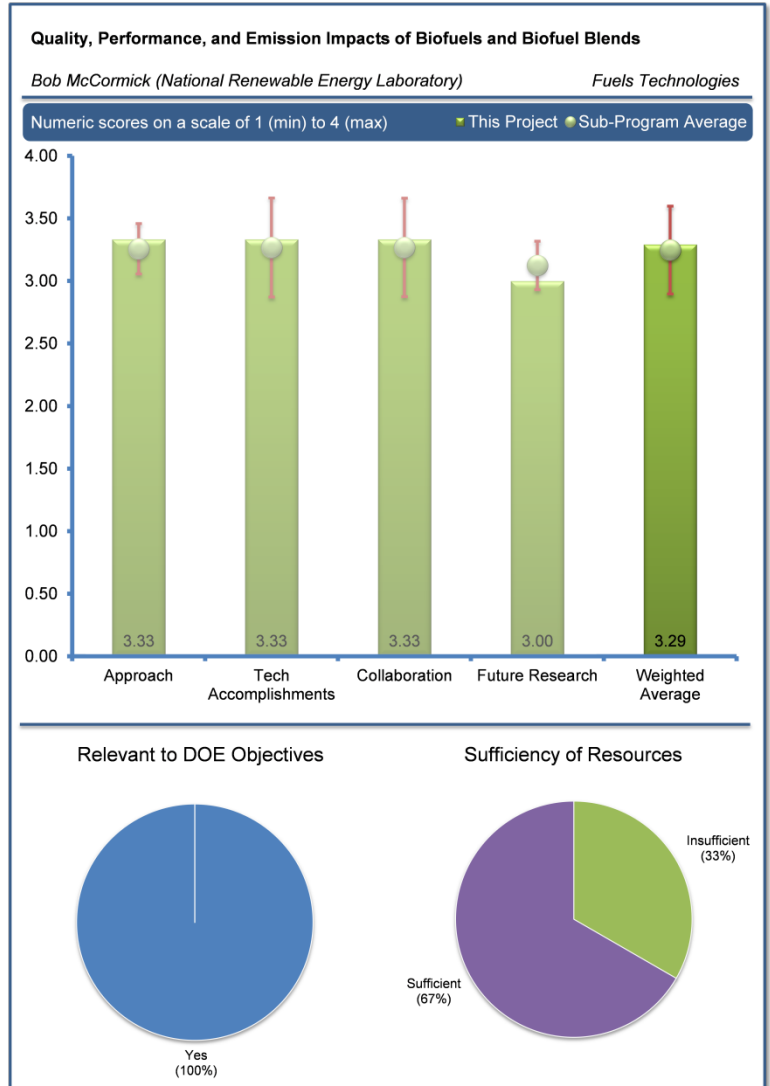
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One evaluation noted a very-disciplined approach with highlighted milestones, timing, and go/no-go decision points. A second reviewer said there is a good tie to the current research and the further unknowns that are a result of the current research. One reviewer mentioned the project had covered a broad scope of biofuels. The reviewer added that fuel quality, performance properties, and compatibility with engines have been addressed. The evaluator believed there still are some barriers that prevent the wide use of biofuels, which include cold temperature operability, oxidation stability and other impurities, which must be addressed.

One reviewer mentioned the project had covered a broad scope of biofuels. The reviewer added that fuel quality, performance properties, and compatibility with engines have been addressed. The evaluator believed there still are some barriers that prevent the wide use of biofuels, which include cold temperature operability, oxidation stability and other impurities, which must be addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that the project had clearly listed the technical accomplishments, such as having good data on fuels storage/handling, and ADT durability with B20/metallic contaminants. The reviewer also noted that, among other things, there had been a B100 quality survey. Another evaluator commented that the work on catalyst stability, and determining the effects of biofuels in long term aging, was well presented and the results show promise. The reviewer added that the results indicated no long-term issues associated with the use of B20 in light-duty diesel applications. The reviewer continued by saying that the work on transit bus B20 applications proved that there were little to no effects of biodiesel in newer technology engines that use SCR. The reviewer thought findings on long-term storage of biodiesel were interesting; additionally, how much biodiesel oxidizes demonstrates that the fuel refiner and the type and blend of feedstocks will be critical to the overall performance with respect to emissions performance. This evaluator also noted that the project team was able to show that the oxidation of these fuels was reversible and that the properties of the fuel were not changed; these highly oxidized fuels can be rescued. One expert found the



project accomplishments to be good. The reviewer stated that the characterization of acids in hydrotreated pyrolysis products, mixed alcohols from biomass-derived syngas, and biodiesel catalyst durability study addressed the negative impact of sodium, potassium and calcium. The E85 survey and specification changes were interesting. This reviewer also thought the project needs more focus on addressing quality, performance and specification issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated the team of partners in these projects was extensive and some aspects of the work were strongly tied to more real world demonstration tests. A reviewer commented that the project was still missing collaboration with universities, such as Pennsylvania State University or University of Michigan. Another reviewer suggested that it would be nice to have the OEM and the energy companies in the list.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer believes that B20's impact on oil dilution needs to be continued, adding that European data shows examples of high fuel in oil dilution levels, which can impact hardware life. A separate commenter stated that there was a good plan for future work, adding that future work must focus on issues that are preventing the commercialization and use of biofuels. An evaluator saw the work about determining what parameters and requirements are critical for defining this equivalent drop-in fuel will be needed to be able to support the work of biofuel refineries as well as proper feedstock preparation. The reviewer added that this downstream to upstream approach needs to be further leveraged so that we can understand how to better provide a less broad range of fuel from these different biorefiners.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Sufficient resources were observed by two respondents, of which one specifically commented that the resources appeared to be sufficient. One reviewer noted insufficient resources.

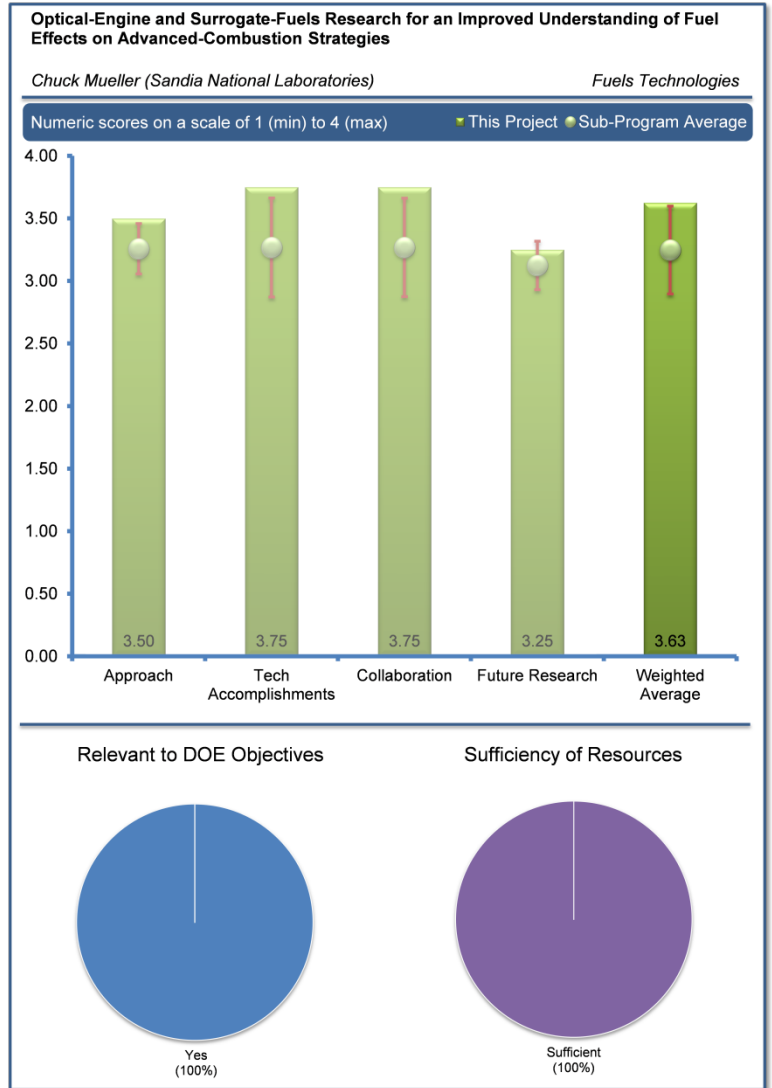
Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies: Chuck Mueller (Sandia National Laboratories) – ft004

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer said that the project would develop science-based approaches for high energy clean combustion (HECC) engines using fuels that can improve U.S. energy security. A commenter was of the view that the project was developing the science to enable high efficiency engines using fuels that improve U.S. energy security. The reviewer added that the project also advances the state of the art of diesel surrogate fuels. An evaluator asserted that by advancing knowledge of leaner lifted flame combustion, the project could ultimately enable sootless compression ignition combustion, avoiding the need for aftertreatment while reducing weight and otherwise increasing fuel efficiency. One evaluator stated that this project is very relevant to the objective of petroleum displacement. The reviewer added that the development of new and surrogate fuels will help in the development of engine optimization in new engines. In addition the reviewer mentioned that the work on reducing soot formation will be extremely valuable to the development of future engines that will produce fewer exhaust emissions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer saw the primary approach of the project as being on biodiesel surrogate fuels, quantifying soot formation and developing a series of screening techniques to understand the effects of changing fuel qualities. Another commenter was of the opinion that the diagnostic capabilities and collaborations are excellent and that the methods for solving the barriers being addressed in the project were good. A separate reviewer noted the unique and comprehensive diagnostic capabilities and good collaboration. One reviewer felt the approach is to develop general knowledge of fuel parameter effects through diesel surrogate fuels so as to provide a screening technique to characterize current and future fuels. The reviewer believes that this raises the chicken-and-egg question of to what extent will such future fuels be subject to screening based on this technique. In many cases, the reviewer continued, fuel properties will be determined by feedstocks and limitations of process technologies. The reviewer added that defining fuel component effects might or might not be valuable in development of such process technologies for future fuels. The commenter stated that the research in this project might be more useful defined or at least described this way, presuming that it successfully proceeds to the point where it can be used in this way, rather than just as a screening technique. The reviewer also said that the other side of the research—to enable computational engine optimization—may be more important as the ability to engineer the fuels to optimum properties may be limited.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer felt the project had identified a series of key characteristics for diesel fuels, such as volatility, carbon type and ignition quality. The reviewer also commented that the project has developed and validated the best injector design to limit the soot formation during combustion (no smoke). The same reviewer added that 2 holes provided a longer flame line and introduced the least jetting effects as with injectors with 5 and 10 holes. This reviewer also felt the project was able to determine the list of critical independent variables that need to be controlled and that more understanding of the second order level variable and interdependencies will be investigated in future years. Another evaluator noted that progress on technical accomplishments has been very good and thought it will be interesting to see the engine test of the surrogate fuels in the future. An expert commented that two surrogate fuels were created and that the project had used detailed target-fuel characterization data. The reviewer felt that a good matching of property targets was achieved. One respondent stated that diesel surrogate fuels had been identified by various properties and replicated with mixtures from various component groups. The reviewer saw this as the first step to analyzing fuel effects on and through various diagnostics. The reviewer added that it does not assure that the diagnostics will adequately define the effects on optimizing leaner lifted-flame combustion (LLFC) and the presentation is not clear to what extent progress on the latter is being made. Moreover, the presentation does not make clear to what extent existing literature on LLFC and/or other combustion regimes is being reviewed and applied along with the diagnostics from the optical engine research.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers noted that there is strong collaboration. A reviewer opined that there was a good mix of collaborating institutions with range of perspectives and experience relevant to the research. One respondent felt there was a great collaboration with universities and private sector. A third reviewer noted that the project has had a long list of collaborators for many years. The final reviewer stated that collaboration with CRC is always excellent, and also noted collaboration with the Advanced Engine Combustion (AEC) MOU Working Group and Caterpillar.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer suggested that the project apply these robust screening techniques to quantify mixing controls. The reviewer also encouraged engine testing of the surrogate fuel sets and blends and felt that further testing on fuels will be required to overcome barriers to LLFC. A commenter was of the opinion that the planned engine testing will provide very good data in the future and that the results of the surrogate fuel testing will be very valuable. One evaluator said that the characterization of fuel effects through diagnostics to be performed both on subset of LLFC surrogate fuels (generic), and on some real world fuels –esters and other oxygenates – should give better sense of the utility of the research. A reviewer suggested the researchers apply the engine-based screening technique for quantifying fuel effects, adding that the engine testing of fuels is critical.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the responding reviewers said the resources were sufficient. One reviewer stated that the resources appear sufficient for the work that is planned. Another said that the resources appear to be sufficient. One reviewer noted that there was no indication from presentation or presenter that resources were major constraint and an \$800,000 level seems appropriate, in conjunction with use of an optical engine already existing at a contractor facility.

Advanced Lean-Burn DI Spark Ignition Fuels Research: Magnus Sjoberg (Sandia National Laboratories) – ft006

Reviewer Sample Size

This project was reviewed by four reviewers.

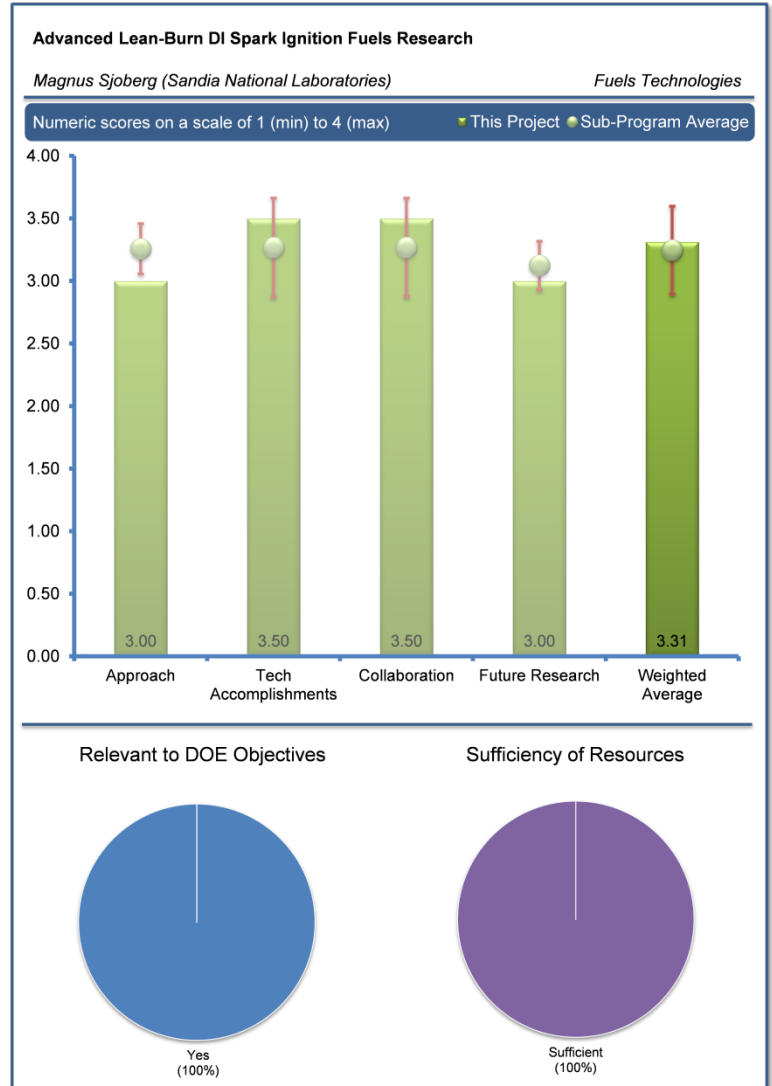
Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally found that the project supports DOE's objectives. A commenter responded yes this project supports the goal of displacing petroleum by helping to maximize efficiency. Another reviewer said that high pressure spray guided direct injection engine technology has great potential to reduce petroleum demand and enable further expansion of petroleum displacement through renewable fuels. An evaluator noted that the focus of the research is how future fuels will impact the combustion systems of new light duty engines, adding that there the focus is also on E85 gasoline and that these support the overall DOE objectives. One reviewer said that apparently the research would contribute to petroleum displacement due to highly efficient direct injection spark ignited (DISI) light-duty engines, although the basis for that efficiency, or even the concept of stratified ignition, is never really explained. The reviewer also felt that the presentation had not explained why the focus is on reducing nitrogen oxides (NO_x) and soot formation because those two pollutants are not normally of major concern with light-duty engines, spark ignition or gasoline/E85 fuels. The reviewer stated that presumably the two are associated with stratified charge ignition but that is never stated or explained. The reviewer elaborated that while the research would apparently support the goal of petroleum displacement, there is some leap of faith in that regard based on the presentation. The reviewer concluded that if this factor had numerical ratings like the others, it would have been downgraded for this but given the choice between yes or no, the answer appears to be yes.

The reviewer stated that presumably the two are associated with stratified charge ignition but that is never stated or explained. The reviewer elaborated that while the research would apparently support the goal of petroleum displacement, there is some leap of faith in that regard based on the presentation. The reviewer concluded that if this factor had numerical ratings like the others, it would have been downgraded for this but given the choice between yes or no, the answer appears to be yes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One evaluator said that the approach of using optical and metal engines with associated modeling technique is excellent. Another reviewer said that the researchers were applying a combination of metal engine and optical engine research to understand barriers and the fundamentals to overcome those barriers. The reviewer went on to note that the experimental studies are supporting numerical studies of these processes, to further the understanding of fundamental aspects of barriers to these combustion processes. An evaluator stated that the general approach as stated – performance testing, testing with optical and conventional diagnostics, and supporting modeling– makes sense, but that beyond that, it is hard to tell to what extent the approach is focusing on the most important technical barriers for the reasons stated above and because the presentation is at a high level of technicality, difficult to understand, includes many slides (images) that do not tell anything to reviewers who are not highly specialized, and uses many unexplained technical terms--including many acronyms that are never spelled out.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers saw that the project has made good progress. One reviewer commented that there was extensive work accomplished on gasoline and E85 fuels, and noted that the researchers had accomplished high speed imaging of the stratified combustion process and planar laser induced fluorescence (PLIF) of the spray process. The reviewer continued that the project had identified operational challenges with controlled NO_x and particulate matter (PM) while improving efficiency. The reviewer also stated that the injection timing control allows for in-cylinder NO_x and PM control, as expected, but E85 allows greater reductions of PM and NO_x into a combined low-emission operating condition, and with unusual spark timing high combustion stability can be achieved as well. The reviewer concluded that clearly, this is very innovative and creative work. A separate reviewer noted the researchers had performed a comparative study and high speed imaging study, and that good progress toward the objectives has been made. One evaluator opined that the progress in this project and accomplishments have been very good, especially the work showing E85 can reach inside the U.S. 2010 NO_x/PM box. A reviewer was not clear on why the engine is only tested with very high compression ratio (12), which is near optimum for E85 but higher than optimum for gasoline. The reviewer wondered if the project is geared only toward E85 use or toward increased efficiency with various fuels, including those likely to be most in use.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the project has a very good list of collaborators. Another reviewer noted that GM and University of Michigan were involved in the program, with new collaboration with the University of Southern California, and the project is also working with other national labs and groups. Another commenter also mentioned the collaboration with GM and AEC MOU, and concluded that it was a good team. One evaluator stated that it was apparently a good collaboration, with other laboratories identified and an industry consortium of ten engine maker partners and five energy companies, though these members are not identified.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer remarked that the present work has raised a number of interesting and valuable questions that the proposed future work will explore. The reviewer concluded that the project should yield additional highly interesting results. One reviewer felt that future work on this project will continue to provide valuable information regarding advanced fuels research. One evaluator mentioned that the effects of temperature on low-NO_x soot operation are addressed, and felt there was a good plan for future research. The final commentator remarked that the technical terminology makes some of the proposed future work difficult to understand. Additionally, it is not clear why intake temperature would be studied. The reviewer was uncertain if the spark ignition direct injection (SIDI) engines would be deployed only in certain climatic regions. The reviewer noted that other parts of the future work, such as spark timing, and fuel vaporization/thermal efficiency, all appear to have merit.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers selected sufficient. A reviewer commented that the project was reasonably well funded, and that the funding level appears stable. The reviewer added that funding for out-years should be maintained or expanded to keep the momentum that this project has built up. One reviewer noted that the resources appear to be sufficient. A separate reviewer stated that there was no basis for concluding that the resources are either excessive or insufficient.

Non-Petroleum-Based Fuels: Effects on Emissions Control Technologies: Scott Sluder (Oak Ridge National Laboratory) – ft007

Reviewer Sample Size

This project was reviewed by one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer stated that understanding of the fuel-property impacts on combustion and emissions control systems is important and supports the overall DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The evaluator stated that the research brings together targeted engine-based micro reactor and bench reactor studies with characterization of PM, hydrocarbons (HC) and the emissions control systems (ECS).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The commenter stated the researchers had identified a pathway for the use of ethanol in gasoline, determined Na effects on ECS and soot oxidation kinetics.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

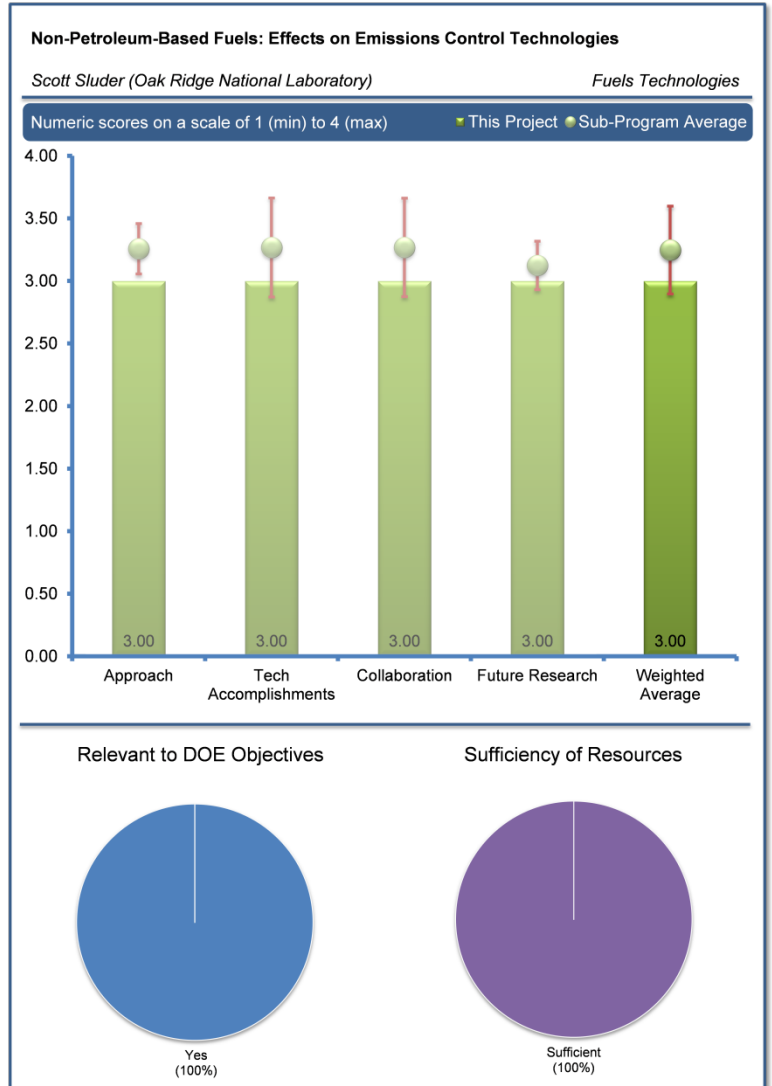
The reviewer noted that there was a good collaboration, including OEMs and others.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer suggested a need to study the fuel effects on exhaust gas recirculation (EGR) cooler fouling, adding that exploiting alcohols in gasoline to enable lean-NO_x is a good idea.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer commented that resources appear sufficient.



Gasoline-like fuel effects on advanced combustion regimes: James Szybist (Oak Ridge National Laboratory) – ft008

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer noted that the project contained advanced research on how to improve combustion of conventional fuels by blending with ethanol and using advanced combustion techniques. One reviewer stated that the research was to determine the effects of fuel properties and chemistries on combustion performance and emissions for advanced combustion regimes, and worked towards direct petroleum displacement with alternate fuels. The reviewer concluded that the work could enable direct petroleum displacement, improved engine efficiency, and reduced emissions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

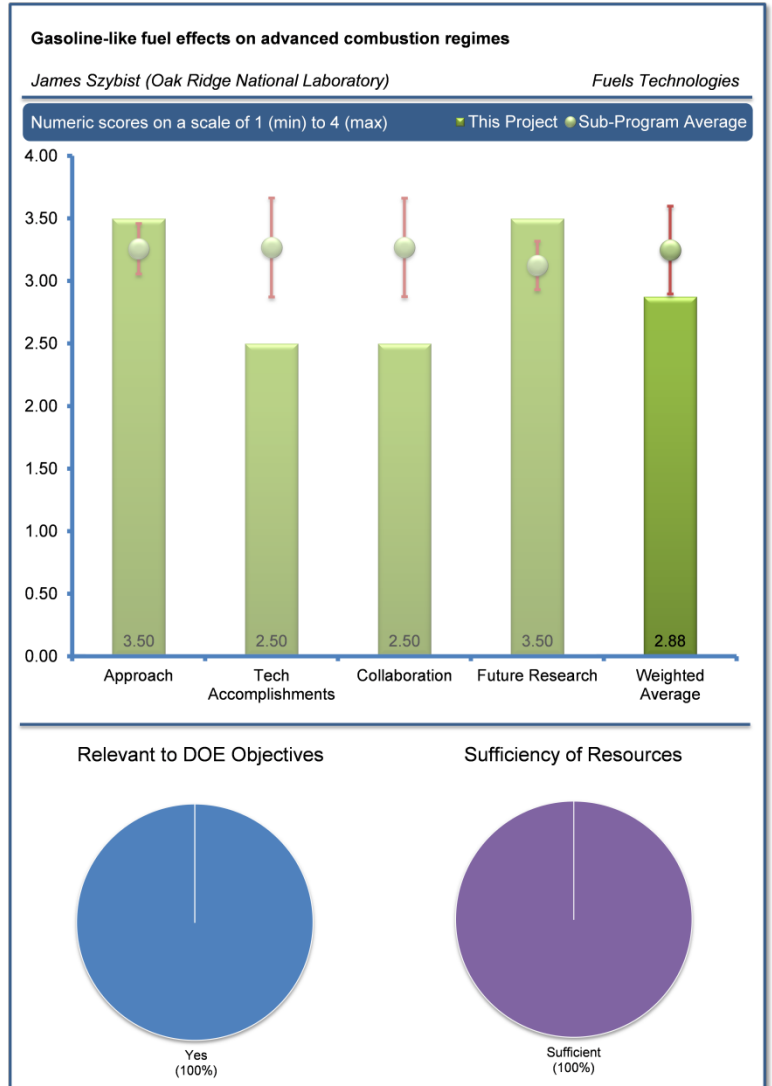
A reviewer commented that there was a strong focus on developing a stable test engine platform with enough flexibility and control to effectively mix the high and low reactivity fuels. The reviewer added that there was an interesting blend of using the OEM equipment as well as a custom applied fuel injection system. Approach to multi-cylinder reactivity controlled compression ignition (RCCI) is good. The experimental approach to determine optimization potential for high ethanol content fuels with low octane number hydrocarbons is a sound approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer believed that a high-level DOE milestone has been completed, and that the three projects are progressing well. One reviewer noted questions regarding the fuels selected for this study, and their relevancy in the industry. The reviewer added that, although the fuel met the needs of the experiment, there was confusion in the technical community as to the relevancy and usability of the research.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted there were good corporate and university partnerships. A second reviewer also said there was good collaboration.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer suggested that future work could include research on further blending ratios, compression regimes, and spark curves. An evaluator noted that numerous activities investigating the effects of gasoline-like fuels on high efficiency operating regimes are going on.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers selected sufficient. One reviewer noted strong lab capabilities, and a second reviewer said that the resources appear to be sufficient.

Chemical Kinetic Modeling of Non-Petroleum Based Fuels: Bill Pitz, (Lawrence Livermore National Laboratory) – ft010

Reviewer Sample Size

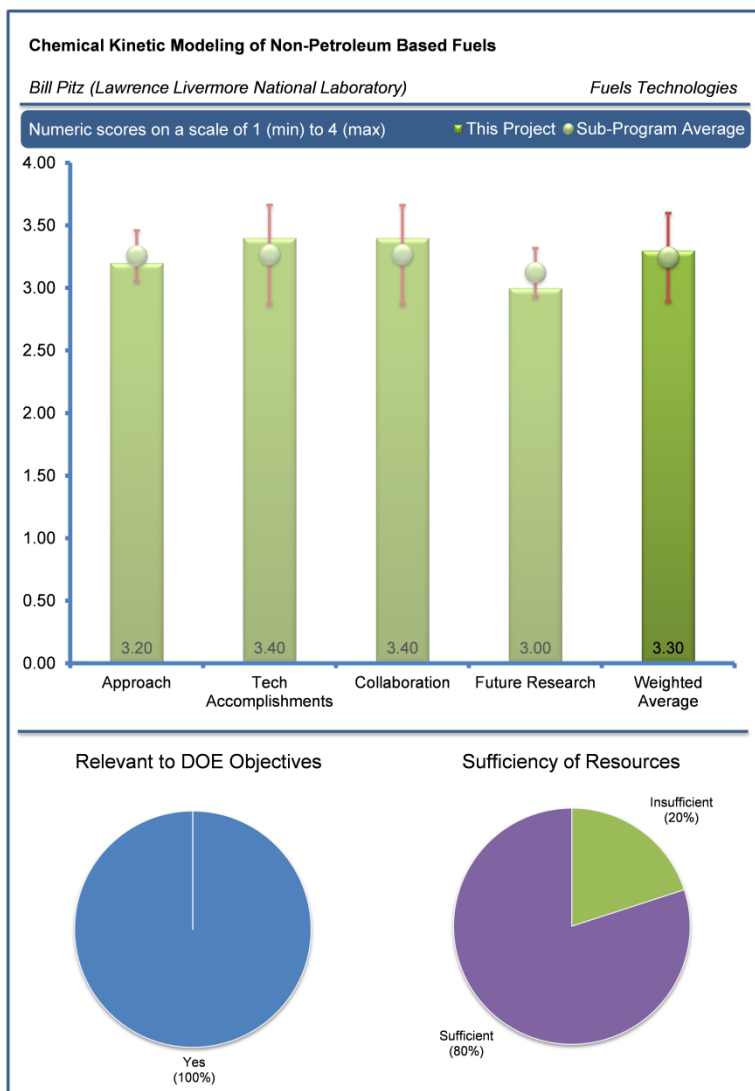
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that the development of kinetic models for combustion of hydrocarbon and alternative fuels is critically important for development of advanced combustion, advanced fuels and new engines. This reviewer added that this will lead to improved efficiency and reduced petroleum demand. One commenter said that it was critical to the development of higher efficiency low emission engine technologies in the future and would also prepare a percentage of petroleum displacement using these new fuel chemistries. Another evaluator stated that the research continues to be extremely relevant to the Vehicles Technologies Program (VTP), and that models being developed will be able to provide information to optimize fuel formulations and ultimately help meet the goal of reducing petroleum use. An expert noted that development of a chemical kinetic model could be useful for future engine/fuels research, use as a screening device, the matching of compatible fuels and components with engine types, etc. The final commentator mentioned the research provides fundamental research to support DOE/industry fuel technology projects, and would develop predictive chemical kinetic models. The reviewer added that it would develop chemical models for larger alkanes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One evaluator noted that the research was developing new kinetic models and performing validation with a variety of partners. The reviewer mentioned that new fuels being considered include pentanol, larger esters, cycloalkanes and other species. The reviewer also stated that the models are combined to provide the kinetics to describe combustion of surrogate fuels to represent practical and unconventional fuel combustion, and are also reducing mechanisms to enable detailed computational fluid dynamics (CFD) calculations of internal combustion engine combustion. One reviewer mentioned the developing of predictive chemical kinetic reactive models of alternative fuel blends of individual fuel components and that the approach included combining mechanisms to provide surrogate models of these new fuel blends. The reviewer stated that the surrogate models are published on the website for diesel and diesel blends as well as ethanol and ethanol/gasoline blends. Another reviewer said that the approach of looking at a variety of fuel mechanisms to obtain models to help determine future fuel formulations is an excellent approach. The reviewer added that the number of fuels being evaluated is very good. Another reviewer said that developing chemical kinetic reaction models for each fuel component for advanced non-petroleum based fuels may overcome some barriers. The final commenter stated that the use of a rapid compression machine (RCM) and shock tubes to simulate engine combustion is only partial surrogate for



actual engine regimes. The reviewer noted that while various different fuel types are being tested to help build and validate the model, a number of those chosen seem to have ultimately no practical value, chosen perhaps because of connections/relationships to particular researchers, such as isomers of pentanols, individual methyl esters, and diethyl carbonate.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer said that the project had developed and validated kinetic models for methyl oleate, methyl palmitate and pentanol. One commenter also noted that the project developed methyl palmitate and methyl oleate models, and also were considering iso pentanol and also 1-pentanol. The reviewer noted that this was fully validated. One expert said that good progress has been made, noting that the research validated a chemical kinetic model for real biodiesel component methyl palmitate, methyl oleate. Another reviewer noted that experimental validation of these biodiesel fuels used many different combustion methods. The reviewer also stated that the project had collaborated with many universities, including Stanford and University of Michigan, as well as Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories (SNL). An evaluator said that the results presented of the validated biodiesel results and alcohols were very impressive will be extremely valuable information to help in optimizing fuels in the future. A final reviewer said that the experimental results conform closely to the predictions of the model, indicating that the model is fairly accurate as far as it goes with the two diagnostic variables. The reviewer added that there is no explanation of how these two variables translate into practical knowledge or how additional diagnostics will be determined by the model.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One commenter said that collaborations with university and national lab groups, including University of Michigan, Stanford University, Rensselaer Polytechnic Institute (RPI) and others, uses a variety of experimental techniques. The reviewer also noted the project is collaborating with several other national laboratories. Another reviewer said that the working collaboration included the University of Michigan, Stanford, RPI, University of Ireland, the nation of Columbia, the University of Connecticut and the FACE working collaboration. Another commenter said that there was a very impressive list of collaborators in this work. A reviewer said that there was good collaboration with academia and also mentioned AEC, CRC and FACE. One reviewer acknowledged the various linkages to other laboratories and research programs identified in a list, but felt that no real explanation of the relationships was indicated. The reviewer added that private sector interest or commitment was shown only through listing a consortium of engine and energy companies.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert stated that all of the planned future work would provide needed additional results that will be extremely valuable to help optimize fuel formulations. A reviewer said that future work will continue validation of the large ester models and will consider additional cycloalkanes and gasoline-ethanol surrogate models. The reviewer said the future research would also consider the effect of double bonds on ignition behavior. The commenter concluded that this would continue to be highly valuable and high impact work. One evaluator remarked that future research would develop the surrogate models for Cyclohexane and Cyclohexane/diesel blends and develop and enhance the CFD models as they compare to empirical data. The reviewer also mentioned Methyl Linolenate and Methyl Stearate. One reviewer remarked that future research would continue the validation of larger ester models, validate gasoline-ethanol model and investigate the effect of double bond on ignition characteristics. The final reviewer felt that the project proposes extending the research to other fuels, not all of which are of particular interest, whereas the existing results for the two variables shown appears to already validate the model for those variables. The reviewer said there was no reference to expanding the model to other variables, and that the value of simply testing more fuels is not clear.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of the reviewers selected sufficient, and one reviewer selected insufficient. One reviewer commented that as important as this work is, the funding level should be increased, and adding that stability in the budget for this program would help maintain the momentum and continuity of this program and its many collaborative activities. One reviewer suggested that for the future work

planned, the resources are adequate. Another reviewer also said that resources appear to be sufficient. One evaluator said that a low level of resources appears to be appropriate for the type of work being done and the utility of the results. The reviewer added that, if more resources were required to elaborate the model to provide more diagnostic data (going beyond shock tube and RCM) and meaningful results could realistically be expected, that greater resources might be justified.

Lubricants Activities: George Fenske (Argonne National Laboratory) – ft012

Reviewer Sample Size

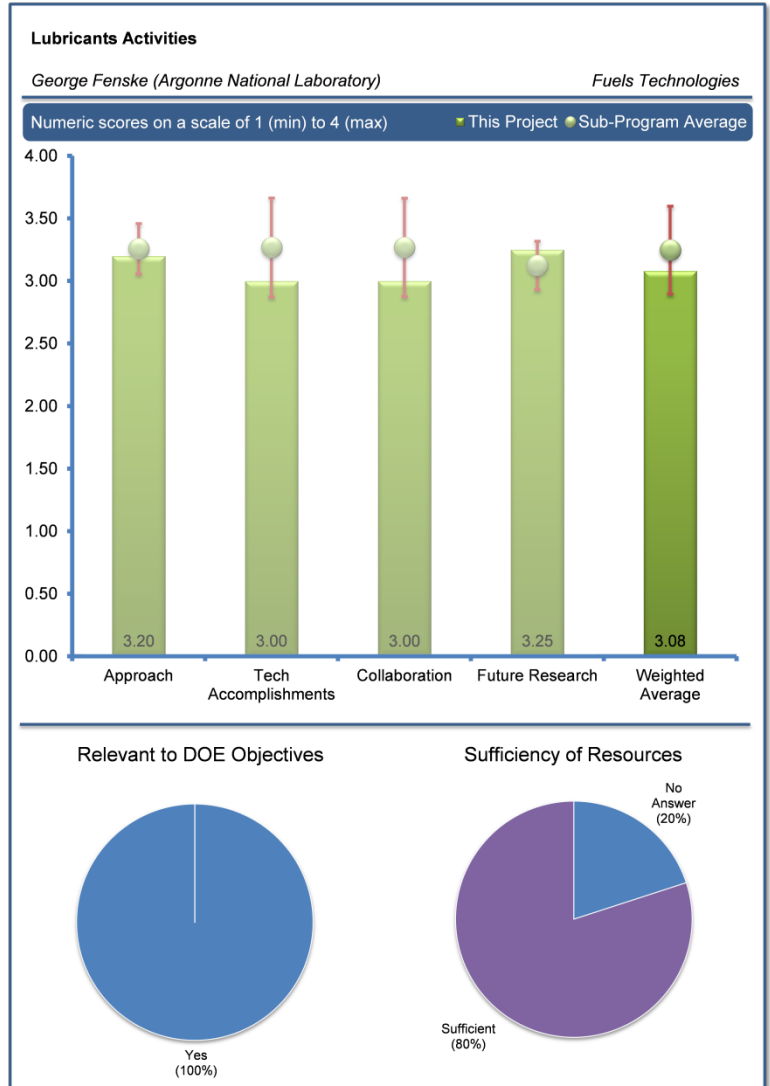
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that this research is very relevant to the goal of reducing petroleum use because by making advancements in lubricants, you can have a 1% or 2% improvement in fuel economy, and because there is a significant loss of fuel economy due to friction of up to 10%, improving lubricants will have an impact on petroleum displacement. A second reviewer noted that lubricants improve fuel efficiency of the vehicles, and can reduce parasitic losses in the engine by 10%. The reviewer added that low viscosity lubricants help a lot, and that up to 2% improvements in the fuel economy is expected. The reviewer concluded that these attributes support the DOE overall objectives. A third reviewer said that the results could increase fuel economy by 5%-7% in new vehicles and 1%-2% in legacy vehicles by reducing friction parasitic losses. A commenter said that the research was on lubricants and how they can affect vehicle performance and fuel economy. The final reviewer suggested that additional impact should be addressed by looking at interaction with aftertreatment systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that lubricants and tribology is a relatively neglected area of energy research to date. The reviewer continued that in recognition of that, this phase of the project proceeds from major consultation with stakeholder to identify pre-requisite needs for meaningful future research programs, test methods equipment, metrics, facilities, data needs, areas of initial focus, applications, etc. This will provide the basis of meaningful research for years to come in this promising but neglected field. The reviewer also mentioned a high level of sophistication in planning and coordination rather than jumping headlong into specific disjointed research projects. A reviewer said that good progress has been made in developing goals targets and barriers in support of the DOE multiyear program plan (MYPP) development, and that a comprehensive set of barriers has been developed. One evaluator said that the research had developed multiple pathways to address the barriers. A reviewer described a well focused approach to overcome barriers, adding that the barriers are inadequate data and predictive tools, limited base stocks and additive formulations and that validation is limited. Another commenter said that the approach was good and followed industry and academically approved methods. A final reviewer stated there was minimal focus on aged oil in old engines and there were no projects proposed for transmission fluids.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally observed good technical progress. A reviewer said that there had been good progress towards the characterization of the lubricants in order to screen these different constituents that can offer greater fuel economy and engine performance. One commenter stated that good progress has been made in the lab-engine validation project and the lubricant additive studies work. An evaluator noted that protocols and lab/engine validation methods were developed to screen candidate lubricants and friction modifiers without the need for expensive and time consuming engine testing of each candidate. The reviewer added that initial testing had been done on some sample lubricants and additives, and that methods for investigating mechanisms of friction and friction reduction, boundary films, etc. are set in motion. One expert stated that multiple goals are addressed, adding that issues are identified, such as fuel economy, emissions, alternate fuels and cost. The project identified multiple pathways and approaches to improve fuel economy. A reviewer said that a number of new projects have started this year but no data is available yet. The reviewer noted that it will be interesting to see the results next year.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

An evaluator cited collaboration, not only with the normal labs, universities and automakers, but also with key vehicle component makers, lubricant and additive makers, etc. all being brought into the process. Another reviewer mentioned there was good collaboration with university and oil company support. A third commenter mentioned the good collaborations with industry lab, academia and other institutions. A final commenter noted collaboration with the Massachusetts Institute of Technology, OEMs and lubricant and additives suppliers.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One evaluator stated that there was a well scoped plan for completing the process of putting the protocols and methodologies in place and getting wide input while transitioning to initial research on specific types of lubricants, films, etc. Another reviewer believed that future work would be to further develop the models that can help characterize the characteristics and correlate those to actual engine testing. Another commenter mentioned that several projects were established to address the development of advanced lubrication concepts. A final evaluator said that the proposed future activities are adequate.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All responding reviewers selected sufficient. One reviewer said that the resources appear sufficient for the work that is planned. Another evaluator commented that resource levels appear to be appropriate based on reported progress. A third reviewer noted a need for phasing, adding that there was a need and opportunity for substantial follow-on work, which was strongly suggested. The final commenter said that the resources appear to be sufficient.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
ADT	Accelerated Durability Test
AEC	Advanced Engine Combustion
AVFL	Advanced Vehicle/Fuel/Lubricant Committee
AVFL-19	Project 19 under Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council
B20	Biodiesel blend of 20% neat biodiesel
B100	Biodiesel blend of 100% neat biodiesel
CFD	Computational Fluid Dynamics
CRC	Coordinating Research Council
DISI	Direct Injection Spark Ignited
DOE	Department of Energy
E85	85 percent Ethanol blend with gasoline
ECS	Emission Control Systems
EGR	Exhaust Gas Recirculation
FACE	Fuels for Advanced Combustion Engines
FY	Fiscal Year
GM	General Motors Corporation
HC	Hydrocarbon
HD	Heavy-Duty
HECC	High Efficiency Clean Combustion
LD	Light-Duty
LLFC	Lean Lifted Flame Combustion
LLNL	Lawrence Livermore National Laboratory
MOU	Memorandum of Understanding
MYPP	Multiyear Program Plan
NO_x	Oxides of Nitrogen
OEM	Original Equipment Manufacturer
PLIF	Planar Laser-Induced Fluorescence
PM	Particulate Matter
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid Compression Machine
RPI	Rensselaer Polytechnic Institute
SCR	Selective Catalytic Reduction
SIDI	Spark Ignition Direct Injection
SNL	Sandia National Laboratory
VTP	Vehicle Technologies Program

6. Materials Technologies

Advanced materials, including metals, polymers, composites, and intermetallic compounds, can play an important role in improving the efficiency of transportation engines and vehicles. Weight reduction is one of the most effective ways to increase the fuel economy of vehicles while reducing exhaust emissions. The use of lightweight, high-performance materials will contribute to the development of vehicles that provide better fuel economy, yet are comparable in size, comfort, and safety to today's vehicles. The development of propulsion materials and enabling technologies will help reduce costs while improving the durability, efficiency, and performance of advanced internal combustion, diesel, hybrid, and fuel-cell-powered vehicles. The advanced materials research conducted under the direction of the U.S. Department of Energy and the Vehicle Technologies Program will help ensure the nation's transportation energy and environmental future by making affordable full-function cars and trucks that use less oil and produce fewer harmful emissions.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Technical Cost Modeling - Life Cycle Analysis Basis for Program Focus	Sujit Das (Oak Ridge National Laboratory)	6-3	2.00	2.20	2.20	2.40	2.18
Carbon Fiber Technology Facility	Dave Warren (Oak Ridge National Laboratory)	6-6	3.50	2.75	2.75	3.00	2.97
Lower Cost Carbon Fiber Precursors	Dave Warren (Oak Ridge National Laboratory)	6-8	3.75	3.00	3.00	3.50	3.25
Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers	Dave Warren (Oak Ridge National Laboratory)	6-10	3.00	2.75	2.75	3.00	2.84
Magnesium Front End Development (AMD 603/604/904)	Alan Luo (General Motors)	6-12	4.00	3.50	3.50	3.00	3.56
Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project	Mei Li (USAMP/AMD)	6-14	3.50	3.00	3.00	3.00	3.13
Supporting Vehicle Weight Reduction Through Characterization	Edgar Lara-Curzio (ORNL/HTML)	6-16	4.00	4.00	4.00	3.33	3.92
Friction Stir and Ultrasonic Solid State Joining of Magnesium to Steel	Yuri Hovanski (Pacific Northwest National Laboratory)	6-18	4.00	3.33	3.33	3.00	3.46
Pulse-Pressure Forming of Lightweight Metals	Rich Davies (Pacific Northwest National Laboratory)	6-20	3.33	2.50	2.50	2.33	2.69
Solid Oxide Membrane (SOM) Electrolysis of Magnesium: Scale-Up Research and Engineering for Light-Weight Vehicles	Steve Derezinski (MOxST)	6-22	3.75	3.00	3.00	3.75	3.28
High Throughput Isotopic Diffusion Databases for Magnesium Integrated Computational Materials Engineering	Dave Warren (Oak Ridge National Laboratory)	6-24	3.00	3.00	3.00	3.00	3.00
Southern Regional Center for Lightweight Innovative Design (SRCLID)	Mark Horstemeyer (Mississippi State University)	6-26	2.75	3.25	3.25	2.25	3.00

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Advanced Materials and Processing of Composites for High Volume Applications (ACC932)	Dan Houston (USAMP/ACC)	6-28	3.00	3.33	3.33	2.00	3.08
Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts	Jim Stike (Materials Innovation Tech)	6-30	3.50	3.67	3.67	3.67	3.63
Development and Commercialization of a Novel Low-Cost Carbon Fiber	George Husman (Zoltek)	6-32	3.75	3.50	3.50	3.75	3.59
Structural Automotive Components from Composite Materials	Libby Berger (USAMP/AMD)	6-34	3.33	3.33	3.33	3.00	3.29
Reliability Tools for Resonance Inspection of Light Metal Castings	Martin Jones (USAMP/NDE)	6-36	4.00	3.00	3.00	3.00	3.25
Hybrid NDE Method for Spot Weld Quality Evaluation	Leo Lev (USAMP/NDE)	6-38	2.67	3.00	3.00	3.00	2.92
Development of Steel Fastener Nano-Ceramic Coatings for Corrosion Protection of Magnesium Parts (AMD-704)	Richard Osborne (USAMP/AMD)	6-40	2.33	3.33	3.33	2.50	2.98
Development of Corrosion Inhibiting E-Coat System for Body-in-White Assemblies	Yar-Ming Wang (USAMP/ACC)	6-42	3.67	3.00	3.00	3.00	3.17
On-Line Weld NDE with IR Thermography	Dave Warren (Oak Ridge National Laboratory)	6-44	3.00	2.67	2.67	3.00	2.79
Ablation Casting Evaluation for High Volume Structural Castings	Jake Zindel (USAMP/AMD)	6-46	2.67	3.00	3.00	2.00	2.79
Non-Rare Earth High-Performance Wrought Magnesium Alloys	Curt Lavender (Pacific Northwest National Laboratory)	6-48	3.25	3.00	3.00	3.00	3.06
PNNL: Mechanistic-Based Ductility Prediction for Complex Mg Castings	Xin Sun (Pacific Northwest National Laboratory)	6-50	4.00	4.00	4.00	3.00	3.88
Low-Cost Magnesium Sheet Production using the Twin Roll Casting Process and Asymmetric Rolling	Dave Warren (Oak Ridge National Laboratory)	6-51	2.67	3.00	3.00	2.50	2.85
Aerodynamic Lightweight Cab Structure Components	Mark Smith (Pacific Northwest National Laboratory)	6-53	2.50	3.00	3.00	2.50	2.81
Optimization of High-Volume Warm Forming for Lightweight Sheet Alloys	Nia Harrison (USAMP/AMD)	6-54	3.33	3.00	3.00	3.33	3.13
Improving Fatigue Performance of AHSS Welds	Dave Warren (Oak Ridge National Laboratory)	6-56	3.50	3.33	3.33	3.50	3.40
Advanced High-Strength Steel Stamping	Gene Hsiung (USAMP/AMD)	6-58	3.67	3.67	3.67	3.00	3.58
Nonlinear Strain Paths	Thomas Stoughton (USAMP/AMD)	6-60	3.67	3.67	3.67	3.50	3.65
Mapping of Forming Effects to Structural Models	Raj Sohmshtetty (USAMP/AMD)	6-62	3.33	3.33	3.33	3.00	3.29
Lightweight Sealed Steel Fuel Tanks	Phil Yaccarino (USAMP/AMD)	6-63	3.33	3.00	3.00	3.00	3.08
First Generation Advanced High-Strength Steels Deformation Fundamentals	Xin Sun (Pacific Northwest National Laboratory)	6-64	2.50	2.50	2.50	2.00	2.44
Engineering Property Prediction Tools for Tailored Polymer Composite Structures	Ba Nguyen (Pacific Northwest National Laboratory)	6-66	2.00	2.67	2.67	2.67	2.50
Overall Average			3.24	3.13	3.13	2.93	3.13

Technical Cost Modeling - Life Cycle Analysis Basis for Program Focus: Sujit Das (Oak Ridge National Laboratory) – Im001

Reviewer Sample Size

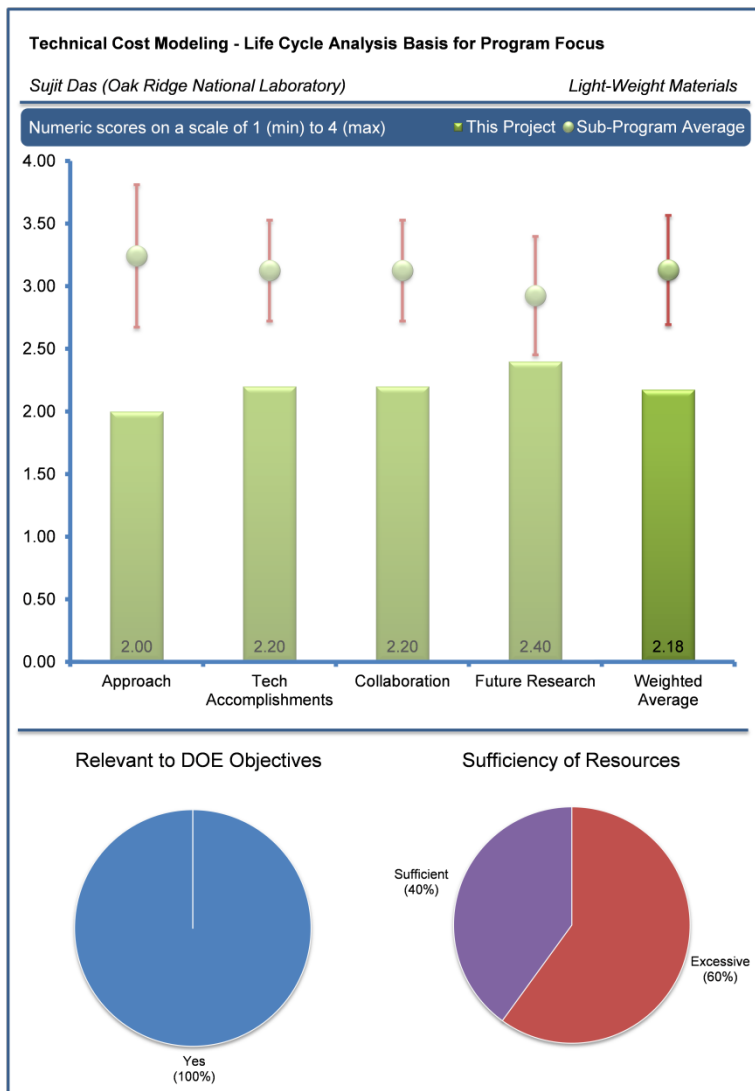
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Of the five reviewers commenting, two responded affirmatively. One said yes, for vehicle lightweighting. The other called the basic premise of the function good, to provide some guidance to Department of Energy (DOE) management on the financial impact of projects and technologies. Two others offered additional approval, one noting that while the project does not provide any technology advances to meet the objective of petroleum displacement, it does evaluate multiple scenarios that are alternatives to increasing fuel economy and thus reducing petroleum use, assuming that total vehicle miles traveled remain the same. The other said that cost modeling of lightweight material systems is equally important to implementing and enabling the technology for product applications, thus enabling us to reduce dependence on imported petroleum. The reviewer said that staying connected to the multi-material lightweight vehicle (MMLV) project is encouraged. The final reviewer termed the PowerPoint presentation very poor, with very little original content, but rather a literature review of lightweighting trends and a conglomeration of various studies previously published (yesterday's news). There was no take-away. The DOE literature review should not be published, as it implies validation of the data. This reviewer recommended, at a minimum, a formal peer review/approval. Example is of greenhouse gas (GHG) calculations developed by Metal Oxygen Separation Technologies, Inc. (MOxST), not DOE and based on industrial-scale predictions of a future, much larger system that MOxST does not know whether or when will be developed. DOE should only publish and validate actual peer-reviewed calculations by chemists and scientists and state assumptions. Reference process information must also be certified to be correct. Assumptions and sources need be documented, this reviewer concluded.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Five reviewers again offered comments on this aspect of the project. One gave qualified approval of the approach, observing that preliminary data is extracted from lower-volume, niche products - a good starting point - but cost models will be significantly improved as higher-volume materials and processes are considered at volumes exceeding 60,000 unit production per annum (UPA). This reviewer recommended that the researchers continue to direct the project to higher-volume cost analysis for a 25% lightweighted vehicle at higher volumes. The other four reviewers were critical of the approach. One called it generally less accurate compared with the process-based technical cost modeling, and cited the need to benchmark the Massachusetts Institute of Technology (MIT) approach and improve the robustness of the technical cost modeling (TCM) approach in this study. Another



said an overly simplified view is taken of automotive applications. For example, it is not appropriate to assume that you can automatically achieve an arbitrary ~50% secondary weight saved for all vehicle systems. Many cannot be downsized due to a reduction in mass of other systems. For example, you cannot reduce the mass of glass in a vehicle another 40% just because a smaller engine is used. A third said the approach is fragmented and results presented do not address objectives. Manufacturer's suggested retail price (MSRP) vs. lifecycle cost. We may want to identify the components of the Internal Revenue Service (IRS) mileage guideline of \$0.50 /mile for internal combustion engine (ICE) vehicles, and develop a model (formula) describing MSRP, insurance, maintenance and fuel usage (6% for every 10% mass) thus a 30% mass savings yields an 18% fuel usage reduction = 20 mpg baseline at \$4/gal = \$0.20/mile, vs. \$0.30 savings/mile = 200K useful life = \$6,000 fuel economy offset. This reviewer went on to say that results presented do not address the objectives of cost modeling. Manufacturing cost and MSRP are of no technical or commercial value and can be easily described using a 1.3 ratio cost vs. selling price. In reality, a technical cost model would include raw material (cost/kg); manufacturing conversion (cost/kg); product, subassembly (cost/kg); corrosion cost/kg; vehicle assembly; paint (cost/ vehicle) and MSRP (1.3 cost). The percent mass reduction potential appears to accomplish the objective to classify materials selection and to realize a 30%, 40% and 50% mass reduction using a power train change from V8 to V6, 170 kg to 190 kg plus a mass compounding factor of 1.4 gets you to the target numbers. Primary GHG and CO₂ comparison for solid oxide membrane (SOM) process is interesting but is only one component of the life cycle. Further work regarding life cycle components associated with manufacture of magnesium auto components, corrosion protection, automotive use and recycling need be addressed. The last of these four reviewers noted that the project's first listed objective for fiscal year (FY) 2012 is validate the cost-effectiveness of reducing the weight of passenger vehicle by 25%, with safety, performance, and recyclability comparable to 2002 vehicles (FY 2012 focus). According to this reviewer, there is no effort reported in the presentation that gives any confidence that the proposed lightweight designs could meet the safety, fatigue, vibration, recyclability or other performance measures comparable to a 2002 vehicle. With any use of composites, the recyclability would be substantially degraded relative to the predominantly steel 2002 vehicle. There is nothing that indicates the lightweight designs proposed would meet 2002 safety requirements or Insurance Institute for Highway Safety (IIHS) performance. This reviewer added that the 2002 vehicle would be illegal to sell today and would be illegal in the future.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer of five offered general approval of the technical accomplishments and progress, saying the project tries to address some of the most important questions facing the automotive industry. It has made some good progress and provided directionally correct answers. The other four reviewers were more critical. One found it unclear how the mass saved analysis will translate into cost impact. But, according to this reviewer, it appears that the carbon fiber cost modeling is more specific and therefore more accurate and useful than the mass studies. The second said the literature search lacks contribution of technical content. Shallow content reports devalue the technical capability of the DOE and DOE laboratories. This reviewer commented that if I presented such depth to justify a project, industrial management would walk out of the room. Another reviewer noted that the information presented shows considerable work has been performed, but unfortunately little of the work addresses the objective. While the cost of production and ownership is shown, nothing is presented that speaks to the cost modeling or how different scenarios would affect the production cost or the cost of ownership. Additionally, nothing in the presentation addresses the safety or performance of the proposed vehicle scenarios. The efforts on the pickup truck and carbon fiber costs appear disconnected from the core of the project. There are deficiencies in the pickup truck lightweight scenarios since, for example, most V6 engines are already built with aluminum blocks and heads and unlikely to become lighter while maintaining performance. For the pickup truck, the assumption of 50% secondary mass savings is questionable, since most engine, driveline and chassis components as well as the truck bed are sized for the maximum towing and cargo. With the proposed weight reduction scenarios, the study should specifically state that the resulting truck would not meet the performance and capabilities of the baseline truck. In the carbon fiber cost work there is no information on the performance of the carbon fiber from the proposed different processes. Again, there is no discussion or examples of how the cost model works to explore sensitivities. The third reviewer generally concurred, saying the mass saving scenarios for the F150 need additional refinement. The three scenarios which include advanced high-strength steel (AHSS), aluminum and carbon fiber (CF) composites does not define whether that included making the chassis (primary) weight out of these lightweight materials or was it limited to the body in white. This reviewer also felt that a 50% weight saving on a pickup is

too much of a stretch and should be reconsidered, due to the above scenario wherein it is highly unlikely we would make a CF truck frame, whereas even a AHSS truck frame with a CF body will not deliver a 50% weight savings.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers were generally unimpressed with the degree of collaboration and inter-institutional coordination in this project. One noted an interesting list of collaborators spanning the projects, but the contributions are not clear. The effort with Tier 1 suppliers and original equipment manufacturers (OEMs) is lacking for filtering the effects from low-volume examples to high volume production. A second reviewer urged the project to stay connected with VEHMA and Ford as well as other OEMs to get a fair and accurate assessment of what we can deliver by way of lightweight materials beyond 2020. A third cited the need for input from a broader base of OEMs and suppliers. Another reviewer said it is obvious that the studies involved the firms cited; however, there is no obvious interaction or interdependencies. It appears the others likely provided some general information, but there is no indication that they were deeply involved in the studies or that they provided any validation/confirmation of the results. Finally, the fifth reviewer said the nature of the literature review did not include collaboration and coordination with other institutions. Inherently, an incorrect, high-risk conclusion is the result. Research summarized and published by DOE presents a huge problem. Example includes Ford truck lightweighting as well as the MOxST assumptions for energy and CO₂ comparison. Business decisions continue to be made on old, unqualified data.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to one reviewer, the plans look good; their value will be in how they are executed. A second commented that research should continue, but Oak Ridge National Laboratory (ORNL) must continue to engage the OEMs regarding the real potential for using magnesium (Mg), aluminum (Al) and especially CF. It will be imperative, in this reviewer's opinion, that we do not oversell the merits of CF prematurely. It was suggested by the third reviewer that the costs of lightweighting be compared to advanced powertrains (ICE, hybrid and electric vehicle (EV)). Many of the proposed future efforts are properly aligned with the project goals, in the view of the fourth reviewer. However, this reviewer went on, there is little or no proposed effort on ascertaining the performance, safety and recyclability of the potential lightweight alternatives. The efforts on trucks must address capability at a reduced weight truck. The last reviewer commented that future task ordered funding was not identified. This reviewer strongly discouraged publication of results prior to peer review.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers termed resources sufficient. Of the two reviewers who deemed the project resources sufficient, only one elaborated, saying task ordered funding by definition utilizes available resources and inherently lacks building a sustainable infrastructure. Establishing a group of professionals capable of conducting life cycle analysis and performing an independent third-party cost/benefit assessment is required. This reviewer recommended that effort be focused on validation of third-party claims and conduct of complete life-cycle calculations, considering this to be imperative. An example is Western Europe-focused magnesium research without addressing GHG impact/cost of primary production (which MOxST does address). Further, application of magnesium for commercial use requires recycling and corrosion resistance, which are synergistic. This type of task ordered funding is needed and will provide independent assessment, considering the complete life cycle for both environmental impact and cost. Three reviewers characterized the project resources as excessive. One reviewer commented that the project is based on surveys and simple spreadsheet analyses. No specialized skills/manpower are needed in design, finite element analysis (FEA) and advanced simulation. This reviewer concluded that the work could be done with much less funding. Another opined that given the lack of attention to half the primary objective -with safety, performance, and recyclability comparable to 2002 vehicles (FY 2012 focus) - the resources appear excessive for the results presented. The third emphatically stated that no additional funding is necessary.

Carbon Fiber Technology Facility: Dave Warren (Oak Ridge National Laboratory) – Im003

Reviewer Sample Size

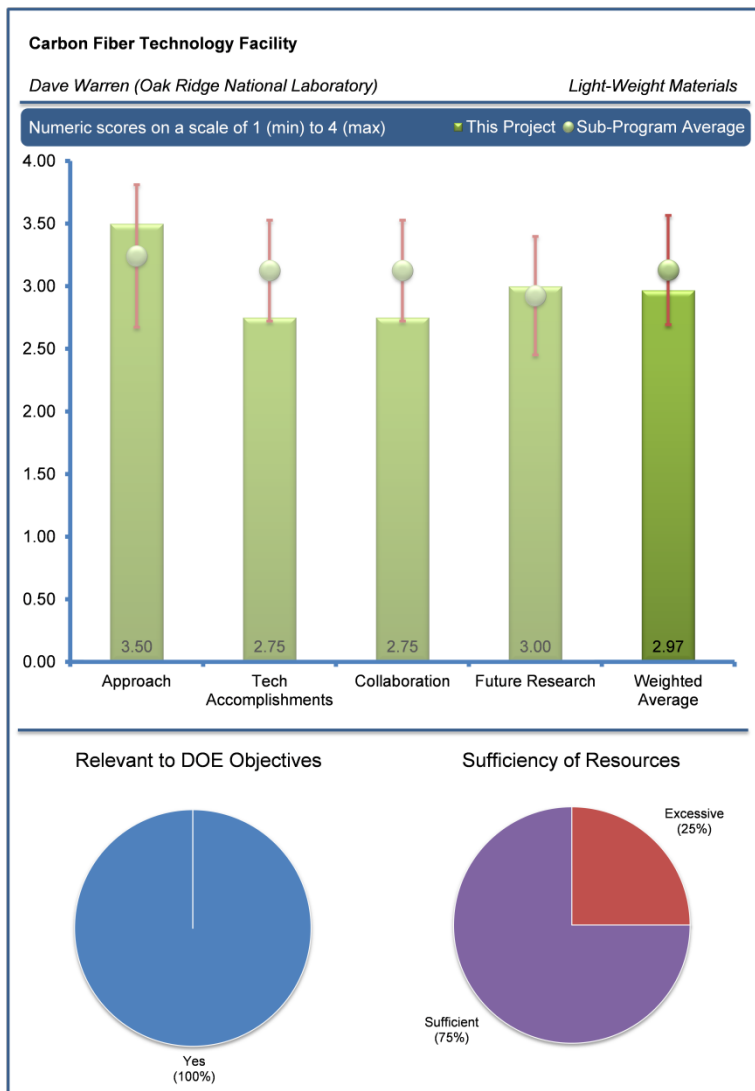
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers agreed that this project furthers the overarching DOE goal. One noted that it creates an avenue for testing various ideas at a large scale, another observing that if it truly does facilitate introduction of low-cost carbon fiber into the marketplace, it will greatly help reduce vehicle weights. The other two reviewers offered more detailed assessments, one affirming that reducing the weight of vehicles is a route to improve fuel economy and reduce petroleum dependency and deeming carbon fibers to be the material of the future with great potential for reducing the weight of vehicles. More and more carbon fiber-based components are being used in aerospace applications, this reviewer continued, but the cost is considerably higher for economic automotive applications. The project involves construction of a prototype facility which can facilitate research and development (R&D) to reduce the cost of the fibers and make them accessible for vehicle applications. The fourth commented that this project supports a critical element of the infrastructure to make future use of carbon fiber in automotive and other industries. The country needs a facility to demonstrate carbon fiber manufacturing processes at the pilot plant level to reduce the risk for larger-scale production facility investments.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three of four commenting reviewers praised the project approach warmly, one saying that funding such facility is a great approach, another calling the project well planned and noting that the facilities are flexible to accommodate variations in the process. The third reviewer cited a great definition of the project for the capital investment. The project addresses one of the critical technical barriers to increased use of carbon fiber for lightweight components – the cost of manufacturing carbon fiber. The availability of prototype-level carbon fiber in multiple formats is a key to understanding the effects of carbon fiber production on the material properties of the final fiber and composites. The final reviewer qualified approval of the project approach somewhat. According to this reviewer, the facility is set up to address and evaluate changes to existing conventional technologies for producing carbon fiber. However, it lacks the ability to incorporate game changing technologies. For example it cannot accommodate the technologies employed by Zoltek in its low-cost carbon fiber efforts. Also it appears the expenses for staff, and facility maintenance will be a drain on resources that would be better spent on material technology research, for the foreseeable future and there is no specific vision or plan for making the center self-sustaining in a reasonable amount of time.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Here, too, three of four reviewers offered positive assessments. One simply noted on time implementation. Another said the project is ahead of time and on budget. The facilities will include the best ideas and options for processing different feedstock materials and different processing stages into carbon fiber. The third observed that while this is not an R&D project, the accomplishments are quite significant in that most of the project tasks are on or ahead of schedule. The final commenter expressed the view that thus far there is good progress against construction targets, but tempered this by saying there have been no research accomplishments achieved during the construction.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Three reviewers commented favorably on the project's collaboration and coordination. One reviewer commented that it is in process. A second noted that many discussions are being held with equipment suppliers, manufacturers and end users. According to the presentation, this reviewer went on, at least five new proposals are being prepared or submitted for the use of this facility. The third reviewer remarked that collaboration with the industrial base for potential future users is only beginning. Collaboration within the project team must be great, given the construction, logistics and installation successes. The last reviewer offered qualified praise of the work approach, saying the principal research organization appeared to have a good working relationship with construction contractors, but said that does not truly indicate collaboration as much as cooperation. There appears to be collaboration forming relative to workforce training efforts, but this reviewer felt it is premature to assess its effectiveness.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt proposed future work offers a good opportunity for all to participate. A second concurred, saying it appears equipment producers and some fiber producers would make use of the facility. However, this reviewer added, research details and plans are sketchy at this time. The third reviewer commented that the project is at the beginnings of identifying future projects to test and use the carbon fiber from the facility. There is good outreach to the educational base for training. Finally, the last reviewer felt the operating cost of the facility needs to be estimated more accurately. Also, industrial partners should be engaged in developing new projects which will support the facilities.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of four reviewers deemed project resources to be sufficient. One of these reviewer commented good plan, right resources. One reviewer considered resources excessive. This reviewer commented that \$35 million plus an estimated \$6 million per year to staff and run a facility with limited capability to try out any technologies other than conventional seems unreasonably high.

Lower Cost Carbon Fiber Precursors: Dave Warren (Oak Ridge National Laboratory) – Im004

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

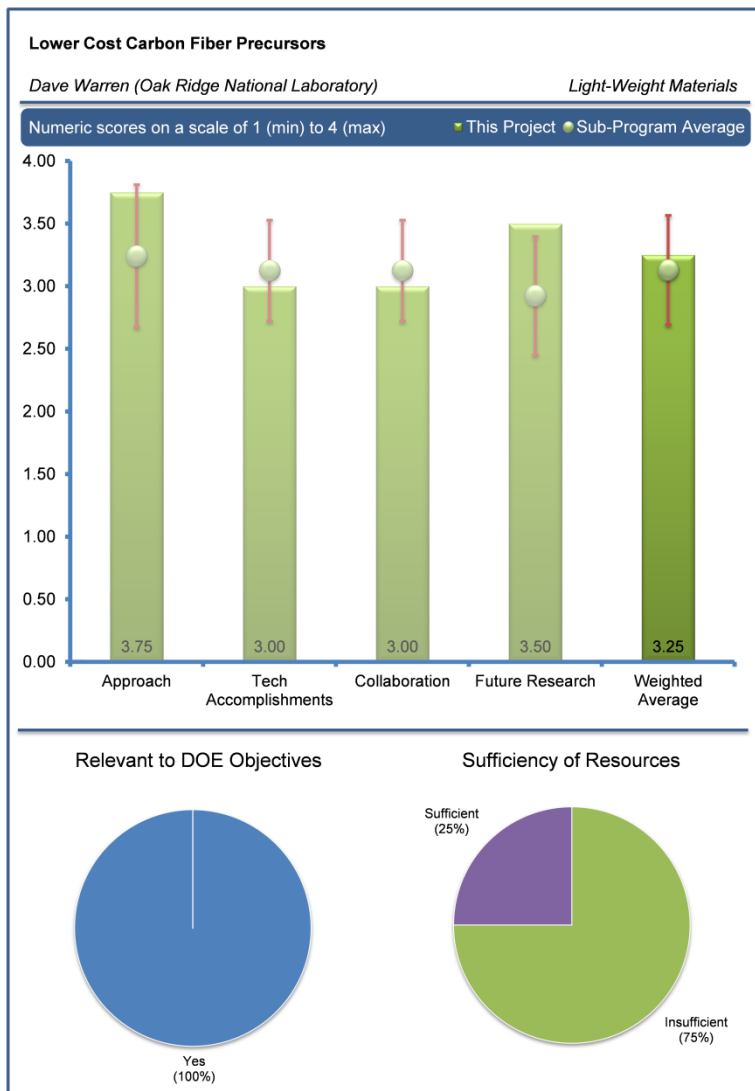
Reviewers concurred in a generally positive assessment of this project’s advancement of DOE goals. One noted that polyolefins can be a great low-cost precursor and a second said the project addresses a major cost element of carbon fiber. A third agreed, saying the low- cost precursor has the largest leverage for potentially producing affordable carbon fiber. This project supports DOE’s objectives of petroleum displacement through the associated goal of reducing the weight of automobiles and other manufactured products. The fourth said that continued emphasis on low-cost carbon fiber continues to be a future enabler for vehicle lightweighting and will reduce dependence of future oil imports.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
Reviewer comments were uniformly positive. One was that the project embodied good science in resolving the pertinent issues. Another cited the clear vision for what is to be addressed. The project, the third reviewer said, is directly focused on the barriers to low- cost carbon fiber for automotive and other industrial uses. The precursor cost to provide the strength and stiffness required for weight saving and performance is being targeted. The polyolefin precursor is a great material to investigate since it has the potential to deliver the performance at higher yield ratios. The fourth reviewer cited excellent technical achievements to date, and a well-planned approach. This reviewer urged the researchers to look at the details of the lab oxidation furnace and to seek to scale process from a test tube type of oven to one that is more scaled to production units.

The project, the third reviewer said, is directly focused on the barriers to low- cost carbon fiber for automotive and other industrial uses. The precursor cost to provide the strength and stiffness required for weight saving and performance is being targeted. The polyolefin precursor is a great material to investigate since it has the potential to deliver the performance at higher yield ratios. The fourth reviewer cited excellent technical achievements to date, and a well-planned approach. This reviewer urged the researchers to look at the details of the lab oxidation furnace and to seek to scale process from a test tube type of oven to one that is more scaled to production units.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Here, too, reviewers were strongly positive in their comments. The project has made excellent progress in a relatively short time, according to one reviewer. A second reviewer noted that progress was substantial in spite of funding reduction. Another reviewer agreed, calling technical accomplishments strong. This reviewer went on to observe that achieving the 200 thousand pounds per square inch (KSI) strength and 20 million pounds per square inch (MSI) stiffness is a great 2011 accomplishment. Many of the barriers have already been overcome. The fundamental investigations into the cores and sulfonation as they depend on fiber thickness gives the necessary insights into what is required for manufacturing. Noting that these small diameter fibers will be tough to process, the reviewer recommended that work focus on the polyolefin precursor since it has the greatest potential for low-cost carbon fiber production. The reviewer suggested that efforts on polyethylene (PE) be reduced. The last reviewer observed that carbon fiber is recognized as getting close to the 250 KSI tensile strength and 25 MSI modulus. Accordingly, this reviewer’s



recommendation was to continue to push the process to achieve the goal while thinking about process scale from lab to the make-like production line scale.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

While one reviewer noted that the efforts are focused in ORNL, the others generally approved of the level of collaboration. One opined that there appears to be good involvement, with the active participation by collaborating firms. Another agreed, saying the collaboration with partners is good, but that it was only briefly described in the presentation. The success to date, this reviewer added, indicates that the team is working well. The last reviewer found an acceptable amount of collaboration, praised the work as a good job, and urged the researchers to press on.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the researchers have developed a plan to complete work that was originally anticipated prior to funding cut and to address newly identified barriers. The proposed future work, in the view of another reviewer, while only briefly described in the presentation, addresses the logical next steps to improving the quality of the carbon fibers produced from polyolefin or polyethylene. Work to improve the properties appears well conceived, needs further definition. Another reviewer, while noting that no new future research was presented, nonetheless felt that the target mechanical properties and progress to date indicates the project should stay the course and hit the final tensile strength and modulus targets. The final reviewer commented if the funding is provided.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of four reviewers called project resources insufficient. One said this project needs funding. A second agreed, urging that funds cut during FY 2012 be restored, since this technology has potential greatly to improve process time and throughput while reducing cost. A similar comment was offered by a third reviewer, who said the resources should be increased, given the success of this project to date. The polyolefin precursors appear very promising for reducing the final cost of carbon fiber. The fourth reviewer said this program is well funded and on track; no changes in funding are recommended.

Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers: Dave Warren (Oak Ridge National Laboratory) – Im006

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

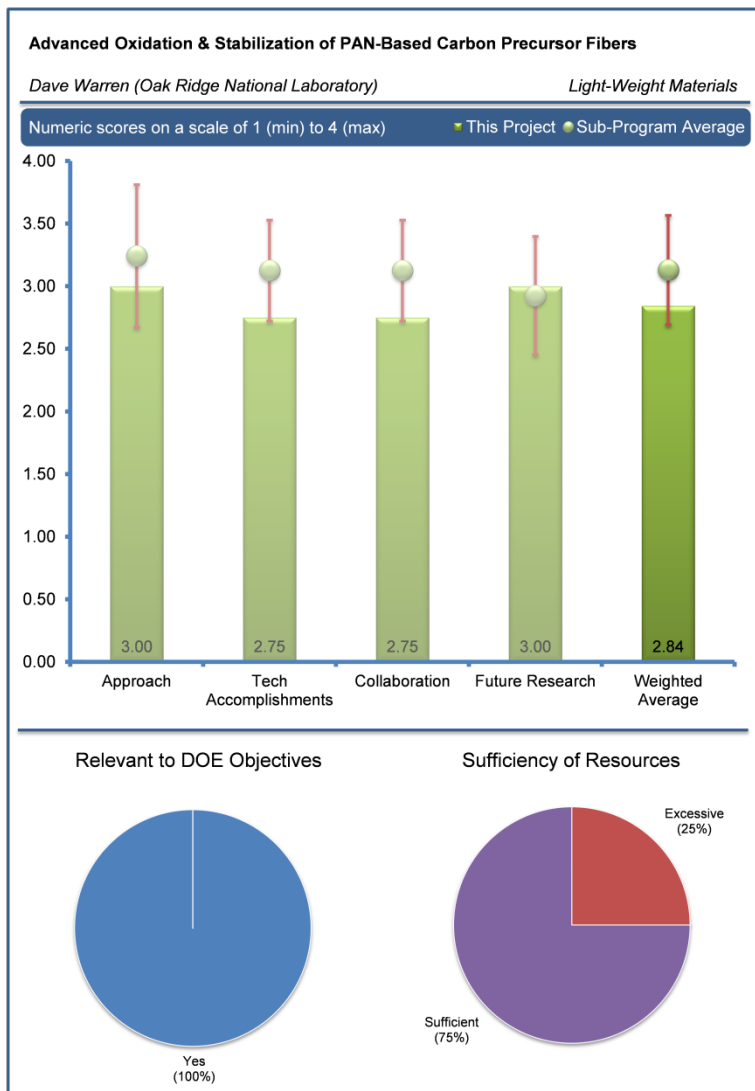
Two reviewers addressed this question explicitly; one observing that low-cost carbon fiber continues to be a common theme and future enabler for vehicle lightweighting and a direct impact on future reduction in dependence of oil imports. This view was concurred by the second reviewer who said the project indirectly supports the DOE goal of petroleum displacement through reducing one of the costly parts of the carbon fiber production process. The other two commenters noted that reducing the oxidation time reduces the overall cost of carbon fiber, and that the project addresses reducing the cost of producing and using carbon fiber.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Opinions were more or less equally split on this question. One reviewer said plasma oxidation is the right way to go. Another felt that the new lab furnace looks like a significant improvement over the previous oxidation/plasma treatment systems and urged continued development of this system. The remaining reviewers submitted more nuanced comments. One noted that after many years effort it appears to be making progress but not in a clearly focused manner. It appears that there is no clear vision of how much more improvement is needed, how much research will be needed, or what the economic benefit will be. The other reviewer called the approach well focused on the technical barrier of oxidation and stabilization of polyacrylonitrile- (PAN)-based fibers. The project, this reviewer said, addresses one of the lower contributors to the overall cost of carbon fiber. The reviewer continued that while it is a residency time bottleneck, the stabilization and oxidation step contributes far less to the cost of carbon fiber than either the precursor or the carbonization step. The same reviewer opined that great success on this project will make a small but important contribution to reducing the cost of carbon fiber.

The reviewer continued that while it is a residency time bottleneck, the stabilization and oxidation step contributes far less to the cost of carbon fiber than either the precursor or the carbonization step. The same reviewer opined that great success on this project will make a small but important contribution to reducing the cost of carbon fiber.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer cited the identification of humidity as the source of the problem and said many issues were resolved. The second reviewer said the development and testing of the close proximity, indirect exposure methods gives good results. Accomplishments in improving the fiber performance properties (strength, stiffness and elongation) are laudable. Efforts on the improved properties appear successful for this lab-scale project. Effort to scale this process to larger tows and faster speeds is the best next step. The last reviewer felt the key to plasma processing is to focus on high volume rates and commercial equipment that can help to reduce



system-level costs. Nonetheless, the plasma process does have the potential to reduce the oxidation cost portion of carbon fiber processing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Four reviewers commented on this question. One reviewer said that the center of expertise is at ORNL. Two others lauded the project's collaboration with other institutions. One said this project is demonstrating the right amount of collaboration and found it encouraging that ORNL is securing intellectual property. The other reviewer deemed the collaboration with the equipment supplier to be good for this lab-scale project. To the final reviewer, however it was not clear how closely ORNL is working with ReMaxCo Technologies or what they are contributing.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers mentioned issues surrounding process scale-up specifically, one saying such issues need to be resolved, the other urging that the project be accelerated to get into the pilot plant facility. The latter reviewer also offered the opinion that the focus on PAN-based fiber does not seem as valuable as a focus on polyolefin-based fiber. Unless the stabilization and oxidation step is completely independent of the base chemistry, this project should be redirected to reduce the processing time and energy consumption of the polyolefin-based fibers. Another reviewer described project plans and targets as general in nature, offering as examples to develop a revolutionary new method for converting carbon fiber, which offers much higher potential for achieving significant cost reduction than evolutionary improvements to existing conversion technology, and process and equipment scaling, as well as textile PAN adaptation, will constitute the majority of future work. In the view of the last reviewer, there is plenty of future potential in current and future programs using plasma processing of low-cost carbon fibers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers considered funding levels to be sufficient. One reviewer said funding is sufficient, assuming there are no further cuts. If DOE is forced to reduce funding, something this reviewer did not recommend, the project would be considered underfunded. The third deemed the project to be adequately resourced. Another reviewer thought project resources at \$2 million a year to be excessive in view of the amount of progress reported.

Magnesium Front End Development (AMD 603/604/904): Alan Luo (USAMP/AMD) – Im008

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers commented, both in agreement that this project is relevant to DOE goals. One noted that systems-level integration of components including magnesium, joints, etc. is naturally of concern going forward if magnesium use is to increase. The other termed the project a typical example of what DOE should be supporting. The front end is an important part of any vehicle to be considered for weight reduction while keeping safety at its optimum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The only reviewer offering a comment felt that for a largely trial-and-error project, the project covered a great deal and have generated a lot of experimental results that can be used to tweak modeling going forward. If there is any criticism, this reviewer felt, it is that they seem to have cast their net very wide, working on formability, performance, joining, casting alloy development, sheet alloy development, etc. At this point in the development cycle for magnesium, this reviewer thought, focusing on alloy development would have the biggest payoff. The reviewer acknowledged, however, that this is a prototype project at base.

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Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

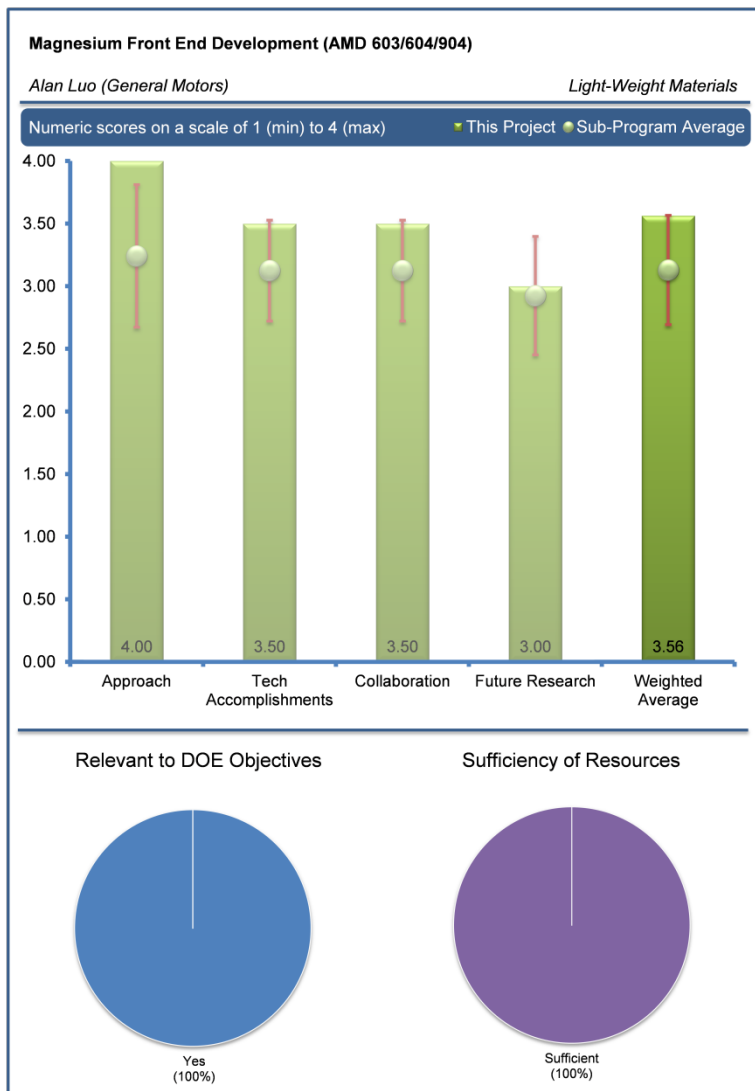
One reviewer noted that the auto industry used to adapt solutions from the aerospace industry. Here, the auto industry goes beyond the aerospace industry and leads the way - quite an achievement. The second reviewer felt the researchers have accomplished quite a bit, although the depth in any of the many various task items is not clear.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer cited very wide collaboration. The other asked why this team cannot work with a European auto maker, also.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The sole commenting reviewer expressed hope that there will be future work along those lines.



Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers felt resources to be sufficient. One reviewer commented sufficient, but probably on the minus side.

Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project: Mei Li (USAMP/AMD) – Im012

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer comments were generally positive. One reviewer termed this project a good example of a project that suits DOE's objectives very well. It goes hand in hand with Dr. Luo's presentation. Both are tackling a real problem of weight and safety. The other reviewer called it a good start, but the FEA modeling using porosity, etc. is an overextension. Perhaps a simpler comparison with all parameters being predicted and not measured would be more convincing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer, noting that the project has ended, said the approach was excellent. This reviewer, however, questioned the strategy of little steps. At some point the team will have to take a big leap starting from the physical properties of magnesium and leading to a new geometry of the front end, instead of the other way around. The other reviewer noted that the capability of predicting yield strengths is in its infancy and looks promising. The reviewer expressed the hope the researchers will be able to use it with additional information on the thermodynamic variables as a function of composition for new alloying constituents.

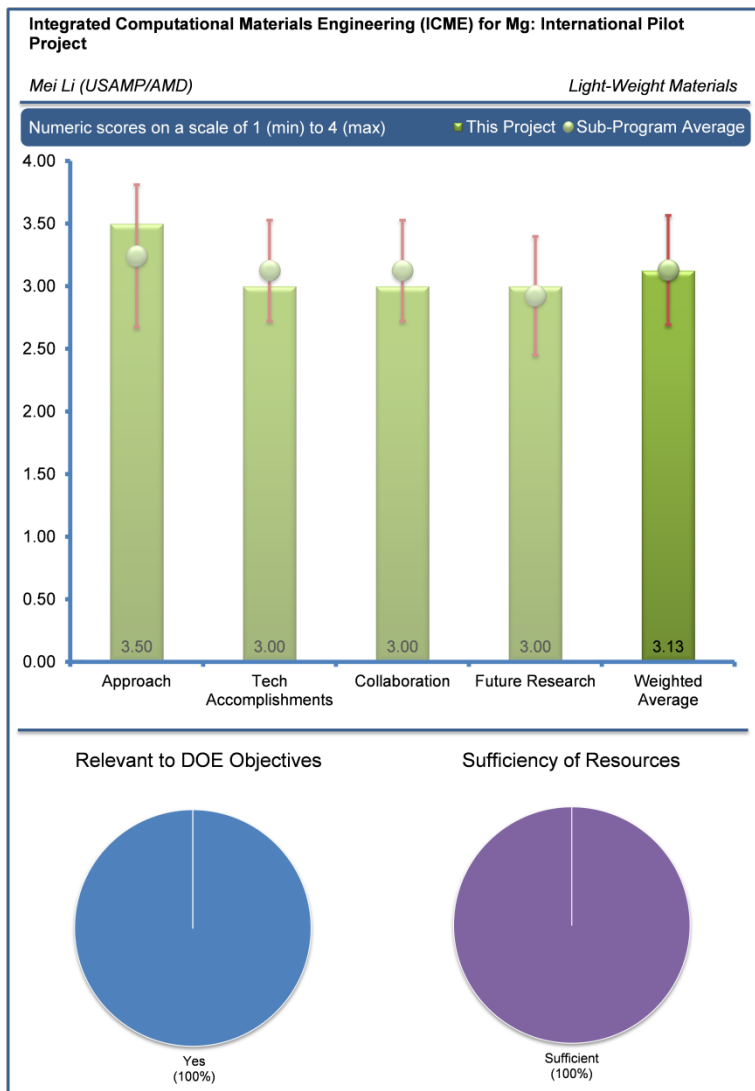
The reviewer expressed the hope the researchers will be able to use it with additional information on the thermodynamic variables as a function of composition for new alloying constituents.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

In the view of one reviewer, the goals were achieved, so excellent progress was made. The other felt that for the time they had available, the Ford people have done a really nice job so far. This reviewer counseled the researchers not to reach so hard to show applicability with a complicated part.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Mississippi State University, in the opinion of one reviewer, seems to have been left alone to work on what they usually work on. The other reviewer reiterated the view that collaboration should include a European automaker.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed the hopes that this line of work can be continued and broadened to include more participants and that the main actors will dare new lines of thought.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers thought project resources to be sufficient. One reviewer commented sufficient, but on the minus side.

Supporting Vehicle Weight Reduction Through Characterization: Edgar Lara-Curzio (ORNL/HTML) – Im028

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers offered comments on this question, both in substantial agreement. One said the project provides unique equipment and skills capable of characterizing materials needed for reducing the weight of future vehicles, and the other affirmed that this center provides a critical capability to attack the fundamental materials questions of technologies that lead to petroleum displacement. The materials characterization efforts support many lightweighting projects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

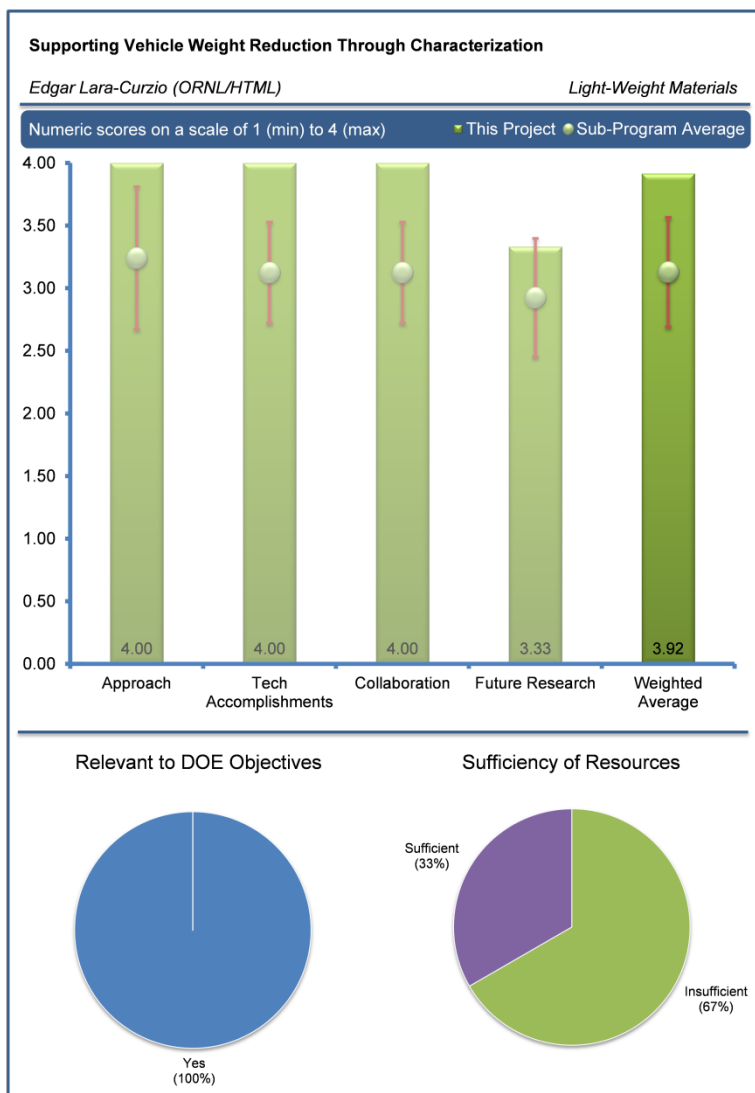
Two of three reviewers submitted comments and they were again in accord. The approach, in the view of one, was a very good approach inasmuch as the High Temperature Materials Laboratory (HTML) deals with numerous independent activities, each addressing a unique challenge and need, which cannot be met elsewhere. The collaborative user facility, said the other, is an outstanding example for a national center to focus efforts on critical materials problems. The facilities and staff at the HTML provide a tremendous resource to the nation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The project came in for high praise in this category also. One reviewer said the examples cited seemed to be of high importance and value. The other reviewer agreed, saying the technical accomplishments are strong. Since this is a user facility, there are not deliverables associated with the lab. The projects and deliverables come from the requesters. The large number of research efforts in FY 2011 indicate the technical merits of the HTML. Great work is done at HTML.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The center, in the words of one reviewer, is used by numerous high-quality and highly talented entities. The other reviewer cited great collaboration with industry, universities and other labs.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that future research unfortunately appears to be in jeopardy, since it appears that the HTML has to focus on survival in FY 2013 rather than on the technologies to be developed. The other reviewer wanted to see the plan for the continuation of this national resource in some fashion. The equipment and researchers need to be kept at the cutting edge of material characterization.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers deemed project resources insufficient. One called FY 2012 funding precariously low. The researchers and testing equipment must be maintained and improved each year. The second said this program should be continued, although its work might have to be more selective due to budget constraints. The reviewer who considered resources to have been sufficient in FY2012 also opined that they should continue in the future.

Friction Stir and Ultrasonic Solid State Joining of Magnesium to Steel: Yuri Hovanski (Pacific Northwest National Laboratory) – Im030

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers appeared to agree that this project supports DOE goals. One noted that joining of dissimilar metals is a key barrier in the development of lightweight vehicles to displace petroleum. If the joining of magnesium to steel were robust, more body and chassis parts would be able to be considered in magnesium. The second agreed, remarking that reliable dis-similar joining technologies are an obvious need for a lightweight, multi-material body. The third reviewer said lightweighting with mixed material applications of steel and magnesium.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

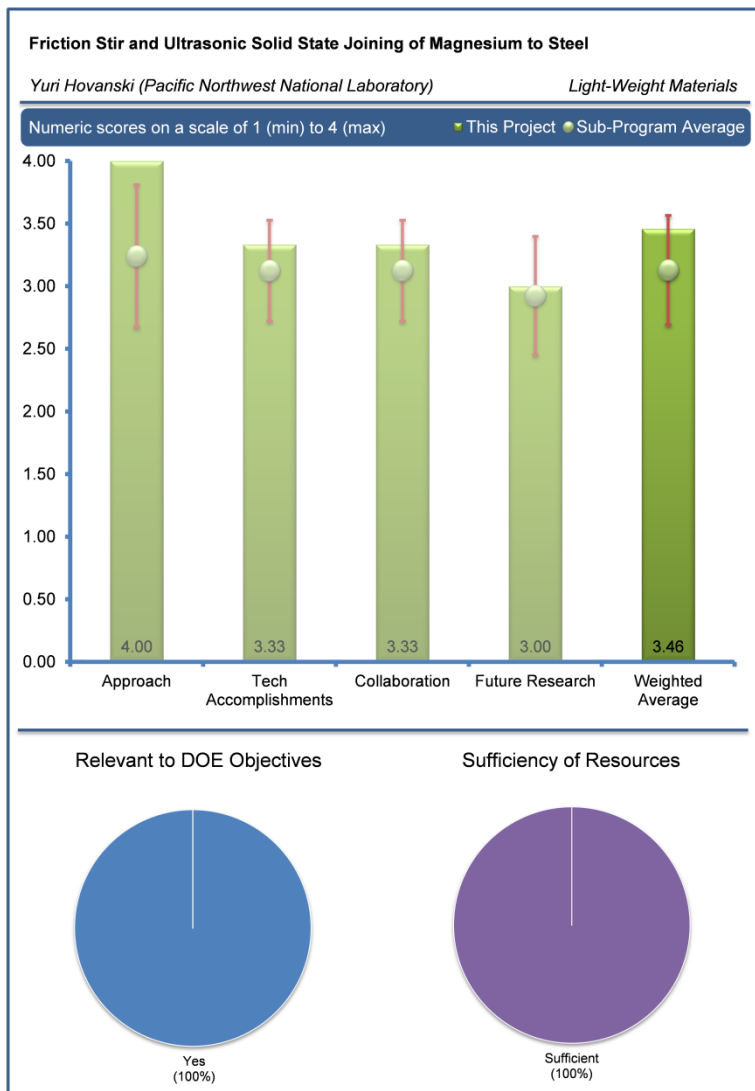
Two reviewers offered comments on this question. They were in general agreement. One took the view that the project researchers seem to be studying what is required, but wonders about the long-term stability of magnesium-steel components, such as when they are heated to 40-50°C in sunlight and whether this could result in formation of iron-magnesium compounds within the mechanically mixed structure. This was a minor concern. The other reviewer said the approach of focusing on the magnesium AZ31-to-high strength, low alloy (HSLA)-steel appeared pragmatic, as these are likely candidates for automotive body structure materials. The technical GATES are appropriate and the focus on corrosion is key.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Only one reviewer commented, noting good accomplishments this year toward the end of the project. The tool development is creative. The testing showing the separation in the 0.8 mm steel rather than the weld tells the best story. Showing that ultrasonic joining is possible for steel on top of magnesium for the joint is a key finding for mixed material joining. The data on the corrosion with and without adhesives is extremely valuable for future design studies.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers offered positive comments. One observed lots of interactive teaming and data sharing, building work upon work. The other called project collaboration good, but wanted to see interactions with a tooling company. The work with PPG for coatings was termed a good start.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

In the single response to this question, the reviewer predicted that the final efforts in this project will be good deliverables. The proposed future projects are not yet clearly focused.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers deemed project resources sufficient. One reviewer observed that the project is all concluded now.

Pulse-Pressure Forming of Lightweight Metals: Rich Davies (PNNL) – Im033

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Only one of the four reviewers offered a comment. That was to the effect that pulse pressure forming of aluminum is an enabling technology for forming deep-drawn aluminum to depths not achievable via conventional stamping and can stretch the application of aluminum for vehicle lightweighting, thus improving fuel economy and reducing our dependence of petroleum imports.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

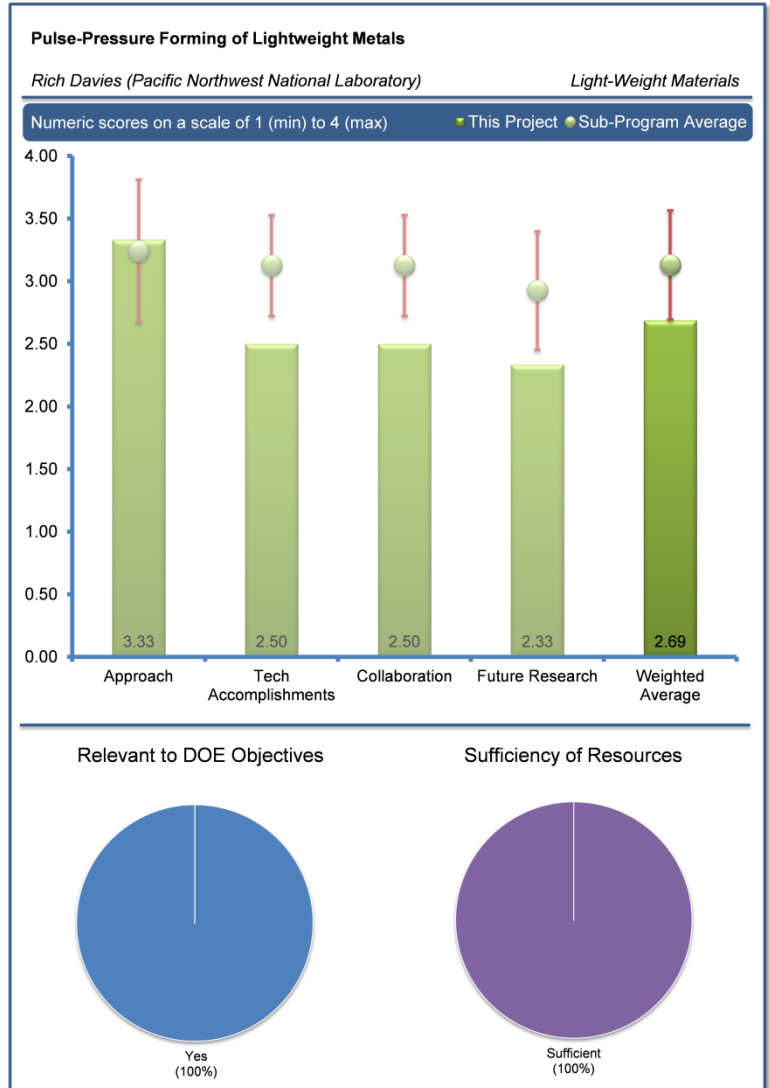
Two of the four reviewers offered opinions on the project's technical approach, one calling it an interesting and rather scientific approach, the other saying this work nicely extends work started at OEMs and the U.S. Automotive Materials Partnership (USAMP) and encouraging that it be continued. The third reviewer observed that the work was directed at enhanced formability at very high strain rates.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer comments were generally positive but tempered. One said the project had produced interesting insight on the change in sign of the strain rate coefficient and its implications for the much higher formability in aluminum at high strain rates. The second saw a significant amount of good work relative to basic research but could see no practical application. The third also noted good progress, but felt that system scale should be the focus, including reducing cycle time and extending the life of the electrodes.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Here again, qualified praise was the general tone of reviewer comments. One recognized a continued interface with OEMs and USAMP and encouraged it for offering direction and guidance. The second acknowledged project collaborators at GM, Ford and Chrysler, but felt they lacked a vision for potential application. The third comment took a contrary view, assessing the project work to be all in-house, except Vecchio's work at the University of California San Diego (UCSD).



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said the focus of future work must be on cycle time improvement and urged a concerted effort to extend electrode life. The other commenting reviewer said the project accomplished the objective, and therefore, concurred with its termination.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers considered resources to be sufficient. One commented further that the project had achieved its goals, another that the project was appropriate and adequate. The third cited a need for greater understanding of magnesium sheet forming.

Solid Oxide Membrane (SOM) Electrolysis of Magnesium: Scale-Up Research and Engineering for Light-Weight Vehicles: Steve Derezinski (MOxST) – Im035

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

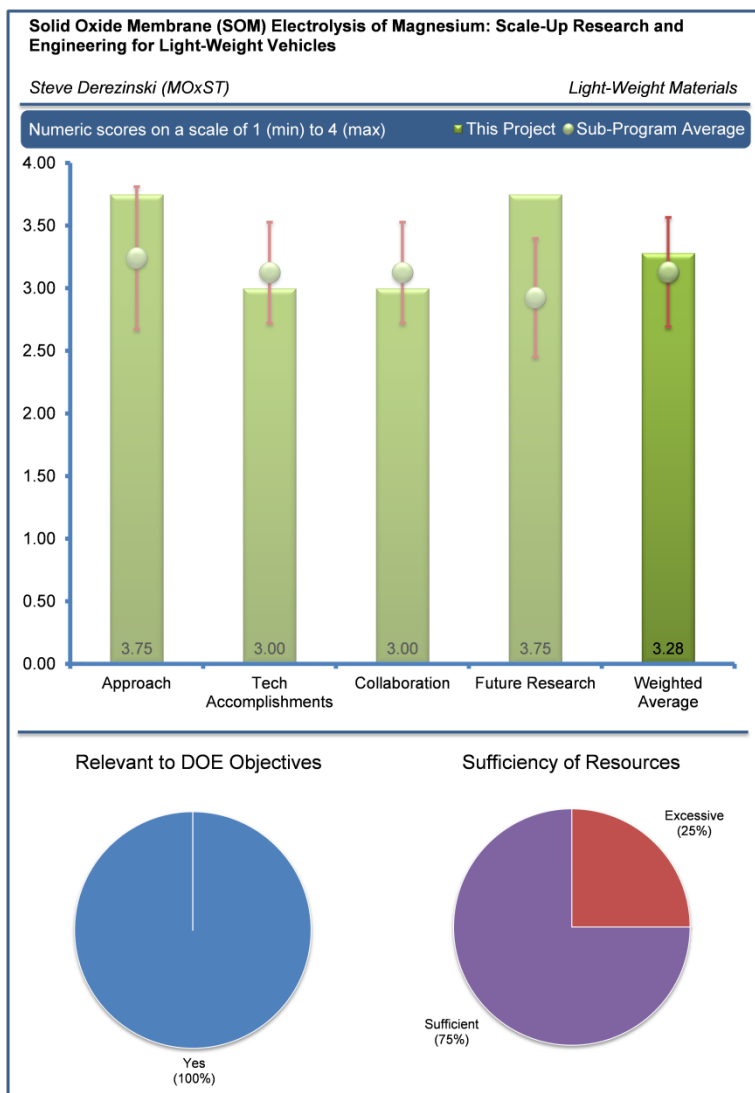
Reviewers seemed in general to agree that the project supports DOE's goals. One affirmed that we need low-cost and clean production of magnesium in the United States for automotive lightweighting. Echoing this view, a second reviewer observed that the availability of cost-effective magnesium would be a major enabler for its increased usage, which in turn would lead to substantial reduction in the weight of passenger vehicles. The third comment was similar, asserting that MOxST and the process for refining magnesium is directly related to enabling future lightweighting of automobiles and heavy trucks and ultimately reducing use of fuel and decreasing dependence on foreign petroleum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers approved of the project work approach. One reviewer said there appears to be a clear understanding of what will have to be done to make the technology viable. There is also a reasonable scale-up plan and an aggressive timeline established. The second saw a good approach to scale laboratory efforts up to commercial application. The third reviewer termed the concept for reducing the magnesium oxide sound and very novel and deemed the results to date to be very promising regarding the technology to reduce magnesium oxide. This reviewer further suggested a focus on complementary report-outs on the status of equipment life and capital projects based on durability of systems to deliver lower-cost magnesium.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer cited excellent progress, urging that more chemical data on purity of magnesium produced via the MOxST process be presented. Most of the 2012 slides, this reviewer observed, were focused on the system-level development, i.e., the equipment. This reviewer expressed a desire to see data on the properties (purity) of the magnesium produced to date even via the prototype system operational to date. Other reviewers observed significant progress being made in areas such as anode materials and noted a good approach to overcoming obstacles identified during scale-up. The fourth reviewer expressed reservations concerning the kilo-scale demonstration, noting that it is still small and wondering whether it will facilitate enough learning for commercial production.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers offered lukewarm approval in this area. One noted that the lead organization is working with several pertinent partners, although most will participate after the technology is more fully developed by MOxST. In a similar vein, a reviewer noted that the work was primarily a MOxST operation, but recognized the collaboration and discussions with OEMs and encouraged its continuation in the development of this important magnesium oxide reduction process. The third reviewer felt the project does not really involve collaboration. Cosma will evaluate material for commercial use at the end of the project, but there will be no participation until the development program is completed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer cited the project's sharp focus and aggressive timeline, and a second reviewer noted its good goals, low greenhouse gas production and low cost potentials. Another reviewer urged continued progress to the large scale process capability development.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers considered project resources to be sufficient. These reviewers said variously that resources seem appropriate for the level of research and technical risk; that the project appears to be hiring necessary subject matter experts as required during the commercialization laboratory scale-up process; and that the project represented well-funded and planned R&D for this scale-up process. One reviewer deemed resources excessive. This reviewer felt that the scale of the demonstration (40 tons per year), did not justify the funding. A larger-scale demonstration unit should be considered to learn more about the potential for commercialization.

High Throughput Isotopic Diffusion Databases for Magnesium Integrated Computational Materials Engineering: Dave Warren (Oak Ridge National Laboratory) – Im036

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

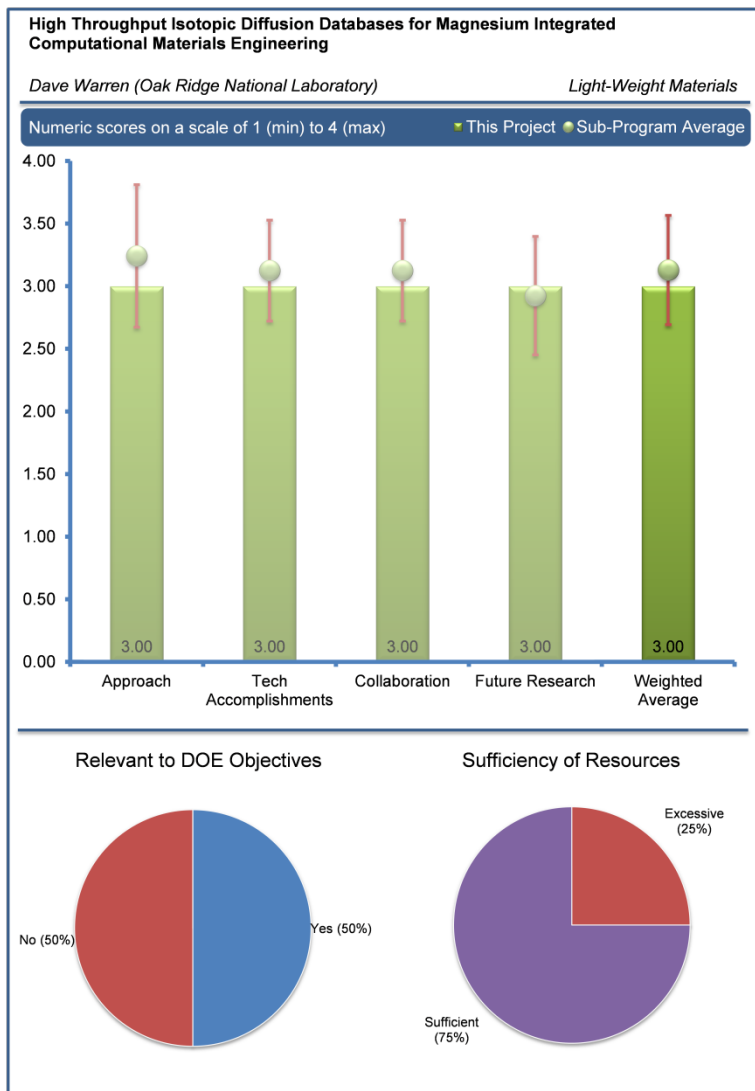
Opinion on this question was sharply split. Two of the four reviewers deemed the project to be relevant to DOE goals. One said it is providing valuable insights into Integrated Computational Material Engineering (ICME) of magnesium, which will ultimately enable more its more extensive use and lead to lighter-weight vehicles. One other reviewer agreed, calling magnesium an enabler for vehicle lightweighting and a long-term feeder of vital importance to first-principles design and development of magnesium alloys, thus indirectly and proactively supporting the reduction of dependence on foreign petroleum. The other two reviewers were more skeptical. One said this is nice diffusion work, but its relevance to lightweighting is more than a stretch. The final reviewer said this project is quite a reach to claim it supports petroleum displacement. The tie, at best, is to improved magnesium alloys. However, this is fundamental materials research that is not yet aligned to produce improved alloys. This research, this reviewer continued, should be funded through a different, more basic science path. There is quite a gap between this diffusion project and lightweight vehicles to displace petroleum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

If reviewers were not unanimously persuaded of this project’s direct relevance to DOE’s overarching petroleum conservation goal, they nonetheless felt the work approach to be praiseworthy. One reviewer called it a nice piece of work, well-constructed, logically led. Another said this is an excellent technique for measuring diffusion of magnesium in magnesium and very difficult. This work is applauded as novel and very important. The final reviewer concurred, saying the fundamental approach is good to address the basic diffusion rates for magnesium. However, the principal barrier is the cost of magnesium and the lack of predictive models for magnesium materials characterization, so the approach does not address the high-level barriers.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers offered somewhat different assessments. One, noting that magnesium diffusion is very difficult to measure, called this research focused, targeted and important. Attention to detail was noted and lauded. The other reviewer observed that progress is being made, though not as quickly as hoped. Technical progress toward the milestones appeared to be lagging compared to the



calendar-scheduled milestones, in this reviewer's estimation. The progress on diffusion measurements is good, but the progress is somewhat disjointed from the objectives and the goals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers opined that there was good collaboration with other researchers. One singled out the website as a potentially valuable tool for collaboration and wanted to see more data on the number of users and hours of activity or some other such measure. The other reviewer expressed the hope that this can be connected and contribute to the Materials Genome Initiative (MGI). The third reviewer dissented, noting that although there are a number of pertinent partners involved, there did not appear to be a link to automotive products or auto manufacturers.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt this project needs to clarify the short-term goals and anticipated deliverables against a timeline. Efforts on the rare earth elements are less important than the cesium, manganese and tin systems. The other said continued R&D of a suite of alloy diffusivities in magnesium and its alloys is highly recommended.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three of four reviewers called resources sufficient. One of these reviewers called current funding appropriate and recommended it be continued. The fourth reviewer felt resources excessive. This reviewer commented that since that project is too far from lightweighting objectives, it should not be here and therefore the funding was excessive.

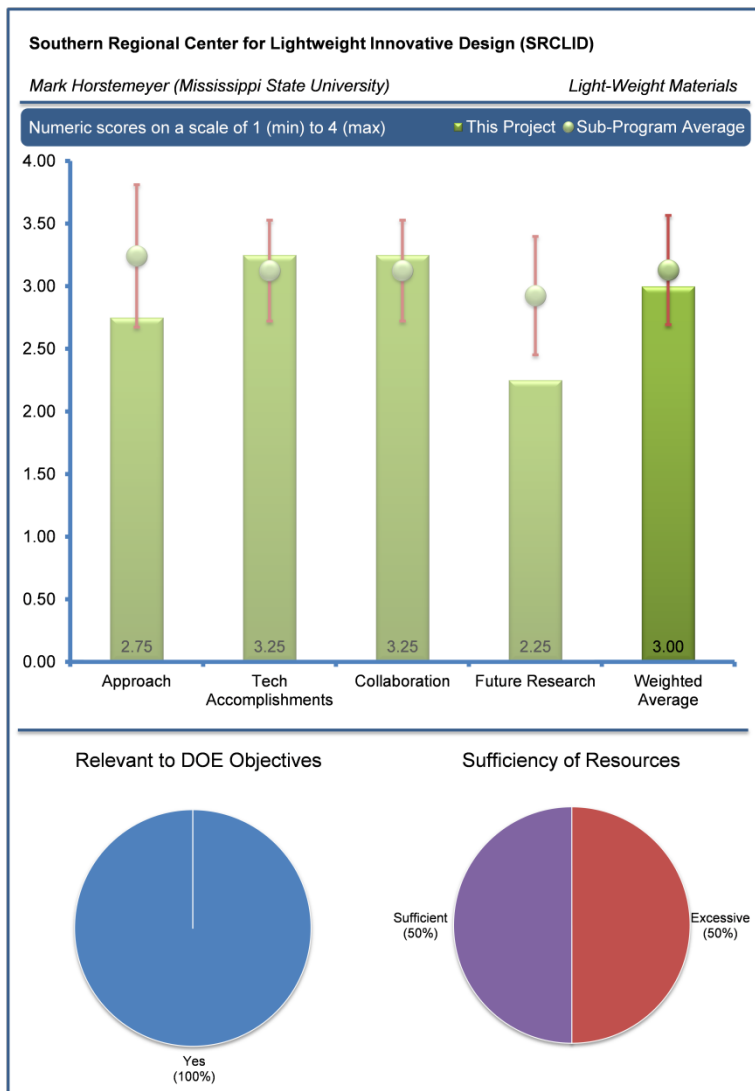
Southern Regional Center for Lightweight Innovative Design (SRCLID): Mark Horstemeyer (Mississippi State University) – Im037

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers' comments were generally positive. One said the project has several activities focused on understanding and improving performance of materials that can be used to reduce vehicle mass. Another agreed that the overall project will help to identify key material processing effects on structural material properties to help optimize part geometries and therefore reduce weight. The other two comments offered more mixed assessments. One found the project to be important and to fit DOE objectives. However, this reviewer said the fit would be even better if this work were part of the development of a new, lighter, stronger and cheaper vehicle front end. To that end, the reviewer suggested collaborative work with any or all of the Detroit automakers. This effort, the reviewer felt, could go on for decades without truly helping the auto industry. The last reviewer termed the project an all-encompassing project that does contribute to existing computational modeling of lightweight material efforts already established at other organizations and institutions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers submitted comments that, while generally approving some aspects of the work under this project, offered suggestions for its improvement. A first reviewer said that while the work is probably outstanding as far as the database construction is concerned, it could benefit from a more hands-on approach. Another said the approach to the from-atoms-to-autos project is solid but lacks sufficient usable intermediate deliverables. The developments should focus on those barriers that can be overcome first and deploy solutions to overcome them as quickly as possible. The presentation identified 12 bridges but did not quantify (or even qualify) which are in place, which are under construction and which are not yet started. A third reviewer termed this a collection of work that expands on other work that has been done extensively to date, which has been shared and provided to Mississippi State University (MSU). This reviewer urged project researchers to keep up the effort but to recognize that it is complementary to existing work and not new to academia or industry. The final reviewer said the program appears to lack focus. The teams are making incremental progress in several areas rather than substantial progress through a concerted effort in any one or few areas.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers largely reiterated the comments made in the previous section. One repeated that the teams are making incremental progress in several areas rather than substantial progress through a concerted effort in any one or a few areas. Another again noted good contributions and complementary work to existing efforts at other institutions. During the last year, a third reviewer commented, there has been only fair progress on many of the technical paths. This reviewer offered further criticism of the project's accomplishments and progress. This reviewer noted the 2012 status of the magnesium material developments and the cyber infrastructure appears to be only slightly ahead of 2011. According to this reviewer, the future work stated in 2011 – develop and validate material models and deploy them for use – the Magnesium Front End Research and Development (MFERD) Phase II demo project (September 2011) –has not been accomplished. Only a few of the models have been verified and none has been deployed. Last year the second item in future work was establish magnesium alloy design method using lower-length scale models. There has been no progress reported toward this work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers commenting on this question seemed unclear on the extent and breadth of collaboration in this project. One, acknowledging that the team has engaged a number of pertinent partners, found it difficult to determine the extent to which those collaborators are involved. For example, the steel overview slide indicates partnerships and cost share from several steel suppliers, yet the future plans indicate MSU intends to establish partnership with steel companies to direct steel R&D. The same claims apply to the plastic industry. A second reviewer concurred, saying the presentation is not clear on what collaboration has taken place in the past year. While partners are listed on Slide 7, their interactions have not been quantified. Another urged that collaboration be extended so as to directly influence the manufacturing of auto parts. The fourth noted that to date, MSU has engaged other institutions and organizations doing comparable work. This reviewer cautioned against trying to give the impression it is leading a new field and continue to focus on contributing to the overall effort.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer said that, provided MSU remains connected to the technical experts in the field, this research will contribute to the common good of computational materials and manufacturing design of lightweight vehicles. A reviewer noted that project goals appear to be general in nature, and another reviewer remarked that less theory, less modeling (theoretical?) and more front end applications are needed. A final reviewer said the proposed future work is so close to what was suggested a year ago as to call the effectiveness or the robustness of the research planning into question.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found project resources to be sufficient. One of these reviewers said the level of R&D funding should continue until completion, but additional should be focused on what is new and needed by industry, and less on replication and existing projects. Two reviewers deemed resources excessive. One of these reviewers commented that \$12 million since 2008 appears excessive for the few specific accomplishments claimed. Another reviewer noted that nothing was said about the resources until the Q&A. If the investment is \$12 million, as Dr. Wang stated, this effort is excessively funded compared to the results distributed from 2008.

Advanced Materials and Processing of Composites for High Volume Applications (ACC932): Dan Houston (USAMP/ACC) – Im046

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally viewed this project as relevant to the DOE goal. One was explicit, stating that this kind of project is relevant to DOE's mission. Another called work on reducing the complication and costs of carbon fiber composite processing highly relevant, and added that changing how fiber is produced (avoiding the pelletizing steps) seems smart and very useful. The third reviewer noted that sheet molding compound (SMC) carbon fiber is too expensive for commercial use.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The researchers, in the view of one reviewer, seem to have a good plan and to have followed a nice progression of design steps, but there was insufficient detail in the presentation to know if their process was the best way to go. A concurring view was expressed by the second reviewer, who deemed the project to have taken

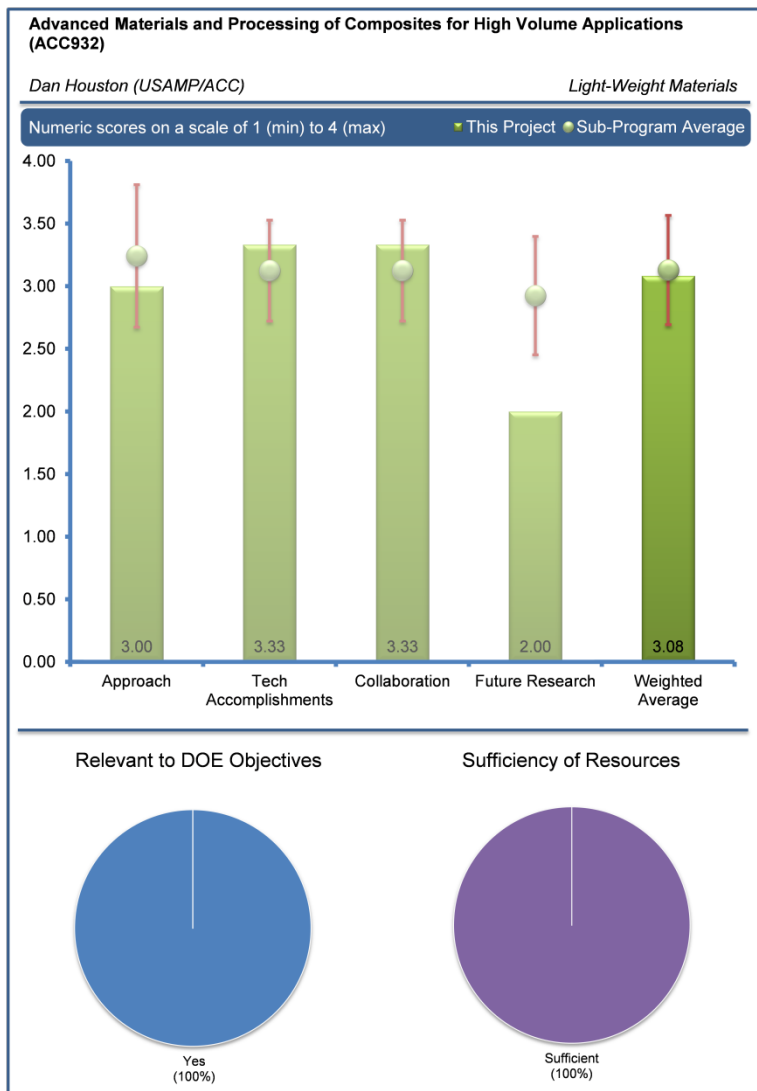
a good approach to a new subject over a long period of time. The final reviewer said that compression molding versus injection molding was well explained in the presentation, but not fully exploited. This should be pursued, the reviewer said. The two techniques are complementary: some applications will be better suited to compression molding, others to injection molding. The reviewer did not think that one is necessarily better than the other in a given application.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The project team seem to have developed some good insights, said one reviewer, and a second agreed, noting good accomplishment, albeit not a commercial application or direction. The third reviewer noted the speaker's statement that all goals had been achieved.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted an excellent list of collaborators. Another reviewer found it not terribly clear, but concluded the project researchers seem to have developed complete teams.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the project is over. This reviewer questioned if it would lead to future work, and expressed the strong hope that it would. The second reviewer saw no plan for future work and wondered if time and money had been wasted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers viewed resources as sufficient. One reviewer remarked that funding was sufficient to support adequate resources. A second reviewer guesses that funding was sufficient because the project is over.

Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts: Jim Stike (Materials Innovation Tech) – Im047

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

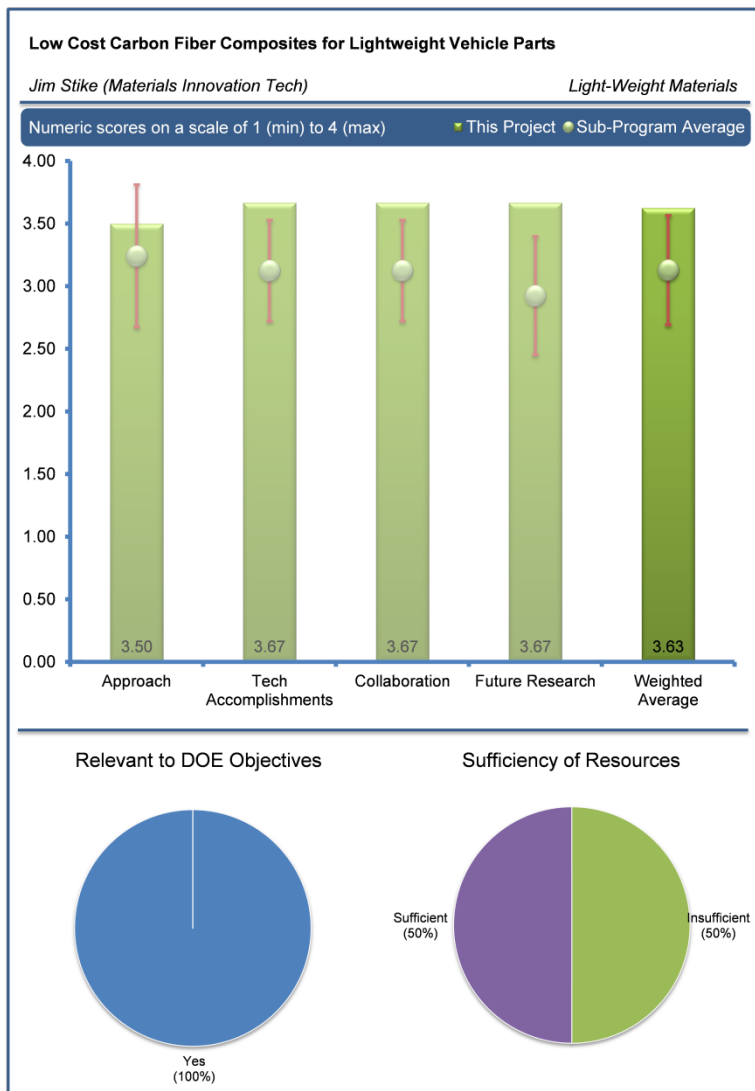
Two reviewers were of opinion that this project was relevant to the Department’s petroleum conservation goal. One said it supports the petroleum displacement by developing reduced-weight parts with recycled carbon and other fibers. This reviewer added that using reclaimed carbon fiber to make lightweight parts supports petroleum displacement twice over. The second reviewer considered working on recycled carbon fiber to be an excellent direction for the DOE to support by weight of lightweight materials development. Another reviewer asserted that carbon fiber must be recycled to meet GHG requirements and called for parallel projects/programs in same subject area. Finally, a reviewer called recycling an important issue to be addressed.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The approach is sharply focused on attacking the barriers of cost, manufacturing speed and supply base, according to one reviewer, who called the prototype 3-DEP process and roll goods equipment a perfect demonstration for developing improved manufacturing. Another said this is the best way to make preform out of reclaimed fiber, and a third lauded a good approach, but felt funding adequate to achieve production scale at projected volumes was lacking. The final reviewer sounded a cautionary note, observing that if recycled carbon fiber can bring costs down, do not lose sight of \$3 per pound for high-volume applications. Even aluminum at \$1.50 a pound is a challenge to justify and introduce into high-volume automotive applications.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The technical accomplishments are outstanding, said one reviewer. Accelerating the 50-inch-wide roll goods line so that larger parts can be produced is a great accomplishment. The 25% to 40% weight reduction seen in trim panels and close-out panels is at or above expectations. This reviewer anticipated information on material properties and especially the temperature dependence of the material properties, expressing concern about fracture resistance at -30°C. A second reviewer noted good progress during the past year and recommended efforts to promote volume process capability. The third reviewer likewise called progress good but noted that some 50% of information presented was recycled from the project’s 2011 presentation. The last reviewer noted the project’s recent initiation and offered no comment of its technical progress.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers offered relevant comments on this question. One noted the project included a good number of OEMs and suppliers to make actual components, and the other reviewer saw strong collaboration with suppliers and end users of the materials. This second reviewer termed the investment in a 50-inch-wide roll system a very proactive step for future scaling of the process.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer asserted that making those parts and testing them is the only way to go. The other reviewer viewed future efforts as focused on the key barriers of reducing manufacturing time and cost and deemed use of reclaimed and recycled carbon fibers an added feature.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The four reviewers split evenly on this question. Two reviewers viewed resources as inadequate. One reviewer commented that additional funding is required to support additional resources. Dumpster picking indicates insufficient funding. The other said that future efforts in this project should be funded to the maximum amount allowable, as this project is delivering much-needed results. Two considered resources to be sufficient. One of these reviewers commented that research is well-funded and planned, and believes no changes are necessary.

Development and Commercialization of a Novel Low-Cost Carbon Fiber: George Husman (Zoltek) – Im048

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

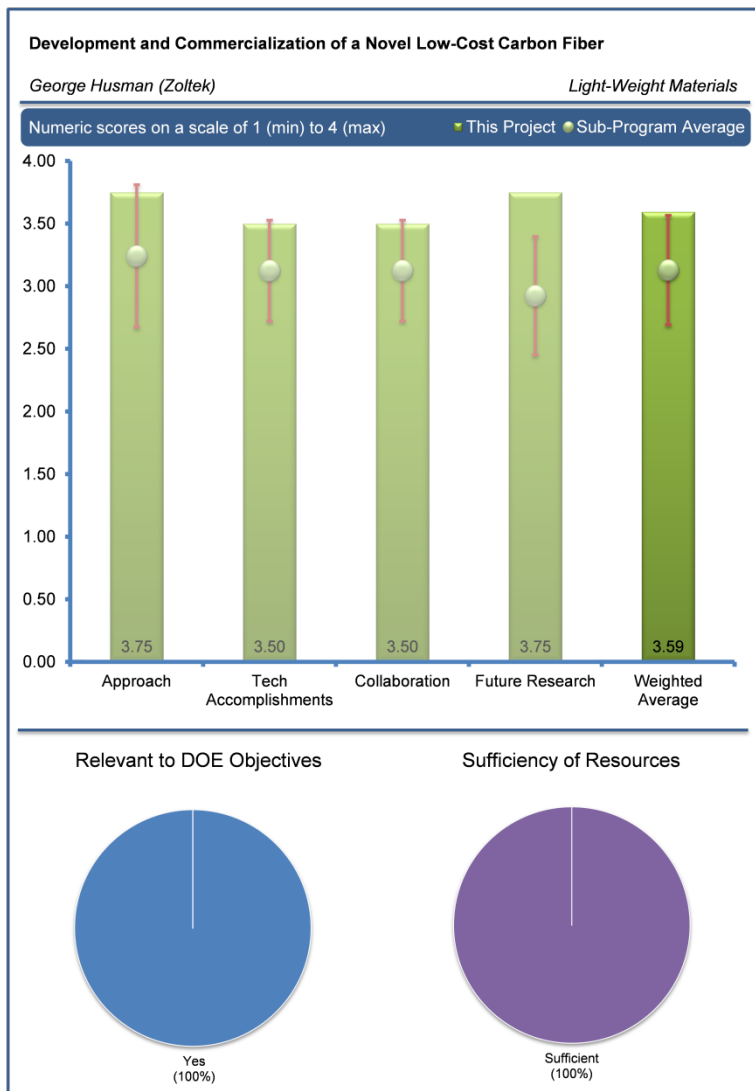
All four reviewers agreed this project furthers DOE goals. One said that reducing carbon fiber costs and using a bio-based precursor both support the goal of petroleum displacement. Using lignin directly displaces petroleum in the production of carbon fiber. Reducing the cost of carbon fiber has an indirect relationship to displacing petroleum through lighter weight parts for cars and trucks. Low-cost carbon fiber is a significant part of the future lightweighting strategy and provides a significant weight save potential, according to a second reviewer. A third called lignin a good alternative precursor, noting that since it does not lead to the right crystal structure as a neat material, its combination with PAN could change the picture. Finally, the fourth reviewer observed that low-cost carbon fiber is still the target and expressed the hope that with multiple people working in this space, it would be possible to deliver \$5 per pound carbon fiber, leading to a less costly composite.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally approved the work approach. One commented that developing solution-spun fibers as the basis for carbon fibers using current production equipment is a sound approach to quickly commercialize a reduced-cost and reduced-petroleum carbon fiber. The push to commercialization is a great approach to start making the carbon fiber. Concurring views were expressed by two other reviewers. The first reviewer observed a very good approach, addressing scale manufacturing to meet price and quality requirements. The other reviewer commented excellent progress and work plan, and urged the research team to continue on to the July 2012 make-like-production plans. The last reviewer speculated that identifying the proper ratio of the mixture, the right oxidation temperature profile, and the applied strain can show a window of opportunity.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers lauded the progress that had been made in this recently initiated project. One saw great progress, considering that the project has just started, and the other reviewer, noting the project is at the beginning, said good progress has been made on using a mixture of lignin and PAN in solution spinning for initial fiber production. The accomplishments since October 2011 project start are solid in improving the morphology of the precursor fibers. A third reviewer highlighted great progress in the pilot oxidation line (POL) and the target of 45% lignin/PAN carbon fiber system. The fourth reviewer saw both significant accomplishments to date and planned accomplishments.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers were emphatically positive in their responses to this question. The right people are doing this project, said one. Another cited outstanding relationships and collaboration. A third noted strong collaboration between the two principal companies and anticipated that future efforts will bring in more collaborators. Collaboration between Zoltek and Weyerhaeuser was rated excellent by a fourth reviewer, who urged continuing connection with ORNL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

In this area, too, reviewers were strongly positive in their assessments of this project. Comments included very well planned and staffed; great, specific future plans for development; and excellent work plan and meeting milestones stated in the funding opportunity announcement (FOA) 239 solicitation. The fourth reviewer suggested more focused localized X-ray and morphology analysis to get a better picture of what is happening at the molecular level in this process.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers deemed project resources sufficient. One reviewer termed the project well-staffed; another urged the project team to press on and described the project as well-funded and well-resourced.

Structural Automotive Components from Composite Materials: Libby Berger (USAMP/ACC) – Im049

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the hybrid scheme for integrating materials shows likely promise, and the research team seems to understand the limitations (fatigue, joining, crash, etc.). Another discerned good scope integrating load floor and seat for weight savings. The third, noting that the project had ended, professed to be at a loss for what to say. Nevertheless, that reviewer said this was a good project that has potential for applications and encouraged DOE to pursue that line of projects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

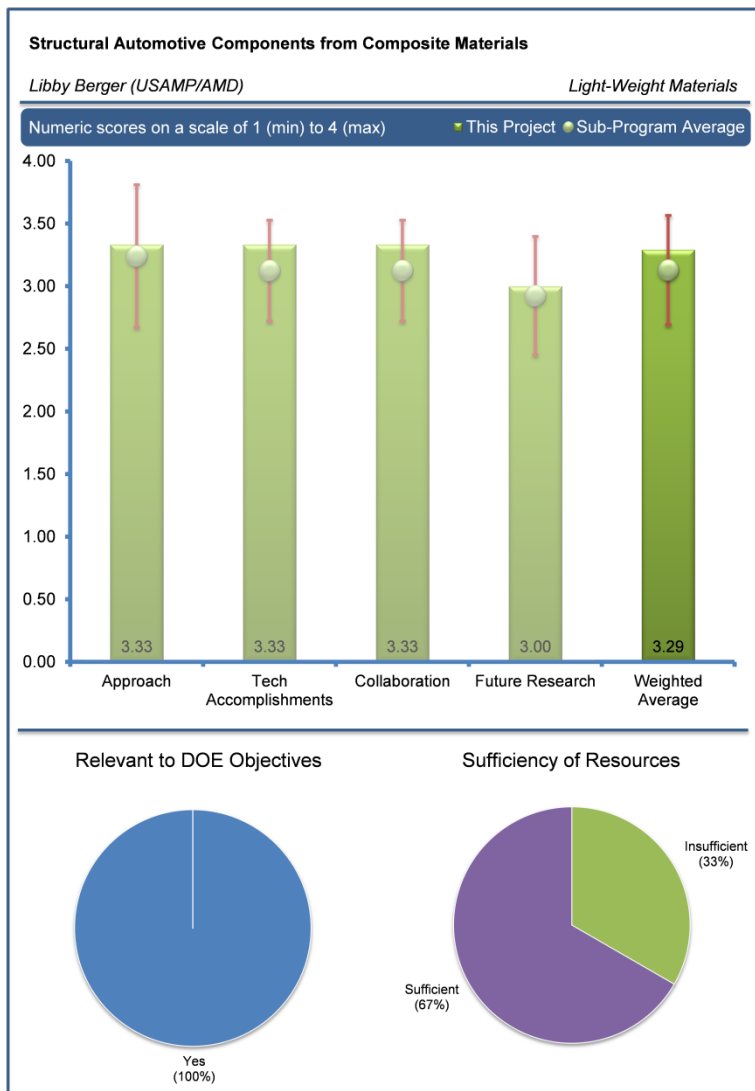
A reviewer expressed regret that time limitations and the absence of the two principal investigators (PIs) limited the reviewer's ability to analyze the approach. The presentation, this reviewer said, was basically we-are-done, here-are-some-results. The reviewer noted that the score is caveated by these limitations. The second said the approach was good and addressed joining and crash barriers. The third felt the approach should be applied to other parts and/or applications such as wind turbines, especially the nacelle and support for the drivetrain.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed feedback. One reviewer found the background and flow of the project lacking in the presentation. The researchers, this reviewer said, seem to have made good progress and have created some intellectual property, but at least some of it is irrelevant as the project passed it by. This reviewer noted that there has been no commitment by the car companies to move forward, and wondered if there were potential applications to the front end. The second reviewer said good technical accomplishment, but the effort did not and will not result in commercial application in any form. The third reviewer questioned the huge amount of different materials that are in that bottom panel; that seems unrealistic for large production scale.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer cited good collaboration. The other saw almost no mention of the topic in the presentation.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer called for more projects, saying this line of work is far from finished. The other termed the project dead, with no potential for commercial application. This reviewer called the project a good effort but time and money was somewhat wasted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt resources were insufficient. Two reviewers termed project resources sufficient. One reviewer commented good funding to support sufficient resources. The other reviewer guessed funding to have been sufficient since the project is finished.

Reliability Tools for Resonance Inspection of Light Metal Castings: Martin Jones (USAMP/NDE) – Im050

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers spoke positively about the project. One reviewer noted that better non-destructive evaluation (NDE) tools for lightweight castings, especially for materials like magnesium that are brittle at room temperature, have obvious applications and utility. Knowing whether and how well things lend themselves to NDE is always of high use. The other reviewer asserted that quality control has to be part of DOE's mission, regardless of the field. Quality control of welds is fundamental to lightweighting, but it is necessary to have it done in situ to be fully effective. This project shows that the industry is not there yet. While important, this reviewer concluded, the project is done. Much more needs to be done to ensure this can be used elsewhere.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said the project team hit all the points they needed to and expressed personal approval of all the analytical techniques employed. The other, noting that the project had concluded, observed that it was no longer possible to influence the approach. The approach could have benefited from comparisons with other techniques, such as x-ray topography and acoustic emission.

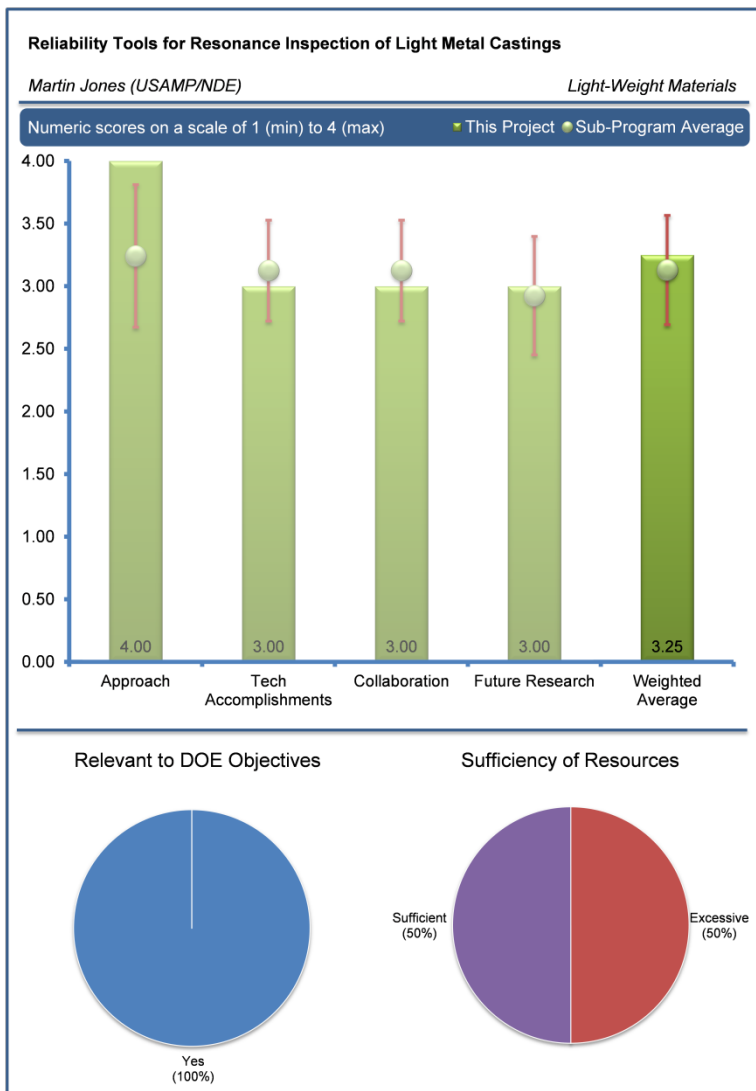
The approach could have benefited from comparisons with other techniques, such as x-ray topography and acoustic emission.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Technical accomplishments and progress, in the view of one of the commenters, were commensurate with the stochastic nature of the flaw production and the observation technique. The project, the other reviewer offered, showed one possible way to assess weld quality. There are other techniques, which may or may not prove better than that used in the present study, but there was no indication which one may be used in situ.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said it was unclear, but that there seemed to have been a complete team.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said that such a work needs to be pursued, but only with the goal of on-line and in situ testing, so as to not disrupt production.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer inferred that resources must have been sufficient, since the project is over. A second reviewer considered resources to have been excessive, and said they could probably have done much more useful work if they had more time and money.

Hybrid NDE Method for Spot Weld Quality Evaluation: Leo Lev (USAMP/NDE) – Im051

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the use of multi-materials-based structure is an important solution for energy saving in vehicles. Because spot welding is the most prevalent joining technique in the auto industry, inspection of this joining process is necessary and this project is developing a process to do this. The second reviewer called this a good preliminary study that begs much more work. This reviewer acknowledged that it is important to check spot welds but was unconvinced that this study is sufficient to ensure the quality and the reliability of welds. Work needs to be continued.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

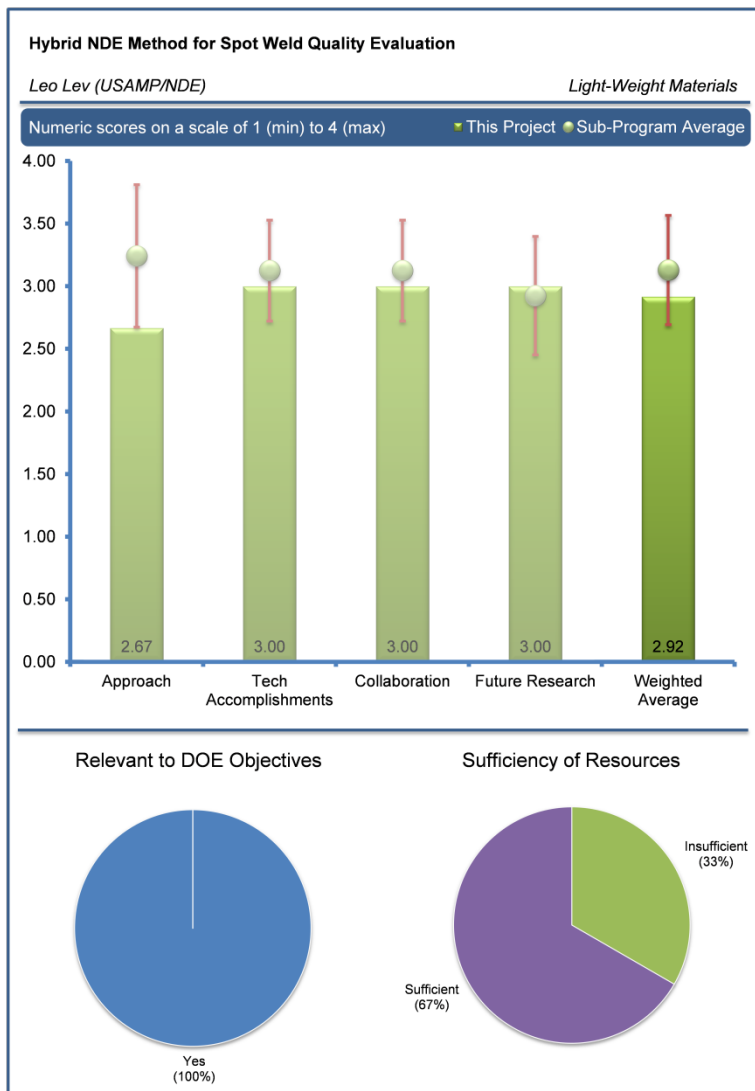
A reviewer described the work as well planned, and that the problem is well defined with experiments and modeling tasks. The second reviewer felt that comparison with other techniques is essential to establish whether shearography is the tool for on-line testing. The third reviewer found it interesting, but believed the research team is ignoring a number of key variables that would need to be evaluated to ascertain true viability, such as maintaining focus or their over-riding faith in FEA.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer praised the experimental work as rigorous and having produced enough data for model development. A tool has been developed to measure the nugget size in a spot weld; validation of the measurement and the tool has been carried out. A second reviewer noted that work has been confined to the laboratory so far, and a third commented that the project is over.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One of the two commenting reviewers approved the degree of collaboration, citing good participation by three OEMs in this USAMP project and the involvement of university researchers, which has helped in development of mathematical models. The other reviewer commented that the collaborator at the University of Oakland is not the best.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer urged the project's continuation, as other techniques and broader collaboration are necessary for this to become a success. According to the second reviewer, this project is complete, but the project team has identified the future action plan for implementation of its findings.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer termed resources insufficient. This reviewer commented for feasibility. Two reviewers deemed project resources to have been sufficient.

Development of Steel Fastener Nano-Ceramic Coatings for Corrosion Protection of Magnesium Parts (AMD-704): Richard Osborne (USAMP/AMD) – Im052

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

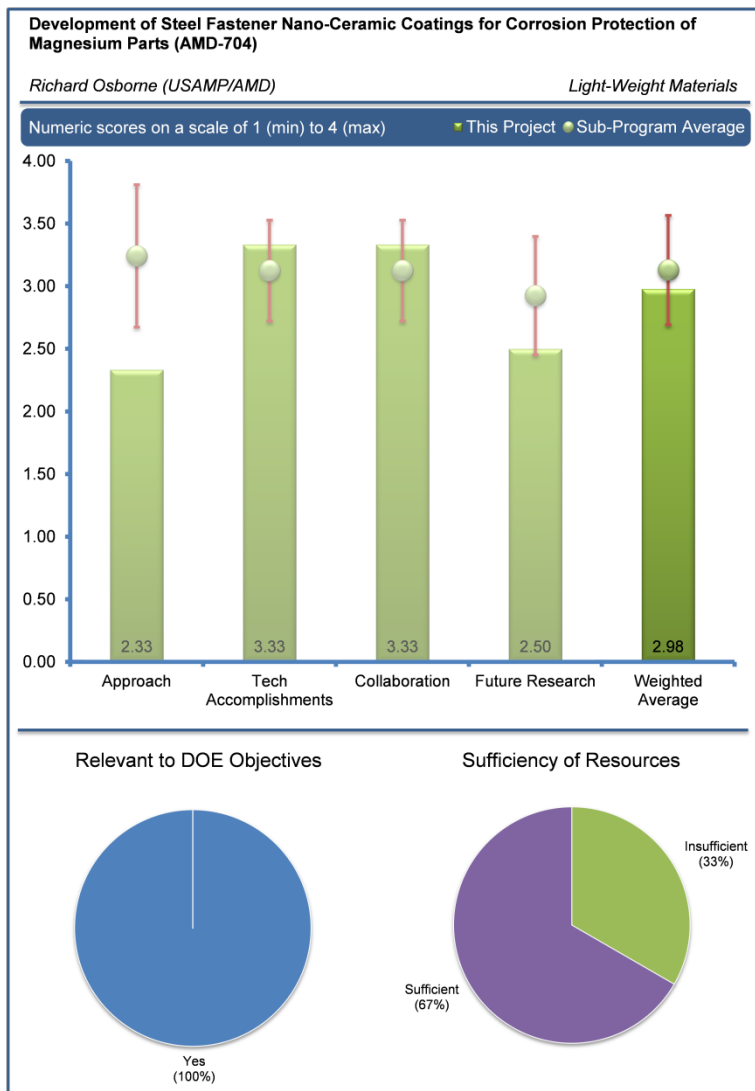
One reviewer said that use of magnesium in vehicle structure will reduce the mass and thus enable increased fuel efficiency. One of the major impediments to the use of magnesium is the high corrosion rates the metal experiences when joined to steel structures due to galvanic corrosion. This work is developing methods to reduce this problem, which will enable wider use of magnesium in structures. Another reviewer said that coatings to protect magnesium parts from corrosion are an obvious solution to a major factor inhibiting application of magnesium in automotive bodies. A third reviewer said yes, in the sense that it would enable the use of lighter materials than steel. However, this reviewer was not persuaded that nanocoatings are necessary, speculating that they have intermediate results between micro- and nanocoatings, but the presentation, as it stands, does not satisfy this reviewer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed input on the project's approach. The approach to solving the problem of galvanic current is good, in the opinion of one reviewer, but could have been better. Rather than making a lot of different coatings, this reviewer suggested the team would have been better advised to pick one specific coating and work on eliminating these currents by refining the deposition technique and ensuring that there are no possible paths for these currents. Another reviewer felt there was poor justification for using nanomaterials for this application. The research team, in this view, did not investigate the coating microstructure to look for density or any microstructural issues that might be controlling behavior. The last reviewer identified the objective as the reduction of galvanic coupling between steel and magnesium when joined using a fastener. However, the experimental work had only magnesium sheet joined with the new fastener and the reviewer did not see how this addresses the question of coupling between steel and magnesium.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt the coating process had been well selected and the results were encouraging but felt more work is needed to determine the durability of the coating and a more rigorous cost analysis should be done. Another reviewer, noting the project had ended, said more needs to be done, as this is an important consideration for combining lighter materials. The other reviewer said the team had made some rudimentary observations, but the real issue of reliability was a can kicked down the road.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers commented, agreeing in general. The team, said one, was complete and well integrated. As with any other USAMP project, said the second, participation from the three OEMs is good; also, the team consists of suppliers, users and university, making the supply chain complete.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that this project is complete, and no further work is funded. The team has identified the future developments required for the implementation of this project's findings. The second reviewer recommended that this line of work be pursued, as corrosion is a critical problem.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer found funding was insufficient. Two reviewers thought resources had been sufficient, with one reviewer commenting that funding must have been sufficient since the project is over.

Development of Corrosion Inhibiting E-Coat System for Body-in-White Assemblies: Yar-Ming Wang (USAMP/ACC) – Im053

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that use of multi-materials in the structure is necessary to optimize the weight of the vehicle, making it possible to improve its fuel efficiency. This project, the reviewer opined, is developing a technology which can make the process much easier and cheaper. The second reviewer called corrosion a critical problem to be solved to achieve lighter-weight vehicles, and so felt this project supports DOE's objectives. Describing corrosion as such a vast and complicated problem, the reviewer said it must be on DOE radar's screen for a long time and that DOE must commit to efforts beyond those of this project. The third reviewer observed that multi-material coats will be needed for multi-material bodies-in-white, and might have spillover benefits, such as isolating corrosively active joints by encapsulation rather than needing to resort to individual isolation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

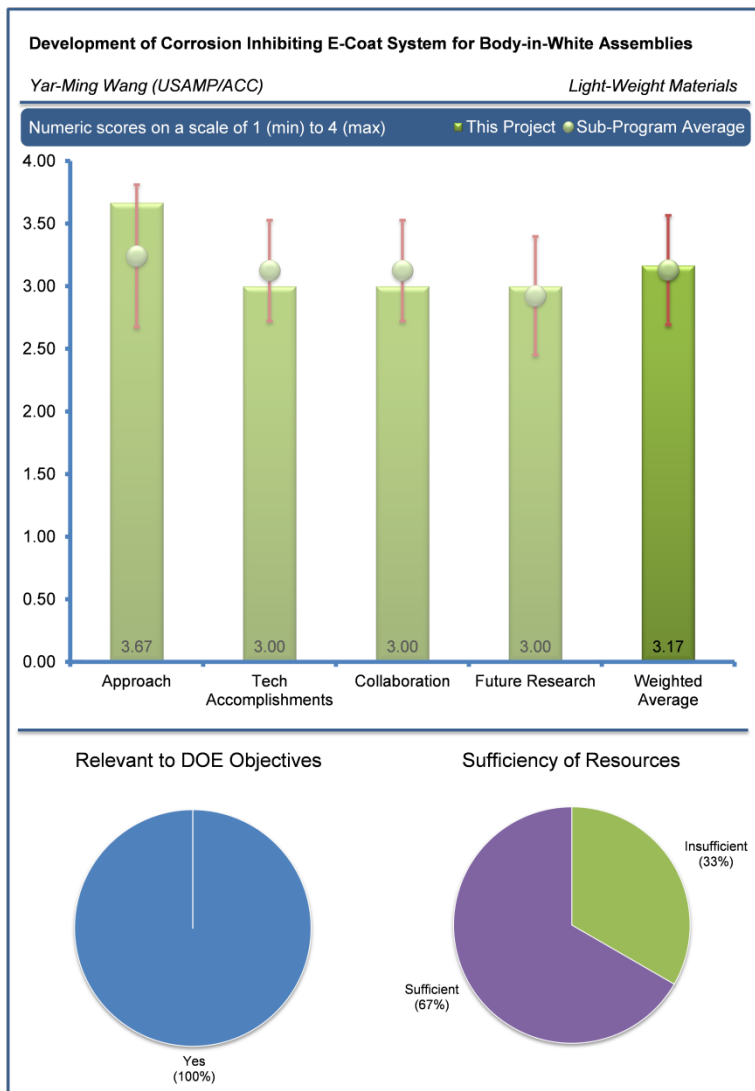
One reviewer called the project well planned and the problem well defined. According to this reviewer, the galvanic coupling problem due to multi-material joints is well explained. The experimental work has covered all aspects of the problem and various solutions have been tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer commented that the work has tested various combinations and the results are quite encouraging. The technology should be tested on a larger scale to validate the outcomes. If fully developed, this can be a game-changer in the use of multi-material structure.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that the team consists of OEMs, a material supplier and a university, which is good. This enables easy technology transfer.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the project is complete, and said the proposed testing of the coating process in a demonstration structure is good. Another reviewer called for the restructuring of research on corrosion for industrial applications with the help of all interested parties.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer characterized project resources as insufficient, and two reviewers found resources sufficient.

On-Line Weld NDE with IR Thermography: Dave Warren (Oak Ridge National Laboratory) – Im054

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

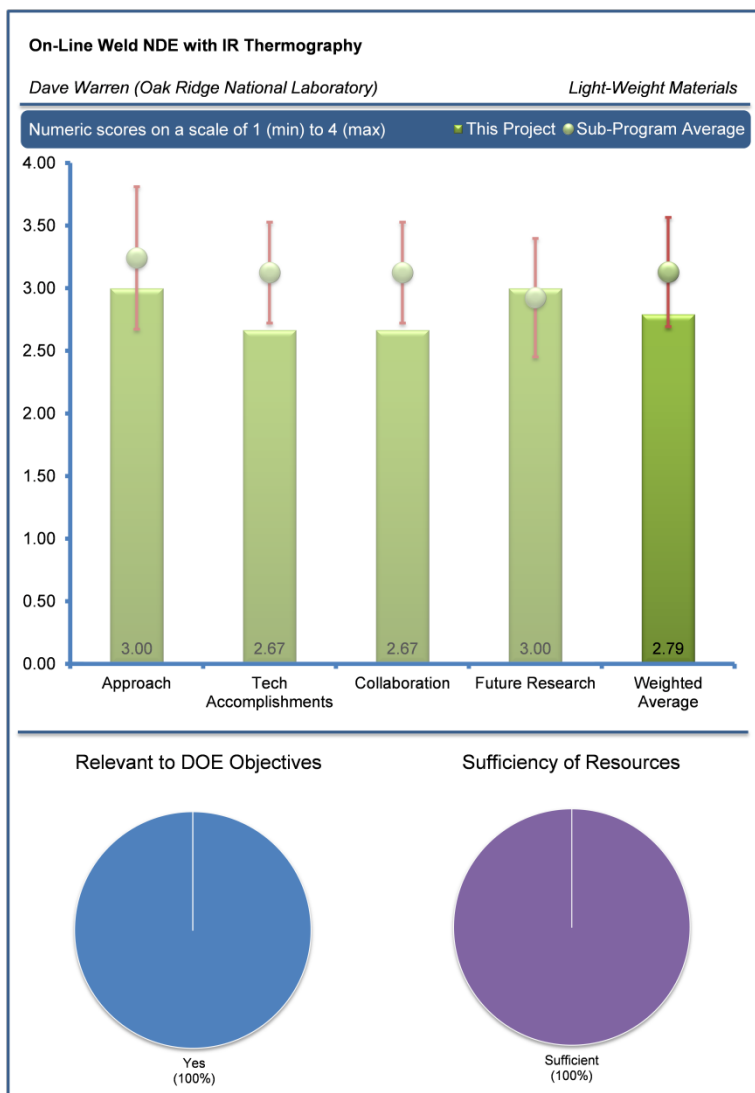
One reviewer offered the opinion that robust evaluation of spot welds without destructive teardown testing indirectly supports the goal of petroleum displacement by making manufacturing of lightweight spot-welded body structures more robust and cost-effective. A second called this project's focus an enabling technology for on-line quality control of automotive manufacturing using AHSS for vehicle lightweighting. The third noted that joining is an enabling technology for lightweight metals and nondestructive evaluation is an important element of moving forward with lightweight steels and aluminum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two reviewers endorsed the approach, one calling the technical approach sound, the other terming it a good approach to investigate the non-destructive evaluation of two touch and three touch spot welds of high strength and ultra-high strength steels. The second reviewer also noted one aspect of the approach in particular, saying the prioritization of weld attributes and potential defects is a good addition to the approach for a robust NDE method, but wanted to learn if the detection algorithm would have to be developed for each stack-up in the entire body or structure. The third reviewer asserted this work replicates similar technology developed in 1995 by Thermal Wave Imaging using their Ecotherm process employing a heating source and an infrared (IR) camera to look at heat decay in a resistance spot weld (RSW) without the need to paint the surface black. The company also investigated inspecting an e-coated surface. This reviewer deemed it unfortunate that this project is a replication of work done in the past and urged a literature search be performed to see what has been done, to learn from it and improve upon what has been done to date in this project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer cited good progress and noted the project is on schedule. From the second reviewer's perspective, the biggest new development is staring at welds from oblique angles, whereas such systems in the past required this be done perpendicular to the surface. This reviewer singled out a look-up table for weld quality for praise as an excellent part of this program and the research and encouraged continued effort on this aspect of the work. The presentation, said the final reviewer, detailed good progress toward the goals of robust NDE for spot welds. Correlation of the NDE signature to weld size is a good start for the full system. However, calibration for every stack-up in a vehicle will be daunting if this is required. The reviewer wanted to see more



details on the temperature increases required to get a good signal and felt there was a lack of detail on the surface conditions and emissivity sensitivity of the results. Effort on the reduced-cost IR camera was good, but this is still expensive for all but critical welds.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said the list of collaborators is good but saw no mention of their specific contributions and interactions, about which more information was desired. The second reviewer likewise was unsure how much OEM input is involved. The third cited excellent direction and overall progress, and encouraged the research team to contact Thermal Wave Imaging Inc. to make sure both are looking at the same opportunities to implement this technology.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The proposed future work is reasonable, in the view of one reviewer, but lacking in details on the joints, materials and robustness metrics. Another reviewer cited the need to demonstrate the technique in an actual production environment. The third felt that less future research should be needed, but identifying a supplier to develop and replicate a system that is production capable is the next step.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers considered resources to be sufficient. One reviewer termed them sufficient for the timing and goals. The other recommended continuing this research to a conclusion, but suggested it go into a commercialization mode, and then only for welding aluminum.

Ablation Casting Evaluation for High Volume Structural Castings Structural Castings: Jake Zindel (USAMP/AMD) – Im055

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer opinions on this question varied. One reviewer said that any casting technique that improves the cast quality fits DOE’s objectives. Stronger materials lead to lighter parts because less material is required to satisfy the specifications. Another reviewer noted that as more and more light-metal (aluminum, magnesium) components are used in vehicles, the demand for high-integrity castings will also increase. Ablation is one of the emerging processes to produce high-strength, light metal castings. The third commenter said that the presentation really did not reveal the broad-based benefits of this technology.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

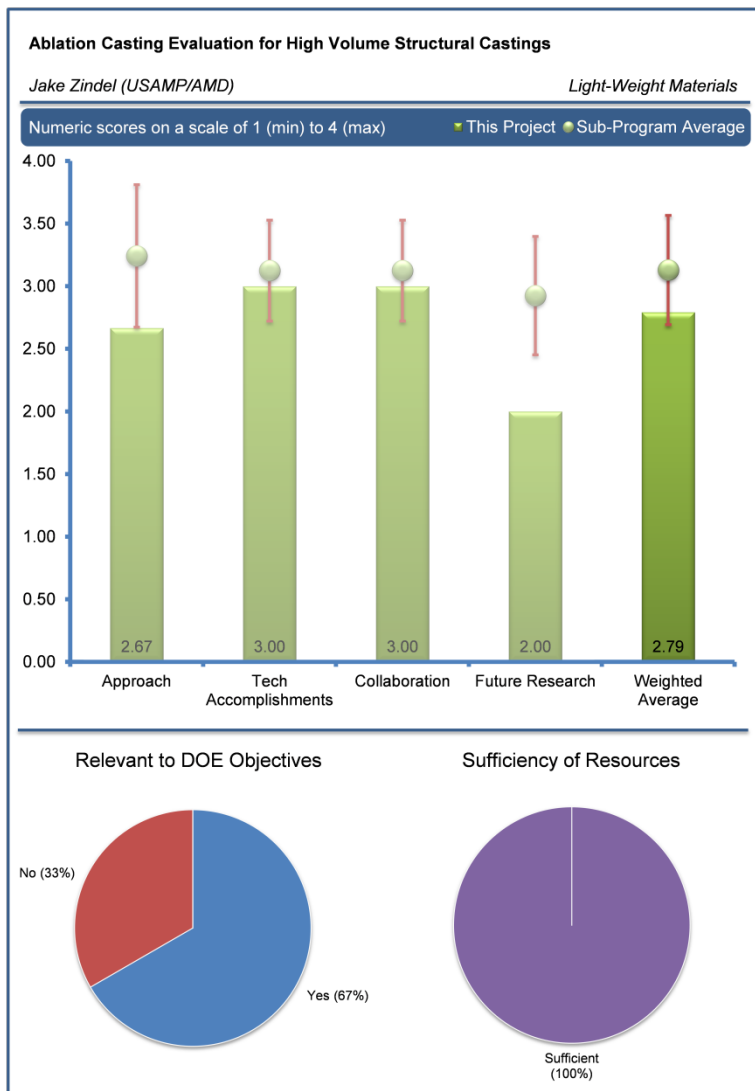
One reviewer noted that the project had validated the process for repeatability and reliability and that this project supports another current project by the team. The cost modeling is one of the required project tasks and the feasibility of mass production has been evaluated. The second reviewer commented that this project’s purpose is confusing. This reviewer inquired whether the project team checks out technologies like this on the project team’s dime all the time. The third reviewer speculated that the real approach may well be better than was presented.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that a wrought alloy such as 6061 aluminum has been cast using conventional process, making it unique. As this aluminum alloy is susceptible for hot tearing, it is difficult to cast; this project proves the viability of ablation casting. According to this reviewer, comparing alloy A356 with the wrought alloy may not be appropriate; it would have been better if the properties of wrought alloy were provided.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer commented that this project partnered with another current project on ablation, hence, in the reviewer’s opinion, it has many partners, including the supplier and end users.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer offered the opinion that additional work needs to be done to validate such a casting technique. A second reviewer noted the project has been completed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers deemed project resources sufficient.

Non-Rare Earth High-Performance Wrought Magnesium Alloys: Curt Lavender (PNNL) – Im056

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers agreed that this project supports DOE’s petroleum displacement goals directly and/or indirectly. One cited the need for new magnesium alloys’ high strength/ductility for automotive lightweighting. The second noted the project is targeted at enabling more use of magnesium which will in turn lower vehicle mass and increase efficiency. The third noted the strength limitations of magnesium which inhibit the number of its automotive applications. Success of this work, the reviewer predicted, will develop a high-strength magnesium alloy which will increase strength and reduce vehicle weight by expanding the number of automotive applications in which high-strength steel can be replaced with lightweight, high-strength aluminum. The last reviewer described non-rare earth (RE) magnesium alloys as an enabling technology to reduce the cost of magnesium and allow vehicle weight reduction, reducing dependence of foreign petroleum and thus supporting the DOE/Vehicle Technologies Program (VTP) goals.

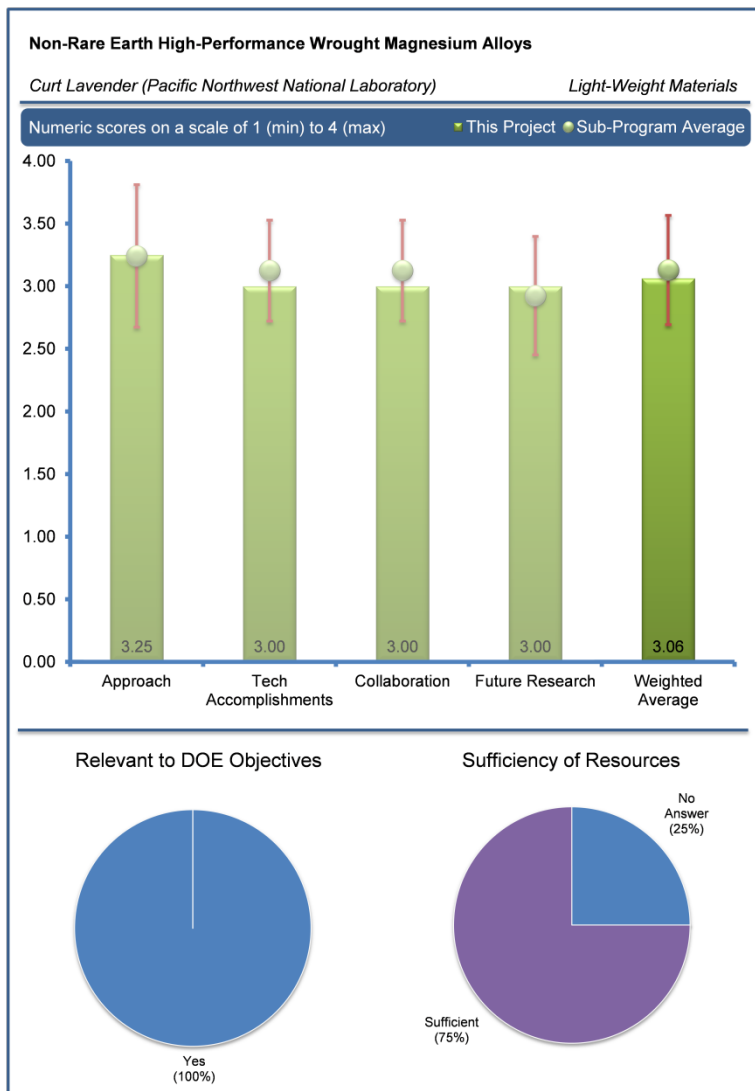
Question 2: What is your assessment of the

approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said this work nicely parallels what others in the industry are trying to achieve and complements much-needed R&D on non-RE magnesium alloys. This work should continue as planned. The second reviewer commented good focus, but does not comprehend the auto industry application. Energy absorption would be important for crash cans, whereas the bumper beam (the targeted application) needs the strength to transfer load to the crash cans. Even with somewhat improved energy absorption of the magnesium alloy, it would not be as suitable for crash can use as aluminum or similar materials. The last reviewer agreed that the approach is good, but felt there was some distraction in attempting to develop an energy-absorbing magnesium alloy. However, the work to develop a high-strength magnesium alloy, in this reviewer’s opinion, is outstanding. The work must address reduction in corrosion resistance of magnesium alloys with manganese additions. The weldability of magnesium alloys, on the other hand, is improved by manganese additions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked very good results to date, incorporating past research and applying them to current commercial needs based on Magnesium Front End lessons learned to develop tailored material properties for extrusion application. The second urged the research team to narrow down to potential new alloy systems with high strength/ductility soon. The third reviewer observed



that the presentation described work on both RE and non-RE alloys encouraged the team to try to direct the primary R&D to the non-RE magnesium alloys and to continue the R&D. This reviewer emphasizes future work in modeling and verification or the texture grain orientation as an ICME tool.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer cited great interaction with Magna, MENA and the project's interface with OEMs, urging that the dialogue with them be kept open as alloy development progresses. The other felt that appropriate partners are identified, but that they were not deeply involved.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted a good plan to go forward. This reviewer sees the need to focus on application needs rather than attempting to develop ultraluminum to have high strength, high elongation, and high-energy absorption. Need to refine focus on the application, replacing extruded Al and boron-steel. The second reviewer noted a good research plan and target to engineer Mg alloys by design.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers described resources as sufficient. One reviewer commented an appropriate amount of funding to continue this research effort.

PNNL: Mechanistic-Based Ductility Prediction for Complex Mg Castings: Xin Sun (Pacific Northwest National Laboratory) – Im057

Reviewer Sample Size

This project was reviewed by one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer commented supporting lightweight magnesium casting applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

There were no comments submitted.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

There were no comments submitted.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

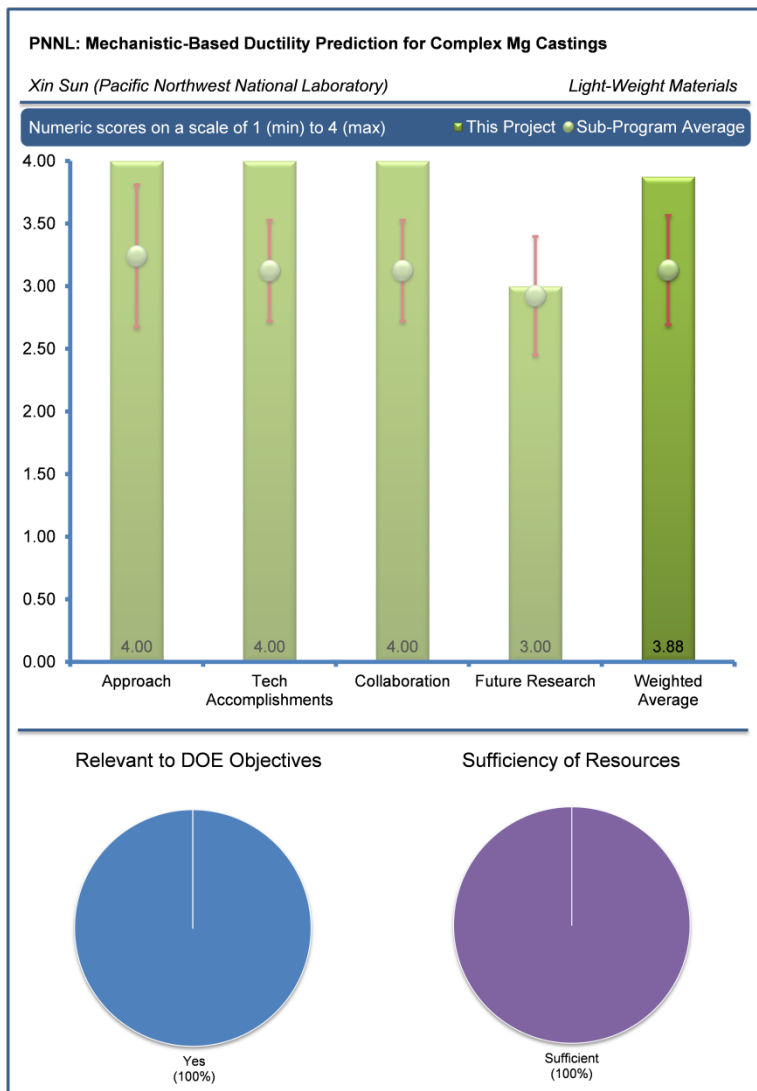
There were no comments submitted.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

There were no comments submitted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer found resources sufficient.



Low-Cost Magnesium Sheet Production using the Twin Roll Casting Process and Asymmetric Rolling: Dave Warren (Oak Ridge National Laboratory) – Im058

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said it is relatively obvious that affordable magnesium sheet with enhanced properties would be of use in advancing the goals of the program. The second reviewer remarked lightweighting with magnesium applications. The third said the project addresses anisotropic material properties in wrought alloys.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said it would have been nice to see how this work slots into existing work in this field and what is novel here versus other current efforts. The second reviewer called for a more focused approach, citing a lot of activity, many alloys, heated rolls, but a very small sample and no real plan.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

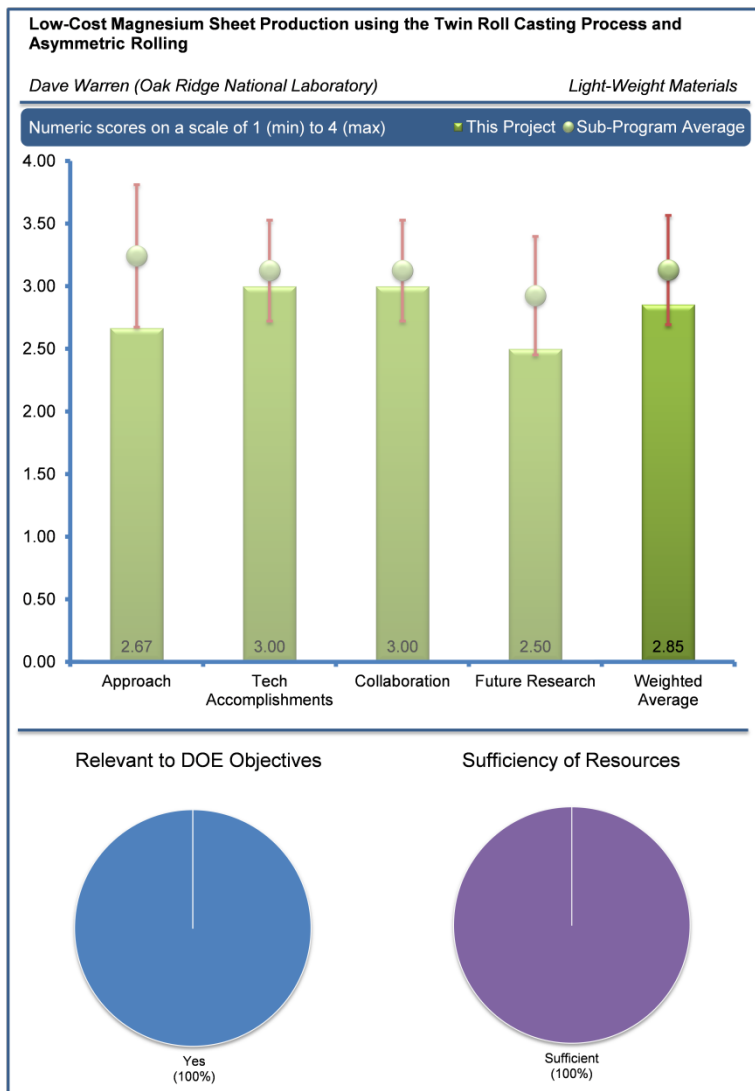
The first reviewer discerned some interesting results to compare to the work of others. The second reviewer noted good progress on equipment procurement, but little accomplishments.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted good collaboration with a machinery supplier, to whom it appeared there was minimal collaboration with Magnesium Electron. To this reviewer it also appeared there was no collaboration or pull from industry, which is working on alloy development to address anisotropy. The other reviewer wondered whether the project team had re-invented the wheel or whether the implementers had been in contact with other groups doing similar work.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt the presentation left the details unclear as to exactly where the project team is going to make this controllable or predictable. The other reviewer urged development of a plan to determine the benefit, commercial feasibility and cost. Shear rolling is limited to individual sheets versus roll product, which most probably will not be cost-effective for automotive use.



Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers deemed resources sufficient. One said the project needs to focus its resources toward specific goals.

Aerodynamic Lightweight Cab Structure Components: Mark Smith (Pacific Northwest National Laboratory) – Im060

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reducing the weight of heavy vehicles may not be the top priority, one reviewer commented, but any development in the aluminum sheet forming process is an enabler for the economic use of this material in vehicles. The second reviewer stated lightweighting.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented more engineering work than scientific development.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said the research team had identified the issue in achieving the property goals; tested several variables (forming temperature, quenching and ageing cycles) and assessed the performance of the part and material.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

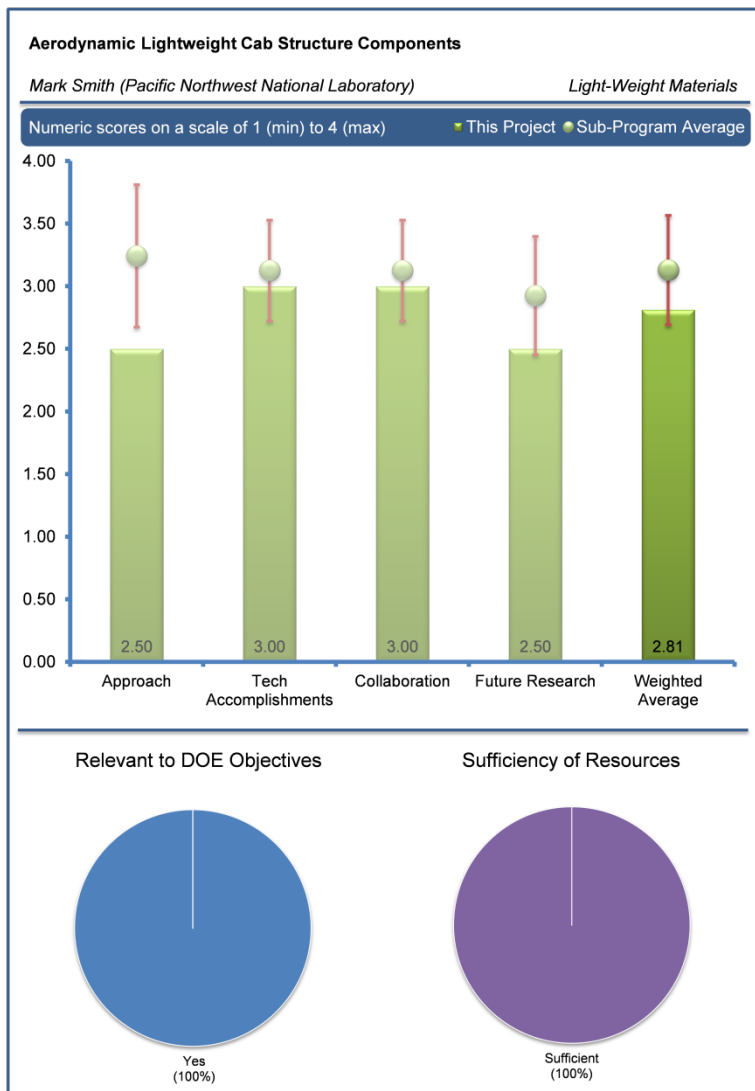
A reviewer noted that an end user (PACCAR), auto Tier 1 supplier (Magna) and material supplier (Novelis) are involved, along with the research team. This completes the supply chain and will enable an effective technology transfer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer called for more scientific and innovative research. The second reviewer noted that no plan for the next year's work is provided, and that discussions are undergoing with industrial partners for demonstration of parts. This reviewer would like to know what will be the work to be carried out at PNNL.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers felt project resources to be sufficient. One reviewer reiterated the question of what the role of PNNL would be in the next year's work.



Optimization of High-Volume Warm Forming for Lightweight Sheet Alloys: Nia Harrison (USAMP/AMD) – Im061

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers expressed the view that this work is supportive of DOE's overarching goal of fuel conservation. One said light metals can significantly contribute to the weight reduction of vehicles. Forming of aluminum is important in making parts and this project is developing understanding in the area of warm forming. The other said manufacturing and weight saving is doubly supportive of DOE's objectives. The third reviewer observed that enhanced formability of lightweight aluminum sheet under conditions that tend to produce failures treats a problem encountered with aluminum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer called this well planned work; the experimental trials have simulated actual manufacturing conditions, making it easy for adaptation. Also, many aspects have been incorporated into the project plan, including experiments, data collection and modeling. The second reviewer termed the project basic but effective. The punch appears to be as much a challenge as the manufactured parts.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

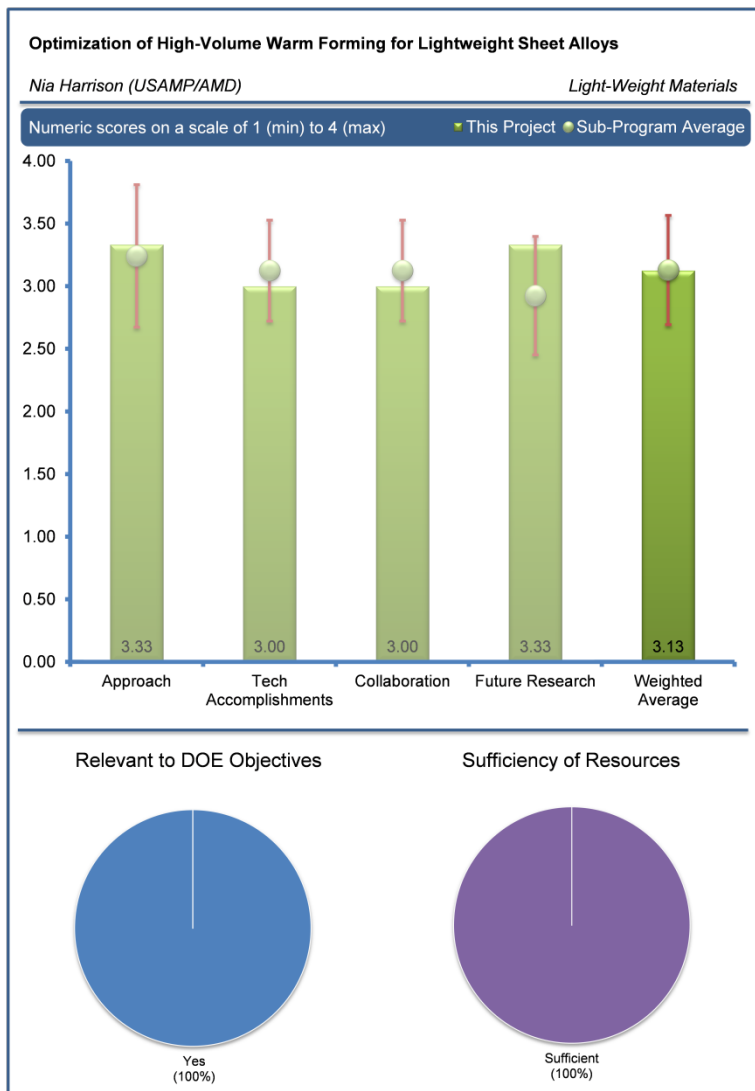
Reviewers offered positive comments, one citing good results and calling the projects very promising and urging its continuation. The results, the second reviewer said, indicate the feasibility of the process and noted that guidance has been developed for the tool design.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer said the research team has developed an excellent partnership with many suppliers and users.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The research team has identified the gaps to be filled in before the process is implemented in actual production, one reviewer said, and some possible paths have been suggested. Another reviewer expressed hope that the effort will be continued.



Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers deemed project resources to be sufficient.

Improving Fatigue Performance of AHSS Welds: Dave Warren (Oak Ridge National Laboratory) – Im062

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers appeared to believe the project supports DOE goals. One reviewer said that as an enabler of AHSS implementation, fatigue testing of joints and weldments will lead to wider application of lightweight steels, reducing weight, improving fuel economy and reducing dependence on imported petroleum. A second said that understanding what adversely impacts the fatigue life of AHSS, and finding ways to extend that fatigue life, will enable better use of the improved properties of AHSS. Currently, this limits application of some AHSS and causes less than mass-optimized designs. A third comment was that weld fatigue durability is key to lightweighting, providing an opportunity to reduce safety factor, which drives gauge reduction. The final reviewer said enabling the use of AHSS in automotive lightweighting.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

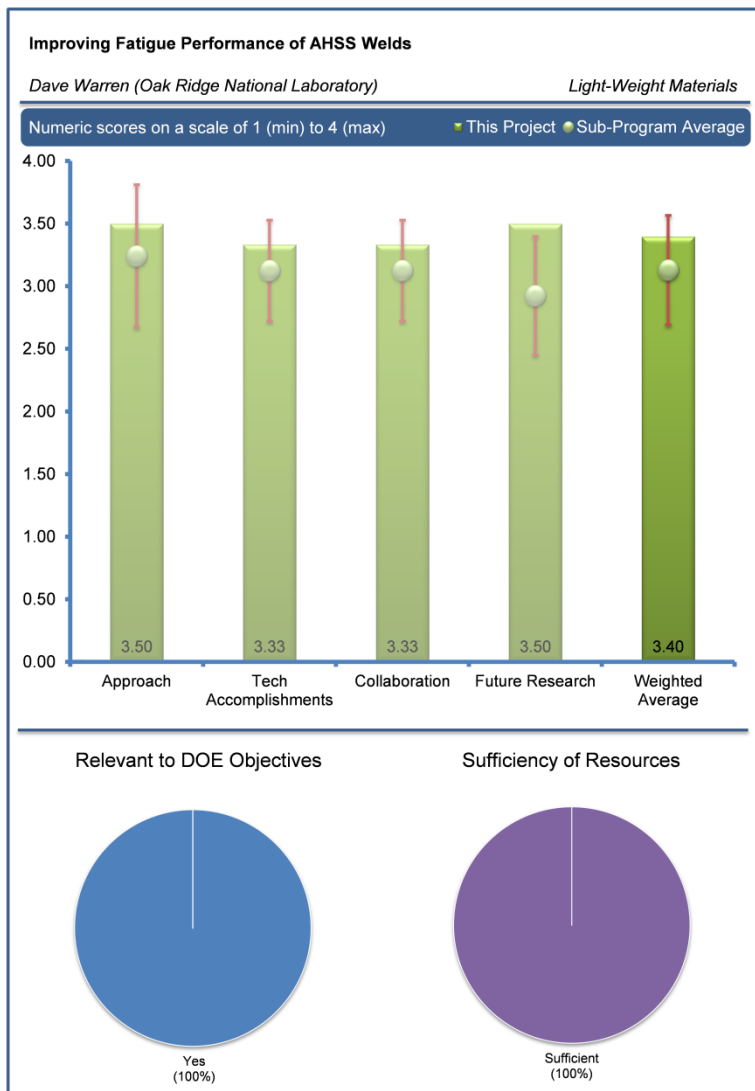
One reviewer said the approach is very good -- reviewing past literature and understanding the problem prior to engagement and proving your initial assumptions are true. When successful, added this reviewer, initial assumptions no longer fit the needs and these are not implemented. The second reviewer termed the project an interesting and promising assessment of cause of current fatigue life deficiency, and an investigation of means to assess residual stress and to increase residual compressive stress. The final commenter described the project as very relative welding work applicable to high-volume processing of AHSS.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two of the three reviewers were impressed by the project's accomplishments and progress. One called the initial results very encouraging and said it is refreshing to see time spent planning the project. The second reviewer said the data behind this work is well received, considered valuable and usable by the automotive industry. The last reviewer remarked using the low-temperature transformation to reduce tensile stress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented excellent collaboration between Fatigue and Fracture Research Laboratory (FFRL), OEMs and academia. A second reviewer commented seems like appropriate choice of partners, each with clearly defined roles and



responsibilities. A third reviewer noted very good vertical alignment of participants to solve problem: scientist, steel supplier, weld process and weld wire.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers concurred in their positive assessment of the future direction of project effort. One cited good direction and focus. Another cited a very good plan to identify solutions to meet project objectives, and the third said good progress toward future and endorsed continuation of the work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers were unanimous in considering project resources sufficient. One reviewer remarked resources seem sufficient, and a second reviewer commented this project is appropriately funded for the research being delivered.

Advanced High-Strength Steel Stamping: Gene Hsiung (USAMP/AMD) – Im063

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said this project shows clear relevance to greater implementation of AHSS through investigation of the primary limiting factors, cracking at stress risers and springback. The second, calling stamping the workhorse of the auto industry, agreed that the use of AHSS is in DOE's objective for lightweighting.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer called the approach good and well thought out. The team is steadily working on achieving good stamping characteristics. However, materials batches consistencies have so far been problematic; perhaps such work is premature. It is good to try something, this reviewer acknowledged, but if the material is not sufficiently known, perhaps it is time to try something new. Moreover, using conventional dies, i.e., for standard steel materials may not be appropriate for AHSS. A new die material and/or new die design may be required to make this work. More thought should be given before starting a new project of the kind. The

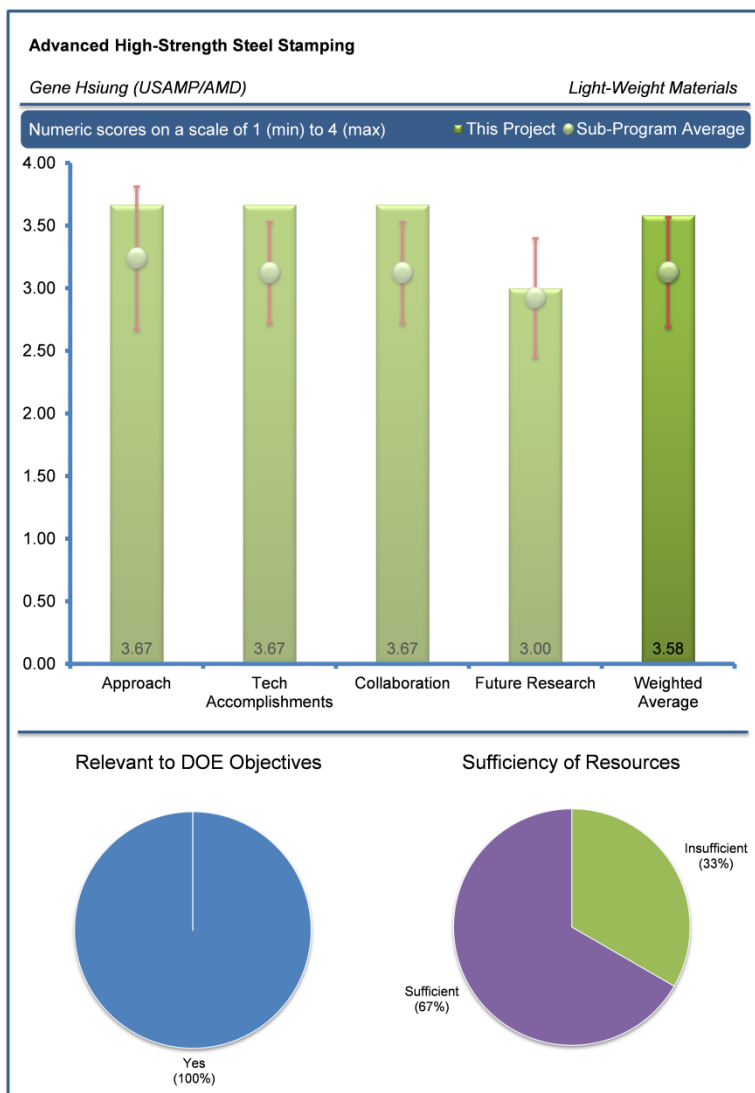
second reviewer noted there had been a full range of tests with a good amount of innovation for fixing things, but not much work had been done on what the researchers say is the real problem – springback. The last reviewer said this project was focused on the technical barriers to understanding how to address edge fracture and evaluate local softening techniques.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewers offered general approval of project accomplishments. One said the accomplishments and results supported the objectives and approach and will advance the understanding and state of the art for AHSS stamping. Another said the project seems to have developed some insights, but springback seems to be the killer. The third reviewer said in view of the tooling used, the results are very good.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that the project included a key contributor from major OEMs, material suppliers, software designer and universities.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed the hope that there will be future research, not only on AHSS materials, but also on die materials and design.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer called resources insufficient. This reviewer said that working on new die material and/or new die design is expensive, clearly indicating that funding is insufficient. Such work offers great promise, not only for the auto industry, but elsewhere. The reviewer termed this enabling work. Two reviewers termed resources sufficient.

Nonlinear Strain Paths: Thomas Stoughton (USAMP/AMD) – Im064

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers affirmed that this project is supportive of DOE's goal. Yes, one said, the project objectives target greater implementation of AHSS which supports the lightweighting mission which improves fuel economy and thus petroleum displacement. The other said the project, by enabling the use of stronger materials as replacements for standard ones, and creating lighter structures, is in line with DOE's objective of petroleum displacements.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

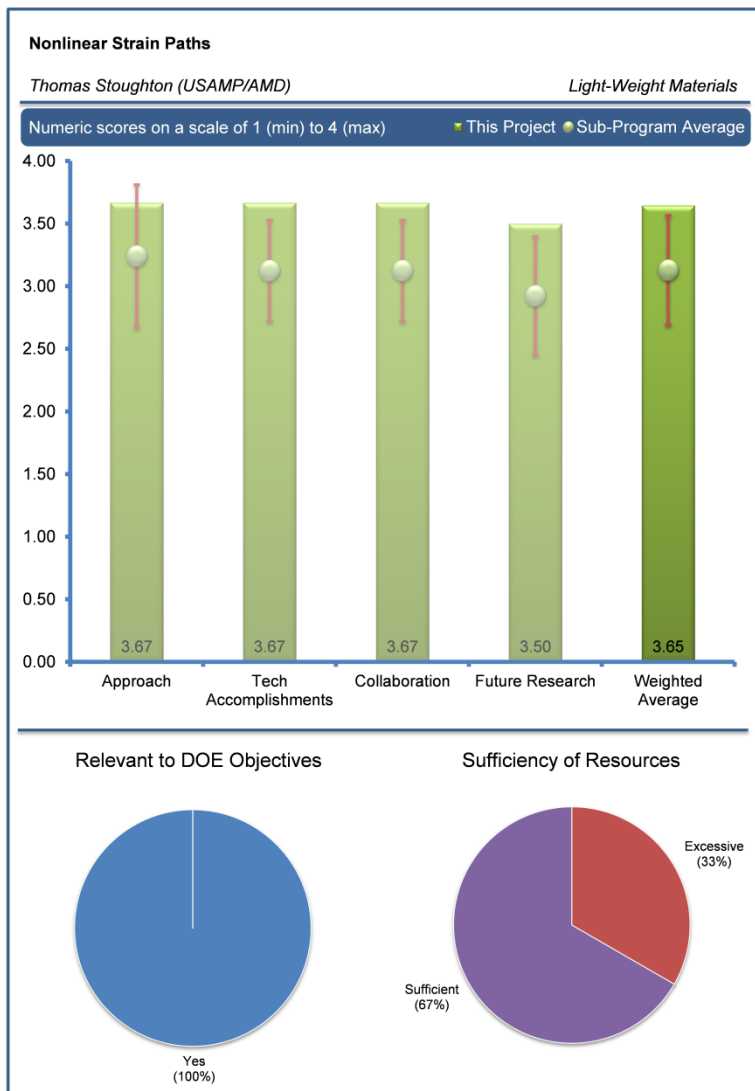
All reviewers commented favorably on the work approach. Very focused and innovative work, one offered, and a lot of work. The tube expansion test has problems with bending and the introduction of non-uniform material properties due to the presence of the weld. The approach, as described by the second reviewer, aims to better understand and take credit for the hardening behavior of existing materials in modeling to improve design efficiency as well as reducing the validation time to implementation. The third reviewer praised the work as solid.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said the technical accomplishments and results presented showed significant progress in understanding non-linear strain paths and showed numerous cases of unexpected material behavior that required further investigation. The second reviewer noted that the project team has gathered quite a bit of data, and it is nice that the OEMs intend to continue the analysis. The third, noting the project had been completed, said the team had achieved everything.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that the project included a key contributor from major OEMs, material suppliers, software designer, universities, and a Federal laboratory.



Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Future work being conducted with non-Federal funding is an excellent metric for successful technology transfer, said one reviewer. The second said the work should be continued and extended.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers considered that resources were sufficient. One reviewer deemed project resources to have been excessive. This reviewer expressed the view that it is strange that AHSS modeling was better funded than AHSS stamping; it should be the other way around as then the modeling will be significantly better and more important for the user.

Mapping of Forming Effects to Structural Models: Raj Sohmshtetty (USAMP/AMD) – Im065

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer affirmed that since the project objectives target greater implementation of AHSS, which supports the lightweighting mission and thus improves fuel economy and displaces petroleum, it supports the DOE goal.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer termed the approach good, taking into account the small amount of funding. This reviewer expressed the hope that this is preliminary work. A second reviewer described the approach as aiming to better understand the effect of stamping on component properties of existing materials and to use that information during modeling to improve design efficiency and reduce the validation time to implementation. The third reviewer found it difficult to extract from the presentation the information needed to assess this aspect of the project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer said including forming effects seems like a low-burden way to get enhanced performance, and called this a good case study looking at a specific performance metric (crash) and offering a good return on investment for DOE.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

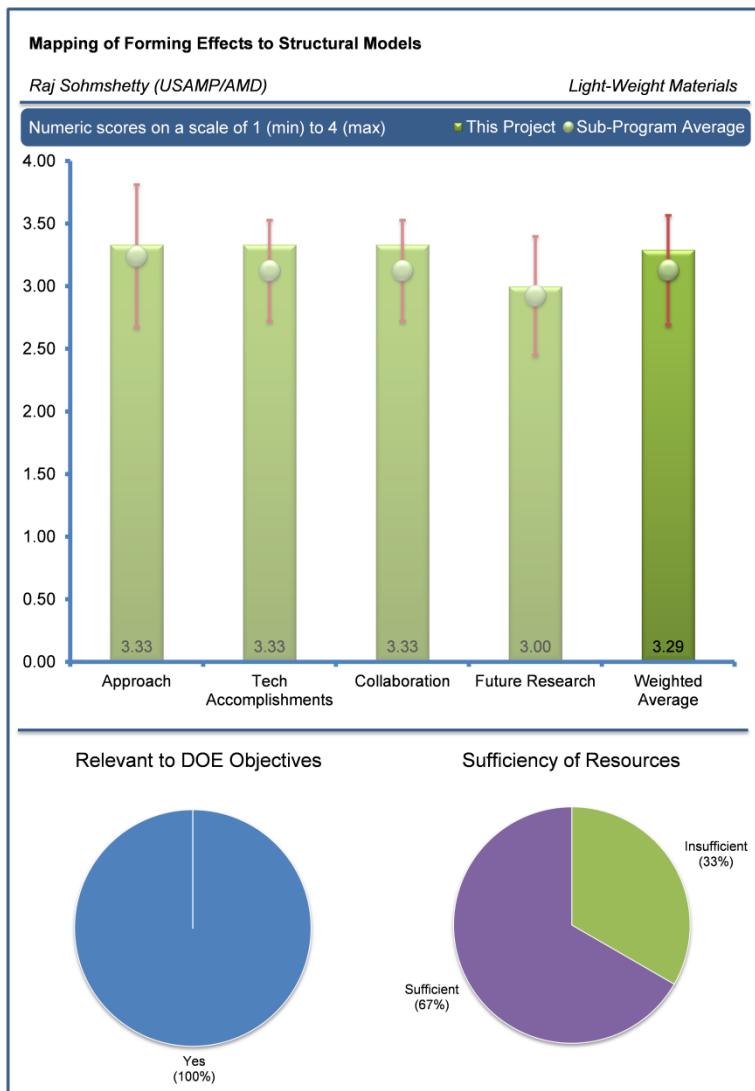
This project, said one reviewer, included a key contributor from major OEMs, material suppliers, and a software designer. A second reviewer discerned little information in the presentation on who did what.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The significance of the research, in the estimation of the one reviewer, will depend on funding.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer was of opinion resources are insufficient, and commented that resources are clearly insufficient. Two reviewers thought the resources were sufficient.



Lightweight Sealed Steel Fuel Tanks: Phil Yaccarino (USAMP/AMD) – Im066

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer found the project support's DOE's goals, and commented that the project objectives target implementation of AHSS and/or stainless steel, furthering the lightweighting mission which improves fuel economy and thus aids in displacing petroleum. Another reviewer remarked this sure looks like ordinary, fairly easy development work that the company should be doing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented that the team employed a well-organized and systematic design approach to evaluate new materials/design features and compared against the design baseline.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The design results showed a 30%-40% weight savings by implementing this material and design features relative to the baseline, noted one reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

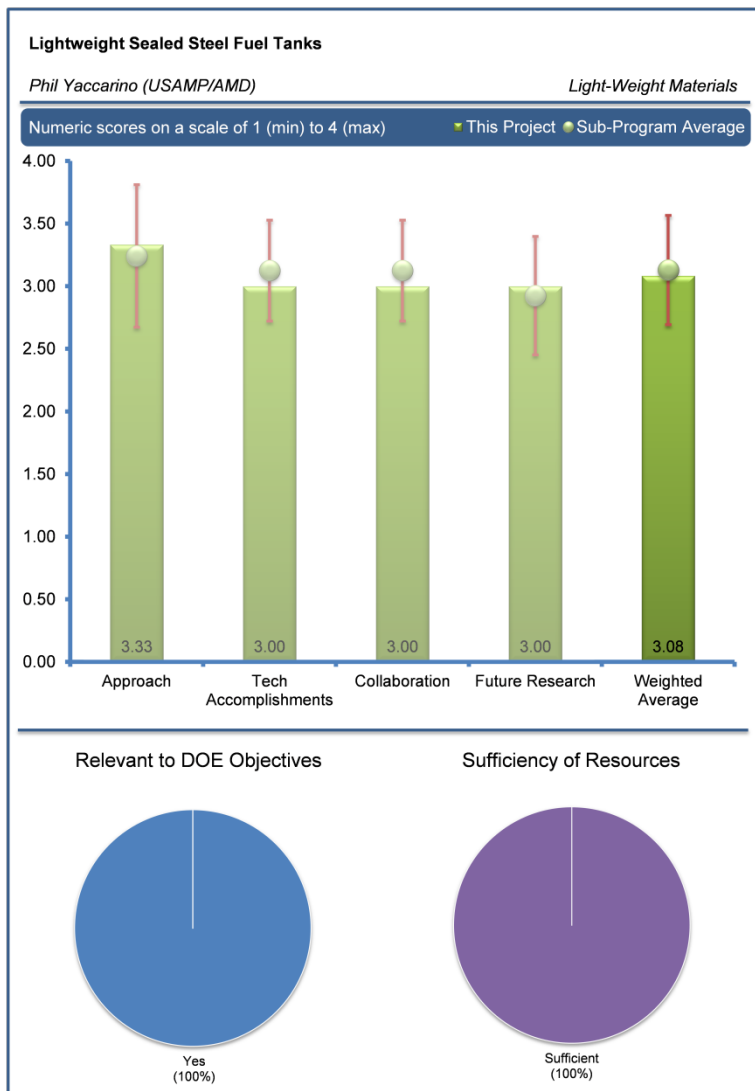
This project included a key contributor from major OEMs, material suppliers, and Tier 1 design contractors, said one reviewer.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

There were no comments submitted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers deemed resources sufficient.



First Generation Advanced High-Strength Steels Deformation Fundamentals: Xin Sun (Pacific Northwest National Laboratory) – Im067

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that understanding what is controlling sudden fracture in AHSS, now that the stresses are high enough that we are fracturing constituents instead of failing by ductile fracture, is critical to this class of materials moving forward in automotive lightweighting. The other reviewer commented the project concerned lightweighting with AHSS.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Both reviewers' comments faulted the approach. One noted that a key part of the analysis that is missing is any way or intention of measuring the strength of interphase boundaries: ferrite/martensite, martensite/austenite, etc. These may turn out to be the key weak link in these steels. The second cited the project's challenging objective, but believed it was unclear that the approach is well thought out.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

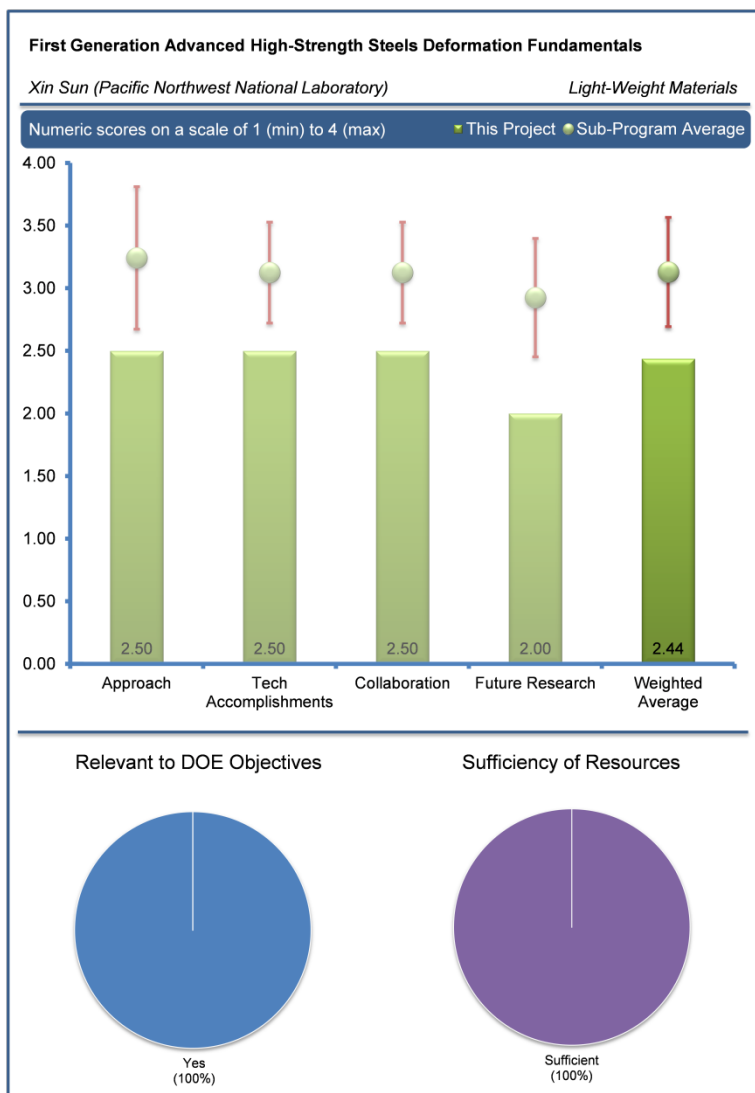
While recognizing the effort that had been exerted, the reviewers did not discern significant progress. One said not much real progress, and the project did not get too into the microstructures, but relied instead on macro measurements. The other reviewer said significant effort, but not conclusive results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer cited the need to list the names of industrial participants so that findings can be shared with industry. Another reviewer commented mostly looky-loos.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer was unsure if the proposed plan can achieve the project objective.



Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers found project resources sufficient. Neither commented further.

Engineering Property Prediction Tools for Tailored Polymer Composite Structures: Ba Nguyen (Pacific Northwest National Laboratory) – Im068

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

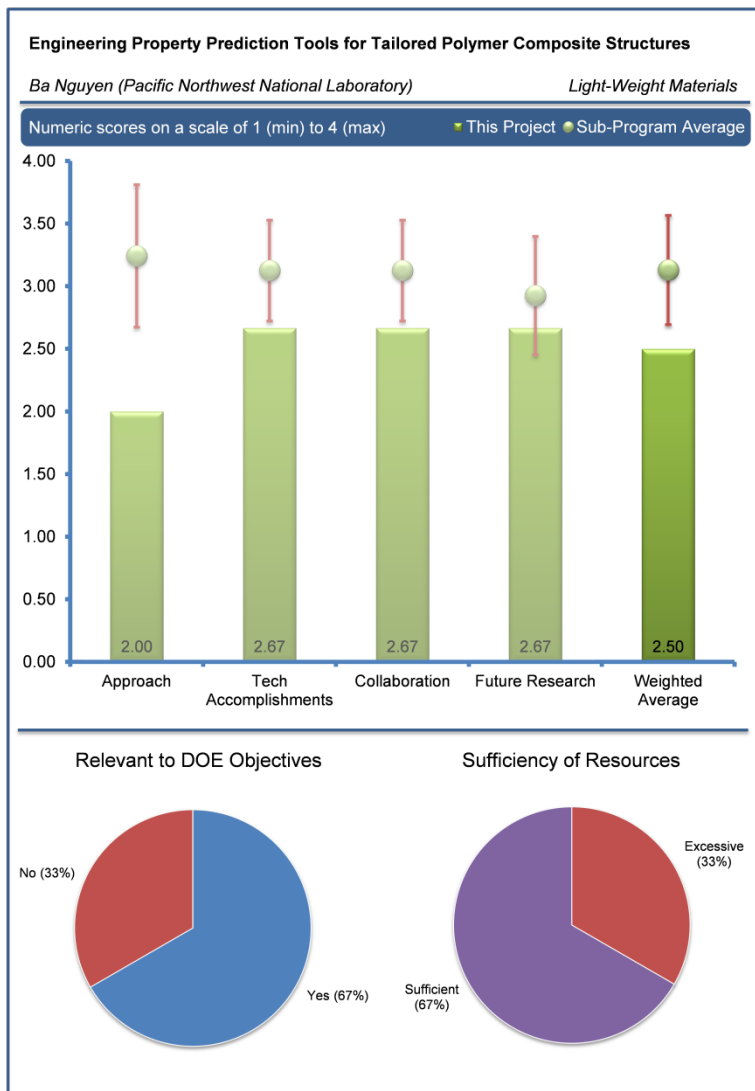
One reviewer said lightweighting of vehicles depends on effective use of many materials, including polymer composites. It is necessary to predict the performance of these materials under stress before producing components. The project is aimed at developing preliminary models to predict the properties. This is an enabler for the use of composite materials in vehicle structures. The second reviewer disagreed explicitly, commenting this project does not support the DOE goal of petroleum displacement. Even if the project is wildly successful, the opportunity to reduce part thickness is minimal with the long fiber thermoplastics (LFT) materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer called the problem well defined and said the approach is planned. However, it should be mentioned that the effort is preliminary; continued development is necessary to understand the problem. The fiber distribution and its impact on properties are well understood and this project is trying to develop some predictive models so that the issue can be quantified. The second reviewer felt there was little discussion of the approach. It appears, this reviewer said, that the approach is limited to MoldFlow computational fluid dynamics (CFD) predictions and using the typical distribution statistics to estimate properties. There is no discussion of any feedback loop for mold design. The flow in a center-gated panel is not particularly difficult to calculate, or to guess, for that matter.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses. In the view of one commenter, the results are good. However, this reviewer continued, more rigorous analysis is required. For example, the prediction of cracking at particular locations in the test plate has been confirmed, but more analysis is needed to predict the properties in other locations. This reviewer also asked if it is possible to predict how the process can be modified to achieve certain properties. The second reviewer concurred in part, saying progress for the last year had not been clearly reported. Flow simulation and property prediction are limited to simple samples. More complex parts are needed to validate the models developed. The third reviewer cited apparent project shortcomings. The predictions of stress-strain response are outside the scatter band of the five experiments, this reviewer noted, concluding that if, after six years, this is the best the technology can predict for a center-gated panel, it would have been better just to use the handbook properties with an appropriate



safety factor. Since the two sets of experiments showed that the stress-strain behavior is almost isotropic, this reviewer questioned the necessity of this effort.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers spoke favorably of project collaboration. One noted that inputs from the OEM had been obtained and involvement of the team from USAMP is valuable. The second cited good collaboration with partners in industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The project is complete, one reviewer noted, but the investigators have provided the future path and issues that need to be investigated. The second reviewer deemed the proposed future work – to move from a center-gated flat plaque to a three-dimensional, multi-faceted part to provide a more interesting validation – to be the proper next step. However, given the nearly isotropic stress-strain material response, the weight associated with overdesign is likely to be minimal.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers called project resources sufficient. One deemed resources excessive. This reviewer said resources appear excessive for this project. The costs for parts are from the partners and the costs for computer modeling and testing should not be this high.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
3-DEP	Three Dimensional Engineered Preform
AHSS	Advanced High Strength Steel
Al	Aluminum
AZ31	A Magnesium alloy
C	Degrees Celsius
CF	Carbon Fiber
CFD	Computational Fluid Dynamics
CO2	Carbon Dioxide
DOE	Department of Energy
EV	Electric Vehicle
FEA	Finite Element Analysis
FFRL	Fatigue and Fracture Research Laboratory
FOA	Funding Opportunity Announcement
FY	Fiscal Year
GATE	Graduate Automotive Technology Education
GHG	Greenhouse Gases
HSLA	High Strength Low Alloy Steel
HTML	High Temperature Materials Laboratory
ICE	Internal Combustion Engine
ICME	Integrated Computational Material Engineering
IIHS	Insurance Institute for Highway Safety
IR	Infrared
IRS	Internal Revenue Service
ksi	Thousand pounds per Square Inch
LFT	Long Fiber Thermoplastics
MENA	Magnesium Electron North America
MFERD	Magnesium Front End Research and Development
Mg	Magnesium
MGI	Materials Genome Initiative
MIT	Massachusetts Institute of Technology
MMLV	Multi-Material Lightweight Vehicle
MOxST	Metal Oxygen Separation Technologies, Inc.
msi	Million Pounds per Square Inch
MSRP	Manufacturer Suggested Retail Price
MSU	Michigan State University
MSU	Mississippi State University
NDE	Non-Destructive Evaluation
OEM	Original Equipment Manufacturer

Acronym	Definition
ORNL	Oak Ridge National Laboratory
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAN	Polyacrylonitrile
PE	Polyethylene
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
POL	Pilot Oxidation Line
R&D	Research and Development
RE	Rare Earth
RSW	Resistance Spot Welding
SMC	Sheet Molding Compound
SOM	Solid Oxygen Ion Membrane
TCM	Technical Cost Modeling
UCSD	University of California San Diego
UPA	Unit Production per Annum
USAMP	U.S. Automotive Materials Partnership
VEHMA	Vehma International
VTP	Vehicle Technologies Program

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7. Materials Technologies: Propulsion Materials

Propulsion materials research is critical to bringing advanced high-efficiency powertrains to the marketplace. The use of innovative materials in specialized applications throughout the powertrain can help to improve system efficiency and reduce emissions. Applications include engines, electrical drive systems, fuel systems, charge air systems, thermal management systems, exhaust aftertreatment systems (EATS), and engine accessories. U.S. Department of Energy (DOE) researchers and industry partners work together to identify the types of materials technologies required for advanced engines. These include material compositions and properties, as well as manufacturing processes, component cost, life prediction, and durability. In addition, propulsion materials research develops "enabling technologies" to ensure the success of new power electronics, advanced internal combustion engines, hybrid systems, and emission reduction technologies.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores (*on a scale of 1 to 4*). In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors	Glenn Grant (Pacific Northwest National Laboratory)	7-3	2.75	3.00	3.00	2.75	2.91
NOx Sensor Development	Robert Glass (Lawrence Livermore National Laboratory)	7-6	3.38	3.50	3.50	3.13	3.42
Materials Issues Associated with EGR Systems	Michael Lance (Oak Ridge National Laboratory)	7-9	3.50	4.00	4.00	3.00	3.75
Durability of Diesel Engine Particulate Filters	Thomas Watkins (Oak Ridge National Laboratory)	7-11	3.20	3.00	3.00	2.60	3.00
Thermoelectric Mechanical Reliability	Andrew Wereszczak (Oak Ridge National Laboratory)	7-13	3.20	3.20	3.20	2.80	3.15
Thermoelectrics Theory and Structure	David J. Singh (Oak Ridge National Laboratory)	7-15	3.25	3.50	3.50	3.00	3.38
Low-Cost Direct Bonded Aluminum (DBA) Substrates	Hua-Tay Lin (Oak Ridge National Laboratory)	7-17	3.00	2.50	2.50	3.25	2.72
Improved Organics for Power Electronics and Electric Motors	Andy Wereszczak (Oak Ridge National Laboratory)	7-19	3.40	2.80	2.80	3.20	3.00
Materials for Advanced Turbocharger Designs	Phil Maziasz (Oak Ridge National Laboratory)	7-22	3.00	3.00	3.00	3.00	3.00
Engine Materials Compatibility with Alternative Fuels	Steve Pawel (Oak Ridge National Laboratory)	7-25	3.33	3.17	3.17	3.17	3.21
Biofuels Impact on DPF Durability	Michael Lance (Oak Ridge National Laboratory)	7-28	3.00	2.83	2.83	2.83	2.88
Electrically-Assisted Diesel Particulate Filter Regeneration	Michael Lance (Oak Ridge National Laboratory)	7-31	3.00	3.00	3.00	3.00	3.00
Compact Potentiometric NOx Sensor	Dileep Singh (Argonne National Laboratory)	7-33	3.29	2.57	2.57	3.00	2.80

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Temperature Aluminum Alloys	Mark Smith (Pacific Northwest National Laboratory)	7-36	3.00	2.80	2.80	2.80	2.85
Overall Average			3.16	3.06	3.06	2.97	3.08

Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors: Glenn Grant (Pacific Northwest National Laboratory) – pm004

Reviewer Sample Size

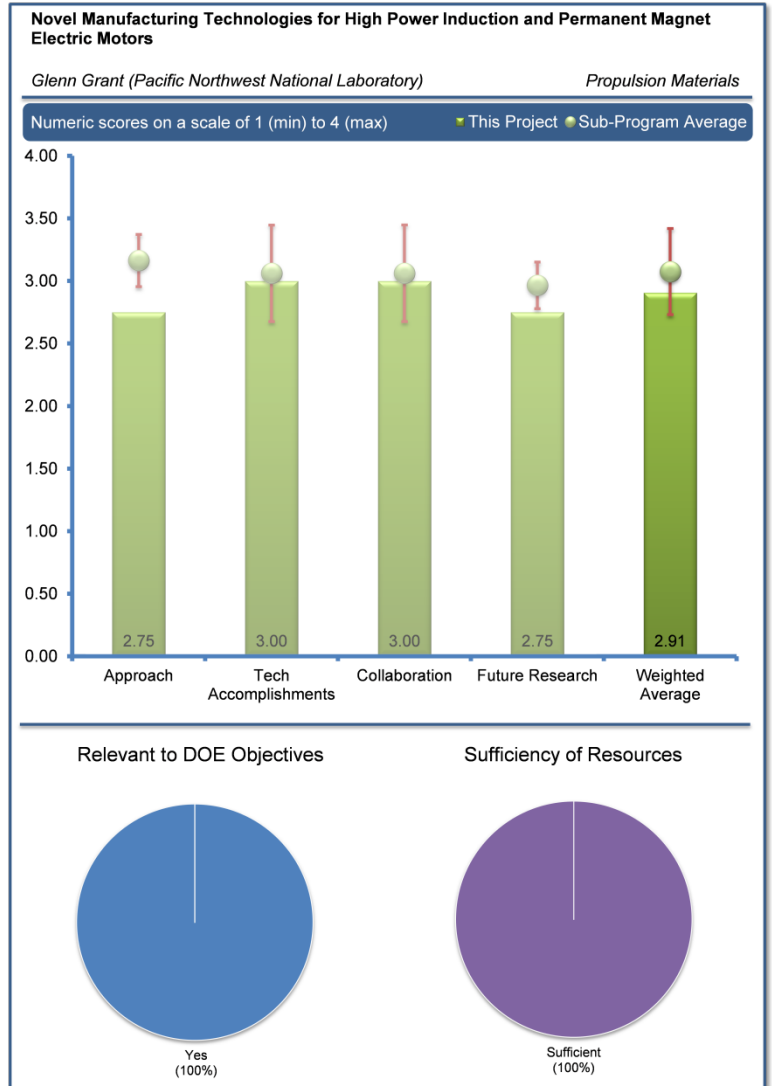
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments for this question were generally positive. One reviewer stated that this project does indeed support the overall DOE objectives of petroleum displacement or reduction. The reviewer pointed out that the researchers hope to develop novel low temperature solid state joining strategies that should reduce distortion, improve the structural integrity, and increase the thermal and electrical conductivities of the components. The reviewer further noted that the presenter stated that all of these benefits should enable the fabrication of smaller, lighter, less costly and more reliable traction motors and other electrical components. The next commenter agreed that continuing and deepening electrification of the highway transportation sector is a generally agreed means of reducing the petroleum demand of this sector, which is currently based almost entirely on petroleum-derived energy, by increasing overall propulsion efficiency and by diversifying the primary energy sources supplying it. Another observer stated that electrification is one of the ways to improve the energy efficiency of vehicles and motors are integral to that part of the strategy. This reviewer continued that improving the production capability of motors will be beneficial by reducing the cost. Further, this reviewer stated that as this project is developing an enabling technology to improve the production, it contributes to the petroleum reduction. The final reviewer stated that multiple barriers had been clearly addressed by the project.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers provided mixed comments on the approach to the work. One reviewer thought that the researchers employed a good approach, with a good coupling to barriers with measureable parameters. Another reviewer stated that task one and two are on the Friction Stir Welding (FSW) process and the third task is for magnetic material development, but was not sure how these two areas are related. This person asked if other issues were to be considered for electric motors, and noted that the research is aimed to develop linear FSW process for producing joints in copper rotors. The reviewer remarked that even though the idea is unique, the process may not be the suitable, as the geometry of the rotors may call for different joining techniques other than linear joints. This reviewer also wished to know how much of the joining is involved in the rotor production process. The next panel member agreed that the technical approach to this work is sharply focused on several important technical and cost barriers to the wider adoption of electrical propulsion systems and prime movers. This commenter pointed out that the focus of the work (electric motor fabrication and cost optimization), however, is fairly narrow. This reviewer remarked that significant in-kind participation of a major vehicle



manufacturer is testimony to the importance the industry attaches to this work, but that other issues may be of greater ultimate importance to electrical propulsion systems, e.g., energy storage. Another panelist relayed that the researchers stated that they were going to work on copper-copper, copper-aluminum, and new materials using FSW, but the panelist did not feel that the presenter adequately described what they were going to do. Instead the presenter spent additional time on the relevance of the work and how it would reduce the size, weight and cost of motors if successful. The panelist realized that this is a very new project and the specifics of their work are probably still being developed, but next year the panelist would like to see specifics about what the research team is going to do and how it is going to join very small and/or complex shaped parts with very simple and bulky friction stir welding tools. The panelist would also be interested in what General Motors Corporation (GM) plans to do and how that will complement the Pacific Northwest National Laboratory (PNNL) work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviews for this section were mixed. One panel member commented that the technical accomplishments were good for the short length of time since the project's inception. This person commented that the researchers have already investigated a variety of tool materials for both copper-copper (Cu-Cu) and copper-aluminum welds, and a number of process parameters including the spindle speed or revolutions per minute (RPM) of the tool and the travel speed of the tool across the component surface. This panelist looks forward to seeing what the researchers will be able to accomplish in a full year. Another reviewer observed that testing so far is leading to quantified results, but would like the researchers to show how successes tie back to the goals, and to show how close to target they are for areas of focused improvements in cost and weight. The next panel member thought that the project has surfaced some areas, e.g., FSW tool life, that clearly need attention, but that with less than one year's effort to date, it is difficult to assess the extent of progress. Accomplishments in the balance of fiscal year (FY) 2012 and up to the indicated go/no go gates will be critical to an evaluation of progress toward objectives. The final panelist relayed that FSW of Cu-Cu joints was investigated; the quality was assessed but not much was presented about the performance of the joints.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were mixed. One reviewer relayed that the researchers at PNNL have established collaboration with GM, who in turn have a large contract with the Power Electronics and Electric Machines Program to develop a new traction motor. This reviewer noted that the solid state joining technology being developed at PNNL will leverage and/or compliment the motor development at GM and, if successful, could be implemented in GM's new motor. Another observer thought that collaboration with one or more metal fabrication specialty companies would enhance this project. General Motors is likely to be a major beneficiary of the technology(ies) developed in this project, and it is to be hoped they would also be available to other vehicle builders. The second reviewer also thought that it seems unlikely that vehicle manufacturers would be major users of those technologies, as distinct from producers of electric motors and motor components. The next reviewer stated that PNNL developed a Cooperative Research and Development Agreement (CRADA) with GM for the project, but that the involvement of GM researchers is not shown in the presentation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Commenters gave mixed replies to this question. The first reviewer thought that even given the limited extent of past progress due to the recent inception of the project, it seemed clear that plans for the next 20 or so months of this project's future address the stated barriers and are sharply focused on overcoming them. An additional reviewer thought that the future work outlined by the researchers would build on the work that was started this year and will culminate with a very challenging go/no-go decision based on the mechanical performance criteria of welds of different geometries. The third reviewer said in reference to Slide 16 that future work planned is good, but that outputs should focus on delivery of barrier-reducing technology. The next commenter observed that the plan is to concentrate on the FSW joints, but there was no plan for the work on magnetic material development. The final observer believed that some innovative thinking would be required to figure out how to join the small and complex shaped components used in electric motors using conventional friction stir welding tools.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers rated the resources sufficient. One qualified this rating by stating that this project will be receiving \$445,000 during FY 2012, which is one of the highest totals for the Propulsion Materials Program. The reviewer believes that the funding is sufficient for this work.

NO_x Sensor Development: Robert Glass (Lawrence Livermore National Laboratory) – pm005

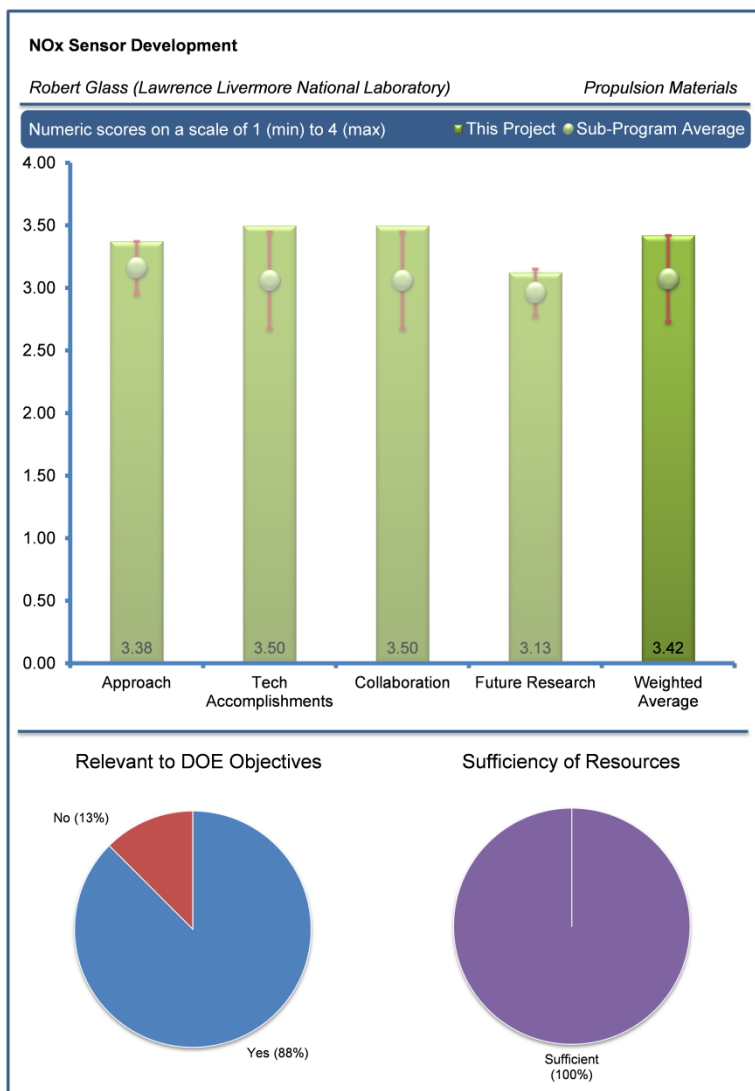
Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviews for this question were mostly positive. One commenter stated that accurate, responsive and above all cost-effective sensors for key emissions species are a key to long-term compliance with relevant emissions standards, without over-compliance, which is usually associated with larger-than-necessary fuel economy penalties. This commenter also stated that optimal control of oxides of nitrogen (NO_x) in particular is crucial for compression ignition (CI) engine vehicles, whose wider adoption would pay significant national dividends in petroleum conservation. Another reviewer thought that dieselization of a greater portion of the vehicle fleet would reduce petroleum consumption, and that development of a robust low cost NO_x sensor will assist in the implementation of diesel vehicles that are clean and efficient. The next reviewer pointed out that sensors are critical to development of fuel efficient and clean engine technology, and that they are the heart of the system; the level of technology in sensors is a critical component of future engine technologies. An additional panelist agreed that a NO_x sensor could be required for enabling diesel technologies, in turn contributing to

reducing consumption by 1.5 million barrels per day through a 33% conversion to diesel. This panelist relayed that cost reduction of sensors as well as durability and accuracy will enable improved control. The panel member also asked what the targeted and estimated cost reductions are with the new technology, since diesels are in production with NO_x sensors today. A subsequent reviewer was not sure if the one-third driver conversion to diesel is realistic; however, the notion of higher fuel efficiency correlates to DOE's petroleum displacement goals. Another person commented that this project does indeed support the objective of reducing petroleum consumption. This person agreed that it is well known that diesel engines are more efficient than gasoline engines, but noted that their emissions, especially NO_x, have traditionally been higher than gasoline engines. This person further stated that to combat high NO_x emission levels, engines were de-tuned to minimize NO_x, and with the development of NO_x treatment strategies, measurement and control, engines can now be tuned for maximum efficiency. This person believes that the development of low-cost, rapid response NO_x sensors is therefore an enabling technology that will help optimize the efficiency of heavy duty (HD) engines used on trucks and will encourage the American public to purchase a higher fraction of more efficient diesel engines. The reviewer concluded with the thought that, with the price of diesel fuel being higher than gasoline, the American public is not likely to buy a lot more diesel automobiles. The next reviewer stated that material cost appeared to be too high, and that there exists long lead times for commercialization. A final reviewer observed that the project's aim is to develop low-cost, durable sensor technology for NO_x measurement and control to accelerate the introduction of clean, high-efficiency, light-duty diesel vehicles. This reviewer noted only one type of exhaust NO_x sensor available on the market, and that solid state electrochemical NO_x sensor technology is a proven robust technology.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Remarks were mixed on the researchers' approach. The first panelist remarked that Ford Motor Company's significant contribution of in-kind support suggests both the importance the automotive industry attaches to development of practical NO_x sensors for light duty (LD) diesel vehicles and the industry's endorsement of the technical approach. An additional observer relayed that Lawrence Livermore National Laboratory (LLNL) developed a unique design and measurement strategy that leverages proven robust solid-state electrochemical technology using complex alternating current (AC) impedance (electrical response to low-amplitude AC signal) as opposed to direct current (DC) signals. This observer also noted that the researchers are developing a novel sensor with the potential to meet original equipment manufacturers' (OEM) cost and operational requirements. The next panelist thought the primary investigator (PI) showed that the project's research developed a solution that is possible, and has now to show low cost manufacturing. Another reviewer confirmed that for this year, researchers were testing prototypes to improve performance, including drift and sample-to-sample reproducibility. The next panel member commented that the technology being developed is challenging, although there seemed to be a reasonable approach to overcoming the barriers and obstacles as information is gained over time. The panelist thinks that there still seem to be many issues that need development before commercialization is imminent. A subsequent reviewer was of the opinion that the researchers' approach was valid and producing good results, but that the presented information on approach did not give detail on what the objectives are nor how those objectives shall be achieved. Another reviewer stated that although this project has been ongoing for a very long time, it was unclear whether the researchers have learned a lot and made great progress, especially in the last three or four years. The reviewer saw that the researchers have developed a novel technology that measures AC impedance instead of DC signals, thus offering better sensitivity for both nitric oxide (NO) and nitrogen dioxide (NO₂) better stability, and a simpler, less expensive technology. The reviewer also appreciated that the researchers have included engine testing in their work, which enables them to determine whether the sensor is robust and durable enough for successful commercialization. The final reviewer characterized the research as using an electrochemical sensor approach, using an alternating current sensing approach, working on testing and mass production fabrication strategies, and developing an electronic interface.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Impressions of the technical accomplishments and progress were mixed. One reviewer remarked that the researchers at LLNL and Ford have made good progress this year. The reviewer relayed that the researchers have investigated two different sensing materials (Au and LSM), recognized that Au was more stable, and that LSM had some drift because of the formation of microcracks due to a thermal expansion mismatch. The reviewer noted that the researchers were able to modify the substrate to change the thermal expansion of the substrate and that significantly reduced the number of microcracks and produced acceptable drift. This first reviewer also thought that the engine testing that was done showed that the sensors were robust and durable in the engine environment and the performance was at least as good as current amperometric NO_x sensors. Another panel member thought the accomplishments regarding sensor measurement advances were good. This panelist also pointed out that NO_x values can range to well over 1,000 parts per million (ppm) in real life, and suggested considering regeneration, etc. The panelist remarked that sensor performance over 100 ppm was undefined, and asked if this was for post NO_x reduction catalyst application only. This panelist went on to ask what the requirements for range, temperature, and other conditions were. The next reviewer thought that the review highlighted the progress in a broad overview with vague milestones, and that it seemed as though the OEM was driving the schedule to keep swift progress, which is fine so long as the development is not compromised. The reviewer thought the presenter did not give a sense of the impact of a swift project conclusion. The reviewer assumed that Ford will continue to work with EmiSense and adopt this technology, but wondered if there was any risk that Ford would not pursue it. Another observer stated the researchers were still developing information from research. This reviewer observed that the researchers' laboratory long-term aging (up to 1,000 hours) confirmed that previously measured minimal drift in Au prototype, but indicated variance in LSM prototype; demonstrated acceptable solution to optimize the tradeoff between micro-crack formation and drift in LSM prototype by modifying substrate composition; demonstrated excellent performance of Au prototype in both high (up to 100 ppm) and low (less than 20 ppm) NO concentrations alongside two commercial amperometric sensors (same design, two different suppliers); and additional advanced engine testing in real diesel exhaust and aggressive conditions continued to show

good results including sensor durability and robustness. The final reviewer thought that significant progress had been made toward the project objectives, and listed the researchers' accomplishments as having demonstrated sensor prototypes in lab and in engine dynamometer testing; having demonstrated prototype electronics; having confirmed aging performance of one prototype and observed drift and sample-to-sample variability with another; having observed microcrack formation in the less stable design and improved performance by minimizing microcrack formation; and finally having demonstrated optimized design.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments on this section were generally positive. One person commented that the collaboration and coordination with other institutions has been outstanding in this project, and pointed out that the researchers have worked with Ford for many years and their guidance has steered the project in the right direction. The reviewer also thought that the additional collaboration with EmiSense (Coors Ceramics & Ceramtec) at this stage of the project has been a big plus because both Ford and EmiSense are pushing this technology toward commercialization. Another commenter thought that collaboration with current industry partners (EMISense and Ford) seems close and appropriate; a rating of Outstanding was therefore justified. However, this commenter thought it seemed likely that virtually all manufacturers of emissions controls and all light-duty vehicle builders will wish to employ the technology and its fruits if this project is ultimately successful. The commenter questioned if control of patents, etc. would allow the technology's universal adoption by OEMs, or if licensing fees, etc. would motivate them to duplicate this work and develop their own proprietary approaches to NO_x sensing. The next reviewer commented that collaboration between the adoption by EmiSense and the interest and direct collaboration with Ford lend commercial credibility to the project. The following reviewer saw significant collaboration with Ford and an established partnership with a patent licensee via a CRADA. The subsequent observer thought the researchers have the right collaborative partner from historical perspective, but that it was difficult to determine whether the partners are working sufficiently collaboratively on the project to match needs for continuing development. The next reviewer noted good collaboration with Ford and EmiSense, and a final panelist stated that there was collaboration with Ford and EmiSense.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Most comments on this section were positive. One panel member enthused that that the plans for future work were outstanding because partner EmiSense will be involved with the investigation of processing/fabrication techniques like tape casting, slurry painting, spin casting, and photolithography and sputtering. This panelist thought that there should not be any wasted effort because the partner planning commercialization will focus on the technologies that look most promising to them. The panel member also thought for similar reasons that it was very wise to include Ford and EmiSense in the work on sensing strategy and electronics; their participation will ensure that the best path for commercialization is chosen. Another reviewer found that the researchers had a good plan to work with EmiSense to refine fabrication/processing strategy and develop long-term and accelerated testing protocol. The next commenter thought that the researchers employed a logical approach, based on findings. Another observer stated that researchers will perform down-selection of fabrication methods and electronics design, and will validate engine/vehicle performance. The next panelist remarked that plans seemed clear for future testing, and that long term durability was key, but wondered if the testing should be done in an expected environment. A subsequent reviewer thought the presenter did not offer great insight into what appears to be a significant amount of work in the remaining period of the contract. The final panelist remarked that key decision points will be reached this year and next, and appear to have been adequately and logically prepared for. The final reviewer qualified his remark by noting that, on the other hand, this project's eggs are essentially all in one basket (i.e., impedance-based sensing, and should those key decisions be negative, no alternative pathway is apparent).

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Eight reviewers found the resources to be sufficient. One reviewer thought that the project appears to have been adequately funded. Another noted that the project has adequate funding for FY 2012 (\$400,000). The next confirmed that this project received \$400,000 in FY 2012 and has been well funded since its inception. A further reviewer pointed out that no cost share was described other than roughly one-third in-kind support from Ford. The final observer provided that spending was in accordance with plan.

Materials Issues Associated with EGR Systems: Michael Lance (Oak Ridge National Laboratory) – pm009

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer found that this project addresses eliminating a 1-2% efficiency loss, which is aligned with DOE's petroleum displacement objectives. Another panelist stated that this project seeks to mitigate exhaust gas recirculation (EGR) cooler fouling, which reduces the fuel economy of combustion engines. This panel member further explained that EGR cooling is currently the primary approach to reducing NO_x emissions from lean burn engines such as diesel engines which tend to be higher NO_x producers than lower compression gasoline engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer thought that this project employed excellent forensic analysis combined with controlled lab research and problem solving. The next observer noted that the approach was logical and well laid out, but could be improved if sufficient funding were available to enable more engine operating set points to be selected to better simulate the engine map operation in real world conditions. This observer also advised that increased attention should be given to the chemistry taking place within the EGR cooler as the formation of polycyclic aromatic hydrocarbons (PAHs) indicates that quite a bit of chemistry, as opposed to simple condensation, is taking place therein.

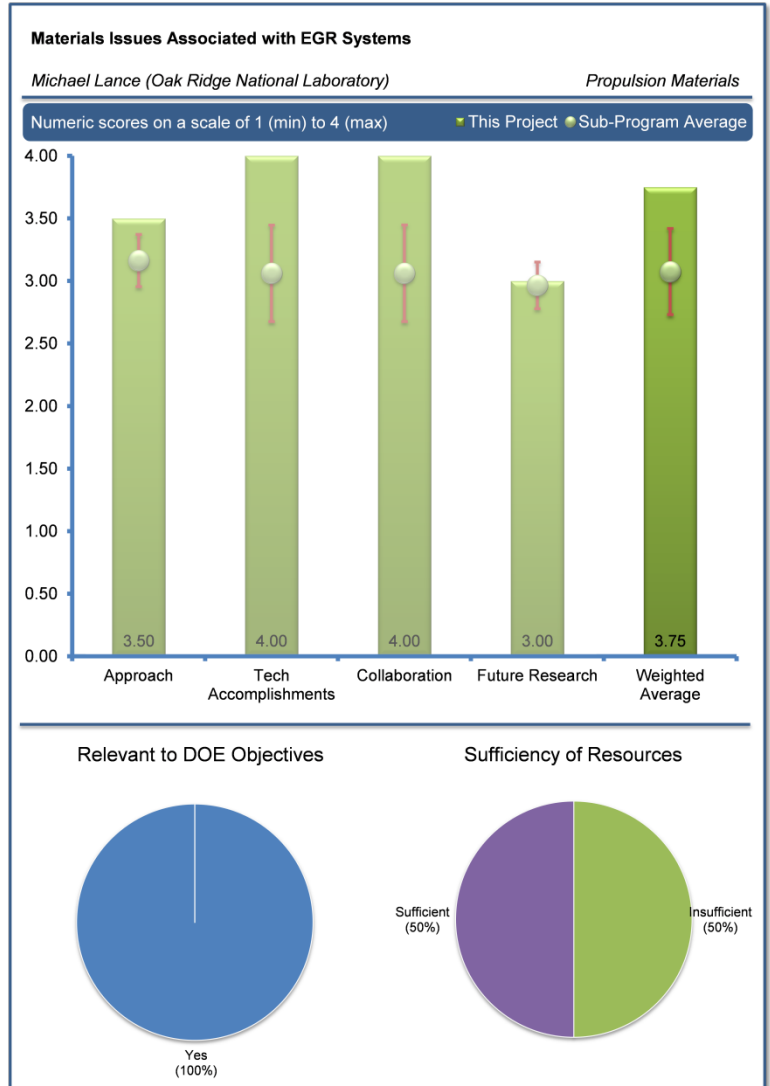
This observer also advised that increased attention should be given to the chemistry taking place within the EGR cooler as the formation of polycyclic aromatic hydrocarbons (PAHs) indicates that quite a bit of chemistry, as opposed to simple condensation, is taking place therein.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that with clear support and interest from OEM community, progress appears to be well monitored and task adjustments seem to be readily adopted. The second reviewer said that given the modest funding level, progress on meeting the milestones has been quite good. The reviewer recommended that increased emphasis should now be given to developing the refreshing protocol suggested by results showing that water vapor has a substantial positive effect on reducing fouling buildup.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One panel member thought that there was an ideal level of partnership and interest from industry OEMs. The panelist qualified this by pointing out that there was no mention of the loss of Army interest from 2011 activity. Post-presentation questions revealed that Army funding did not continue. This reviewer inquired about why Army engagement was not kept. The panelist also commented that the presentation did not describe why some OEMs did not contribute specimens for analysis. Another reviewer stated that while collaboration and coordination of this work with other institutions has been outstanding, perhaps even this could be



enhanced by adding a few fuel providers to the mix. This reviewer believed that by so doing, more attention could be paid to the reaction conditions and the chemistry taking place within the ERG cooler.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer thought that the proposed future research directions are logical and build upon past progress, but also suggested that improvements could be made by investigating whether or not there are any material effects on the fouling build up, perhaps through a catalytic effect. The second observer wrote that while the review offered a rudimentary outline (two main topics) of future work, there was little information presented that described transition to industry adoption.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer rated the resources as sufficient, while the other found resources to be insufficient. The first reviewer noted that no cost share was described, while the other reviewer commented that the level of resources are adequate for the rather slow pace of progress achieved thus far; however, EGR cooler fouling is a serious impediment to achieving the full fuel efficiency of the U.S. heavy duty trucking fleet. This observer points out that EGR cooler failure constitutes a substantial cost penalty to truck operators who are already struggling with reduced profit margins, and that to increase the pace of progress, this project merits at least a 15-20% increase in resources.

Durability of Diesel Engine Particulate Filters: Thomas Watkins (Oak Ridge National Laboratory) – pm010

Reviewer Sample Size

This project was reviewed by five reviewers.

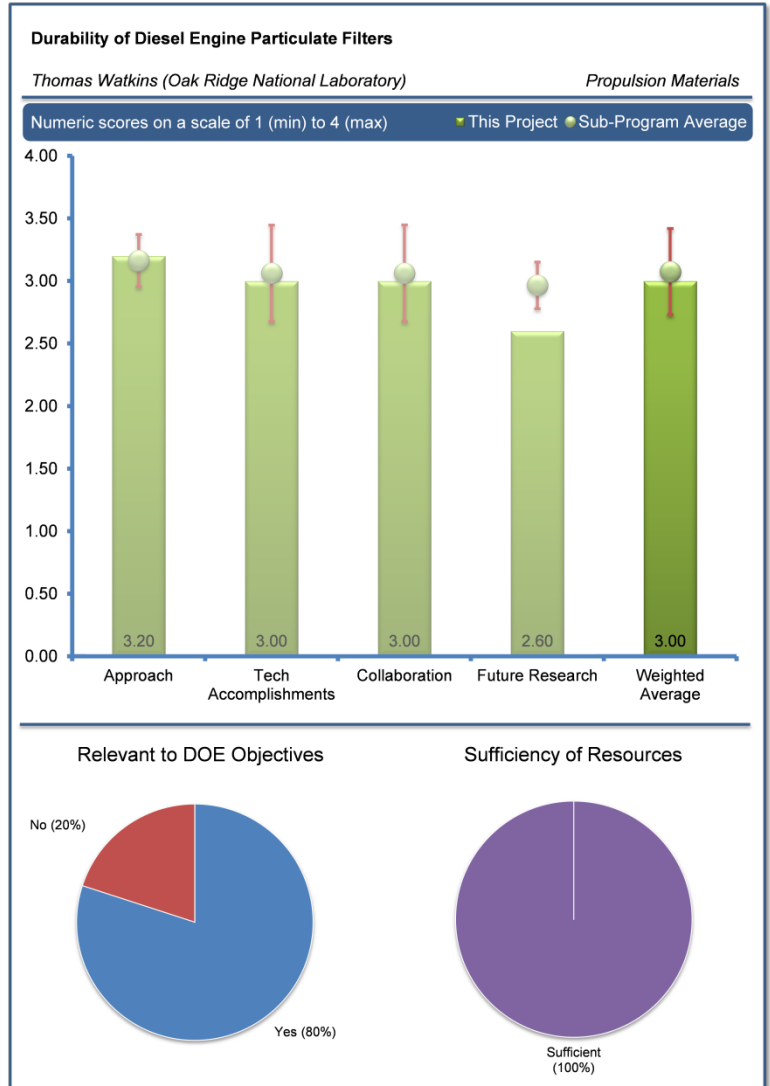
Question 1: Does this project support the overall DOE objectives? Why or why not?

One observer believed that this project supports the DOE objective of petroleum displacement by both optimizing the diesel particulate filter (DPF) regeneration cycle, thereby reducing the quantity of fuel needed to regenerate the DPF, and also by cleaning emissions of particulate matter (PM), thereby making diesel technology more acceptable to the customer, especially the light duty vehicle customer. This observer pointed out that because diesel engines are about 25% more fuel efficient than comparable gasoline engines, enabling more clean diesel engines in U.S. vehicles may lead to substantial petroleum reduction. Another commenter thought that by improving DPF designs, the fuel penalty and durability of DPFs can be improved, enabling greater reliance on efficient, clean diesel technology, which will reduce petroleum consumption. The next reviewer relayed that the stated goal of the project includes material improvement for EATS durability and efficiency improvements, which may reduce fuel economy impact of regeneration by 25%. Another reviewer stated that the review presents correlation to Vehicle Technology Program (VTP) goals

through improved component efficiency over existing systems, but that the vehicle system efficiency improvement is not clearly described in the review. The final reviewer commented that the effect on the internal combustion (IC) engine combustion regime and the high cost material content which needs to be used. Side projects need to be solved for this development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments for this question were generally positive. One reviewer thought that the approach was logical and well designed. In this reviewer’s opinion it is a clear Federal role to assist U.S. industry to develop needed material properties data to enable cost-effective energy efficient technologies. The reviewer further stated that, moreover, partnering between industry and DOE National Laboratories to leverage the Federal investment in scientific tools (ceramic technology instrumentation) increases the probability of success. The reviewer further stipulated, however, that due to the lack of viscoelasticity in ceramic materials, it is difficult to assure reliability in life prediction models of ceramics because failure tends to be catastrophic and stochastic rather than deterministic. Another observer noted that this CRADA activity has generated DPF property data that allows accurate DPF behavior predictions, probabilistic design tools, non-destructive techniques and thermo-mechanical characterization to provide materials behavior and property data to model regeneration. This observer further stated that research focused on SiC substrates, and used Oak Ridge National Laboratory (ORNL) High Temperature Materials Laboratory (HTML) facilities. The next panel member thought the review identified the interest in employing Si-C material for its material properties and logically addresses



technical issues, but that the review did not describe cost other than to identify that the material is more durable. The reviewer wondered about the return on investment. The final panelist inquired how the change in materials would reduce the fuel used in regeneration; why regeneration was any better with this material; and what were the regeneration characteristics that benefit the customer. This reviewer wanted to know if it is better in active regeneration, passive regeneration, both, or other. This reviewer inquired that if it is a matter of data provision for modeling of regenerations, how does this improve regeneration compared to simply improving the modeling of existing materials? This reviewer also was interested in knowing whether cracking is really a problem today, how many cracks, and why.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviews were mixed for this question. One person said that progress toward the objectives has been good and improved materials properties data is being generated for the technical literature. However, this person remarked that the introduction of SiC as a potential DPF filter material is somewhat puzzling, as there does not seem to be an overriding rationale for investigating it as a potential DPF material in this project. Another reviewer remarked analysis of material strength done, and material development is good, but was unsure of the progress towards goals regarding cost reduction, efficiency improvement, or anything other than thermal shock resistance. A final observer relayed that the researchers developed a rig for high temperature fracture toughness testing, and characterized toughness and crack behavior.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer thought that collaboration and coordination with the industry partners appeared to be satisfactory but a stronger (quantitative) link to improvements in DPF performance, e.g., reduced fuel consumption penalty would strengthen the case for this work and indeed, help make the case for investigation of other potential higher performing/lower cost materials such as SiC. Another observer relayed that the review characterized the collaboration and support by Cummins as an active and important partner. The next reviewer reported the researchers have an active CRADA with Cummins. The last reviewer also noted that the researchers are working with Cummins.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer suggested that the researchers consider deeper analysis of what the user needs regarding efficiency of catalyst vs. temperature, ability to store and regenerate soot, and contamination due to fuel/lube/coolant components. Another panelist remarked that future research could focus totally on SiC or other potential DPF materials if a stronger rationale for so doing were articulated in the project objective. The next commenter said that while the review offered a rudimentary outline of future work, there was little information presented that described transition to industry adoption. The final panel member relayed that researchers will continue to perform characterization efforts and consider coated DPFs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers rated the resources to be sufficient. One clarified that resources appear to be sufficient to achieve the stated milestones in a timely fashion, although eliminating SiC as a part of this project could enable completion sooner and with less expenditure of funds. Another reviewer commented that funding appears adequate, and a last reviewer thought the project has an excellent 50/50 cost share.

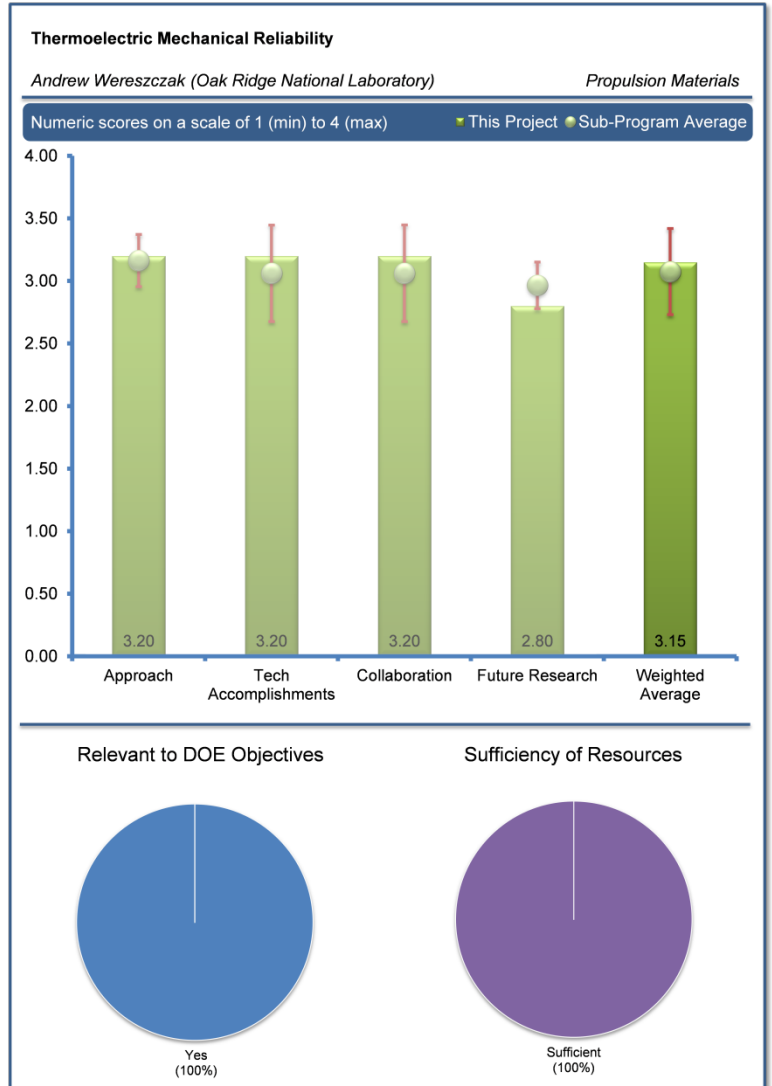
Thermoelectric Mechanical Reliability: Andrew Wereszczak (Oak Ridge National Laboratory) – pm012

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments for this section were positive. One observer stated that the possibility of using thermoelectric generators (TEGs) to capture waste heat from the exhaust to increase fuel efficiency of vehicles clearly does support the overall DOE objective of petroleum displacement, and that the question to be answered is whether or not this can be cost-effective. Another reviewer thought that thermoelectric materials have the potential for a lot of the waste heat in the vehicle to produce electrical power and cooling which should make the vehicle much more efficient. This reviewer said that increasing the mechanical strength of these materials is a key enabler to making these materials feasible in terms of surviving the large temperature gradients experienced in the vehicle. The next panelist rated waste heat recovery a high priority in reduction of fuel consumption, and material for thermoelectrics is the largest barrier in implementation. This panelist also suggested that advances in cooling may have secondary benefits. The final reviewer commented that the function is there, it is just a matter of how to measure and characterize.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive for this section. One commenter said that the approach seems to be reasonable and data driven, and that this systematic approach combines theoretical, analytical and experimental approaches. Another reviewer thought that there was good focus on material strength for application, but there was no focus on efficiency of material or cost of material, only strength. A final reviewer agreed that the approach is quite sound, as the measurement of physical and mechanical properties of these rather complex composition materials is not simple. This reviewer noted that databases of brittle material properties tend to be much less developed and statistically reliable than those of metals due to the essentially unavoidable incorporation of microflaws into the compact. The reviewer also stated that the use of a round robin to have multiple laboratories measure ostensibly the same material parameters from a single batch of material illustrates some of the difficulties inherent to making these measurements. According to this reviewer, it is interesting that one of the supposedly simplest parameters to measure, heat capacity, appeared to be one of the most difficult with which to gain consensus values. The reviewer posited that it might be interesting to compute the heat capacity from first principals to see if this could provide a clue as to the origin of the experimental measurement difficulties.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panel member said that good work was done on stress analysis, but that thermal heat capacity measurement of course needs to be better understood, and test methods need to be developed for repeatable and reliable information. Another panelist remarked that progress toward objectives has been good. However, this panelist was concerned about the problem with the heat capacity measurements, and thought that it was not clear what measures were being proposed to resolve the problem. A third reviewer observed there has been a lot of test data, but the challenge was to draw general deterministic conclusions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviews were mixed for this section. One reviewer commented that there was great work on round robin testing to generate industry agreement. Another thought that coordination with partners and collaboration with other institutions through the International Energy Agency (IEA) round robin has been excellent. This reviewer wondered why the National Institute of Standards and Technology (NIST) was not involved in the materials properties measurement round robin. The final reviewer remarked that most of the work is done at ORNL and the only collaboration is with Marlow Corporation, even though there were specimens from many other institutions that have been tested.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments for this section were mixed. One reviewer thought that the proposed future work seems reasonable and there are plans on addressing identified gaps. Another observer stated that plans for future research to build upon past progress, but no solution to resolve discrepancies in the heat capacity measurements appears to have been proposed. The next panelist commented the researchers should define how the end result of this study will benefit the TEG unit technology development, addressing the reliability, cost, and efficiency of the units.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers found resources to be sufficient. One reviewer commented that given the progress achieved to date the resources for the project appear to be adequate, and another thought that the resources seemed to be sufficient based on the scope of the work to be done.

**Thermoelectrics Theory and Structure:
David J. Singh (Oak Ridge National
Laboratory) – pm013**

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

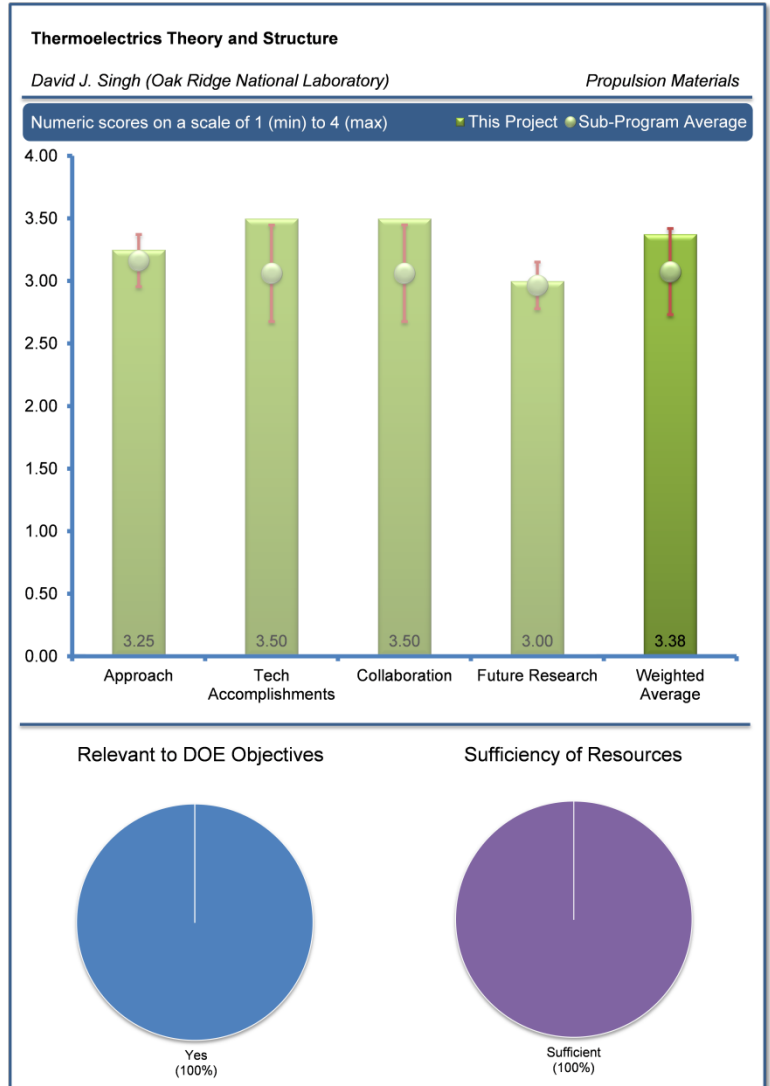
Comments for this section were positive. One reviewer effused that this work is excellent and has the potential to enable the selection, synthesis and development of lower cost, less toxic materials for TEG devices in vehicles and other applications areas where waste heat is available. This reviewer also pointed out that enabling TEG waste heat utilization to become cost effective supports the overall DOE objective of petroleum displacement. Another reviewer commented that recovering as much waste heat as possible using thermoelectric materials can have a significant impact on fuel consumptions. A final observer wrote that coupled to fuel consumption, thermoelectric material is a known roadblock.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviews in this area were mixed. One observer agreed that the researchers employed a systematic approach to scan through the various materials and doping processes to identify the most promising materials. Another explained that the use of theoretical computations to design material structures a priori, which may have promising properties for TEG devices, is a sound scientific approach. However, this reviewer thought that having identified several promising structures, it would make sense to seek to synthesize and experimentally measure relevant mechanical and physical properties to determine if these materials merit further development and corroborate predictions of the theoretical calculations. A final panel member inquired about the weighting values used in material matrix selection, and further queried whether cost, reliability, etc., were considered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One observer considered progress to be excellent and that theoretical computations could be useful to pre-screen material compositions and structures prior to synthesis and material property determinations. However, this observer emphasized that experimental validation of the theoretical predictions is essential and should be pursued prior to extending further effort on other potential materials. Another reviewer saw good progress, with milestones of having established design guidelines and having established trends for thermoelectric materials. A final panelist remarked that it was good to see the model for PbSe directly impacted industry and the model seems valid.



Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were positive. One reviewer thought that there were a good group of collaborators, while another reviewer reported that the researchers had several external partners with a lot of diversity, including renowned universities, national labs and OEMs. The next reviewer remarked that collaboration and coordination with other institutions has been excellent. This reviewer noted that the materials design effort must now morph into a materials synthesis and properties measurement activity to confirm the theoretical or computed predictions prior to continuing to seek other compositions and structures. The reviewer also thought that upon experimental validation of these preliminary predictions, it would make sense to extend the approach to other potential material compositions and structures.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers generally had positive feedback. One observer remarked that there was good proposed future work in trying to address the identified gaps. Another reviewer would like the researchers to please continue research and communicate a matrix of advantages and disadvantages of materials related to targets. The final reviewer relayed that future work is proposed on other potential compositions and structures. This reviewer noted that after some of the preliminary materials already identified have been synthesized, characterized and had their properties measured and validated with the predictions, it would then be appropriate to extend the investigation to other potentially even higher performing materials.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers found resources to be sufficient. One reviewer said that resources for the project appear to be sufficient to achieve the milestones in a timely fashion, and another reported that the resources seem to be sufficient based on the proposed work.

Low-Cost Direct Bonded Aluminum (DBA) Substrates: Hua-Tay Lin (Oak Ridge National Laboratory) – pm036

Reviewer Sample Size

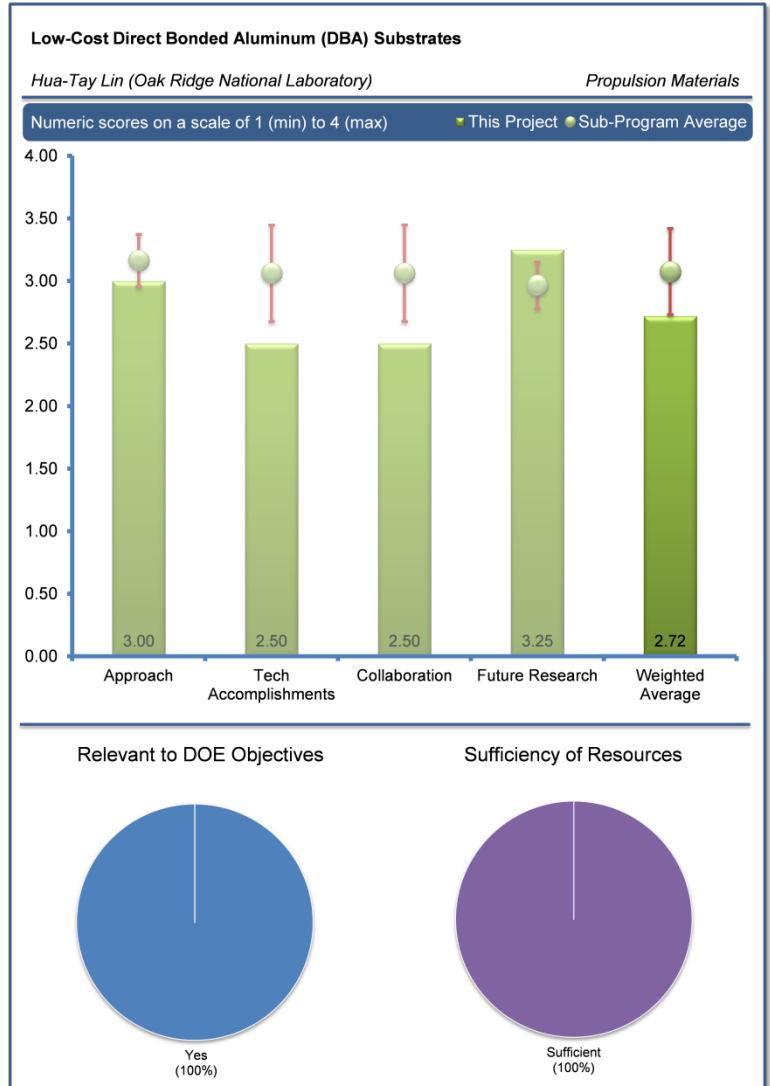
This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer agreed that developing low-cost high-performance direct-bonded aluminum (DBA) can be a key enabler to help semiconductor devices and inverters meet their very challenging cost and performance targets. Another observer also thought it appeared that the technology is focused to advance materials related to energy efficiency, such as weight reduction and cost reduction, but wished that the presenter had clarified the direct impact to the final application, as it was difficult to understand from the deeply technical material development presentation where this is used or how this can and will impact fuel efficiency. The next reviewer expressed concern that this project should focus more on a replacement for conventional substrates. This reviewer also pointed out that DBA is already relatively inexpensive, so cost reduction will not be significant area of progress, but that DBA with direct bonded copper (DBC) performance at the same or lower cost to current DBA would be significant. The final reviewer was of the opinion that Direct Bonded Alumina and Direct Bonded Copper substrates will be a likely location for failure as power electronics operating temperatures increase. This reviewer sees the development of better DBAs that can operate at higher temperatures as needed and therefore supporting the overall DOE objectives. The reviewer, however, thought that improved DBA substrates would likely have only a minimal effect on the size, weight, and cost of the electronics that are part of the vehicle, but that better DBA substrates would improve the reliability of those electronics.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commenter observed that the researchers employed a good approach, including benchmarking compared to the state of the art, as well as using ORNL capabilities to push the state of the art; in general, a systematic and well planned approach. Another reviewer remarked that the approach of selection and development seemed systematic and robust, but that it was difficult to foresee the final impact related to higher level barriers. The next observer relayed that the approach for this research project is to learn as much as possible about commercial direct bonded alumina substrates and benchmark their performance. With that understanding, this reviewer suggested to attempt to develop more reliable DBAs using the researchers' expertise in AlN and Si₃N₄ processing, since those materials reduce the thermal expansion mismatch between the substrates and the coatings.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer observed good progress and lots of analytical and experimental results that will help guide the research effort. Another panelist pointed out that this project was relatively new and was actually in the first full year of operation. This panelist thought that the researchers have made good progress with their literature search and the characterization and benchmarking of commercial DBAs; however, the researchers have not yet produced DBAs that are as good as the ones commercially available. A final observer asked how it was possible to measure the progress of this development versus the target reduction in cost or increase in energy density or lifetime.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback on the level of collaborations. One reviewer believed that the collaboration and coordination with other institutions had been fair to the point of the presentation. This reviewer noted that Dr. Lin has collaborated with researchers at the National Transportation Research Center (NTRC), who are funded by the Power Electronics and Electric Machines Program, and who believe that DBAs are problematic at higher temperatures and need to be improved. This reviewer further observed, however, that it was not obvious from the presentation if there has been much collaboration with companies that produce DBCs or DBAs. Another observer thought that collaboration and coordination could be improved, as it seemed that the bulk of the work was done within ORNL. Another panelist recommended broadening commercial involvement. The last observer thought that it would be a good idea for the researchers to try and widen commercial involvement.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks were generally positive. One reviewer believed that the proposed future work is good, and that that the investigation of copper-clad Al ribbons and the use of reaction bonded silicon nitride substrates are good ideas that should reduce the thermal expansion mismatch and have the potential to produce better DBAs. Another remarked that there was good proposed future work that addresses the gaps and challenges. A final observer noted that the PI had not identified the exact benefits to users with estimates for total system savings in identified benefit areas.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers found resources to be sufficient. One reviewer stated that resources are sufficient based on proposed work. Another observed that this project received \$200,000 in FY 2011 and FY 2012, and believes that the project has been sufficiently funded for about 18 months of effort, because no funding was received until the last quarter of FY 2011. A final commenter thought that this is an important topic that is critical to meeting power electronics cost and performance targets, and that it might be good to consider growing the area of work.

Improved Organics for Power Electronics and Electric Motors: Andy Wereszczak (Oak Ridge National Laboratory) – pm037

Reviewer Sample Size

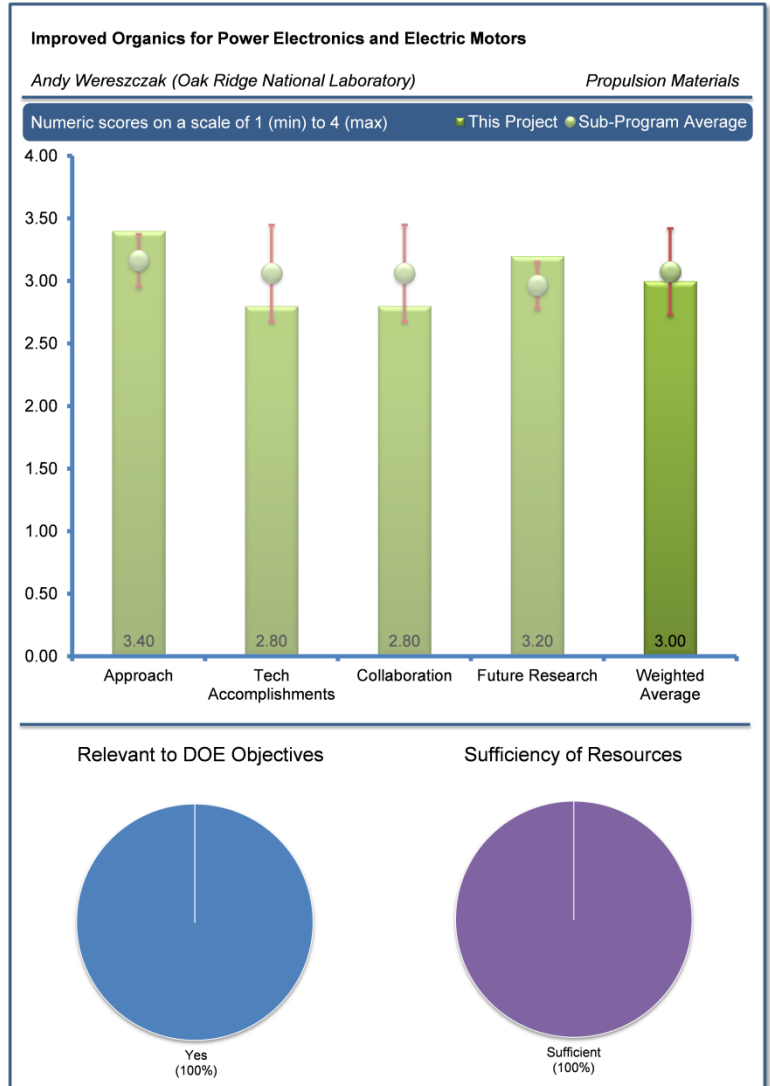
This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One panel member commented that this project is very relevant to the goals of the Power Electronics and Electric Machines Program, which has goals of reducing the size, weight and cost of the electronic components and increasing their reliability. The panelist saw that this project addresses each of these goals; because improved epoxy molding compounds with higher thermal conductivities would reduce the size and decrease the operating temperature of film capacitors and motors, they therefore would reduce the cost and increase the reliability of power electronics. Another observer noted that reducing the size and weight of film capacitors used in inverters and traction motors would definitely reduce the weight of the vehicle and therefore reduce petroleum consumption. The next reviewer remarked that developing low cost high performance epoxy is a key enabler for low cost high-performance power electronics devices and motors. A subsequent reviewer pointed out that the PI was investigating improvement of power electronics in performance, reliability, and reduced cost, but would have liked the presenter to quantify the targeted savings and evaluate with a measureable parameter. A final panelist related that the researchers intend to develop power electronic devices (PEDs) that need less cooling, which can assist development of electric motors, PEDs and other components. This panelist saw that this could lead to volume and weight savings, and might enable vehicle systems operating with higher coolant temperatures and/or require less secondary cooling equipment, but the presentation did not make this link clear.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer thought that the researchers employed a good systematic approach that included scanning and processing of various filler materials. Another found the approach for this project to be well organized with the lab researcher focusing on modeling and leaving the fabrication of sample epoxy molding compounds (EMCs) to the industry partners. This observer related that during the first year of the project, the PI developed a model that predicted the thermal conductivity of an epoxy molding compound when using a given particle size distribution and volume fraction of filler particles, and that later in the project, the PI developed models of different electronic components (motors or layered capacitors) that showed the effect of using epoxy molding compounds with different thermal conductivities on the size and operating temperature of the component. The observer concluded that once the models have identified the particle size distribution volume fraction, and composition of the filler particles, the industry partner can fabricate a number of samples of epoxy molding compounds. The next panelist characterized the research as having considered various filler materials to optimize particle size distribution and volume fraction, and having targeted goals of low



environmental impact, low cost, and improved performance. The final reviewer asked how the researchers identified the candidate matrix of materials to be investigated, how many were considered and rejected, and if there was any consideration of manufacturability and availability of the material. This reviewer stated that in the meeting the presenter explained that the candidate matrix was identified by experience.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first panel member stated that simulation showed that increases in thermal conductivity are beneficial for future thermal management. The second reviewer remarked that the PI has made good progress during the first full year of the project, by developing software to create two dimensional (2D) images of epoxy molding compounds when using different particle size distributions and volume fractions of fillers that enabled thermal conductivity modeling, and by also developing collaboration with SolEpoxy, who manufactures epoxy molding compounds for power electronic components for the automotive industry. This reviewer found that the first samples that were produced approximately doubled the thermal conductivity of the EMC but the electrical conductivity was too high, and also related that another round of samples would be produced using different filler with lower electrical conductivity. Another reviewer remarked that progress was good, but that it was not clear how the results compare to the current state of the art. The last reviewer relayed that the researchers had identified and simulated the materials requirements, particle size distribution (PSD) and volume percentage, and that models allowed the thermal conductivity to be simulated based on input properties, which allowed the most desirable characteristics to be defined. The reviewer wrote that researchers simulated practical devices, such as a film capacitor, motor components, and a power module, in order to explore the impact of thermal conductivity.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed comments on collaboration. The first reviewer thought that this project exhibited outstanding collaboration/coordination with other institutions. This reviewer saw the most important collaborator as SolEpoxy, who manufactures conventional epoxy molding compounds that have low thermal conductivities, and this reviewer was very interested in the project because the reviewer believes that there is a realistic chance of fabricating epoxy molding compounds with included particulates that increase the thermal conductivity by a factor of 10 or more. The reviewer opined that the collaboration was very significant because SolEpoxy agreed to fabricate test samples using filler materials supplied by ORNL. The reviewer thinks that, should this concept prove to be very successful, SolEpoxy would be ready to commercialize the new material in a matter of months. The reviewer further stated that the project is collaborating with researchers funded by the Power Electronics and Electric Machines Program, and that these researchers provide guidance about the components that could benefit most from the use of epoxy molding compounds with higher thermal conductivities. The same reviewer concluded that this project is also collaborating with Ube, who supplies the filler particles that are incorporated into the epoxy compounds. Another panel member observed industrial collaborations, and potential for collaboration with NTRC and ORNL, but no university involvement. Another panelist thought the project needed industry power electronics and motor application partners. The final observer said that it seemed that all the work is done at ORNL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that the proposed work seemed outstanding, and that the use of low-cost MgO fillers with high thermal conductivities but lower electrical conductivities should produce very interesting results. The reviewer also noted that work was also planned to investigate the use of different epoxies that would be stable at the higher temperatures of today's electronics. Another reviewer thought that there was good proposed future work trying to address the identified challenges. The next panelist observed that the researchers will consider another generation of materials and its impact on thermal conductivity and will target getting to greater than 10 W/mk. The final reviewer hopes to see some results taking this selected material, seeing how it would be implemented, and what the benefit relative to DOE goals will be.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers found resources to be sufficient. One reviewer observed sufficient resources based on proposed work, and another reviewer opined that the project seemed adequately funded. The third reviewer reported that funding for this project in FY 2012 is only \$150,000, which is one of the least expensive projects funded by Propulsion Materials. This reviewer hoped the dollar value was sufficient because much of the fabrication was being done by the industry partner. The same reviewer further noted that the lab researcher had developed the models and was characterizing samples.

Materials for Advanced Turbocharger Designs: Phil Maziasz (Oak Ridge National Laboratory) – pm038

Reviewer Sample Size

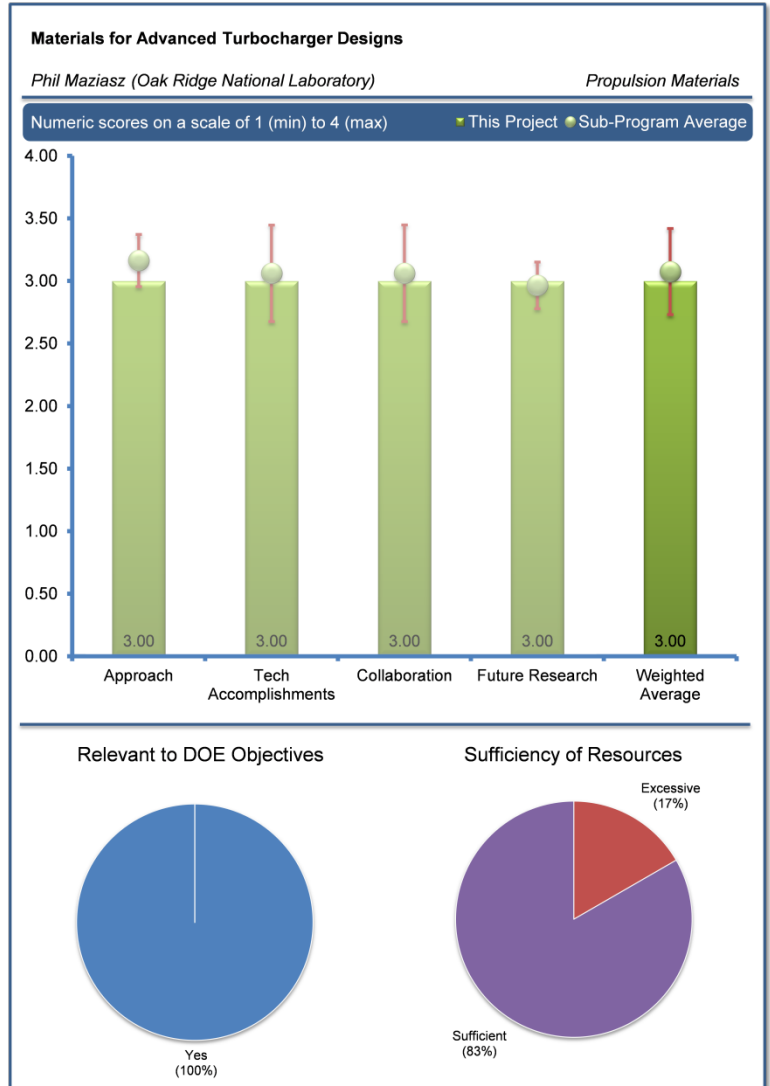
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said that improving the powertrain efficiency will boost fuel economy and help in reducing the petroleum consumption, and that turbochargers are used to enhance the efficiency and will therefore contribute to improved performance. The next reviewer agreed that the long term vision is increased exhaust gas for efficiency improvement of engines. The second panelist remarked that the research addresses the needs for advanced turbochargers, which are elements of higher efficiency engine designs (e.g., downsized boosted gasoline direct injection [GDI] engines), which directly displace or prevent petroleum consumption. The panelist qualified that high efficiency clean combustion places greater thermal demands on the turbochargers; therefore this is a key component of the 20% engine efficiency improvement targeted for commercial truck engines (e.g., the Supertruck program). Another observer noted this project addresses technical challenges in developing a material that can be used at higher temperatures, such as greater than 750°C diesel, or greater than 950°C gasoline, that exceed the strength and temperature capability of current materials, particularly cast-iron for turbocharger housings. This observer further commented that turbocharger housing and other components with more temperature capability and strength will enable higher, sustained operating temperatures, and that stainless steel turbo-housings will also reduce weight and retain exhaust heat relative to cast-irons. The next panel member observed that turbochargers are limited in peak temperature range and durability and this project covers technology which should be enabling for them to perform beyond the current temperature and environment limits. The final reviewer thought that the plan looked feasible in terms of material application and research.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed comments on the project’s approach. One person remarked that the project appears to be highly successful for the application described, and that the alloy developed may have other applications for high temperature service. Another reviewer thought that the work approach discussed seemed valid, but the approach slide in the presentation did not seem to describe a clear method of steps or incremental developments to achieve the goals. The next panelist observed that the research addresses the strength and higher temperature needs for the turbocharger housing by considering new materials. This panelist suggested considering replacing cast iron housings with austenitic stainless steels, and examining residual stress between steel shafts and Nickel (Ni)-based alloy turbine wheels. A subsequent panel member relayed that ORNL and Honeywell identified two areas of focus: cast stainless steel housing, and electron-beam (EB) weld joint residual stress measurement of wheel and shaft. The



final reviewer characterized the first task as measuring residual stress in a manufactured component, and the second task as creep testing of a new alloy composition; the client had identified a component for testing using this new composition. This reviewer noted that this was a good development and that the approach is good, but was unclear on how these two tasks were related and what the rationale was for combining these two tasks. The final reviewer concluded by asking whether this project is supporting one company for start-up trials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first panelist characterized the research as having completed neutron scattering examination of E-beam weld of steel shaft/Ni alloy joint, and having fabricated a turbo housing from cast stainless steel, which showed improved tensile strength and higher creep resistance at higher temperatures (permits thinner housings for the same strength). One reviewer commented that it was difficult to see what improvement was made for the CF8C-Plus cast austenitic stainless steel alloy in this project, but acknowledged that a new alloy has been developed and tested, and that possibly the industrial trials will lead into implementation of the development. This reviewer also said that during the presentation it was revealed that a larger component for another client was made using the same material. Another panel member asked how the solution options compare to current cost and weight and strength, etc. and asked if there was a comparison between the new options and present options. The final reviewer related that the accomplishments, thus far, are doing the following: addressing the concern of residual stresses in weld-joints between Ni-based alloy turbine wheels and steel shafts with neutron scattering experiments on wheel/shaft components at the HTML at ORNL; and acquiring long-term creep-rupture data that has shown that CF8C-Plus cast stainless steel has more performance than HK30-Nb stainless alloy as an upgrade for turbo-housings at 700-900°C.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw coordination with other institutions. The first reviewer saw close collaboration with Honeywell, and participation in the HTML user program. The next reviewer stated that the researchers worked closely with Honeywell in developing material for turbocharger components, identified an application in a Ford V-6 3.5L Ecoboost turbocharged gasoline engine used on light trucks, and utilized the HTML user program in doing residual stress measurements on joints. Another reviewer agreed that there was collaboration between Ford and ORNL. The next reviewer thought that the CRADA with Honeywell was a good vehicle for the collaboration, as Honeywell was seeking a manufacturing partner to produce castings and the technology transfer is well advanced with U.S. manufacturing base enhanced. The final reviewer thought that it was not clear from the report where commercial development is or has proceeded. This reviewer assumes that there is interest, but no specific commercial development appears to have been noted at this particular stage of the research.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One observer pointed out that most of the work appeared to have been completed or significantly demonstrated in actual components. Another agreed that the project had ended, but researchers were seeking an extension for the industrial trials to produce castings for further evaluation. This reviewer thought that it would be nice to see where the follow-on work might lead, and had hoped that the team had identified gaps and areas where improvements need to be made, because follow-up to this work was not presented. The next panel member relayed that researchers will continue working with Honeywell and a foundry to move this work toward production, and will consider additional materials development and testing, including oxidation and fatigue. Another reviewer would like quantification of the thermal advantage of the new housing compared to current housings, and what the new housing does to turbine out temperatures and turbine flow/pressure ratio (eff). The final observer related that Honeywell will work with a stainless steel foundry to produce turbocharger housings of CF8C-Plus steel; noted that future research will expand properties testing for turbine housing and wheel alloys to include oxidation and fatigue; and suggested studying the castability of the stainless steel.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Five reviewers found resources to be sufficient, while one rated funds excessive. One reviewer considered the \$300,000 in FY 2012 to be adequate, given that the project will be ending in September 2012. Another reviewer agreed that funding appeared to be adequate for this project. The last reviewer said that \$300,000 can support more activities than just collecting creep testing and neutron scattering data, which is what the last year's work consisted of.

Engine Materials Compatibility with Alternative Fuels: Steve Pawel (Oak Ridge National Laboratory) – pm039

Reviewer Sample Size

This project was reviewed by six reviewers.

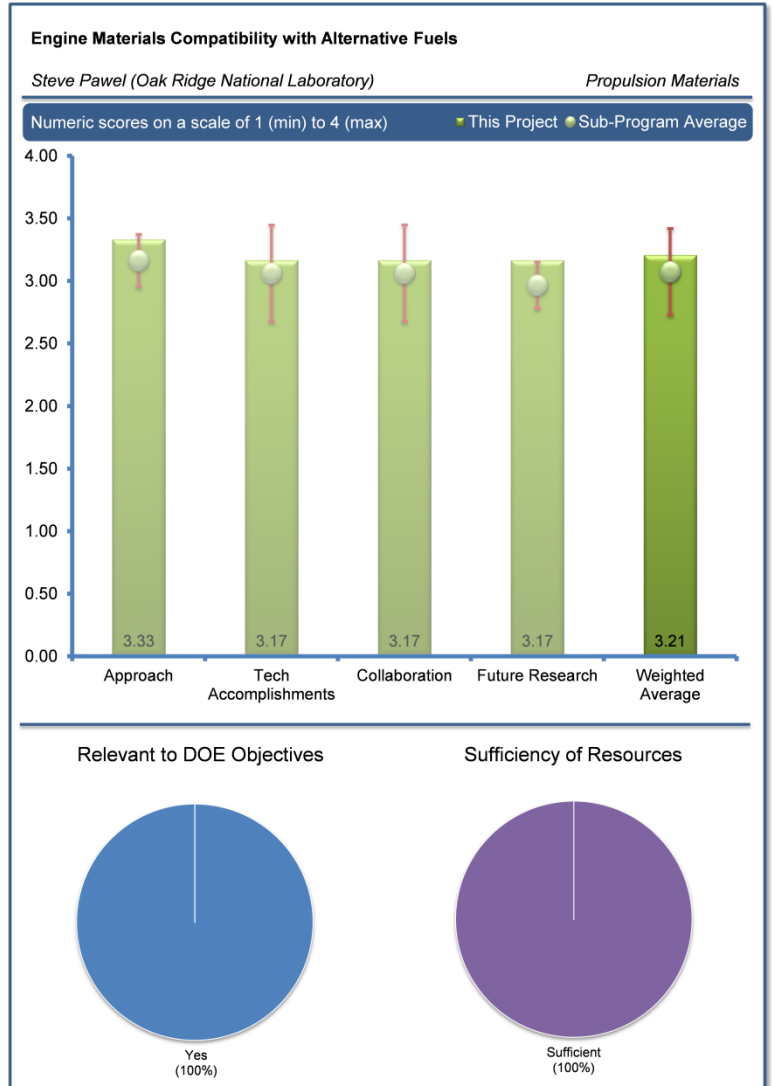
Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer thought this project clearly addresses the need for reliable alternative fuel sources over petroleum by evaluating the risk to engine durability, which is critical to the acceptance of using biofuels. Another panel member pointed out that enabling more effective and more efficient use of alternative fuels can lead to petroleum displacement, and that emphasis of ethanol based flex fuel impacts the corrosion of engine system components. The next person considered information on the use of alternate fuels with light weight engine materials to be directly useful and critical to development of durable and reliable, fuel efficient engines. A subsequent reviewer encouraged replacing petroleum products with fuels derived from bio-based materials, noting that this project is identifying potential issues that may arise due to the increased bio-fuel additives and will be an enabler for the process of petroleum replacement. The next panelist relayed that this project examines the impact of ethanol as an alternate fuel for displacement of petroleum fuels. The final panel member stated that this project utilizes laboratory exposures and forensic analysis of materials

from field testing to assess aluminum corrosion rates/forms and mechanisms as a function of key fuel blend variables and alloy composition and to address a potential compatibility concern with use of alternate fuel, i.e., ethanol.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer praised the researchers for producing excellent work and clear results. Another agreed that this was a well designed project that met task requirements and provided quantitative output. The next observer thought that there was a clear method of determining compatibility tests planned. A subsequent panel member said that for experiments, the team has used pure aluminum, which may not be a candidate material for the engines; and that the completely dry fuel mix may not be the actual environment in the engine. However, this panelist thinks that the work reveals the potential pitfalls if biofuels are used without consideration; that is, the corrosion effects will be different from that caused by current fuel blends. Another person classified the project as laboratory experiments and forensic studies of field components, with the focus on ethanol driven corrosion of aluminum components. This person also relayed that the researchers are looking for rapid protocols to study corrosion by comparing lab and field components. The final reviewer characterized the project as having an integrated approach to examine compatibility issues. The reviewer observed that task one is surface analysis of materials exposed in field and laboratory testing; task two is in-situ extraction of gas and/or fluid from operating engines; task three consists of laboratory corrosion exposures of coupon materials; and task four is development of test protocols for rapid evaluation of material/fuel combinations.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most reviewers saw good progress. One reviewer thought the researchers had done excellent testing, producing usable results. This reviewer considered the work directly applicable for consideration in design of efficient engines using aluminum, in particular, as a light-weight engine component material. Another reviewer agreed that excellent progress was made by having identified the trigger to the corrosion and the mechanism that retards or delays the effect. This reviewer's only concern was that closer surface analysis was not done to the samples that did not exhibit corrosion; the 24 hour test with different water content and heat where the sample did not corrode maybe the result of the corrosion being slowed down but not eliminated, and over a significant time, say ten years, corrosion may be an issue. The next observer asked what the history of fuel for the samples shown in task one engine analysis was, and thought that the galvanic corrosion study was good information from task two. A subsequent observer related that researchers have tested various environments, i.e., ethanol content, and temperatures, and that the effect of the dry fuel on aluminum corrosion has been identified. Also, this observer stated that some possible mitigation techniques including coating had been identified. Another person commented that researchers have completed forensic analyses of field aged components, and observed that corrosion impacts can be masked or obscured by combustion products, which raised a question as to whether organics removal can be done to pre-treat samples prior to corrosion analysis. This person reported that researchers did not observe galvanic corrosion of aluminum components, but did see Aluminum 1100 corrosion increased with dry ethanol concentration in gasoline and duration of exposure. This reviewer concluded that the research showed that coatings can protect the aluminum alloys from corrosion. The final reviewer related that in collaboration with industry partners, corrosion of aluminum as a function of fuel blend exposure conditions was characterized, and that some progress was made in each specific task. The reviewer observed that for task one metallography indicates primarily pitting and some aggressive general attack; some hints that second phase is relatively resistant. For task two, sampling location #1 produced more than twice the condensate of sampling location #2 in both experiments. For task three, no galvanic corrosion of Al observed, Aluminum 1100 exhibited corrosion rates that increased with dry ethanol concentration, and modified surface film on aluminum alloys impacted corrosion susceptibility. Finally, this reviewer noted that for task four, electrochemical testing is not appropriate.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers saw collaboration with industry. One person noted that collaboration was sufficient as needed for the project. Another reviewer agreed, stating that all the major U.S. players were at the table. A subsequent reviewer elaborated that this was a CRADA project between ORNL and United States Council for Automotive Research (USCAR) that includes GM, Ford, and Chrysler. The following panelist observed that the project was a partnership with USCAR under a CRADA activity, and another reviewer stated that collaboration with industry partners exists. The final reviewer stated that the researchers have a collaboration agreement with the USCAR, and that the automakers have provided access to some engine testing and obtained combustion products from engine chambers. However, this reviewer notes that no other interactions have been documented.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed feedback on future research strategies. One reviewer pointed out that the project is wrapping up, but a follow-up plan has been formulated to explore characterization and mitigation. Another reviewer suggested that the team should focus on actual fuel blends and well simulated environments close to actual systems. Also, this reviewer suggested that a comparison should be made to what is being done in other jurisdictions such as Brazil, Europe and Canada, where biofuel is actively promoted. A subsequent reviewer thought that the proposed work to investigate possible fuel additives to mitigate damage from alternative fuel blends could be of benefit to the industry as a whole, and if it could be accomplished, would be of great importance. This reviewer pointed out that the development of coatings is also desirable, but from an engineering point of view, coatings always will hold greater risk due to the inevitable presence of defects or "holidays" in coatings. This reviewer finally suggested that alloy development is desirable, but may be a much longer term approach that may or may not be successful. Another reviewer suggests that researchers continue laboratory testing to expand blend variables, and to continue exploring various mitigation strategies, including fuel additives that would suppress corrosion reaction, surface modification strategies to protect underlying aluminum, and alloy development. This panel member stated that future work may consider surface treatment

of aluminum alloys to minimize corrosion. The final observer thought that broadening the scope of this project may help address some of the following concerns: Ethanol is becoming one of the working fluid choices for Rankine Cycle waste heat recovery; and temperatures exceeding 300°C are possible, which could limit the cost effective use of aluminum for condenser, expander and fluid conveyance hardware.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Six reviewers rated resources to be sufficient. One reviewer noted that the funding level was \$270,000 for FY 2012 and the project is expect to be completed in December 2012. Another reviewer agreed that funding seems to have been adequate. The last commenter thought that if some of the future goals of this project could be achieved, it would be of benefit in enabling the comfortable use of aluminum in products using alternative fuels. This commenter also said the project instead appears to be winding to a close, and that more work would be worth the effort if funds were available.

Biofuels Impact on DPF Durability: Michael Lance (Oak Ridge National Laboratory) – pm040

Reviewer Sample Size

This project was reviewed by six reviewers.

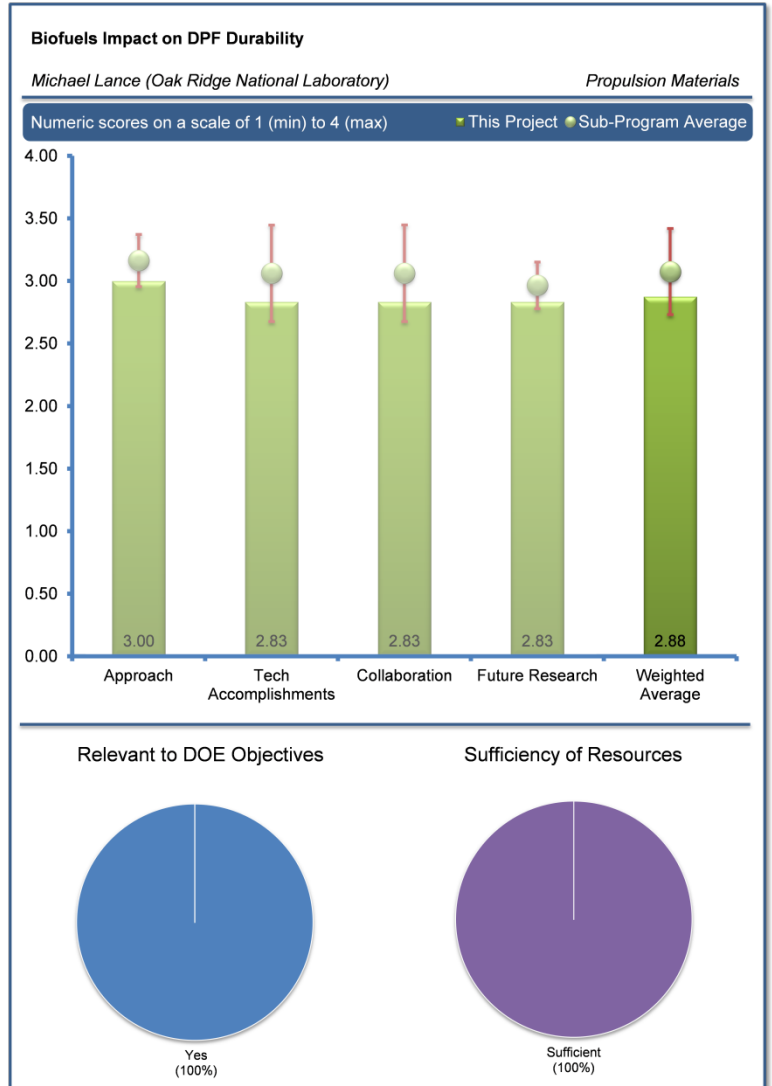
Question 1: Does this project support the overall DOE objectives? Why or why not?

One panel member deduced that this project seeks to bolster the DOE petroleum displacement goals through improved biofuel adoption. Another reviewer remarked that, to the extent that biodiesel can supplement or replace ultra-low sulfur diesel (ULSD) petroleum-based diesel fuel, this project supports the overall DOE objective of petroleum displacement. The next panelist agreed that biofuels are considered a key option for reducing use of petroleum products and understanding the effects that biofuels may have on various parts of the engine system, including the diesel particulate filters, is important. This panelist pointed out that early understanding of what damage biofuels may do and how to prevent such damage is critical to industry and to the commercial use of biofuels. The panel member further reported that industry has already experienced warranty issues and problems with biofuels that were not expected and required unexpected research and product changes to avoid and fix, and that this research may be considered part of that work needed to understand what may happen, to avoid problems. The next reviewer stated that biofuel or alternative fuel impact on

aftertreatment is not fully understood, and understanding of the impact of biofuel quantification is key to improvements. Another observer commented that there was inadequate data on the effects of fuel properties, and that the knowledge base was inadequate for determining the effect of fuel properties on the deterioration rates and durability of engine fuel system and emission control system devices and components. This observer asked if biodiesel would negatively impact DPF performance, and if this project is to characterize changes in the microstructure and material properties of DPFs in exhaust gas produced by biodiesel blends.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed comments on the approach. One commenter thought that the approach to addressing adoption of biofuels with current DPF systems is well addressed in the review. Another observer found the approach to be logical and well laid out to address the technical barriers, and added that addressing the apparent degradation of a stored DPF first enabled the team to ascertain that the problem did not lie in the DPF material itself but rather in the binder used to hold the ceramic together. The next reviewer remarked that it would have been ideal to repeat the failure with an uncoated DPF. This reviewer inquired if, for example, there may be pre- or post- storage conditions such as temperature and humidity conditions that increase or decrease the risk of long term failure while exposed. This reviewer noted that root cause analysis was not done. A following observer said that the presentation did not make clear if catalyst accelerated aging testing was performed under conditions that entirely duplicate field service conditions to the greatest extent possible. This observer found that, in particular, for durability testing at low, medium and



high temperatures with cycling between temperatures, the low temperature testing at 200°C would appear to be too hot for significant exhaust gas (water) condensation to have occurred. The observer added that it depends on where the temperature was measured, and where the sampling location is for sampling exhaust gas condensate, as to whether the DPF filters had experienced the type of heavier water condensation that occurs on initial engine start up. This observer thought the presentation provided some acknowledgement that liquid-form water condensate is damaging, but was not clear whether there was testing performed to verify whether the problem was overcome, or if researchers had allowed that condensation to occur as part of the durability cycle. In addition, the observer noted that the component surfaces must be cool enough for surface condensation to occur; bulk gas temperatures are not necessarily reflective of this. A final reviewer reported two approaches were taken by working with the National Renewable Energy Laboratory (NREL) and Ford, including Low-Temperature Corrosion, and Thermal Aging and Ash Accumulation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer thought that good basic information was gathered that was helpful toward goals. Another agreed, saying that the progress in meeting technical milestones has been good, as has progress in developing a good database for use by the OEM's and DPF manufacturers. This reviewer commented that this project is quite appropriate for Federal support because there is as of yet not quite a well-established biodiesel fuel production industry. The next panelist asked how analysis of DPF failures will be performed, if the researchers could or would ensure that the test generator would have representative emission constituents compared to normal applications, and if the researchers would compare generator emissions to a standard accepted test to ensure that they are representative. A final observer reported that low temperature corrosion was likely caused by biodiesel attack of the polymeric binder holding the skin together; that finite element based approach whereby mechanical properties are determined by iteratively comparing experiment results with finite element analysis (FEA) properties was established; and that long-term low-cost testing of materials in real diesel engine exhaust was established at NTRC.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed responses about collaboration. One reviewer thought that the project exhibited good collaboration. A second reviewer commented that more than one partner was positive. The next panelist observed that there was excellent collaboration between NREL, Manufacturers of Emission Controls Association (MECA), National Biodiesel Board (NBB), and Corning. The next observer stated that collaboration to date had been only fair but it appears that with the addition of NREL, Ford and other collaborators, collaboration and coordination is improving. The final reviewer reported that the projects collaboration has transitioned to new partners. This reviewer inquired about how involved these partners are and what support they offered, and would like to know the reason GM discontinued its collaboration in this effort.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panelist thought that the approach for future work was good, as it built upon past progress and should see rapid progress now that all of the tools for carrying out the work are in place. This panelist hoped that the addition of other collaborators would accelerate results. Another reviewer felt that a study on lube oil and coolant contributions could be key for the next step study. The next observer pointed out that while the review offered a rudimentary outline of future work, no milestones were offered and the potential for strategic redirection, if any, from new partners was not addressed. Another reviewer suggested that the investigator may wish to also consider the possibility of investigating the effects of increased level of metallic corrosion deposits from upstream air handling systems, in addition to the changes in deposits solely from the biofuels themselves, if it is believed that the biodiesel fuels may effectively be more corrosive than straight fuel. A final panel member related that a generator set will be used to conduct accelerated biodiesel aging in order to determine the effect of metal additives on DPF material properties. The final reviewer also recommended considering engine testing at low load conditions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All six reviewers found resources to be sufficient. One reviewer considered \$300,000 in FY 2012 to be adequate, while another agreed that resources appear to be adequate to maintain the current rate of progress of the work. Another reviewer remarked that no cost share was described in the presentation.

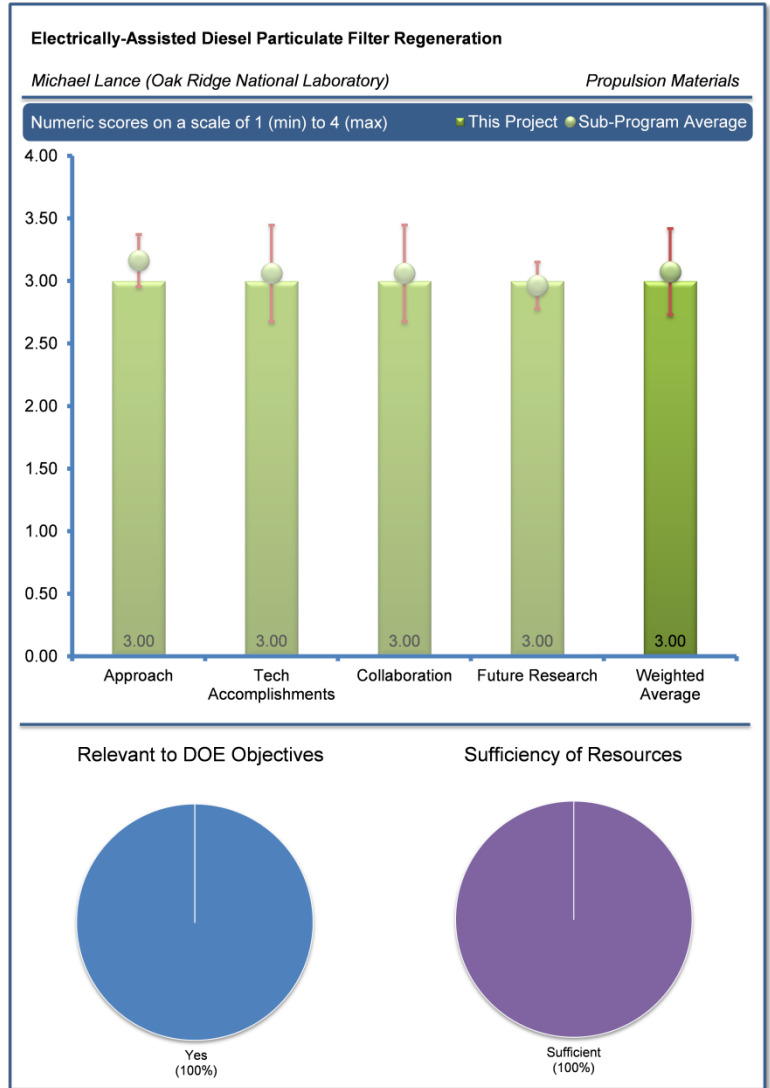
Electrically-Assisted Diesel Particulate Filter Regeneration: Michael Lance (Oak Ridge National Laboratory) – pm041

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented that fuel efficiency improvement is a clear interest in this project, and as such is well aligned with DOE's petroleum displacement goals. Another observer commented that this is a creative example of how energy may be shifted and utilized within the engine system more efficiently to get the desired effects of greater fuel efficiency and improved emissions. The next panelist stated that reduction in fuel consumption during regeneration is relevant. A subsequent reviewer remarked that injecting fuel to burn off accumulated soot from the DPF is one source of fuel economy penalty imposed on diesel engines by environmental emissions requirements, and that any approach which reduces or eliminates this extra fuel consumption will enhance the fuel economy advantage of diesel engines versus conventional gasoline engines. The final panel member reported that the goal of the project is to improve the technologies and strategies for PM filters to achieve reliable regeneration at low exhaust temperatures, and to reduce fuel economy penalty.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One panel member thought the project had an excellent approach to evaluating the system. Another found that the work was providing very basic information to the participants on catalyst filters, and this information is essential for technical development. A subsequent observer saw good thermal and material analysis, but asked how this information could be used to reduce cost or weight of the DPF with new knowledge of failure modes. This observer further asked how the researchers quantified the cost of electricity, speculating that it must come from fuel, and asked what the cost and weight of the system was. Another panelist observed that three tasks were taken to evaluate the efficiency of the device developed by GM. This observer indicated that task one was Efficiency and Temperature Measurement; task two was DPF Mechanical Properties Measurement; and task three was Heater Alloy Selection. The final reviewer commented that the approach to performing the work is quite sophisticated and takes advantage of the Federal investment in ceramic technology research and development (R&D) over the past 20-30 years at ORNL. This reviewer also thought that it was not clear that Federal involvement was really necessary to carry out this work. The reviewer concluded by asking if a ceramic manufacturer, e.g., Corning, could have done this work under a GM subcontract.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer thought that technical progress has been excellent, and appeared to affirm that the goals of the project are being achieved. This reviewer found cost-effectiveness of the approach remains to be demonstrated, however, and that resides in the commercial sector with GM. Another panelist felt there was good technical progress, but that progress should be tied to the consumer regarding true cost and feature benefit. The next panel member observed that the review presented a complete summary of the results in comparing an electrically-assisted DPF to a conventional DPF. The final observer characterized the project as having demonstrated an Electrically-Assisted Diesel Particulate Filter (EADPF) on a GM 1.9-liter engine at ORNL; having demonstrated fiber optic-based temperature measurement on bench scale in preparation for engine-based experiments; and having results consistently showing elastic modulus of DPF cordierite is lower than reported sonic-based-measured literature values while tensile failure stresses are equivalent.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that since this work is a CRADA between ORNL and GM, collaboration and coordination has been good. Another thought that working directly with system designer would enable high project success. The next panelist pointed out the researchers had worked with GM at a 50/50 cost share. The final commenter felt that some of the basic results, e.g., modulus, would not be surprising if greater collaboration had occurred prior to work, or if individuals familiar with the composite/fibrous type structure were involved ahead in the measurement and modeling; however, the information gathered from testing should be useful.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that there was no future work planned, but said that presenting the thermal and structural analysis in more detail would be good. Another panel member stated that there does not appear to be significant work planned ahead on this project, as it is nearly completed. The third panelist thought that progress has been excellent such that this project appears to be successful and complete, and remarked that future work to establish cost-effectiveness of the approach is up to the commercial partner, GM. The final observer observed that task one completed measurements of DPF substrate temperature and task two developed rules of design for the heater and described test methods for standardization. The final observer commented that the researchers should also consider the cost of additional electricity needed to run the device.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The five reviewers found resources to be sufficient. One thought that because progress on the work toward achieving the stated objectives has been on target, the resources appear to have been sufficient. Another reviewer pointed out that the project has an excellent cost share arrangement, and the next reviewer relayed that the project has \$250,000 in funding to be completed in September.

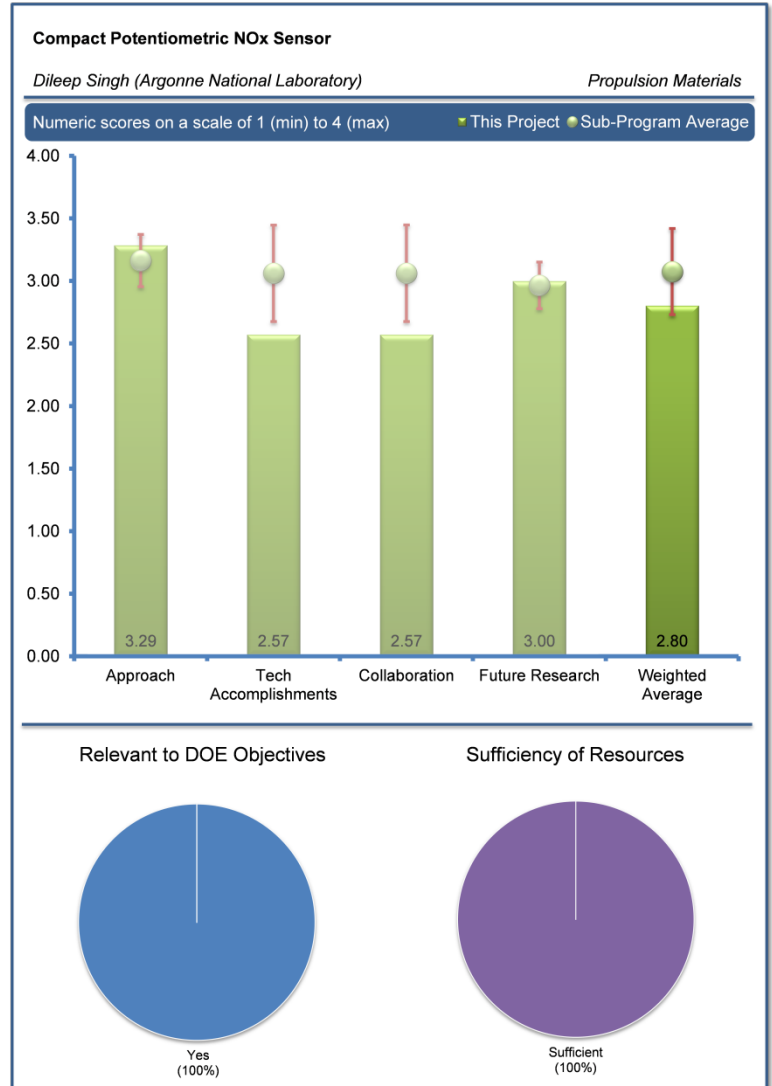
Compact Potentiometric NOx Sensor: Dileep Singh (Argonne National Laboratory) – pm043

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally found that the project supports DOE's objectives. One reviewer commented that this project absolutely supports the DOE objectives of petroleum displacement because emissions and fuel efficiency depend so highly on the sensors which are used for engine operations. This reviewer remarked that without them and without the information they provide, modern efficient engines would not be able to operate. Another panelist agreed that low cost high temperature sensors would enable more efficient and clean combustion processes, thereby reducing petroleum consumption. The next panel member concluded that this project does indeed support the objective of reducing petroleum consumption. This panel member stated that it is well known that diesel engines are more efficient than gasoline engines, but noted that their emissions, especially NO_x, have traditionally been higher than gasoline engines. This panel member further related that to combat high NO_x emission levels, engines were de-tuned to minimize NO_x, and with the development of NO_x treatment strategies, measurement and control, engines can now be tuned for maximum efficiency. The panel member therefore concluded that development of low-cost, rapid response NO_x sensors is an enabling technology that will help optimize the efficiency of HD engines used on trucks and will encourage the American public to purchase a larger fraction of more efficient diesel engines. However, this panel member observed that with the cost of diesel fuel being higher than gasoline, people will not flock to diesel engines. A following reviewer remarked that accurate, durable, and responsive exhaust gas composition sensors are key enablers to long-term compliance with vehicle emissions standards with minimal fuel economy penalty. This reviewer felt that the ability to combine sensing functions in a single sensor, oxygen and NO_x in this case, is a clear cost advantage in mass production. The subsequent observer remarked that more advanced sensors are truly needed in the Heavy Duty Vehicle industry, and that proving that such a sensor can function is critical; and that this work has demonstrated that such a sensor is feasible. This observer noted that the study would have been more complete if there was some description of the team's confidence that the sensor could be mass produced, and confidence that the sensor could continue to meet the application requirements. The observer also noted that petroleum displacement was not described in the briefing; the final report would do well to offers such description. Another panel member reported that the goal of the project was to address the need for a compact, reliable, robust, inexpensive bi-functional sensor technology that is amenable for mass production. The final reviewer relayed the project was focused on the ability to improve engine control and reduce cost through improvements in sensors and industrialization.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer observed that the project appeared to be well laid out, planned and executed, and from the presentation it appeared to have been flawless. Another reviewer agreed that the project employed a good method of approach and clear high level objectives. The next panel member thought that the approach was able to demonstrate that the objectives were satisfied. Another panelist believed that the approach for performing this work has been good. This panelist said that over the years, the researchers have been able to resolve all of the materials and sensing issues that have come up and have produced a sensor that performs well in the laboratory environment. The panelist was concerned, however, that no engine testing has been performed to verify that the sensors are robust and durable enough to function accurately for 10 years or 150,000 miles. A subsequent panelist related that the approach for NO_x sensing was to develop a compact sensor with an internal reference, and suggested considering joining technology, electrode and sensing materials. This panelist relayed that sensor design was based on electrochemical materials. The final panel member commented that sensor design was based on relatively simple and well-known electrochemical principles, by employing a closed end device made from oxygen ion conducting partially stabilized zirconia ceramic (YSZ). This panel member further said that researchers used appropriate filters and sensing materials, modified the oxygen sensor such that NO_x concentrations are measured, and conducted extensive tests to validate the performance of the sensor.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses regarding technical progress. The first panel member thought that the technical accomplishments in this project have been outstanding, as evidenced by multiple patents and what appears to be lots of interest from companies to license and commercialize the sensors. Another reviewer commented that the project appears to have developed and proceeded successfully so far, and is ready for the current stage, which is finding commercial partners. Another panel member agreed that the review indicated some interest from industry, implying that this technology could satisfy a technical need. This panel member pointed out that the objectives did not describe the path to manufacturing, and the review did not comment on it either. The panel member also found that although there was interest, the review did not describe if there are defined manufacturing techniques that could bring the product to market. The panel member hoped that despite a lack of cost objective, that the final report on this project would offer some insight into a notional cost comparison between this solution and the current technology. This panel member concluded that if the current solution is more costly, market commercialization advantages should be addressed. The next reviewer noted that interest in licensing agreements expressed by three manufacturers of emissions controls suggested the significance of project accomplishments, which have been diverse, touching upon sensor performance, fabrication techniques and materials optimization. A subsequent observer wrote that the sensor materials and packaging were developed and demonstrated in previous years, and that the technologies developed have been patented. This observer saw that during the project, the sensor test apparatus was developed, sensitivity was demonstrated, and the project developed alternate (low cost) electrode material. However, this observer commented that it was unclear if the technologies were commercialize-able or could move to mass production. Another reviewer relayed that the researchers had built a sensor to measure oxygen and NO_x, and had run into barriers including durability of solution. This reviewer would like to know about the status of a plan for determining the durability of a solution, and thought the presentation did not make clear if the addition of Al to the ceramic catalyst was the solution to the defined thermal cycling robustness issue. The reviewer questioned how NO_x sensor development would improve efficiency, as sensors are currently on the market and are functioning in reasonable fashion in closed loop control of both engine out emissions and aftertreatment systems. This reviewer would like to see an approach and mechanism that would truly impact the DOE goals. The final reviewer characterized developments as having joined advanced materials by plastic deformation; creating a high temperature sensor with internal reference; achieving good sensor sensitivity to NO_x; having replaced platinum (Pt) with other electrode material (LSAM); having joined LSAM to yttria-stabilized polycrystalline tetragonal zirconia (YTZP); having been awarded an R&D 100 Award; and having several patents issued.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed input regarding the amount of collaboration. One reviewer noted that the collaboration appeared to be appropriate to the development, considering patentability issues. Another reviewer observed growing use of university for research and industry partnership. The next panel member reported that the project was working to establish commercial connections to

migrate the technology toward commercialization, and noted the involvement with Ohio State University. A subsequent panelist said that collaboration only appeared to be with two Ph.D. students from Ohio State University, and that the General Electric collaboration was not well described in the presentation, as the charts only defined the interaction as being a supplier of O₂ sensor. This panelist thought that having an OEM or tier supplier would have offered more requirements driving guidance to ensure compliance with market needs. The following reviewer felt that project collaboration did not seem especially broad, and that the presentation did not make clear what the nature and extent of that collaboration was. This reviewer reported that three of the five collaborating institutions named were manufacturers potentially interested in licensing the technology, but that it was not clear that they collaborated in its development in any significant way. The reviewer found that the other two collaborators' roles were not described in sufficient detail to allow an assessment of how close or appropriate their collaboration was. The next observer relayed that the only collaboration that has taken place during the development phase of this project was with Ohio State. This observer has found that licensing and commercialization of a technology is much more difficult and time consuming than one anticipates, and therefore does not believe that waiting until the final year of a project to focus on licensing is the best strategy. The observer recommended in the future identifying industry partners early on to give them a chance to guide the research and to thoroughly buy into the technology well in advance of commercialization. The final panel member listed the collaborators as Ohio State University, General Electric, Marathon Sensors, Integrated Fuel Technology, and Howell International, which has shown interest.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Some reviewers noted that future work involves commercialization. One reviewer stated that FY 2012 is the final year of this project and all the research has been completed. Therefore, the only future work is trying to license the technology for commercialization. Another reviewer commented that with the project 95% complete, future work appears to be limited to exploring the possibility of licensing the developed technology for commercial production. This reviewer commented that this is a commendable and logical concluding step, but whether partnerships with licensees are necessary for demonstration of the technology is not clear. Demonstration could be left to licensees upon transfer of the technology to them. The next panelist remarked that although the project is complete, to capitalize on the work accomplished, the technology needs to be commercialized. A subsequent panel member thought that the project needed to do engine tests to demonstrate the performance of the sensor in real applications. Another observer related that future work involved defining a test plan for analysis and durability in industrial applications. The final reviewer thought that the proposed future work to bring commercial partners appears timely and according to a well laid-out plan.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Six reviewers rated the resources sufficient, while one found resources excessive. One reviewer believed that this appeared to be a significant project for a university, considering the project needed to spend so much in a short time. However, the results were excellent and timely and the findings in the project are critical to our nation's ability to develop and maintain global competitiveness. The next panelist reported that there was \$60,000 for FY 2012 to finish the project, and another panel member commented that funding appears to have been adequate. A subsequent reviewer noted that this project was allocated only \$60,000 this FY, and noted that while this is a very small number, there was no technical research being performed, only technology transfer and licensing. Another observer indicated that DOE funds were being used for Business Development, which does not appear to be a project objective. The final reviewer explained that the FY 2012 funding of \$60,000 may not be necessary to achieve remaining project goals. This reviewer referred back to whether partnerships were necessary for demonstration of the technology, or if demonstration could be left to licensees upon transfer of the technology to them.

High-Temperature Aluminum Alloys: Mark Smith (Pacific Northwest National Laboratory) – pm044

Reviewer Sample Size

This project was reviewed by five reviewers.

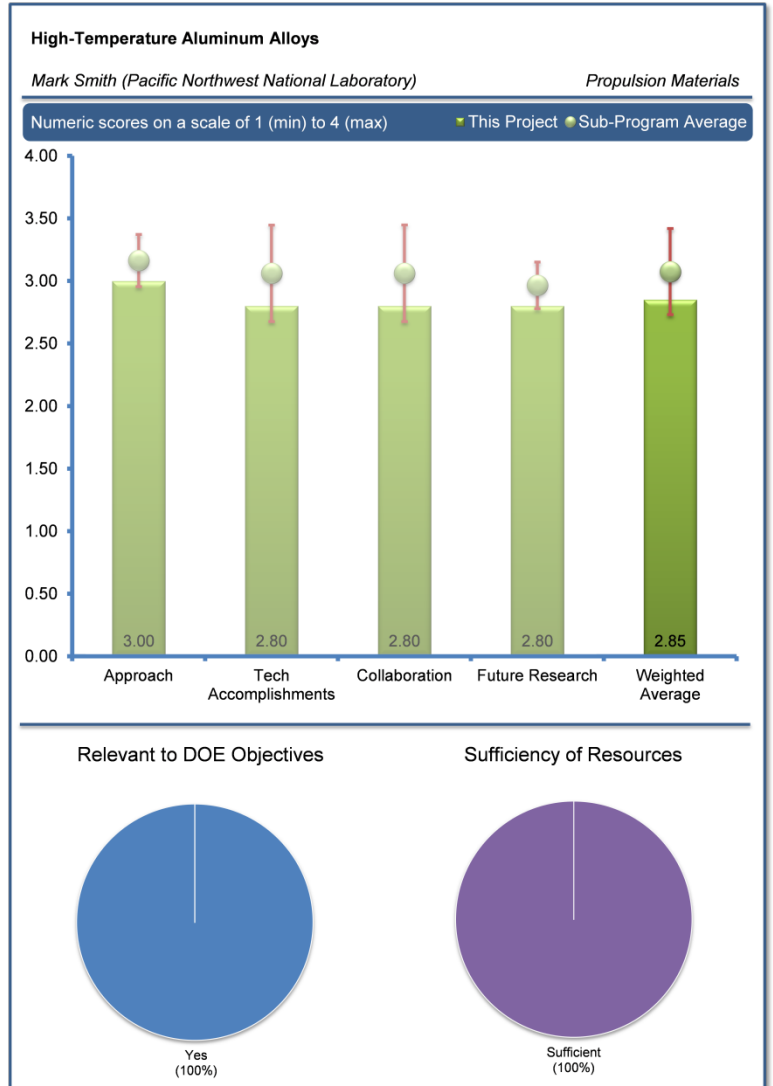
Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that increasing the operating temperature of IC engines will improve the fuel efficiency, and that many efforts are being made to develop cost effective materials for engine applications; this project is one of them. This reviewer noted that if the materials' high temperature capability can be enhanced without increasing the cost significantly, then the engines could operate at higher temperatures consuming less fuel for the same power output. Another observer saw weight reduction as the most basic, straightforward and efficacious approach to improving vehicle fuel economy. This reviewer considered the application of aluminum to drivetrains, chassis, etc. in substitution for steel has long been a proven step toward reducing vehicle weight. The reviewer found that development of aluminum alloys with higher temperature tolerance was an obvious approach to broadening the range of vehicle applications of this lightweight family of alloys, particularly as HD engine technology development proceeds in the direction of higher brake mean effective pressures (BMEPs) and temperatures. The next observer commented that this project was to develop aluminum alloys with better mechanical properties at temperatures above 300°C, which this observer believed to be extremely important and very relevant to the DOE objectives of petroleum reduction. The observer pointed out that operating temperature continues to rise in light-duty and heavy-duty engines, and that the conventional aluminum alloys have reached their upper temperature limit. This observer remarked that the development of an improved Al alloy that can be used in both LD and HD engines would enable more Al to be used in engines and reduce their weight and increase the fuel efficiency. A subsequent reviewer found the project had a good approach in terms of processing technique. The final reviewer acknowledged the importance of high temperature aluminum alloys, but would like to know what DOE barriers were addressed and how the barriers tie to DOE goals.

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Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer believed that the approach identified by the researchers at PNNL is outstanding, emphasizing that the plan is to evaluate candidate Al alloys using cost-effective rapid solidification methods. This reviewer praised the researchers for recognizing that the mechanical properties need to exceed those of the traditional Al alloys used today and those properties must be retained throughout the entire process of consolidation and forming. Finally, the reviewer was glad that the investigators also recognized that the cost of the Al alloys are very important, and for comparing the cost and performance with the best Al alloys available today. Another panelist pointed out that aluminum-iron alloys have been tested in the past and this project is aimed to



develop an alternate production route. However, it was not clear to this panelist whether all the barriers for the manufacturing have been addressed; specifically, the panelist questioned whether the rapid solidification route can reduce the segregation of iron the melting process carried out to obtain the liquid metal was the optimum process. The final observer thought that the task plan was well defined, but was unsure again what barriers are addressed and how barrier reduction will be ensured.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panelist thought that the researchers had made excellent progress while working on four different Al alloy compositions, i.e., Al-8Fe, Al-12Fe, University of Connecticut, and AFM, and had also made some very good progress on the extrusion of rods and billets made from these materials. However, the microstructures are not sufficiently uniform. This panelist was very impressed with the work achieved in less than a year's time. Another reviewer felt that the generation of aluminum flakes and matrix of compositions showed progress, but wondered if any compositions were new to this project or if all were pre-existing. The last reviewer relayed that the structure of the rapidly solidified powder and the consolidated metal were analyzed; however, complete mixture of iron particles had not yet been confirmed. Also, this reviewer observed from the presentation that some areas were iron free and no explanation could be provided for the discrepancy.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed collaboration with other institutions. One observer stated the project identified collaboration with a processing company. Another panelist thought that collaboration with an established processor of RS alloys (Transmet) is a plus. The next panel member felt that involvement from a user (Cummins) and a commercial metal powder producer (Transmet) was good and could result in the development of a viable process, and that the involvement of a material producer (Kaiser Aluminum) made the partnership complete. The final reviewer agreed that the researchers have put together a very good team to investigate higher temperature and stronger Al alloys for HD applications. This reviewer thought that the folks from Cummins would be able to give the researchers the guidance they need as far as the operating temperatures and mechanical properties, and that fellow team member Transmet Corporation, who has a commercial melt spinning operation, may be able to process materials for Cummins. This reviewer felt it was not clear from the presentation whether Kaiser Aluminum was on the team or not as they were not mentioned on the overview slide at the beginning of their presentation, but were mentioned at the end.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panel member thought that the future work described in the list of FY 2012 milestones is very good and will build on all the work accomplished prior to the annual merit review. This panel member reported that it appears the investigators have a lot of work planned for FY 2012, including significant interaction with Cummins. Another panelist thought that the project exhibited good tracking of tasks past and future, insuring that DOE technical barriers are addressed. The next reviewer suggested that attention should be focused on identifying and correcting the anisotropy of the compacted and extruded rod samples. The final reviewer commented that the investigator should look at the distribution of iron in the aluminum matrix, and that the final content of the iron in the matrix need to be analyzed. This reviewer stated that adding iron to aluminum is quite difficult and beyond certain limits iron will precipitate from the melt, and therefore this process needs to be closely monitored.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers found resources to be sufficient. One reviewer stated that the funding for FY 2012 will be \$395,000, one of the larger amounts for all the Propulsion Materials projects, and therefore sufficient for the project.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
2D	Two Dimensional
AC	Alternating Current
AFM	Alumina, ferric oxide, monosulfate phase
Al-12Fe	High-temperature Aluminum Alloy Composition
Al-8Fe	High-temperature Aluminum Alloy Composition
Al	Aluminum
AlN	Aluminum Nitride
Au	Gold
BMEP	Brake Mean Effective Pressure
C	Degrees Celsius
CF8C-Plus	A type of cast austinitic stainless steel
CI	Compression Ignition
CRADA	Cooperative Research and Development Agreement
Cu	Copper
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DC	Direct Current
DOE	Department of Energy
DPF	Diesel Particulate Filter
EADPF	Electrically-Assisted Diesel Particulate Filter
EATS	Exhaust Aftertreatment System
EB	Electron Beam
EGR	Exhaust Gas Recirculation
EMC	Epoxy Molding Compounds
FEA	Finite Element Analysis
FSW	Friction Stir Welding
FY	Fiscal Year
GDI	Gasoline Direct Injection
GM	General Motors Corporation
HK30-Nb	A type of stainless steel alloy
HD	Heavy-Duty
HTML	High Temperature Materials Laboratory
IC	Internal Combustion
IEA	International Energy Agency
LD	Light-Duty
LLNL	Lawrence Livermore National Laboratory
LSAM	Lanthanum-aluminate based oxides
LSM	Lanthanum Strontium Manganite

MECA	Manufacturers of Emissions Control Association
MgO	Magnesium oxide or Magnesia
NBB	National Biodiesel Board
NIST	National Institute of Standards and Technology
Ni	Nickel
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NO₂	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NTRC	National Transportation Research Center
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic Aromatic Hydrocarbon
PbSe	Lead selenide or lead(II) selenide
PED	Power Electronic Device
PI	Principal Investigator
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
ppm	Parts per million
PSD	Particle Size Distribution
Pt	Platinum
R&D	Research and Development
RPM	Revolutions Per Minute
Si₃N₄	Silicon nitride
SiC	Silicon Carbide
TEG	Thermoelectric Generator
ULSD	Ultra-Low Sulfur Diesel
USCAR	United States Council for Automotive Research
VTP	Vehicle Technologies Program
YSZ	Yttria-Stabilized Zirconia
YTZP	Yttria-stabilized Polycrystalline Tetragonal Zirconia

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8. Technology Integration

The Technology Integration subprogram accelerates the adoption and use of alternative fuel and advanced technology vehicles to help meet national energy and environmental goals and accelerate dissemination of advanced vehicle technologies through demonstrations and education. This subprogram's efforts logically follow successful research by industry and government and help to accelerate the commercialization and/or widespread adoption of technologies that are developed in other VT program areas. Deployment activities linked to R&D also provide early market feedback to emerging R&D.

Subprogram functions include both regulatory and voluntary components. The regulatory elements include legislative, rulemaking, and compliance activities associated with alternative fuel requirements identified within the Energy Policy Acts of 1992 and 2005 (EPACT 1992 and EPACT 2005), as well as the Energy Independence and Security Act of 2007 (EISA). Voluntary efforts include demonstration of advanced technology vehicles to verify market readiness and public information, education, outreach and technical assistance efforts. VTP works with public/private partnerships between DOE and local coalitions of key stakeholders across the country (such as through Clean Cities) to implement strategies and projects that displace petroleum. In addition, the annual DOE/EPA Fuel Economy Guide publication and related data dissemination efforts (required by law) are produced, along with the website www.fueleconomy.gov.

Education aids in overcoming institutional barriers to widespread use of advanced vehicle technologies and alternative fuels, and serves to train the next generation of participants in this technology sector. Activities such as the Advanced Vehicle Competitions (EcoCAR) and Graduate Automotive Technology Education (GATE) encourage the interest of university student engineers and engage their participation in advanced technology development.

EcoCAR 2: Plugging In to the Future: EcoCAR 2 is a three-year collegiate engineering competition and the only program of its kind. The mission of EcoCAR 2 is to educate the next generation of automotive engineers through an unparalleled hands-on, real-world engineering experience. The competition challenges 16 North American universities to reduce the environmental impact of vehicles without compromising performance, safety and consumer acceptability. EcoCAR 2 requires students to explore a variety of powertrain architectures and follow a real-world engineering regimen modeled after GM's Global Vehicle Development Process (GVDP). EcoCAR 2 teams will utilize a Chevrolet Malibu, donated by General Motors, as the integration platform for their advanced vehicle design.

Graduate Automotive Technology Education (GATE): DOE established the GATE Program in 1998 to train a future workforce of automotive engineering professionals in developing and commercializing advanced automotive technologies to help overcome technology barriers preventing the development and production of cost-effective, high-efficiency vehicles for the U.S. market. DOE originally established 10 GATE Centers of Excellence at nine U.S. universities that addressed fuel cells, hybrid electric vehicle drivetrains and control systems, lightweight materials, direct-injection engines, and advanced energy storage. In 2005, DOE began a second competition to form new, or expand, existing GATE Centers of Excellence. The eight universities that received awards focused on hybrid propulsion systems, fuel cells, advanced computation and simulation, energy storage systems, biofuels, and lightweight materials. In 2011, DOE supported seven new or expanded Centers of Excellence, focused on hybrid propulsion, energy storage, and lightweight materials.

EPAct Transportation Regulatory Activities: VTP manages several Energy Policy Act (EPAct) transportation regulatory activities that aim to reduce U.S. petroleum consumption through the use of alternative fuels, building a core market for alternative fuel vehicles (AFVs), and other petroleum-displacement methods.

Clean Cities: Clean Cities advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in transportation. Clean Cities is a national network of nearly 100 volunteer coalitions that bring together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle-reduction measures, fuel economy improvements, and emerging transportation technologies.

In August 2009, DOE announced the selection of projects supporting two program areas under ARRA: transportation electrification education; and clean fuels, vehicles and infrastructure development. With funding totaling \$39 million, the 10 ARRA-funded Advanced Electric Drive Vehicle Education activities support educational programs to substantially reduce petroleum consumption. Activities under this program include engineering degree and certificate programs, emergency responder and safety training, consumer and K-12 educational outreach, developing and providing teaching materials, and training service personnel, vehicle mechanics, and supporting infrastructure.

Additionally, the Department announced the selection of 25 projects totaling nearly \$300 million that will speed the transformation of the nation’s fleet. These projects will place more than 8,000 alternative fuel and energy efficient vehicles on the road, and establish hundreds of refueling locations/recharging sites across the country, which are both activities that support efforts to reduce petroleum consumption. Activities include development of alternative fuel infrastructure and alternative fuel corridors; alternative fuel vehicle deployment, including deployments of light-duty alternative fuel vehicles and vehicle conversions; upgrades to existing alternative fuel infrastructure; technical training; and education and outreach.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
‡ Advanced Electric Drive Vehicle Education Program	Al Ebron (West Virginia University)	8-5	2.75	3.50	3.50	2.75	3.22
‡ Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec)	James Caruthers (Purdue University)	8-9	3.40	3.40	3.40	3.40	3.40
‡ Advanced Electric Drive Vehicle Education Program: CSU Ventures	Gary Caille (Colorado State University)	8-12	3.20	3.40	3.40	3.00	3.30
‡ Advanced Electric Drive Vehicles – A Comprehensive Education, Training, and Outreach Program	Mehdi Ferdowsi (Missouri University of Science and Technology)	8-15	3.00	2.60	2.60	2.80	2.73
‡ Development and Implementation of Degree Programs in Electric Drive Vehicle Technology	Ka Yuen Simon Ng (Wayne State University)	8-18	3.75	3.50	3.50	3.00	3.50
‡ Electric Vehicle Safety Training for Emergency Responders	Andrew Klock (National Fire Protection Association)	8-21	3.40	3.40	3.40	3.60	3.43
‡ Recovery Act – An Interdisciplinary Program for Education and Outreach in Transportation Electrification	Carl Anderson (Michigan Technological University)	8-25	3.80	3.60	3.60	3.80	3.68
‡ Recovery Act—Transportation Electrification Education Partnership for Green Jobs and Sustainable Mobility	Huei Peng (University of Michigan)	8-28	3.20	3.20	3.20	3.40	3.23
‡ Advanced Electric Drive Vehicles	Lawrence Schwendeman (J. Sargeant Reynolds Community College)	8-31	2.00	2.20	2.20	2.20	2.15
‡ Electric Vehicle Service Personnel Training Program	Gerald Bernstein (City College of San Francisco)	8-34	3.40	3.00	3.00	3.00	3.10
‡ Idaho Petroleum Reduction Leadership Project	Beth Baird (Idaho Petroleum Reduction Leadership Project)	8-37	3.57	3.14	3.14	3.29	3.27

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
‡ Puget Sound Clean Cities Petroleum Reduction Project	Stephanie Meyn (Puget Sound Clean Air Agency)	8-41	3.57	3.71	3.71	3.43	3.64
‡ Utah Clean Cities Transportation Sector Petroleum Reduction Technologies Program	Robin Erickson (Utah Clean Cities Coalition)	8-45	3.57	3.71	3.71	3.43	3.64
‡ SANBAG - Ryder Natural Gas Vehicle Project	Kelly Lynn (San Bernardino Associated Governments)	8-48	2.83	3.17	3.17	2.67	3.02
‡ Heavy-Duty Natural Gas Drayage Truck Replacement Program	Vicki White (South Coast Air Quality Management District)	8-53	3.83	3.50	3.50	3.33	3.56
‡ UPS Ontario - Las Vegas LNG Corridor Extension Project: Bridging the Gap	Larry Watkins (South Coast Air Quality Management District)	8-59	3.17	3.17	3.17	2.50	3.08
‡ Wisconsin Clean Transportation Program	Maria Redmond (State of Wisconsin)	8-64	3.29	3.71	3.71	3.14	3.54
‡ Connecticut Clean Cities Future Fuels Project	Carla York (Connecticut Clean Cities Future Fuels Project)	8-69	3.50	3.50	3.50	3.50	3.50
‡ State of Indiana/Greater IN Clean Cities Alternative Fuels Implementation Plan	Patrick Flynn (State of Indiana)	8-72	3.67	3.17	3.17	3.50	3.33
‡ NJ Compressed Natural Gas Refuse Trucks, Shuttle Buses and Infrastructure	Chuck Feinberg (New Jersey Clean Cities Coalition)	8-76	3.57	3.43	3.43	3.29	3.45
‡ Promoting a Green Economy through Clean Transportation Alternatives	Rita Ebert (Greater Long Island Clean Cities Coalition)	8-81	3.00	3.67	3.67	3.17	3.44
‡ New York State-wide Alternative Fuel Vehicle Program for Vehicles and Fueling Stations	Patrick Bolton (New York State Energy Research and Development Authority)	8-84	3.40	3.60	3.60	3.20	3.50
‡ The Ohio Advanced Transportation Partnership (OATP)	Cynthia Maves (Clean Fuels Ohio)	8-87	3.29	3.57	3.57	3.14	3.45
‡ RECOVERY ACT -- CLEAN ENERGY COALITION MICHIGAN GREEN FLEETS	Sean Reed (Clean Energy Coalition)	8-92	3.57	3.29	3.29	3.29	3.36
‡ Midwest Region Alternative Fuels Project	Kelly Gilbert (Metropolitan Energy Information Center)	8-97	3.29	3.71	3.71	3.14	3.54
‡ North Central Texas Alternative Fuel and Advanced Technology Investments	Lori Clark (North Central Texas Council of Governments)	8-100	3.50	3.50	3.50	3.67	3.52
‡ Texas Propane Vehicle Pilot Project	Dan Kelly (Railroad Commission of Texas)	8-102	4.00	4.00	4.00	3.00	3.88
‡ Development of National Liquid Propane (Autogas) Refueling Network, Clean School Bus/Vehicle Incentive & Green Jobs Outreach Program	David Day (Texas State Technical College)	8-104	3.00	2.33	2.33	2.67	2.54
‡ DeKalb County/Metropolitan Atlanta Alternative Fuel and Advanced Technology Vehicle Project	Don Francis (DeKalb County)	8-106	3.50	3.83	3.83	3.00	3.65
‡ Chicago Area Alternative Fuels Deployment Project (CAAFDP)	Samantha Bingham (City of Chicago, Department of Environment)	8-110	3.57	3.43	3.43	3.14	3.43
‡ Kentucky Hybrid Electric School Bus Program	Tom Stratton (Kentucky Department of Education)	8-115	2.33	3.17	3.17	3.17	2.96

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
‡ Maryland Hybrid Truck Goods Movement Initiative	Christopher Rice (Maryland Energy Administration)	8-120	3.00	2.71	2.71	2.71	2.79
‡ Carolinas Blue Skies & Green Jobs Initiative	Kathy Boyer (Triangle J Council of Government)	8-124	3.00	3.50	3.50	2.33	3.23
‡ Southeast Propane AutoGas Development Program	Al Christopher (Virginia Department of Mines, Minerals and Energy)	8-129	4.00	3.83	3.83	3.50	3.83
‡ California Low Carbon Fuels Infrastructure Investment Initiative	Robert Bowen (California Department of General Services)	8-132	2.00	2.83	2.83	2.00	2.52
National Alternative Fuels Training Consortium (NAFTC) Clean Cities Learning Program	Al Ebron (West Virginia University)	8-137	3.00	3.60	3.60	3.20	3.40
Overall Average			3.28	3.35	3.35	3.09	3.30

‡ denotes ARRA funded projects

Advanced Electric Drive Vehicle Education Program: Al Ebron (West Virginia University) – arravt031

Reviewer Sample Size

This project was reviewed by four reviewers.

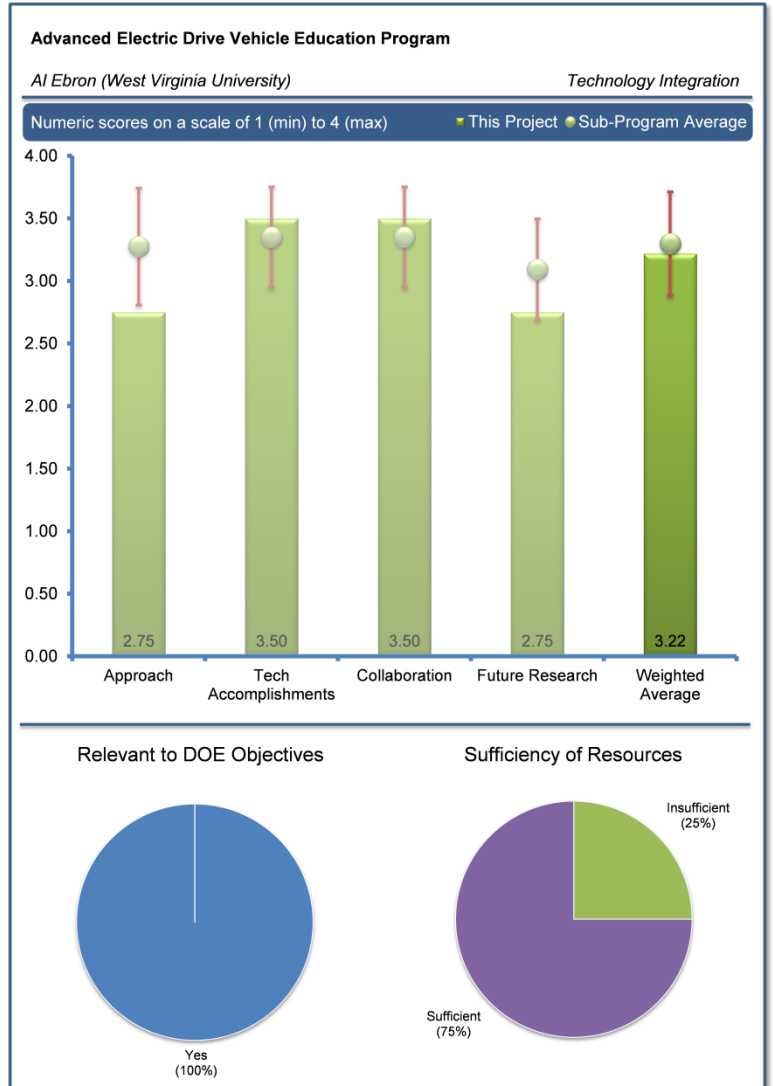
Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers' responses were mixed. A reviewer said that the project supports the petroleum displacement goal in an indirect but important way, adding that technicians would need to be able to diagnose and service electric-drive vehicles as they enter the fleet. The reviewer continued, stating that first responders likewise need to be prepared; perhaps even more so, since first responders do not have time to read manuals when responding to an emergency. The reviewer concluded that outreach efforts help build knowledge, interest, and excitement in electric-drive vehicles and related technologies.

Another commenter stated that training, education, outreach and awareness activities such as these are of value in providing electric vehicle (EV) and hybrid electric vehicle (HEV) literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the Department of Energy (DOE) objectives of petroleum displacement.

The third reviewer noted that the program would reach a large number of people due primarily to the Odyssey Day events and would educate the public about the importance of alternative fuels and advanced technology vehicles and their impact on petroleum reduction.

The final commenter believed that this project would support the overall DOE objectives if it could accomplish its goals within the time frame for the award. The evaluator noted that seven months remain in a three-year project that saw \$6.9 million of federal funds awarded, and only 35% of the project is complete to date. This evaluator wondered what was going on in a project that has created 17.5 new full time equivalent (FTE) jobs and retained 20.5 FTE jobs. The reviewer asked if this is a jobs program at the National Alternative Fuels Training Consortium (NAFTC). The reviewer continued by stating that it could not be understood why the second year goals were still in progress, as well as many of the third year goals. In the reviewer's opinion, at this point in the award, final reviews of curriculum should be taking place and the research should be wrapping up.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewers' responses were mixed. A commenter said that developing curricula, training trainers, and making handbooks and mobile applications ensured that the benefits of this project would continue long after the current effort, as does educating and inspiring young people through the alternative fuel vehicle (AFV) Odyssey Day.

One evaluator said that, while discussed, the reviewer would have liked to see the barriers, and specific steps taken to address them stated in the presentation as was found in other presentations.

Another evaluator said that it was not clear in the presentation how each product would be deployed or to whom. The reviewer was also uncertain on how the materials were evaluated on effectiveness and impact. The reviewer asked if there was a tracking mechanism to determine the scale of deployment and impact and what the outreach strategy was. The reviewer also wished to know how the career and technical education (CTE) would be used beyond the two pilot schools, such as through Clean Cities and schools in those areas.

The final reviewer said that the presentation contained some pretty far-reaching numbers about the audience impact. The reviewer used the example of the number of 105 million people being used as part of the presentation, that is, the number of people that this program would reach. When asked how that number was arrived at, the response was, if a paper had a circulation of 100,000 the entire circulation was counted as reached. The reviewer opined that this was only if readers stopped and read that article or page. The reviewer noted having difficulty with the presentation and described it as smoke and mirrors because, in the reviewer's opinion, to use these types of numbers with no qualifications put the entire program under suspicion. The reviewer suggested that the project needed to qualify the overall effect into more believable terms. The commenter would have preferred a method that stated any news and media sources used would expose 100 million people to the programs and, at best, a 20% interest factor, then 20 million would be reached in terms of their interest. The reviewer felt that this would be more believable. The commenter suggested that the conversion factor for direct mail (i.e., mail that is sent directly to a person's inbox) is 0.5 to 1.5 %. The reviewer ended by stating that those were real numbers so the question is what is real.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewers' responses were mixed. One reviewer noted that excellent progress had been made in the development of multiple products for first responders, trainers, educators and students at 7-12th grade, automotive technicians, and electric vehicle supply equipment (EVSE) installers. The reviewer added that keeping the material updated with current plug-in electric vehicle (PEV) information would continue to be a challenge, but the grantee was mindful of this and made corrections as necessary. The reviewer also said that, in some cases, such as iPhone apps, the grantee has gone beyond the scope of the grant. The commenter also noted that multiple learning methods seemed to be incorporated into each product.

Another evaluator commented that the project looked to be on schedule and finishing milestones and tasks.

The third reviewer said that the project appeared to have made numerous significant accomplishments, adding that the output was impressive. The reviewer noted that the presenter's claim of reaching over 100 million people may or may not be realistic, depending strongly on the definition of reach.

The final reviewer stated that the rate of progress was slow, and wondered about the expenditure to date. The reviewer was of the opinion that if the project had spent \$1.5 million so far, it would be okay. The reviewer went on to suggest that using project management standards, team members might not be happy with the progress, but would have only spent one-third of the money. The reviewer suspected the project team has spent a lot more than one-third. The reviewer had examined the courseware developed to date, and believed there were several issues. In the commenter's opinion, the trainer manual is at least that. The reviewer felt that it was more of a reference manual with lots of great graphics, but did not describe how and what a trainer teaches. The reviewer believed that PowerPoint slides included in the manual were an example of this. The reviewer was concerned that there was no text, no storyline that accompanied the slide, and opined that it was just PowerPoint slides that stood on their own. The

reviewer suggested that the text and slides need to be integrated as one, where a storyline is created that is a guide for the instructor to follow. The reviewer added that this is necessary because slides alone leave much for the instructor to interpret, which means in the end that the training is not standardized. The reviewer noted that they have seen this before. The reviewer continued that what happens is that the instructor interprets what is important and what is not, so the material being taught vacillates from one high to another. The reviewer noted that this does not mean that the instructors cannot add their personal stories. Rather, continued this reviewer, it means that those stories are taken along a particular knowledge path. The reviewer finished by saying that the material in the rest of the course book (emergency responder) might be that which is required with the PowerPoint slides, but that it needs to have an integrated narrative that helps the learner know the beginning and end of the program.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers' responses were mixed. One reviewer said that their collaboration seems to be good with a number of good partners. The second reviewer commented that there was an extensive set of appropriate collaborations with a nationwide consortium of training centers. This expert wondered if the creation of the first-responder safety-training manual duplicated work done by the National Fire Protection Association (NFPA), and if that was reported in another session. The same reviewer noted that the presenter said that West Virginia University (WVU) is not currently coordinating with NFPA.

The third expert stated that the collaboration with the OEM is good and helped to develop quality first responder materials. SME was involved in reviewing documents. The reviewer went on to say that one EVSE equipment company would help with infrastructure guide, wondering if perhaps others should be brought in for review. The reviewer suggested that a large network seemed to be in place to ensure quality products.

The final reviewer would like to have heard more specific examples on what role the partnerships and collaborations have played, adding that this was the same with most of the presentations, being sure they cannot talk to everything in the allotted time given. The reviewer added that the information was present in summary form on the slide, which was adequate.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that the curricula and train the trainer programs probably yielded a greater bang for the buck than the direct technician and first-responder training, so DOE may want to consider increasing the emphasis on this pathway in the future. The second reviewer would have liked to have heard more about the sustainability of the project past its end date.

The third commenter was curious how the materials would be offered to organizations outside of NAFTA schools and how much these materials would cost and how to host the varying courses. The reviewer also wondered how those trained as trainers and their locations would be tracked. The reviewer asked if there was a mechanism in place that can easily transmit new materials and information to those who have been trained since the technology is rapidly evolving and how will the products just coming on-line be evaluated in time to make any necessary corrections.

The final reviewer was unsure if this project could be finished on time with 65% of the work yet to be completed, and an expenditure rate that the reviewer believed exceeded the funds necessary to finish up. The reviewer suggested that DOE ask how much money was left and what the end of project plan looks like. When questioned about how much of the money awarded under the grant was used to develop first responder training, the reviewer was not satisfied with the project's response, that it was not broken down that way. The reviewer believed this was a bad sign, and that each project task should have a funding line associated with it. The reviewer noted that this response made them wonder.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Three reviewers observed that resources were sufficient, while one noted resources were insufficient. A reviewer responded that there was a large funding source for multiple complicated tasks. The commenter added that milestones appeared to be on track by the end of the year. The reviewer wondered that if course corrections needed to be adopted if there would be sufficient time.

Another reviewer said that this was a hard question to answer, because the reviewer believes that excessive money was awarded in the curriculum development area and the presentation did not show what funds were specifically allocated towards those tasks. The reviewer selected insufficient only because they believed the project team had overspent the funds and that too many of the tasks were in process, noting that not even a percentage was offered as to how in process those tasks are. The reviewer recommended that someone at DOE find out how much money had been spent in total, what the exact progress of the tasks as they currently exist were, and what the plan for finishing up the project on time and at budget was. The reviewer also suggested a written plan.

Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec): James Caruthers (Purdue University) – arravt032

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer responses were generally positive. A commenter said that the project creates an EV relevant curriculum at a number of higher education institutions and for secondary education in Indiana. The reviewer noted that with the creation of a hub for online material, this program would target a broad audience with different needs for understanding technology, adding that with additional focus on outreach (EV grand prix, science fair), the project seems well poised to inspire interest across the community in petroleum-displacing technologies.

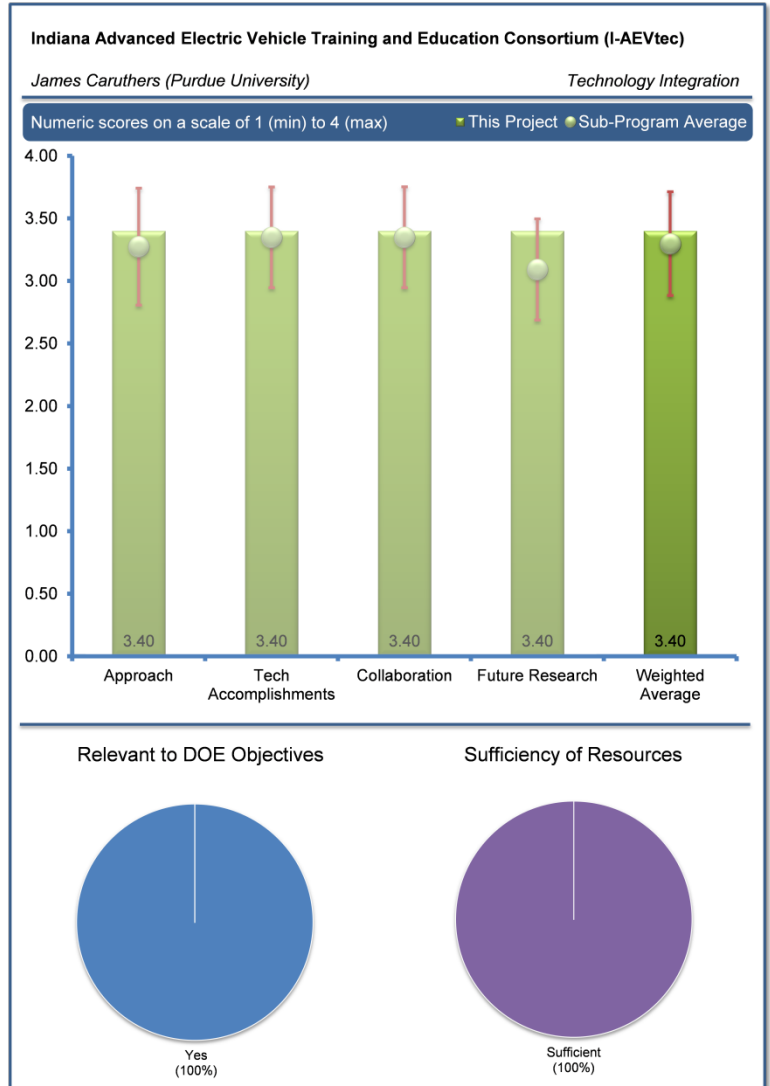
One evaluator commented that training and education activities, such as these, were of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, accelerating mass market introduction and penetration of advanced electric drive vehicles, thus resulting in the DOE objectives of petroleum displacement.

Another commenter was of the opinion that electric vehicles could contribute to significant petroleum displacement only if their use became widespread and was sustainable. The reviewer added that support of new technology in the hands of actual users is always necessary for gaining consumer acceptance. The reviewer also stated that the development of engineers and technicians was at the core of that support, and additionally exposing the minds of the young to the basic principles of electric vehicles would create a demand for the education and training in this field in the coming years.

The fourth reviewer stated that this was an excellent, well-interconnected education and consortium-building project. The final reviewer opined that the project supported the objective of petroleum displacement although it provided secondary support. The reviewer added that the project addressed part of the overall system that is necessary to make electric vehicles successful, which can displace petroleum, but that this displacement was not directly tied to the project. The reviewer concluded by saying that it was not necessarily a bad thing, just a clarification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer responses were generally positive. One reviewer stated that the project was well organized, making execution straightforward. Another reviewer mentioned that the project presented clear objectives and a strategy for deployment. The third reviewer commented that there was a very impressive group of networked supporting companies, and an impressive grouping of



schools each contributing to the deliverables. The reviewer observed a broad impact in the region, and commented that it was nice that they were getting the visible outreach at the racetrack.

The fourth expert said that the project had a high level of integration across various institutions, and that the hub for online information served and would serve as a valuable resource in addressing the different educational needs of the audiences the project sponsors were trying to reach. The reviewer added that it allowed them to effectively target different parts of the community, different technical capacities, and different interests. The commenter did caution that, because the project was at a moderate level of implementation, it was difficult to assess the degree to which the sponsors were addressing technical barriers. The reviewer continued by saying that some of the institutions covered by the project appeared to be offering limited courses at this point, but the reviewer also stated that the high level of planning and integration across institutions indicated that the project sponsors were addressing technical barriers.

The final evaluator stated that, overall, the project seemed well designed and seemed to be addressing barriers. The reviewer added that it was somewhat hard to tell given the amount of information that can be provided in the way U.S. DOE conducted these reviews. The commenter did not find it clear whether or not feedback from K-12 teachers were being collected and used to continuously improve that portion of the project, but the reviewer added that this was because of the time available to discuss the project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer responses were generally positive. A commenter said that the project demonstrated clear objectives, relevance to the overall project goals, and how each objective dealt with addressing barriers. The second reviewer noted that significant progress towards overcoming the barriers had been achieved, adding that the project is on track to achieve all goals by the close of the project. The third evaluator stated that as an education-focused project there were fewer tangible technical accomplishments, per se. This reviewer added that the educational impact is great and thus the workforce development role is very important, and because of the visibility of the outreach then it is possible that it will lead to attracting more students into this important field.

The fourth reviewer felt the project indicated substantial progress toward the goals of creating and implementing curriculum at the higher educational and secondary levels. This evaluator also stated that the project sponsors have worked to create a dialog with partners in industry and government, and that participation in outreach activities (grand prix, science fair) indicated a high level of community engagement, and successive years indicated increasing engagement.

Another expert stated that, at least based on the presentation and what the presenter verbally said, the project seemed very much on track. The reviewer cautioned that they were taking the presenter's word for that. The reviewer said that good progress appeared to be being made towards meeting the goals of the project, which may almost be met. The reviewer also said that the Grand Prix race was very impressive and looked to be a great piece of work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer responses were generally positive. One reviewer noted there was good collaboration across multiple universities. A second expert said that Purdue has formed collaboration and coordination with most every possible EV and automotive organization in the Midwest, including Cummins and the Indianapolis Motor Speedway. The third evaluator said that it was a very nice network of impacted companies, and suggested that it needed to be cultivated to be the source of continuation funding to keep this activity vital into the long-term future. The fourth commenter stated that significant progress has been made in project management, adding that the project demonstrated collaboration with industry, government, and institutional partners. This reviewer concluded by saying that it appeared that collaboration with industry and local governments had been established, but was in the beginning stages. The final commenter mentioned that there was good collaboration within Indiana in terms of educational institutions and industry. This reviewer also said that it was unclear how, if at all, collaboration was happening outside of the state.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer responses were generally positive. A reviewer noted there was a very strong focus on barriers to providing technical workforce in this important area.

Another commenter stated that even though the project was coming to a close and most all barriers had been overcome, Purdue continues to refine its approach towards success. This reviewer gave the example that they have now aligned the International EV Grand Prix at Indy with opening day activities at the racetrack for the Indy 500. The reviewer added that this capitalized on the large attendance already occurring at the racetrack to increase the exposure of their EV program and EV technology.

The third evaluator said that given what was in the presentation, the project appeared to have well planned out future activities to complete the remaining pieces of the project. The final expert said that the project had clear goals for continuing curriculum development at partner institutions and continuing development of the EV hub. The reviewer added that precise future decision points regarding curriculum and alternative development pathways were less clear.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All commenters indicated sufficient resources. One reviewer said that things appeared to be allocated appropriately to complete the stated objectives of the project in a timely fashion. Another evaluator commented that the project was set to finish in roughly six months, and according to the presentation, less than half of the obligated funds had been used. The third reviewer noted that at the two-third schedule mark the project was 55% expended, concluding that barring an unidentified large expense, the project should finish under well under budget. The fourth reviewer noted that it was difficult to evaluate the sufficiency or insufficiency of the funding when the reviewers had been provided with so little information about how the money had been allocated or spent. The commenter added that this was definitely a large budget and probably had been dispersed among the participants broadly, and that this was consistent with the large number of schools involved and the network of companies that were participating.

Advanced Electric Drive Vehicle Education Program: CSU Ventures: Gary Caille (Colorado State University) – arravt033

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer responses were generally positive. One commenter said that the project addressed challenges in the EV industry in a well-thought manner and approached shortages in workforce from multiple angles at all educational levels. This reviewer also said that the project was aiming to improve knowledge of the industry both from within academia and in the workforce. The second reviewer said that there was an excellent network of educational impact in the EV and hybrid technology area.

The third commenter opined that, indirectly, the project supported DOE’s objectives in that it supported the overall ecosystem that allowed electric vehicles to be successful, but that the project does not directly displace petroleum. This reviewer added that this was not meant as a disparagement of the project, just a clarification.

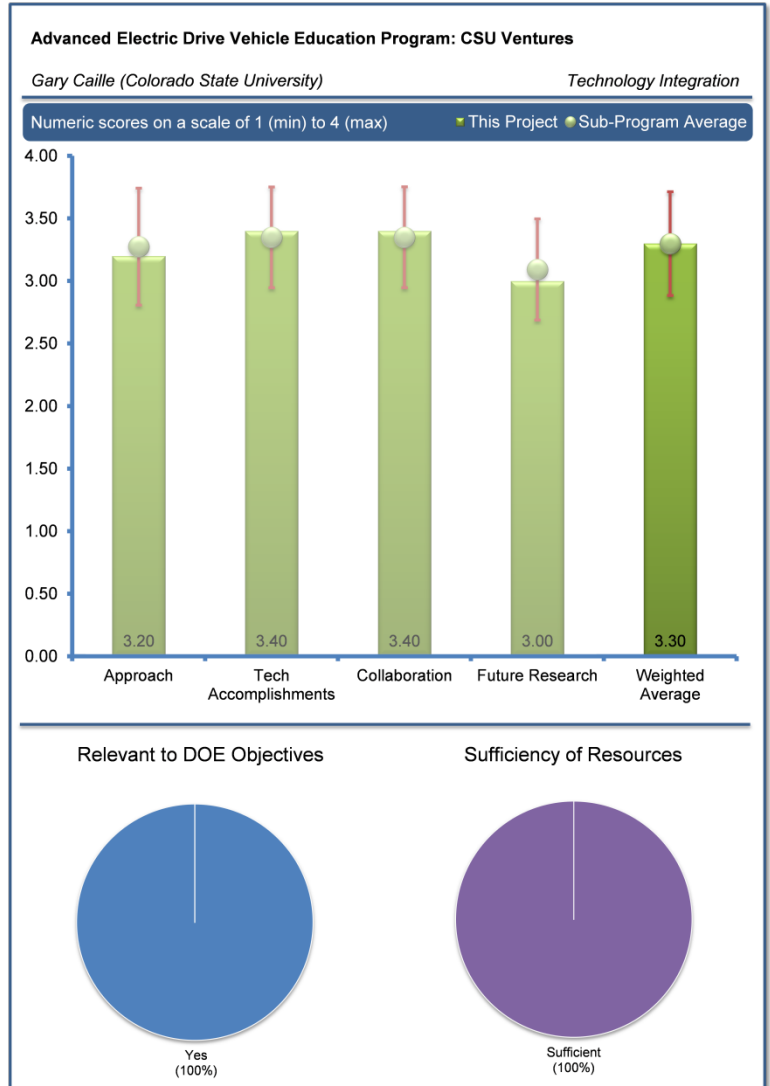
The fourth evaluator said that training and education activities, such as these, were of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement. The fifth reviewer noted that the development of service technicians, engineers, and emergency responders was vital to the success and proliferation of EVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer responses were mixed. A commenter cited a very nice linkage between higher education and feeder groups in the region as well as a connection to those who may be interested in retooling for career advancement. The reviewer added that the outreach provided to the Native American groups was excellent and a very difficult challenge, broadly speaking. The commenter continued by stating that the use and development of Gooru as an internet teaching platform is an excellent way to have broader deployment for the long run.

Another expert said that the program sponsor did an excellent job of recognizing barriers toward accomplishing the program’s goals, noting that in order to address these barriers, the program formed collaborations with many organizations, and was clearly carrying on a robust dialog with those organizations and the groups they represented.

The third reviewer mentioned the use and leveraging of technology and the technical non-profit partnership. The fourth commenter said that the overall strategy was logical, adding that it was not fully clear how the success of activity would be determined. The



final evaluator stated that the project had very good components focused on K-12 education. This reviewer also said that it was hard to see what exactly the project's strategy was (or success around) for professional and engineer education and that it appeared the project may be duplicating previous efforts by other groups, especially around first-responder training.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer responses were mixed. One reviewer said that the project team has made excellent attempts to break down the barriers and thus have accomplished a great deal. This reviewer also said that the technical tool of Gooru is expected to have a lasting impact for EV training in the future. Another commenter stated that the project was moving along as expected, and accomplishing and meeting its goals, and tasks. The third reviewer noted that the progress towards goals was apparent but was difficult to assess quantitatively. This reviewer added that several barriers should be overcome through this effort.

The fourth evaluator commented that significant progress had clearly been made toward implementing educational and workforce development programs. The reviewer continued by saying that, across all levels targeted (e.g., secondary, higher education, first responder training), that the sponsors have made demonstrated progress toward the project goals. The reviewer cited an example of the project taking innovative steps in teacher training and developing a common interface for communicating information. The reviewer also said that sponsors have formed solid connections and collaborations with organizations across the spectrum of the EV workforce. The commenter suggested that absolute measures of progress toward stated goals could be more clearly stated.

The fifth evaluator stated that it was hard to tell how much progress was being made against goals because the presentation did not detail this very clearly or in detail. The reviewer added that things looked good for K-12 educational work, but it was unclear how effective activities had been in other areas. The reviewer also said that the Gooru work was particularly interesting and showed a big potential impact.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer responses were generally positive. A reviewer stated that the collaboration with other institutions was strong based on the functionality needed for each segment of the training. A separate evaluator said the presentation showed connections and activities with a lot of project partners. The third expert noted a very good collaboration and use of partnerships in both academic and non-profit, non-government organizations. The fourth commenter noted that the project had formed collaborations with industry, educational institutions, and a wide variety of key stakeholders, including veterans and Native American groups.

The fifth expert also reiterated that the project had very nice teaming with veterans and Native American groups. The reviewer continued by saying that the development of curriculum at several institutions was definitely a great achievement in the coordination area. The reviewer also mentioned that, as the presentation noted, universities were very bureaucratic and slow moving. The commenter concluded by saying that this project had collaborations in many directions so it provided useful linkages for the broadest range of possible participants for the long run.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer responses were mixed. The first reviewer believed that future continuation would depend on having enough students to populate the new classes that had been created, adding that the network of outreach and partnerships discussed in their presentation were critical for that future vitality. Another reviewer said that the presentation and presenter stated that the project would complete future activities and seemed on track, but the reviewer found it hard to tell for sure, given the level of detail provided. The same reviewer pointed out this is more of a commentary on the review process than this particular project. The third evaluator suggested that while the project had stated goals including continuing developing short courses, continuing outreach, and implementing first responder training, the project could more clearly state the specific metrics of future activities. The fourth commenter would have liked to see more on efforts for sustainability past the end of the grant period.

The fifth reviewer said that it was hard to determine exactly which barriers would be overcome and which still need more emphasis. The commenter added not being sure about where the remaining effort would be placed. The reviewer suggested that the program needed to look at other means to reach out to veterans if this has not been successful to date, noting that the military trains and deploys a great number of ground vehicle maintainers. The reviewer wondered if the Veterans Administration had been engaged in job placement for veterans. The reviewer added that the Navajo Nation is also interested in this type of training.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers indicated resources were sufficient. A reviewer said that the resourcing appeared to be sufficient, adding that there was no information to indicate the status of the funding.

The second commenter stated that it was difficult to evaluate the sufficiency or insufficiency of the funding when the reviewers had been provided with so little information about how the money had been allocated or spent. The reviewer continued by saying that this was definitely a large budget and probably had been dispersed among the participants broadly. The evaluator also said that it would be nice to have a network of companies who would be interested in providing support in the future. The reviewer concluded by saying that the EV and hybrid technology area is very rapidly moving and it is important to keep up with it.

Another reviewer noted that remaining funds are not stated on the contract, but that the project states it is 72% complete and has requested an extension through 9/13.

Advanced Electric Drive Vehicles - A Comprehensive Education, Training, and Outreach Program: Mehdi Ferdowsi (Missouri University of Science and Technology) – arravt034

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

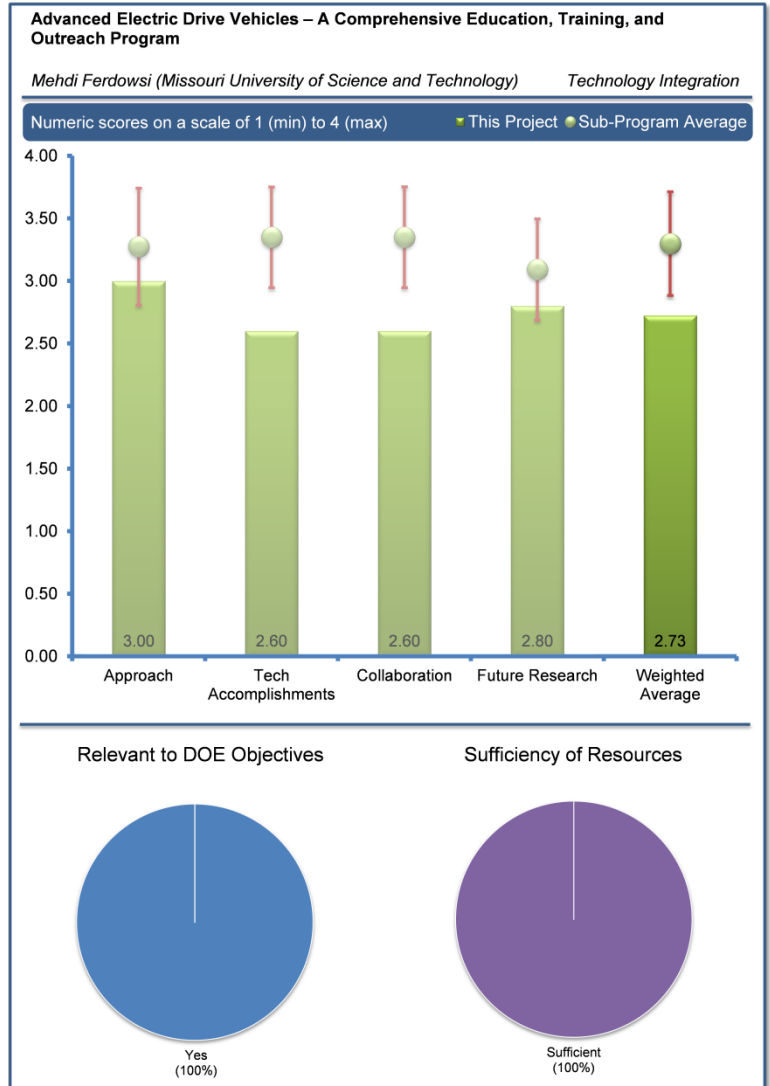
The reviewer responses were generally positive. A reviewer noted that there was a very diverse and intense educational rework to emphasize EV and hybrids. The second reviewer stated that professional development of EV engineers and technicians supported the objective of petroleum displacement. The third commenter stated that the project took a comprehensive approach to encouraging interest and knowledge in electric vehicle technology ranging from integrating courses at the undergraduate and graduate level, to community outreach.

The fourth evaluator opined that the project indirectly supports DOE objectives, in that it supports the overall ecosystem that allows electric vehicles to be successful, but that the project does not directly displace petroleum. The reviewer did not mean this as a disparagement of the project, just a clarification.

According to the final reviewer, training, education, outreach and awareness activities such as these are of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector; thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer responses were mixed. A commenter said that the project was organized well and equally targeted the spectrum of post-secondary students. The reviewer noted that the outreach component addressed the education of the general public. An evaluator said that the project seemed to be on track and has implemented a number of objectives, including courses across the participating institutions. The reviewer went on to say that, while the project identified a number of program barriers (including fast-evolving technology, input from industry, etc.), it appeared that barriers had not been a significant impediment. The reviewer suggested that more detail on this would be helpful. A reviewer said that this program has shown the most intensive curriculum modernization and the most testing. The reviewer added that this was a difficult challenge and had been well achieved. The reviewer commented that it would be nice to have a better connection to companies and jobs especially as this could help with the future continuation of the efforts into the long-term future. An evaluator said that the presentation was not very clear as to what exactly the group was doing, adding that the presenter listed the things they have either done or were going to do, but the



underlying strategy was often not clear so it was hard to say it was better than fair. A separate reviewer said that although it was communicated during the presentation, it would be helpful to put these in the form of a slide.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer responses were mixed. A reviewer said that significant progress has been made to integrate EV subject matter into the curriculum at three separate institutions, adding that more input from industry is needed to balance the theoretical with the practical. The reviewer suggested that incorporation of the most common industry model and simulations related to EV system optimization into the curriculum would benefit students and further attract employers. The reviewer also said that, if not already incorporated, training for engineers on the scope of EV design standards from the Society of Automotive Engineers and the American National Standards Institute, and others could be very helpful.

One commenter stated that the project demonstrated significant progress toward goals of implementing courses across participating institutions, obtaining necessary technology and software, and community outreach. The reviewer went on to say that there appeared to be no significant barriers to finalizing remaining project goals. The evaluator commented that the project stated that roughly 40% remained. The reviewer suggested that, given the time remaining on the contract, additional information about accomplishing remaining goals would be useful.

A reviewer suggested that significant progress had been made, but the number of classes and numbers of students impacted seemed overstated in some cases. The reviewer noted that it was possible that examples were brought to many of these classes, but it was difficult to believe that the examples had been revamped entirely.

One expert opined that the presentation and presenter at first appeared to try to take credit for existing engineering classes, adding that even after a specific question on this, it was not clear that the project really had anything to do with some of the courses listed in the presentation so these likely should not be included in a list of accomplishments. The reviewer suggested that at a minimum, it should be clearly stated how these were related to the project but that the project cannot take any specific credit for them. The reviewer concluded that this called into question everything else in the presentation whether deserved or not.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer responses were mixed. An evaluator stated that the project had established a collaborative effort with partner institutions; efforts on designing and implementing courses, as well as specific aspects of program goals (e.g., outreach) material seemed complementary.

Another reviewer felt there was good outreach to the science museum and good coordination among the various educational institutions. The reviewer suggested that it would have been good to have some connection to employers in the region to assist in connecting education with job placement and continuation efforts that would go beyond the end of this grant.

A different expert noted that the list of collaborators made sense for the scale of the project, but that the reviewer would be interested to see if more business partners could be fostered, with respect to internships, jobs.

Another commenter said that the collaboration with the other learning institutions was strong. However, more connection to the industry was needed. This was challenging given the location of the program. Smith Electric appeared to be the only industry partner.

The final reviewer said that the project had several active partners, but they appeared to be more affiliated institutions than true partners. The reviewer added that the project appeared to really only have the three educational partners. The reviewer concluded that the industry partners seemed to be marginally connected at best to this specific project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer responses were mixed. A commenter stated that future plans were based on completing the original project scope even after a couple of setbacks with the lab software.

A different reviewer said that while the project plans were good, that the reviewer would have liked to see more effort to connect to companies, to lead to a more sustainable program after this grant has been finished.

Another evaluator asked if there were plans to share best practices to other institutions that are conducting similar education and outreach efforts.

A different expert commented that while the program stated that there were no significant barriers to remaining project goals and appeared to be on track to finish on target, the remaining tasks were stated in relatively general terms. The reviewer suggested that the presentation could be more specific regarding the tasks remaining.

The final evaluator said that it was very hard to assess future activities in the terms of this review. The evaluator felt that little clear information was provided other than to say that future deadlines would be met. Because of questions previously mentioned, the reviewer felt that it was difficult to have a lot of confidence in the statements in the presentation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers indicated that the resources were sufficient. A reviewer said that the project was on-target for completion with the resources provided. A reviewer noted that it was difficult to evaluate the sufficiency or insufficiency of the funding when the reviewers had been provided with so little information about how the money had been allocated or spent. The reviewer went on to say that this was definitely a large budget and probably had been dispersed among the participants broadly. One reviewer commented that the funds remaining were unclear.

Development and Implementation of Degree Programs in Electric Drive Vehicle Technology: Ka Yuen Simon Ng (Wayne State University) – arravt035

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer responses were generally positive. The first reviewer stated that the project was very relevant to DOE objectives, if indirectly. The reviewer expressed concern whether these courses prepared students for working with more conventional and/or hybrid vehicles also, since it is not yet clear which way the industry will go. The reviewer was impressed by the presenter’s statement that students were getting jobs in Michigan after taking only one energy storage course.

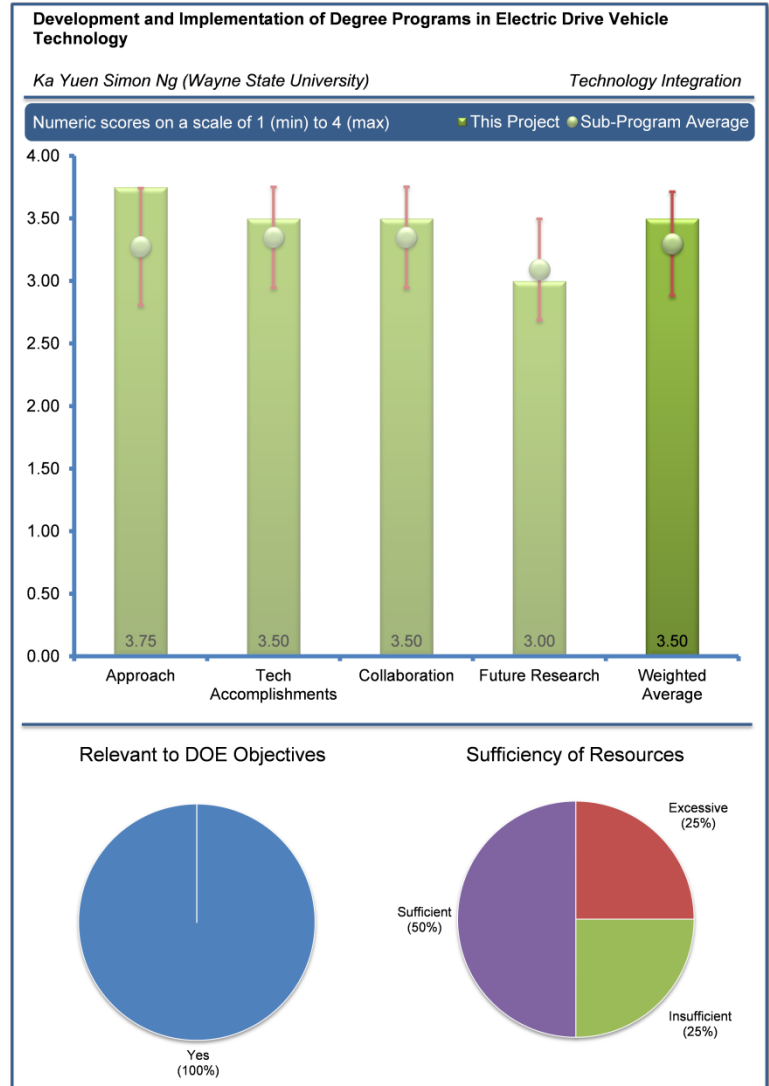
Another commenter said that, with electric vehicle technology being part of the current and future vehicle technology, engineers are needed to improve, develop, and design for manufacture electric vehicle technology.

The third expert said that the project has trained students in chemical, mechanical and electrical engineering, adding that many would be hired by various companies through the automotive industry supply chain, supporting the industry with the potential to be working on fuel economy improvements and advanced vehicle technologies. The reviewer suggested that the program could track placement of the students who have graduated from the various programs to confirm the percentage who are now in the automotive industry working on advanced vehicle technologies.

The final evaluator believed the program accomplished the goals of DOE. The reviewer added that the project was well conceived and the numbers given for students trained were believable. For the reviewer, one of the best parts of the program was that the majority if not all of the courses were taught in the evening. The reviewer noted that this enabled students who have jobs during the day to receive the necessary training so that the students could shift or develop a specialty in electric drive systems. The reviewer also had a general comment about the presentation, noting that reviewers have 20 minutes to listen to the awardee describe the program and that there were entirely too many slides with so much data on them that were very hard to digest in 20 minutes. The reviewer suggested that awardees should be reminded of this fact and cut their presentations downs to no more than 10 slides (which the reviewer thought was generous). The reviewer felt the presenters can bring other slides as backup but they should give the goals of their award, items accomplished, results and planned future activities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewers’ responses were generally positive. A reviewer said that the range of courses developed was comprehensive, including associate, bachelors, and graduate degrees, even short courses for K-12 and community college teachers. The reviewer



added that the laboratory emphasis was good. This reviewer noted that Wayne State University had access to engine dynamos for hybrid auxiliary power unit (APU) work, but they do not have (or have funding for) an integrated hybrid powertrain testing and development lab. One evaluator commented that the project's strategy was well done and that the team has procured the necessary lab equipment to foster a learn-by-doing methodology, which the reviewer was convinced is the best way to learn. The reviewer added that the program had a steady by moving forward approach to the creation and implementation of new courses that fulfill the DOE training requirements.

An expert commented on the nice integration of design, develop, implement, and validate, adding that more information and results were needed on the validation for each component since this was part of the project's approach.

A reviewer opined that there was a comprehensive approach, with an associate degree building to a Master's degree, including three state of the art laboratories. The commenter noted that one barrier that was addressed was the procurement of various tools for the labs, and that this has now been completed. The reviewer added that the focus is now on validation. The reviewer went on to say that 663 students have taken the classes, and that in regard to curriculum design, most tasks have been finished. The reviewer noted that the project was oversubscribed for the high school teachers program and went on to say that Macomb Community College created the program and expanded the program. The reviewer stated that the project had developed a capstone course, which averaged 60 students, approximately a little less than anticipated. The reviewer concluded by saying that the lab is for undergraduate and for associate's degree students, which leverages even greater use.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewers' responses were generally positive. An evaluator said that a laboratory had been established and 15 relevant courses were developed with 663 cumulative enrollees.

A different reviewer noted the development of the three state-of-the art engineering laboratories being completed, where the barrier was being able to purchase certain items for the labs addressed. The reviewer added that the approval process for the various curricula seemed to be done expeditiously by the Wayne State University Board of Governors and that the education of teachers and others in the community had been successful.

Another expert stated that one of the best courses that they taught in this program, EVE 5620/CHE5620, helped make this program stand out. The reviewer added that this course, as it was described, looked at the politics of the energy program and no other program this reviewer had evaluated even mentioned a course or training of this nature. The reviewer continued by saying that the course looked at the overall effect of energy programs on the entire energy grid, which signified to the reviewer that this program worked to look at the entire energy issue, not just the implementation of specific energy efforts. The reviewer thought it was absolutely important for students to have the BIG picture about anything they sought knowledge about. The reviewer finished by saying that the program trusted the students to make good choices and the reviewer felt this was very important. The reviewer also commented that the laboratories the project procured as well as the equipment was noteworthy.

The fourth reviewer stated that many students had taken part in the M.S. and A.A.S. program, adding that hopefully, low enrollment in the B.S. program would increase in the future from A.A.S students. The reviewer suggested that feedback on the job placement would be nice, wondering if all the students got jobs in the electric vehicle areas.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer's responses were generally positive. A reviewer noted that the project was working with a community college, NextEnergy, and an industrial advisory board and was very impressed with the advisory board and the feedback that could be provided.

A different commenter stated that, for the size of the program, their collaborative partners Macomb Community College and NextEnergy were judged as good. The reviewer felt there might be more partners if the program were to attract the attention of GM or Ford and include them in their efforts, as these companies were looking for these types of students for their organizations.

A third evaluator said that the advisory board had an excellent array of individuals from the automotive industry, academia, and etc. to oversee the program development and to offer site visits for the students to their organizations' facilities. The reviewer noted that two-thirds of the students in the program were part of the EcoCAR 2 program. The reviewer continued by saying that having the local community college as a partner demonstrated additional leveraging and support and would reach another important segment of the population. The reviewer suggested that the program consider active outreach activities with the local Ann Arbor/Detroit Clean Cities coalition, whom the reviewer felt could be helpful with the summer program for teachers or other educational workshops.

The last reviewer noted that the program was closely integrated with EcoCar team, noting that 75% of the team members were in the program. The reviewer added that there was a strong advisory board, although it appeared to be composed almost exclusively of high-level people (e.g., presidents, vice presidents, etc.). The reviewer suggested the project consider adding some shop-floor-supervisor-level people to the advisory board.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer responses were generally positive. An evaluator commented that future work ends in December 2012, and believes the program is on track to finish what it has planned by that time.

The second reviewer said that the project was winding down with less new activities for the next seven months.

The third reviewer said that future activities seemed completed and appropriate and suggested the project may want to put some effort into exploring funding or partnerships to expand laboratory capabilities (e.g., to create an integrated hybrid powertrain testing and development lab).

The final commenter said that the investment would also be used for the EcoCar 2 program. The reviewer went on to note that one barrier listed was the funding of the internship program, but did not recall this being addressed during the remainder of the year. The reviewer felt that it seemed as if this was no longer a priority by the partners. The reviewer noted that it was excellent that the presenters have developed a strategy for students who received associate degrees to be able to successfully enter into the B.S. program, and a plan for those who want to go to graduate school...and a continuing education course. The reviewer ended by stating that the survey would be used to identify additional changes need to curricula.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer stated that the project resources were insufficient; two felt the resources were sufficient and one reviewer found the resources to be excessive. A reviewer stated that the project appeared to be on track to finish the project work by the end of 2012. One evaluator said that the speaker suggested 75% of the funding had been expended, so it appeared that they will be on-time with the program. The reviewer added that summer activities remained, but the resources seemed quite sufficient to complete the milestones in a timely manner. A reviewer suggested that adding resources to enable creation of an integrated, hybrid powertrain testing and development laboratory be considered. A commenter said that there was a pretty substantial budget of \$6.25 million, suggesting that future work, which is stated as 25% of the project (approximately \$1.5 million), might be high for the planned activities of maintaining classes and outreach activities.

Electric Vehicle Safety Training for Emergency Responders: Andrew Klock (National Fire Protection Association) – arravt036

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer’s responses were generally positive. One commenter stated that training, education, outreach and awareness activities such as these were of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

Another evaluator noted that effective EV knowledge transfer to emergency responders would reduce property damage, injury, loss of life, and help achieve public acceptance of high volume EV/hybrid production in the United States.

The third reviewer said that first-responder/safety training was very important to enabling a successful increased market penetration of electric-drive vehicles.

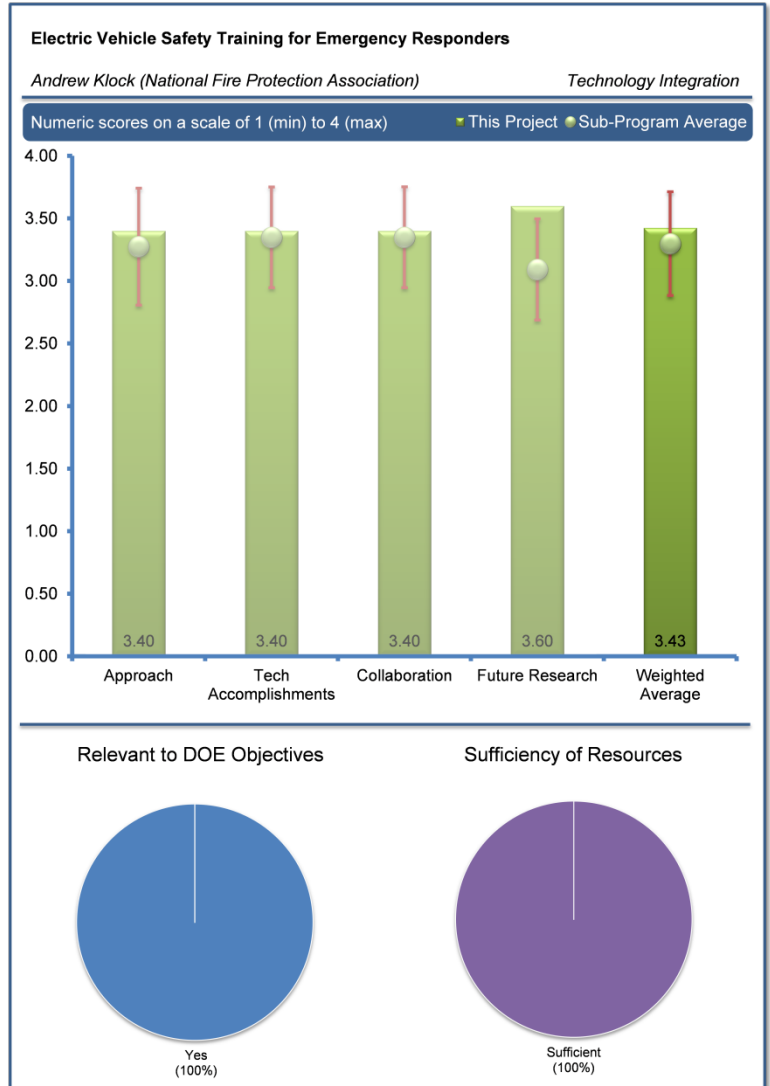
A fourth expert commented that the program’s goal was to reach a million first responders and provide them with the knowledge base to assist PEV drivers in crash or other emergency situations. The reviewer added that this would lead to a sustainable program if accidents are handled properly and consumers would continue to purchase these vehicles, which would lead to petroleum reduction. The reviewer said that the project’s approach seemed to be effective and yielding strong results.

The last commenter commented the project does meet DOE’s overall objectives as it is part of the network support infrastructure to assure electric vehicles are safe to operate and that response to electric vehicle incidents is in place.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer responses were generally positive. The first reviewer remarked that the approach seemed to be effective and yielding strong results. Another reviewer said that the program had a very good strategy for deployment of efforts and products from work performed.

The third reviewer said that through a carefully planned and executed development, partnership and distribution strategy, National Fire Protection Association (NFPA) offers high value, standards- based training programs, a web based centralized EV safety repository, and an EV quick reference guide (EFG).



The fourth evaluator said that an overall barrier had been with the lack of high speed internet at local firefighting departments and volunteer fire departments which prohibited access to the web portal that was designed initially, although 16,000 have been trained through the online course. The reviewer went on to say that train the trainer programs have been implemented with 25 of 50 state fire academies, with 3 trainers hired. The reviewer added, that while the goal was admirable, there appeared to be no strategy as to why high priority roll-out states were not targeted first, such as California and Arizona. The evaluator asked what strategy was there to complete the training, and if there was a tracking system in place that would allow trainers from each of the academies to report the first responders who have been trained throughout their state. The reviewer felt this would allow for course updates and new product information to be easily distributed. The reviewer also wondered how it would be known whether one million people were reached. The commenter said that on the other hand, close collaboration with the auto industry, National Highway Traffic Safety Administration NHTSA and General Motors (GM) in particular, was to be commended and has helped achieve the development of quality materials. The reviewer is sure this was a monumental task in coordination. This evaluator suggested that greater integration with other courses funded by DOE on this topic (i.e., NAFTC) should be considered to leverage resources and collaboration with other DOE programs to increase the knowledge of these materials on the web. In addition, continued this reviewer, ways to communicate it to greater audiences should be added to the outreach strategy. The reviewer gave the example of the speaker that was receptive to having the Wayne State program take advantage of these materials.

The fifth commenter acknowledged reviewing this program two years ago and noted that it is a great deal better than it was. The reviewer had one issue with the implementation strategy, which might be an in-house bias issue, this is, the inclusion of police first responders from the beginning. The reviewer acknowledged that the project was now considering police and are working with the New York State police, but the researchers are preparing to roll out this program and much should have been done from the start. The reviewer believed this was important because the police are usually first at the scene and fire is called upon later on in the incident. The reviewer was concerned there might be a lot of blue canaries if any type of hazmat exists and police are not aware of the present dangers. The reviewer was concerned that Slide 2 in the presentation barriers section includes that fire service and law enforcement suffer, but the partner's section below had no police agencies named. The reviewer suggested it would have been great to have the International Association of Chiefs of Police (IACP) as a partner there. The reviewer concluded by saying that partnering with law enforcement was acknowledged and this was a noteworthy change.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer responses were generally positive. A reviewer said that the project had accomplished much and it seemed that the funding or expenditures were in line with what was accomplished.

The second commenter said that the materials were developed and reviewed by OEMs and incorporated vehicle designs that may be proprietary in nature. The reviewer added that the online course had modules that have individual tests that must be taken in order to receive a certificate of completion and that the course (possibly the train the trainer course) had been revised three times already, which showed that the grantee wanted to ensure a quality product and would not cut corners. The evaluator noted that the feedback forms suggested a 90% approval rate and that the project developed a quick reference guide, which is user friendly.

The third reviewer said that the program had developed classroom and online EV safety training courses (29,000 trained), videos, Emergency Field Guide (print and electronic), and an EV safety web portal (101,000 hits). The evaluator commented that the project team had established numerous working partnerships with auto manufacturers to facilitate information flow, availability of EV safety related documents, and improvement of industry Emergency Response Guides.

The fourth commenter stated that the content created was of very high quality and immersiveness.

The final reviewer said that the program had created a one-stop-shop web portal for electric drive first-responder information, set up and delivered train the trainer programs, created the EVsafetytraining.org web portal (which is now available online), and created a quick-reference field guide with concise summaries of the most critical safety information on all electric-drive cars currently in production or on the road in significant numbers. The reviewer noted that 29,000 emergency responders had been trained. The reviewer was uncertain whether this number double-counted some trainees who took multiple courses. The evaluator

noted the project had created a structure for ensuring that the content stayed current, that the course has been revised three times in last nine months, and there were plans to continue updating it at least every six months. The reviewer also said that while California is not on the list of 30 states trainers trained, that the state would be on the list the following week.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer responses were generally positive. One evaluator mentioned that the program had great collaborations and partnerships. The second commenter observed that the project had a number of active partnerships, including automobile manufacturers, government agencies and one law enforcement agency. Another reviewer mentioned that there were active partnerships with all high level United States fire service organizations, automobile manufacturers (15 total), law enforcement and governmental agencies.

The fourth reviewer detailed that the project collaborated with all OEMs producing electric-drive vehicles in the United States and set up partnerships with every state. The reviewer also commented that the project was working with NHTSA, an insurance company, and many major fire safety organizations. The reviewer stated that the Society of Fire Protection Engineers was conspicuously absent. The reviewer also noted that working feedback forms are provided for all courses/products and feedback has been 90% positive.

The fifth reviewer stated that close collaboration seems apparent with state fire academies, the OEMs, State Farm, but was not sure about EVSE companies. The reviewer suggested that NFPA should consider greater collaboration with local Clean Cities coalitions and with other similar programs to leverage resources. The reviewer felt that feedback from focus groups were a successful way to develop quality materials and tools.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer responses were generally positive. One commenter mentioned that the program had a very good plan for sustainability of efforts.

The second reviewer said that the project would continue course and vehicle-specific updates to fire service training, while expanding to law enforcement and emergency medical services (EMS) personnel.

A different evaluator said that the program appeared to be on track to finish, with the law enforcement training piece under development. The reviewer anticipated the project would be able to achieve this by collaborating with the New York State police.

A fourth expert said that the project would train fire, law enforcement and EMS personnel to deliver course content and curriculum throughout the first responder community, and would continue to develop emergency responder and automotive partnerships, while updating training programs and reference material to stay current with emerging technology.

The last reviewer said that the project's future plans for 2012 included information dissemination at nationwide fire association events and developing future revenue streams through advertising and fundraising in order to ensure product materials can be updated. The reviewer suggested new outreach strategies (EVSEs, Clean Cities, AAA, etc.) should be considered to leverage resources now and in the future. The reviewer noted that future plans also included law enforcement academies with a pilot in New York in the process of being completed. The reviewer ended by saying that this was an excellent next step as well as EMS.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers said the resources were sufficient. One reviewer said that the project has been well funded for its effort and it appears the project is on track to finish at budget on time. One commenter said that resources were sufficient now that the project has been extended to 2013. A reviewer said the program was on task with funding. The reviewer also expressed concern with the future of the electric vehicle knowledge, wondering if when this funding ends and the group starts charging for this information if

emergency responders would be active in staying current on electric vehicle technology and vehicles. The reviewer suggested that some government mandated training or requirement should be implemented.

Recovery Act - An Interdisciplinary Program for Education and Outreach in Transportation Electrification: Carl Anderson (Michigan Technological University) – arravt037

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer remarked that the project displayed excellent connections between education and potential future careers, all of which was leading to an increase in the adoption of alternative fuel vehicles nationally.

The second reviewer remarked that the professional training of engineers and outreach to the public on EV technology was vital to the goal of petroleum displacement.

According to the third reviewer, this project took a comprehensive approach to the program's objectives, by training undergraduate and graduate students, engineers in the workforce, and conducting an impressive outreach program through the mobile lab. The project worked closely with industry to ensure that courses matched industry needs.

The fourth reviewer stated that training, education, outreach and awareness activities such as these are of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

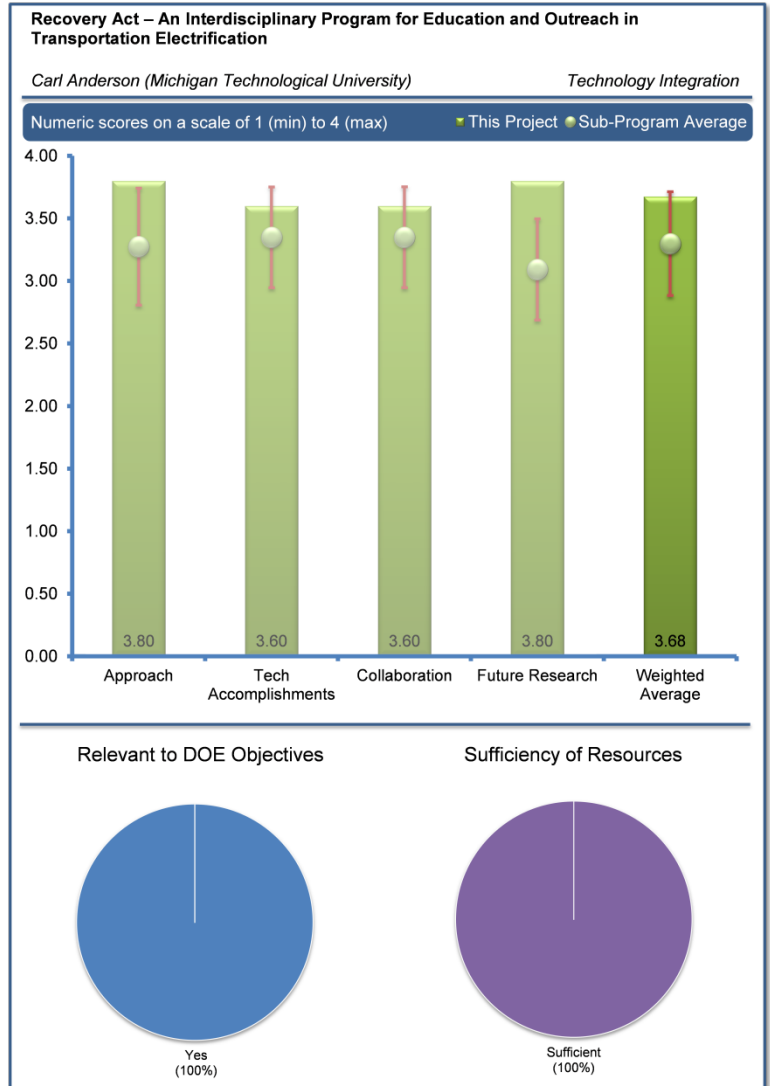
The final reviewer remarked that the project indirectly supported objectives in that it supported the overall ecosystem that allowed electric vehicles to be successful, but that the project does not directly displace petroleum. That is not meant as a disparagement of the project, just a clarification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer really liked the travelling lab and the ability to provide training and outreach anywhere. This reviewer was impressed with the capability that was built in there and thus allowing lab experiences relevant to vehicle technology in many locations. The curriculum changes appeared to be very well-thought-out and implemented.

The second reviewer thought that the project appeared to be very well-designed and put together.

According to the third reviewer, the project identified several barriers to implementation, including lack of defined curriculum and lack of clear direction from the industry. The project has done a great job of overcoming these barriers in particular, both through



developing courses and seeking and integrating feedback into future courses, and through strong collaboration with industry. In addition, the progress the project has made overall, including the development of courses, development of the mobile lab, and extensive outreach conducted and planned, demonstrated that project has targeted and overcome barriers.

The fourth reviewer commented that both the content development and the outreach activity using the mobile lab were well used in addressing the goals and barriers stated with the project.

The final reviewer observed a complete, immersed training program for engineers that is very hard to improve on, and that the project goes well beyond just concepts of electrified vehicles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers observed that the project has had technical accomplishments and made effective progress. According to the first reviewer, emphasis on the curriculum and being able to meaningfully take it on the road was excellent, was a major technical accomplishment, and should provide long-range impact as it is used in the future.

The second reviewer remarked that the project seems to be making very strong progress and has achieved most of its objectives already.

According to the third reviewer, again, this project has made substantial progress toward completion of the project goals. For instance, the reviewer noted, the project has developed and updated a number of courses, with demonstrated increases in enrollment. The project has made significant technical progress by building and integrating learning opportunities into the mobile lab. In addition, the project has looked for and worked toward an innovative means of outreach, including demonstrations of hybrid technology, and development of specific hybrid gaming software.

The fourth reviewer remarked that goals and barriers within the scope of this project were adequately stated and that steps to overcome barriers and meet goals were as well.

The final reviewer observed that a lot has been accomplished given the resources provided, and that barriers have been overcome already. This reviewer suggested that if not currently covered in the program, consider adding a section or course on EV standards and safety as it would be the next frontier in the evolution of EVs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers saw meaningful collaboration. The first reviewer was very impressed with the network of companies that were networked in to link with this training program. The reviewer noted that this was important for job placement as well as for future sponsorship when this grant has been expended. The second reviewer remarked that the project has demonstrated significant collaborations with industry, including the Michigan Academy for Green Mobility Alliance. The third reviewer stated collaboration with other stakeholder organizations was outstanding. The final reviewer saw very strong industry connections. The reviewer added that the project possibly could be doing more to connect and collaborate with other educational institutions if only to spread the good work that this project is doing with government support to additional audiences.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that this project looked like it could be sustainable and beneficial for the education that it can achieve for students who were attracted to vehicle technology jobs. By working and training students in this space then it enabled companies to be moving their product lines and designs more into this electric and hybrid framework. The second reviewer commented that the project seemed to have everything in place to complete all necessary future activities. The third reviewer remarked that the project was 85% complete, and has clearly defined remaining steps toward completion. These included ongoing marketing and student recruitment, ongoing course improvements in response to course feedback, and integrations of final stage simulators to

mobile lab. The final reviewer remarked future activities were focused on shifting the program into self-sustaining mode as part of the regular Michigan Tech offerings. Some work remained for completion of the laboratory.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers stated that resources were sufficient. The first reviewer saw excellent use of resources. According to another reviewer, it was difficult to evaluate the sufficiency or insufficiency of the funding when so little information about how the money had been allocated or spent has been provided. In general, this reviewer was impressed with what has been accomplished.

Recovery Act-Transportation Electrification Education Partnership for Green Jobs and Sustainable Mobility: Hwei Peng (University of Michigan) – arravt038

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

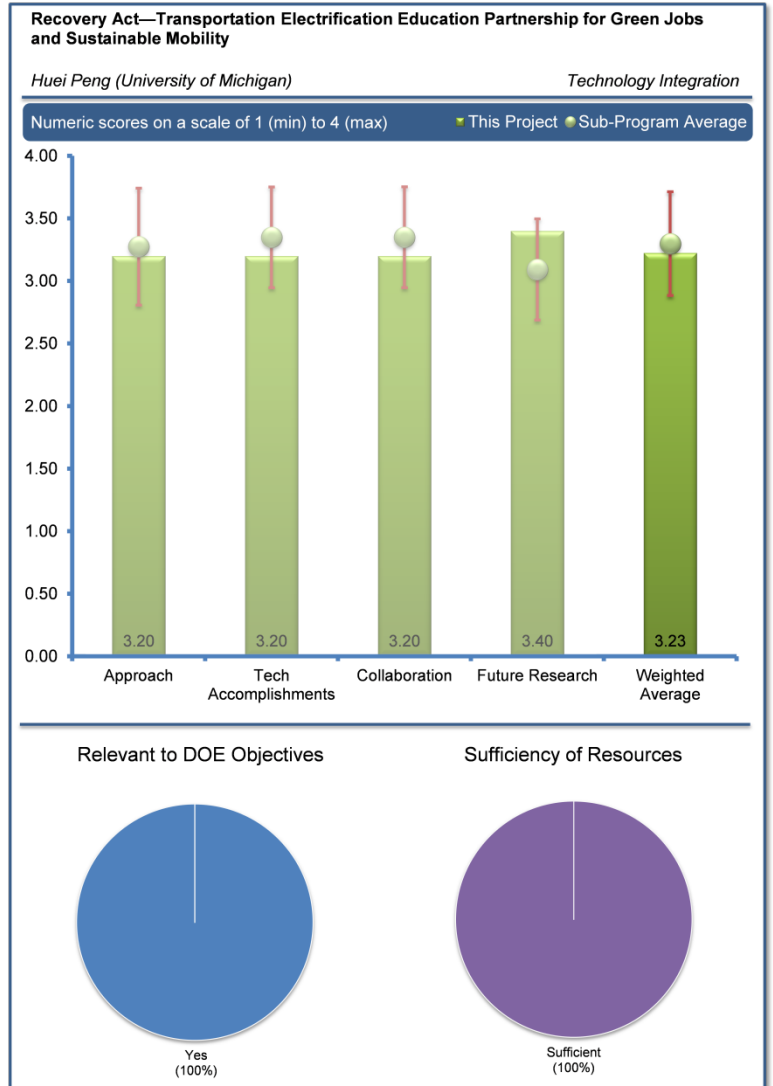
The first reviewer remarked the project supports petroleum displacement by educating the next generation(s) of vehicle engineers and designers about advanced propulsion technologies.

According to the second reviewer, training and education activities such as these are of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

The third reviewer remarked that with electric vehicle technology being part of the current and future vehicle technology, engineers are needed to improve, develop, and design for manufacture EV technology.

The fourth reviewer commented that the program would train future engineers about advanced vehicle technologies, encourage younger students to think about engineering and sciences educational track and the community as a whole to purchase plug-in electric vehicles. The 10 courses would reach 300-500 students annually and train 50-100 professional engineers in this new area.

The final reviewer thought the project does as it is designed; the project creates courses and learning for the design and development of electrified vehicles, so its long term goal is to create a cadre of design engineers who will take vehicle technologies to the next step. So the DOE objectives are seen in terms of long term goals. This reviewer noted that while the presenter did a fair to good job, the presentation was terrible. This reviewer indicated that the presentation was so busy, confusing, and unable to be read, that even the presenter had trouble figuring out what was on the slides. This reviewer noted that reviewers have 20 minutes to really get the gist of what the program is about, make a determination as whether it is meritorious, and reviewers have 10 minutes to ask questions. The reviewer indicated that the presentation should generously have been no more than 10 slides. The presenter should have had backup slides in case anyone wanted to know more. The lab pictures were nice and one or two of those would have been okay, but that would be part of the 10 slide presentation. This reviewer indicated that a degree in cryptology was needed just to decipher the slides.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked that the development of curriculum, and the outreach activities, was well within the confines of the project's parameters and capacities.

The second reviewer remarked that the project was providing education at all levels, from kindergarten through graduate-level, short courses through degree programs. This reviewer was a little concerned by a statement that the PI concentrated on developing top-notch courses, rather than a program.

The third reviewer remarked that the objective was to develop graduate, undergraduate and short courses and outreach activities in the field of Electrified Transportation. The deployment was then to create some undergraduate, graduate, and short courses and do some outreach. Currently, students were taking these undergraduate and graduate courses. This reviewer inquired as to how it was known that these were the courses the students needed for Electrified Transportation or if there were courses that were lacking.

The fourth reviewer observed one technical barrier was the development of one of the laboratories was a problem due to the upgrade necessary to the University of Michigan (UM) facility. This reviewer questioned whether adding Pennsylvania State to the program was a distraction when time (and maximizing resources) could have been spent focusing on in-state universities. The success rate of student enrollment into the classes was unclear. This reviewer inquired about how many students were moving on to further education, which field, or careers in the automotive (advanced technology vehicle) industry. This reviewer would like to know what the student satisfaction rate with the new courses and laboratories was. This reviewer questioned how UM measured the success of integration of the labs with the courses that had been developed.

The final reviewer remarked grade might have been higher if the presentation information was clearer, but from indications it appears the project has done a good job on this.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that the Green Mobility lab has created nine jobs: five co-ops; a small desktop dyno; and fuel cell system integration and power electronics at Kettering, which was a great boost to the Kettering program. The laboratories appeared to be excellent for additional learning beyond the classroom and were the cornerstone of this project.

The second reviewer remarked that the project developed a diverse set of courses, and noted nearly 800 enrollees to date. This reviewer observed that two labs were established, a high school summer camp was offered, videos were created, and educational kits and a (crude) video game were developed. This reviewer commented that the education lab has been helping the university attract paid research.

The third reviewer said the outreach activities and curriculum development resulting in courses and the mobile laboratory was in sync with the project's goals and methods for addressing barriers.

The fourth reviewer remarked that the project created some really neat and exciting laboratories. The outreach activities look very interesting and engaging, especially the education kit. This reviewer would like to know how recruiting for short courses would be improved in the future because this is a barrier.

The final reviewer thought the technical accomplishments appeared to be substantial but this reviewer was just not sure because the slides looked designed to overwhelm the reviewers with technical details. Moreover, the 2011 and 2012 achievements presented on Slide 9 did not seem to reflect what the other slides seemed to be saying, which was very confusing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer saw collaboration with a recognized set of universities with strong capabilities and backgrounds in automotive technology, and appropriate industry partners including OEMs and Tier 1 suppliers.

The second reviewer commented that collaboration is good, and noted that collaboration with General Motors Corporation (GM), Ford, DTE, and Bosch in course development as well as A&D equipment is noteworthy, and also noted collaborations with the University of Michigan-Ann Arbor, Dearborn Kettering and Pennsylvania State University.

The third reviewer saw four partner schools and many industrial partners, and the presentation showed some good work by Kettering and the University of Michigan. This reviewer questioned how Pennsylvania State fit into the project because Pennsylvania State was a collaborator.

The final reviewer remarked that courses were developed in partnership with GM, Ford, Bosch, and two others but broader collaboration with the vast network of companies in Michigan could lead to future resources and opportunities for students to be placed. Working with the business schools could increase participation in the green manufacturing course, which seemed like an excellent addition to a mechanical, chemical or electrical engineering degree. This reviewer remarked that collaboration with Pennsylvania State seemed like a good idea but questioned if it was a distraction. This reviewer suggested that future collaboration with Ann Arbor/Detroit Clean Cities is a possibility for the student events and other outreach courses for the community. The Pennsylvania State effort can work with the EcoCAR 2 outreach teams and Pittsburgh/Philadelphia Clean Cities, as well, to reach a greater audience. Online tools and videos could be promoted or linked from local Clean Cities' web sites.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter observed that project funding was nearing completion. Appropriate future work included finishing out a lab, developing another course, and continuing to deliver courses and camps. The second reviewer thought that the project was on track to finish the work on their labs in the next few months and start use of the I-HES lab in September. This reviewer saw no reason why the project would not finish and have in place the necessary tools and course materials to turn out trained design and development engineers. The third reviewer noted that project was winding down with 10% left. Future work stated that courses would be improved. This reviewer questioned how course work would be improved, and would like information about the process. The final reviewer noted that the main barrier of the third lab being built has now been addressed. This reviewer inquired about what the plans were to keep the curricula and labs current. While future funding was not as critical for the University of Michigan, this reviewer wondered if it may be an issue for Kettering.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers thought that resources were sufficient. One reviewer would like the project to consider extending this highly successful effort. The second reviewer commented that 90% of the project was complete and this reviewer suspected the funds were sufficient. The third reviewer commented that it appeared the third lab would be finished at the end of fiscal year 2012. But, this reviewer pointed out that there is little time to validate how effectively the equipment at the lab augmented the course work.

Advanced Electric Drive Vehicles: Lawrence Schwendeman (J. Sargeant Reynolds Community College) – arravt039

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers found that the project supported DOE’s objectives. The first reviewer stated training and education activities such as these were of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

The second reviewer commented that training of EV service technicians was important to the widespread proliferation of this technology and therefore the displacement of petroleum.

The third reviewer remarked that project targets development of five courses related to EV and PHEV diagnosis and repair. The project has made substantial progress on developing and implementing relevant coursework. Overall, the project recognizes and aims to help address a critical shortage of technicians in this field.

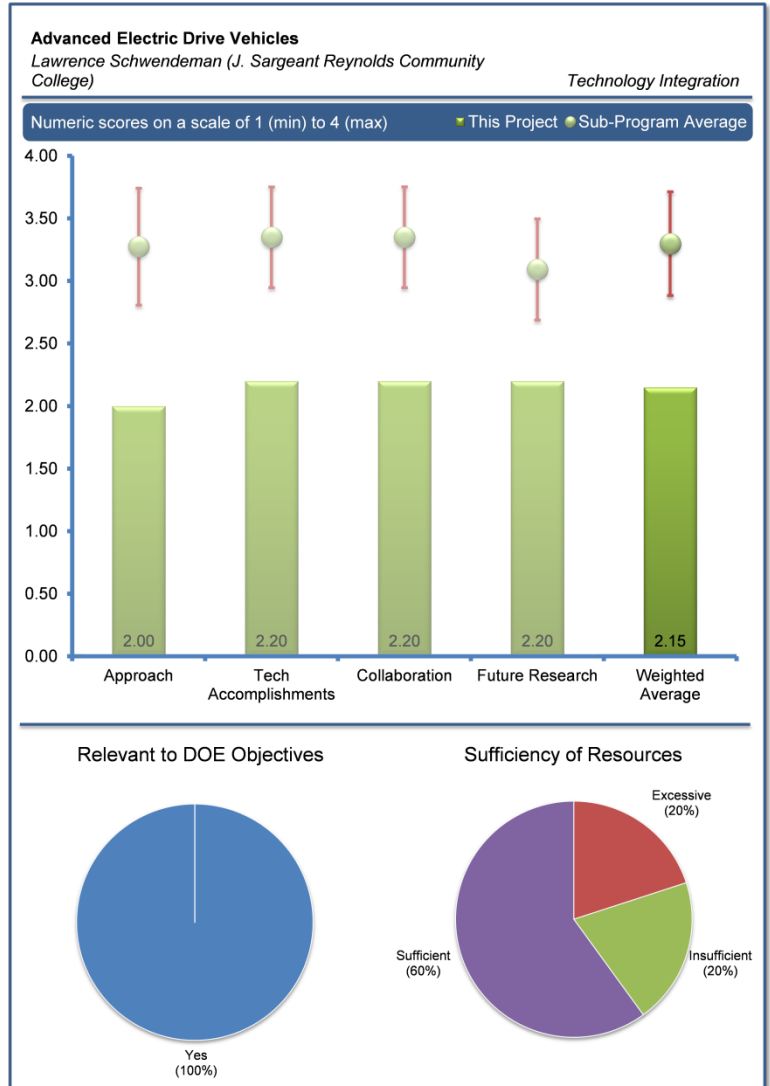
The fourth reviewer commented that the education is aimed at vehicle technology technicians and increasing skills were needed as more cars have hybrid drive or even are purely electric. The intention was good as it provided for skilled service sector jobs to support these new cars.

The final reviewer remarked that the project indirectly supported the objective in that it supported the overall ecosystem that allows electric vehicles to be successful, but that the project does not directly displace petroleum. That is not meant as a disparagement of the project, just a clarification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked the development of courses and delivery in a community college setting.

According to the second reviewer, sponsors recognized a difficulty in attracting students to the program, and seemed to be moving in the direction of more distance learning opportunities. Given the targeting of students for this kind of program, this reviewer recommended putting heightened efforts into distance and evening learning programs.



The third reviewer noted that classes were being developed and have been cycled through several times, but the project has not connected with a market of students who wanted to take these classes. The project has made efforts to connect and share curriculum elements with others nationally, but this has not gone far enough.

The fourth reviewer remarked that the strategy for this local community college was to invent the curriculum without the help of other organizations and industry. This was a very difficult challenge to do alone. The other technician training efforts were done under a larger umbrella of support from universities and industry. The development of training for fuel cell vehicles is premature. Even if fuel cell vehicles (FCVs) penetrated the market in 2015, FCVs would not be seen at independent shops for 8 to 10 years.

The final reviewer opined that the project does not appear to be focused on real industry needs. The reviewer remarked that the presenter did not provide a good rationale, defense or strategy in the presentation for some aspects of the project, especially the pieces that are yet to be accomplished. The presenter referenced how all graduates get jobs, but that seemed more to be about mechanics on traditional vehicles and did not necessarily justify trainings on something like fuel cell vehicles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed comments. The first reviewer stated that the project has had difficulty overcoming the barrier of attracting students into the program. Nonetheless, the project has made significant progress on developing and implementing the curriculum.

According to the second reviewer, given the strategy charted, good progress had been made. Industry partnerships were emerging and the curriculum was developing. Better connections with potential students would help the program along. The third reviewer stated that courses were developed and offered in a timely fashion.

The fourth reviewer commented progress has been good in creating the classes, but the actual impact has been rather small because fewer students have signed up for these classes than originally hoped. The reviewer mentioned that perhaps the project should have had more effort and mechanisms to provide outreach about the kinds of new education that was being offered.

According to the final reviewer, the project appears to have accomplished a couple of its goals, but that it was very difficult to tell how effective these were or how valuable the progress has been. As a side note, this reviewer observed that the presenter should do a better job in the future of listening to questions from reviewers. There were several times that the presenter would answer a different question than the one asked, even if the question was repeated and stated differently. It got to the point that it seemed as if the reviewer did not care to answer the questions being asked, that the presenter just heard what he wanted to hear and was going to talk about what he wanted to talk about. This was probably not the case, but that was how it seemed at least to this reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed responses on collaboration. According to the first reviewer, the project has formed collaborations with OEMs and with one partner institution. In addition, the project was engaged in frequent communication with local technicians about training needs. The second reviewer observed that the emerging industry collaborators and the other school in San Francisco seemed to have propelled the effort forward.

According to the third reviewer, most work was done at the lead organization with little outside collaboration. City Colleges of San Francisco is mentioned as a collaborator on instructional development. Additionally, Ford, GM and others were mentioned as industrial partners, but it was not clear what their role has been. This reviewer inquired whether Ford, GM, and others would be sponsors who would help continue this into the future.

The fourth reviewer noted that the project mentioned one partner – City College of San Francisco – although the extent of collaboration seemed pretty limited. In addition, industry partners were listed but as partners of the automotive program. The reviewer noted that it was hard to tell if these partners had specific roles in this particular project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer observed that one course remained to be developed and two new courses would be held for the first time this summer and next fall. Another reviewer noted that the presentation and presenter indicated that the project would complete future activities, but the details were lacking so it was hard to make a good assessment of the prospects for completing future activities.

The third reviewer commented that the project seemed to be just continuing. However, since the project had recognized difficulty in attracting students, the project should be doing something to change the outreach or curriculum advertising to improve the impact.

The fourth reviewer expressed that the development of fuel cell vehicle curriculum was notable but out of step with reality. The reviewer suggested that that effort be repurposed towards the other curriculum development or inventing new methods of training delivery that are attractive to the potential students in the area.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers had mixed responses. One reviewer stated that funds were insufficient and that the strategy for deployment and the level of funding do not match. Just the procurement of training assets could consume much of the budget. Three reviewers found funds to be sufficient. One reviewer stated that funds were excessive. This reviewer commented that because of the low number of students, this project has a low return on investment. It was difficult to evaluate the sufficiency or insufficiency of the funding when reviewers have been provided with so little information about how the money has been allocated or spent. This was definitely a large budget for the few number of students impacted.

Electric Vehicle Service Personnel Training Program: Gerald Bernstein (City College of San Francisco) – arravt040

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally found that the project supported DOE's objectives. The first reviewer thought the project very relevant to supporting the purchase and operation of petroleum-saving advanced electric-drive vehicles.

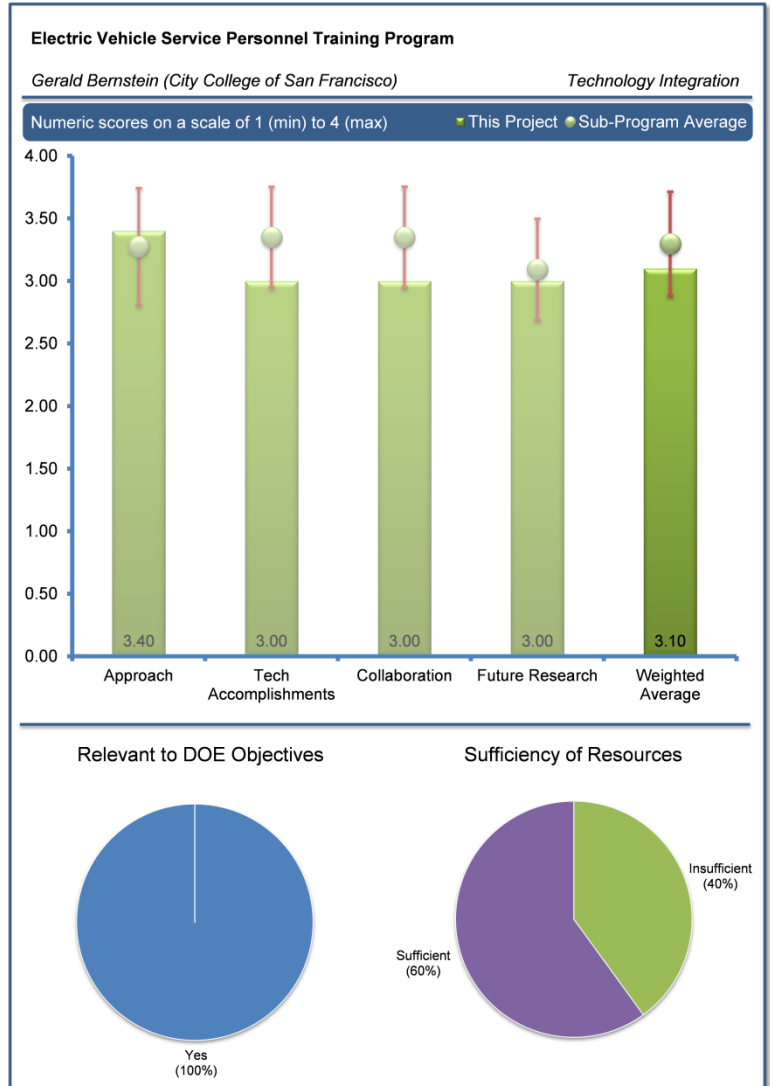
According to the second reviewer, this was a really good project. While the subject was subtle it may very well be the lynchpin of a decision to buy a hybrid or electric vehicle, because it answers two perplexing questions including where and who would repair the reviewer's car when something goes wrong and how much it would cost. Considering the payback for \$600,000 of expenditure, this program may very well yield the highest expenditure to return ratio. The reviewer commented that people make decisions to buy more on the service support than perhaps anything else, especially when it comes to big ticket items like a car. If DOE's objectives of petroleum displacement rely on a significant number of Americans switching to electric vehicles, then service becomes, in many cases, a make-or-break factor. So this project is important to the overall buying decision made by Americans.

The third reviewer stated that training, and education programs such as these are of value in providing EV and HEV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of advanced electric drive vehicles, resulting in the DOE objectives of petroleum displacement.

The fourth reviewer remarked that education is needed for the new generation of auto technicians to become familiar with electric drive vehicles. The fifth reviewer commented this project would lead to sustainability with satisfied customers of PEVs and HEVs, purchasing these vehicles in the future, spreading positive feedback to their neighbors, and getting good performance from their current vehicles. Greater penetration would lead to greater petroleum displacement. San Francisco is the third largest market for HEVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

According to the first reviewer, the strategy for deployment was sound, and this reviewer observed that two college classes with an evolving curriculum at two different colleges, a fleet training program, and independent tech training were good first steps. The overall program called for expansion to four colleges and one in a neighboring state, the fourth fleet training, and independent



training to third California location and one to a neighboring state. Again, for the money their work was aggressive and the plan appeared to be sound.

The second reviewer remarked that with a small budget, the project has managed to successfully create and deploy education and training content and classes addressing a local need for a gap in workforce in EVs and HEVs.

The third reviewer observed an interesting and accurate observation that maintenance of advanced technology vehicles was going to move increasingly outside of factory-trained dealer networks as vehicles age past their warranty periods. A three-county survey showed that working technicians generally do not want a program, just specific courses. This reviewer questioned whether a three-county survey was sufficient to reveal statewide or nationwide training needs.

According to the fourth reviewer, although this can be tough for community colleges, better integration with the automotive manufacturers is needed for technology or equipment support. This reviewer was not sure the community college should be given this task, and questioned whether DOE can help with this.

The final reviewer remarked that the baseline for students enrolled in this course to know automotive electronics. The program is reaching automotive mechanics beyond the dealer network. Many HEVs are older and have no warranties so this program is important to keeping performance and customer satisfaction for this technology and future purchases of advanced vehicle technologies. Working technicians are hard to attract and just want specific course or courses on the weekends or at night. This program has adapted to these needs. But greater penetration could be generated by talking to the owners of the independent stations who may see a market opportunity as having skilled technicians in this area. This program is also reaching automotive courses at high schools. The program has been or will be expanded to 10 community colleges in California and one in Oregon.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses regarding the technical accomplishments. The first reviewer noted that the project has done a really good job; the program has expanded and brought other fleets and schools into the process. By 2012, the project will have three independent tech programs, which is not bad when considering the funds in the state that has the most hybrid or electric drive vehicles.

The second reviewer thought the goals and milestones were appropriately met, and that the project is addressing the barriers detailed during the presentation. Also the presentation addressed future barriers along with current barriers. According to the third reviewer, the City College of San Francisco (CCSF) appears to be on or ahead of schedule with regard to milestones, with one or two exceptions. This reviewer observed that the students were learning about safety and fluid changes and diagnostics, but not as much about how to actually repair components and systems. CCSF reported a useful list of lessons learned.

According to the fourth reviewer, some barriers to success are having enough local resources to obtain a PEV or HEV vehicle to work on in the classroom. Having additional diagnostic software is needed so more students have access to learning. Union issues have been a barrier to the San Francisco fleet manager program, preventing attendance on weekends as overtime needs to be accounted for. Students want individual courses, not certification programs, and timing needs to be adjusted to weekends or nights, but not too frequently for working technicians. These barriers were noted by the speaker, and the CCSF adapted or modified direction in a timely manner. Community colleges appeared to be quite eager to offer this training. Safety is always the basis of the course then operational issues. A survey led to addressing much of the lessons learned and then developed course corrections.

The final reviewer perceived that it was tough to gauge progress based on the presentation, other than some courses that were provided. This reviewer would like to know the number of students, fleet maintenance personnel, and independent technicians this program has reached.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally perceived strong collaboration. The first reviewer remarked that within the purview of this program there was noteworthy collaboration with Pat's Garage and Perfect Sky, who were working to increase the training and information about the history, benefits of electric drive vehicles. From all indications, partners were onboard and fully supportive of the college's efforts.

The second reviewer thought that collaboration level appropriate given scale of project.

Another reviewer thought that some higher level collaboration was needed, but very good collaboration with local shops.

The fourth reviewer observed that the college seemed to be working well with other community colleges and were partners of NAFTC. This reviewer assumed the automotive technician curriculum was developed in partnership or was peer reviewed by NAFTC. The reviewer suggested that greater collaboration with local Clean Cities could help with finding outside speakers, resources, coordinating high school or fleet programs, or other outreach activities.

The final reviewer thought that collaborations were adequate, but could be stronger, perhaps with the addition of Automotive Service Excellence (ASE), original equipment manufacturers (OEMs), or service manual developers, e.g., Haynes, Chilton, etc.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer observed that future activities were sound and in line with the overall goals and objectives of the project, and it appeared to be at budget and on time.

Another reviewer thought future activities seemed reasonable. This reviewer observed that the computer-based training aid idea might merit further work. The same reviewer suggested that a hardware-in-the-loop approach might make sense and elaborated that a part that is not operating correctly could be diagnosed while the rest of the vehicle systems are simulated.

The third reviewer would like to know whether funding was available to keep the curriculum updated and to expand the program to other colleges and high school. This reviewer would also like to know what the plan was to raise additional revenue streams. But, according to this reviewer, the program has exceeded its goals in the number of colleges it set out to reach.

The fourth reviewer observed that a major barrier was equipment. While this was not a \$1-5 million project, it was a \$500,000 project and it seemed little was used for major equipment.

The final reviewer would like more information presented on the paths of sustainability of the program.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers thought resources were insufficient. One reviewer marked insufficient not because the work cannot be completed, but because the project should be given a greater level of funding for follow-on work. A second reviewer remarked that the project may need a three-month extension to December 2012. Perhaps having one additional staff member could have helped community colleges find donated vehicles, funding for additional software, finding guest speakers, developing fleet manager programs, and building high school programs. Three reviewers thought that resources were sufficient. One reviewer commented that accomplishments appeared reasonable given the relatively limited resources available.

Idaho Petroleum Reduction Leadership Project: Beth Baird (Idaho Petroleum Reduction Leadership Project) – arravt041

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer responded that the project has not only achieved its goals but exceeded it by a long shot. The reviewer noted that this program should be the poster child for DOE. Not only did Republic Services switch the funded vehicles over to CNG, but the project was so successful that Republic Services decided to switch their entire U.S. fleet over to CNG. This reviewer thought that that the potential 800 vehicle changeover was amazing.

According to the second reviewer, this project displaced petroleum through conversions to CNG that would not have occurred without this project and the persistence of the coordinator.

The third reviewer remarked great job implementing vehicles correlated with infrastructure. The fourth reviewer observed a good amount of petroleum fuel displacement, and that this would lead to more displacement by Republic Services and other fleets.

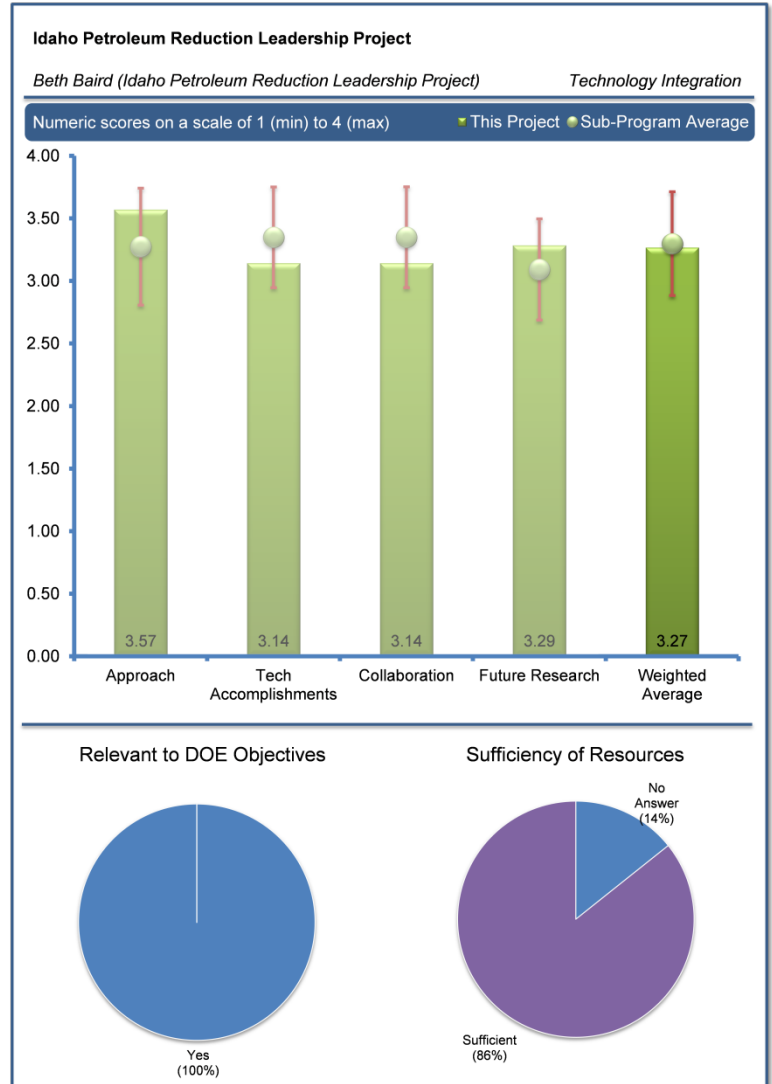
The fifth reviewer observed that the purpose was to introduce CNG as a viable fuel in Idaho, plus raise awareness of it. The project also included at least one national-presence partner, who moved forward with CNG in other areas based upon this project. Jobs were not a primary focus of the proposed project, but the project did see some created along the way.

The sixth reviewer commented that this project was relatively modest in terms of budget but maximized its effectiveness by targeting a large fleet that saw heavy daily use and was very visible to the public. This reviewer observed that Republic Services made the commitment to switch to a cleaner fuel and based on the success of the pilot program in Boise, has decided to switch over more of their fleets nationwide to natural gas. This reviewer considered that a resounding success. This reviewer also observed that the project has resulted in 4 fuel facilities installed, 29 trash trucks and 4 support vehicles.

The seventh reviewer commented that the project achieved a very high majority of goals, good outreach and education, and achieved a significant degree of fuel use and vehicle emission reductions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer recognized a great deal of work up front to assure the success of the program from the start. This included working the political side of the equation by instigating clarification of an Idaho Public Utilities Commission Rule to expressly allow resale of natural gas for use in vehicles. This could have been a major barrier to implementation. Efforts also included raising awareness of the benefits of using CNG and its availability to fleets. The PI worked this award from beginning and really



kept the pressure on to make sure it was successful. This reviewer gathered that a lot of hard work and tenacity went into this project.

A second reviewer commented that the Idaho project appeared to have been well designed by choosing projects that were ready to proceed, exercising good communications with stakeholders, such as the PUC, monitoring construction of fueling infrastructure and maintaining good marketing strategy.

The third reviewer was impressed by how diverse barriers were overcome, such as permitting requirements, and observed that a workshop was held with an OEM, Cummins, which was a key to successful deployment. Another reviewer observed that regulatory and state barriers were overcome.

The fifth reviewer identified that a shovel-ready project was chosen for a greater chance of success. There was a simple fueling setup for the truck fleet at the company-owned overnight parking area. Permitting and CNG resale barriers were addressed and overcome early. It was a well-planned and executed project, albeit limited in scope to just one major fleet. The project spurred a significant investment by Republic Services in their other fleets nationwide, so it was a great return for the relatively small investment.

The sixth reviewer commented that outreach was kept as a key element because of the perceived issue in Idaho. The project took the approach of starting with a ready-to-go project to get some momentum, and had already completed all NEPA work for it. This reviewer observed that the project's approach focused on establishing a fleet, building the first public station in Boise, and doing outreach. A public survey was done early on to determine familiarity with CNG, and then the survey was used to focus outreach efforts. This reviewer's only concern was that the project was largely focused on only one fleet, though acknowledged it was positive to get that fleet to serve as a model, which it did. The reviewer further commented that given the budget size, it was a bit of a concern that the project was initially designed to only focus on that one fleet. Luckily, the fleet came through, reported this reviewer, and others did follow, resulting in greater petroleum displacement than proposed. The same reviewer cautioned that the approach could have fallen short if the target fleet had any issues. This reviewer would have liked to see probably three or so fleets targeted initially.

The final reviewer recommended documenting the permitting lessons learned. This reviewer asked how many PEVs/EVSEs would be deployed if the project team could start now.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally perceived that the project was making good progress. The first reviewer observed successful resolution of all the barriers that would have prevented the implementation of CNG into waste hauling trucks. The fact that the company now wants to convert its entire fleet is a testament to this success. One of the most important aspects of this grant was adherence to the motto "keep it simple." Shovel ready, find and make a win, and allow people to see the effects and get onboard with CNG as an alternative fuel. This was a great idea and a proven way to proceed and succeed.

The second reviewer commented that all targeted objectives were met and with measureable impacts. The third reviewer commented that the project reached goals. Another reviewer commented that the project was nearly complete and on schedule, and has returned a higher than expected reduction in petroleum at the local level, with the likelihood of much higher reductions nationwide as Republic Services continued the strategy on their own.

The fifth reviewer saw a clear focus on what the barriers were and still are. Permitting in particular was an issue. This reviewer observed that, overall, a smaller-scale project than many of other ARRA projects. This reviewer observed that the plan was to put in four CNG stations, which was accomplished, plus acquiring 28 CNG vehicles when 33 were actually acquired. Vehicles were primarily trash trucks, 29 total of these. The project included training for operator, maintenance, and tank inspector personnel, and also facility modifications. A marketing coordinator was hired to do the outreach part, and developed materials that could be used to move the project up the chain. According to this reviewer, overall, the project was looking at annual petroleum displacements

greater than proposed. Republic Services, which is a waste hauler, went CNG in other parts of country based upon this project. Another reviewer noted that the project reported the completion of 10 millstones and added 2 new ones in outreach and training with a community college. Project reported meeting or exceeding technical goals and introduced a significant amount of AFV equipment and infrastructure. Among these were technical training, shop improvements and a robust outreach and marketing campaign and fleet conversion due to opening of public stations. There was an effective pre- and post-public use of surveys to measure change in public awareness. This reviewer noted that the graphics used in the presentation should have been easier to read.

The sixth reviewer perceived that the issues were less technical and more logistical or political.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw effective coordination. According to the first reviewer, during the grant cycle a number of other partners stepped up, i.e., City of Boise, Valley Regional Transit, and the Taxi company, and it appeared by all indications that these partners were not just acting as recipients but as full-on marketing partners as well. Everyone was on the team and working to bring about real change, and this seemed like a real example of 21st century leadership.

The second reviewer remarked that the collaboration with the waste hauler as well as the communities was impressive. This reviewer liked seeing pre- and post-surveys on public awareness as well as calls to fleets. A reviewer commented the project appeared to have been an effective collaboration with local partners.

Another reviewer noted Republic Services has been an ideal partner, advocating the use of CNG locally and taking their CNG program nationwide to 14 other cities. Several initial targeted partners dropped out, while other fleets joined in that were not part of the initial target group. While only one other major partner was landed for this project, perhaps continued success of this program will spur others to take notice and participate in future opportunities.

A fourth reviewer observed that the project collaborated with other local fleets interested in converting to CNG since the stations opened. The reviewer noted that many have already moved toward CNG as a result of outreach and direct fleet contact approach. In Idaho, the cost of CNG was \$1.98/diesel gallon equivalents, versus \$3.80/gallon for diesel. So once the word got out, that was seen as the key to getting interest. Overall, though, this somewhat smaller scope project meant not that many collaborators/partners were anticipated. To be fair, this might be a function of the market, which is Idaho.

Both the fifth and sixth reviewers observed a fairly small amount of partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers perceived that the project has clearly identified future activities. The first reviewer commented this program was as solid as a rock, and that there was an understanding of what needed to be done. Necessary changes were learned and implemented as it occurred, and there was an effort to get more people involved as soon as the word hit the street. The reviewer referenced Thomas Jefferson who once said that states should be the experimental laboratories of the government; in many respects what was done in Idaho was a great example of what can be done to reduce dependence on foreign oil.

For the second reviewer, this project had already overcome its biggest barriers to success, so future activities would be on track.

The third reviewer perceived that the project goals have been met in terms of infrastructure, and future activities would focus on public education and reporting of results. Future goals were similar to other projects, with perhaps more emphasis on public education and building for future projects.

The fourth reviewer did not think much else was needed, and was glad that outreach is continuing. Another reviewer remarked that future follow up activities seemed to have been well thought out.

The final reviewer remarked that all key grant activities were done or nearly done; just finishing things off over next year and that most of the effort remaining appeared to be outreach.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers thought that resources were sufficient. One reviewer remarked the use of resources appeared to be optimum considering that the expense associated with new waste trucks was very high but the realization made by Republic Services that the cost truly justified the end and the switch to CNG. For this reviewer, this reflected that the use of funds and resources were sufficient to get this particular phase complete. This reviewer remarked that the program was well managed, has the momentum to succeed, and should be considered for future opportunities based on this performance.

A second reviewer commented that the allocated resource level appeared appropriate.

The third reviewer observed no indicated shortfall on funding. That makes sense, given that most of activities remaining are outreach.

A fourth reviewer remarked there seemed to be an efficient use of resources to achieve project goals within the established time frame. The final reviewer noted that the project was able to cover incremental costs to purchase a number of CNG refuse haulers and to help with infrastructure, and had money left for building public awareness.

Puget Sound Clean Cities Petroleum Reduction Project: Stephanie Meyn (Puget Sound Clean Air Agency) – arravt042

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Many reviewers noted that the project supported DOE’s objective for petroleum displacement. According to the first reviewer, after reviewing a number of similar programs, this reviewer walked away from the presentation thinking this was an honest program. The program has accounted for 50,000 gallons of fuel displaced and this was a believable figure when considering the number and types of vehicles put into use, which was 237.

The second reviewer thought that this project used multiple strategies to displace petroleum and successfully measured impacts.

The third reviewer observed a major displacement of petroleum.

A fourth reviewer perceived that the project clearly fell within the DOE objectives.

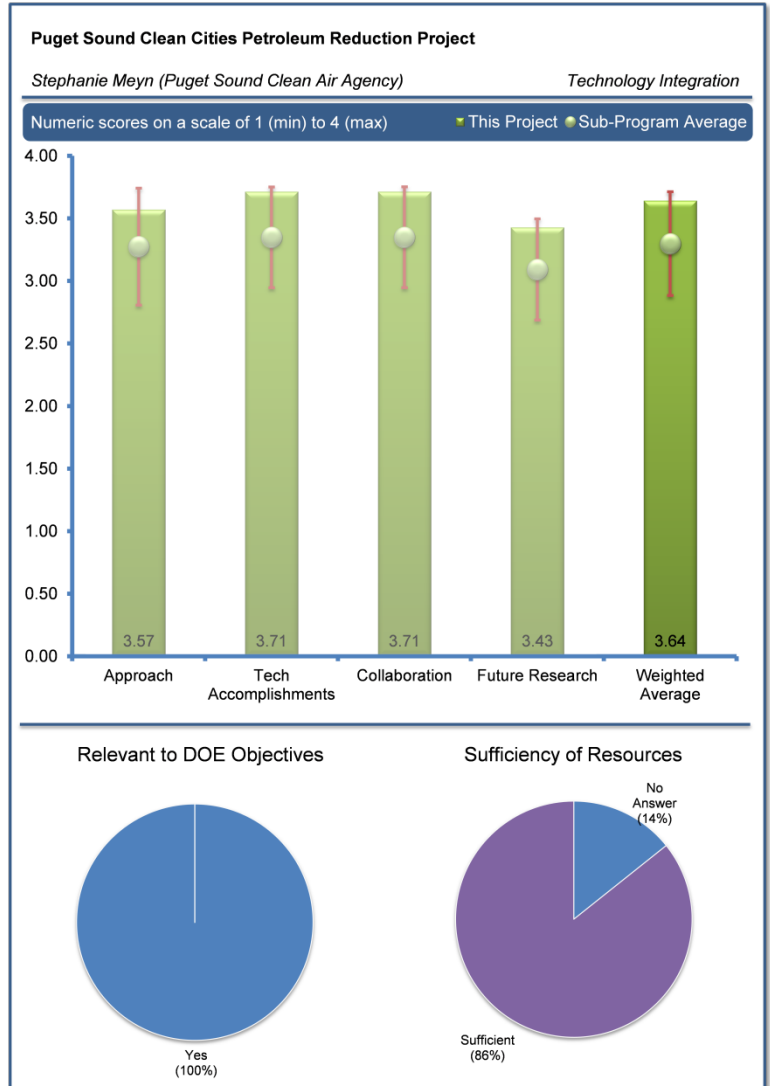
The fifth reviewer saw a wide range of vehicles and types of fuels. The project was leveraging existing CNG acceptance in the area. The reviewer saw a realistic approach that built on existing strengths in the market.

The final reviewer commented the project's goal was to reduce petroleum consumption, create a sustainable market for renewable alternative fuels, create/maintain jobs, and do public awareness through Sea-Tac Airport.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer was particularly drawn to the fourth graphic, which showed the breakdown of funds according to each of the program objectives, AFV stations, vehicles and education and outreach. This reviewer suggested that DOE should insist all programs do a breakdown of this type; this would help reviewers be more accurate with the math as to where the lion's shares of the funds were going. The reviewer observed that this was a simple but a wonderful slide. This reviewer would have liked an overall strategy statement of one or two sentences that summed up the spirit and intent of the program, but what was included in the presentation seemed to work just fine.

The second reviewer commented that this project was very complex, which created challenges. On the other hand, there was a diverse strategy that sought to offer appropriate solutions for diverse stakeholders, ranging from airports to rural communities.



The third reviewer commented that an innovative approach of leasing airport ground vehicles to the airlines by the airport, unfortunately did not work. Now the project has gone to plan B and approached each airline. This reviewer recognized that a dairy farm renewable gas project ran into roadblocks with a gas cleaning system. The reviewer recommended that perhaps complete, better research of feasibility before committing to unproven strategies.

The fourth reviewer liked the diversity of fuels and vehicle powertrains and observed a great focus on renewables. This reviewer was also impressed that each airline was approached individually. This reviewer would like to know what was learned from this process, and whether there would be any documentation.

The fifth reviewer observed that the project appeared to have been based on a unique strategy involving a good variety of relevant partners. Another reviewer remarked that a large complex project created many barriers and it was more difficult to overcome all of them. However, this reviewer thought that the redo in switching from RNG to CNG during the project was clever.

The final reviewer observed there were underutilized refueling stations (CNG and LPG), so the project focused most of the DOE funding on vehicles: 250 CNG/LPG, 220 hybrids, plus electric airport equipment. Hybrids also included electric-bucket utility trucks, which provided an opportunity for quieter operation as well as idle reduction. The strategy focused on the airport as a key opportunity. The airport had set a requirement for cleaner or alternative fuel taxis/shuttles, plus ground-support equipment. Many of the vehicles in the program were very high use (70,000 miles/annually) and visible within the community. This resulted in a relatively big bang for the buck. In addition, the airport was a critical factor used for outreach, including video, handouts, etc. The project also included developing educational materials to provide roadmap for projects. Overall, the reviewer observed a very good approach using a key partner (the airport), and relying upon existing refueling stations meant using most of money on vehicles (nearly 1,000 on-road and airport), resulting in a large project with relatively high long-term fuel displacement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress, and several reviewers commented on the collaboration with the local airport. According to the first reviewer, the project appeared to be well focused and thought-out by planning to achieve its goals by partnering with Sea-Tac airport, taxi fleets, and heavy duty trucks. The economic benefits, job creation, and small business development appeared to have been significant. Through use of signage, video screens at the airport, and driving training the project appeared to have been effective, and has also reported millions of gallons of conventional fuel displacement.

According to the second reviewer, these programs have a trickle-down effect as new stations and vehicles are introduced. The need for repair, maintenance, systems design and development people are needed, so the jobs creation portion of this program lies in the background but is evident. This program was ambitious especially the introduction of the program to Sea-Tac but it was admirable and necessary. Excellent progress was noted by the reviewer, with the introduction of 237 CNG vehicles and a 50,000 gallon displacement. According to this reviewer, the 200 taxis with Clean Cities' logos was a natural advertising campaign that would raise awareness of the implementation in the Seattle area.

The third reviewer noted that working with airports/airlines is complex. However, it appeared that the project has regrouped and is moving forward.

The fourth reviewer remarked that the project has put out two publications to help others understand and deploy alternative fuels. There have been significant strides with a number of fleets.

Another reviewer remarked that 60% of the budget had been spent, but that 85% of the project was complete. This reviewer observed that most of the non-outreach work was done, except for the airport ground-service equipment. The reviewer noted that there had been some hang-ups on working with the airport as a whole, so the project team had to retrench and go to each airline individually. The project was making progress, but slower than if the project had been able to work at an airport level. This reviewer observed that there have been issues with the renewable natural gas system, so there has been a focus on CNG

infrastructure for use by fleets. This reviewer also observed that the project installed fueling infrastructure for E85 (one station), biodiesel, and EVs (137). Biodiesel was coming from a local seed-crusher, so there was a local source for feedstock. The E85 station is only the fifth in the state, and was being used by city vehicles, police, and state EPA fleet vehicles. A new CNG-taxi company was formed, which created 120 jobs, plus a local conversion company grew from 3 to 19 employees. Overall, the reviewer noted very good progress; however, airport/airline issues remained. If not for those remaining issues, the progress would have been judged outstanding.

The fifth reviewer suggested capturing all of those ancillary benefits the presenter mentioned, such as hybrid bucket trucks being quieter and safer. The sixth reviewer observed that the project is still overcoming barriers with RNG and airport vehicle use.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw evidence of strong collaboration. The first reviewer remarked it appeared that the right partners were chosen, including four cities and municipalities/counties. This reviewer thought the project did a great job on collaboration and coordination of other institutions.

The second reviewer observed a lot of hard work had gone into partnerships. Clearly, this collaboration would not have occurred without the strong commitment of the PIs. The third reviewer noted the project had taken on a very large and complex project but had been able to maintain partnerships while working towards solutions.

The fourth reviewer thought CNG for Hire was an interesting startup and a good marketing/outreach benefit, and also observed a lengthy list of partners.

The fifth reviewer observed that the project team was working with many local governments, 14 in total; universities; and companies, including individual airlines. This included nearly all the local municipalities, plus a number of particularly large fuel users (airport, port, etc.). More than 50% cost-share from these partners was received.

The sixth reviewer thought that the Puget Sound project leadership selected a varied and effective array of partnerships including local colleges and universities, regional and local governments, conversion businesses, and etc.

The final reviewer was glad to see a linkage to so many municipalities as well as national programs like the EV Project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that airport ground support equipment work was still underway, and that the project was working with individual airlines. This reviewer noted that outreach was still underway. All else seemed to largely be done.

It was apparent to the second reviewer that the project was effectively working through issues with the airport. However, a resolution of issues with RNG was still unclear. The third reviewer observed that the project focused on addressing failed initiatives and overcoming infrastructure installation barriers, as well as marketing/outreach and reporting of results.

The fourth reviewer commented that the project appeared to have been successful in accordance with goals and objectives, and that future work was well thought out. The fifth reviewer expressed that the project summary was a bit overstated for the current timeframe; for instance, when the presentation indicated millions of gallons of displacement per year, the project's own figures said about 600,000 gallons were currently being displaced. Once the Sea-Tac program is online, then those numbers can be revised upwards. This reviewer advised caution in how the figures are used or stated.

According to the sixth reviewer, the complexity of the project would create challenges, but this reviewer appreciated the candor of the project implementers. The final reviewer wished good luck to the airport.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers thought that resources were sufficient. One reviewer remarked that with 60% funds expended so far and 85% of the work completed that the earned value numbers were very high. This reviewer commented “great job.” The second reviewer commented that funding seemed fine, and that more of project was completed than the budget. No indication of problems with funding. A reviewer noted that reported resources appeared sufficient to accomplish goals within time frame. Another reviewer commented it seemed there were adequate resources budgeted for the project.

Utah Clean Cities Transportation Sector Petroleum Reduction Technologies Program: Robin Erickson (Utah Clean Cities Coalition) – arravt043

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer remarked that this was a great project. According to the presentation, 1 million GGEs a year had been replaced by CNG vehicles.

The second reviewer perceived that private fleets as well as the public benefited from this effort. This reviewer was pleased to see that this project included school buses, which were not included in many other projects reviewed.

The third reviewer observed that the project was focused on CNG, LNG, hybrid, electric, and biodiesel use, and also included creating fuel corridors for AFVs. The project is extremely large in scope, and is displacing 1 million gallons/year, while also providing a base for others to add to that.

The fourth reviewer observed a substantial petroleum fuel displacement. The fifth reviewer stated that the project does support DOE's petroleum displacement objectives.

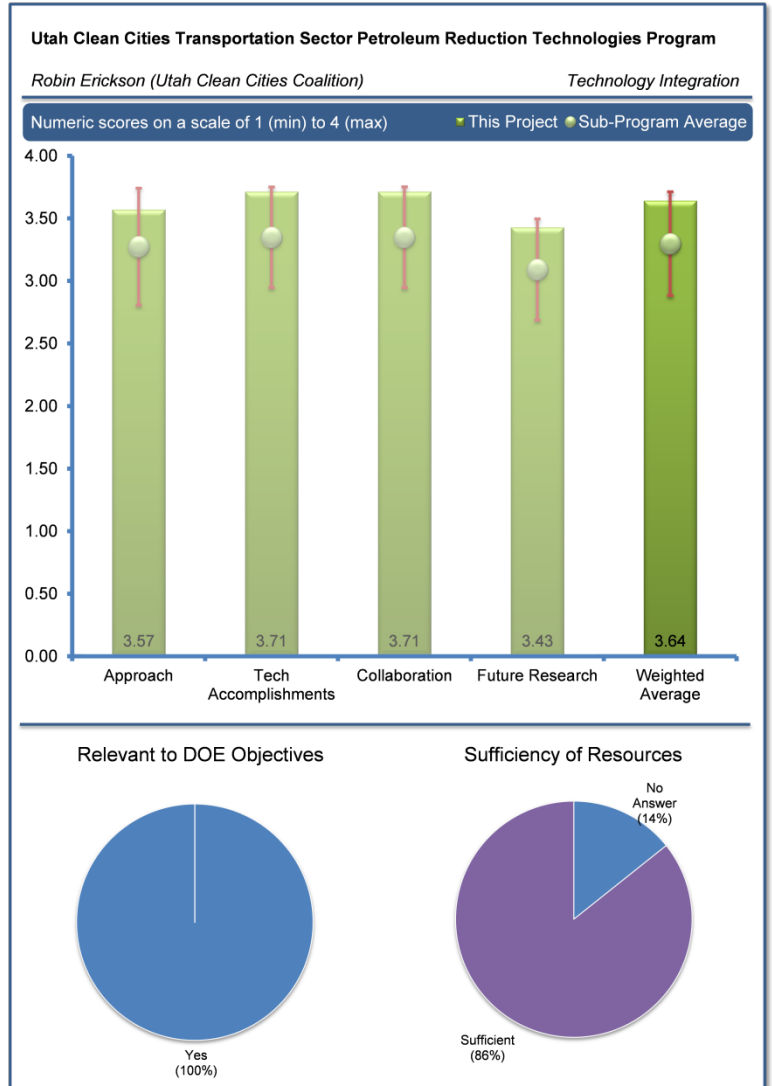
The sixth reviewer commented that there was a good diversity of vehicles and partners, both large and small. This reviewer also observed many upgrades and new stations, and perceived the project was getting a lot of bang for the bucks.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

According to the first reviewer, the project has achieved many goals in two and a half years of time with 80% of the work completed by mid-2012. This was astonishing considering that in the middle of the implementation the project had to endure a retrenchment with their partners, letting some go and bringing new ones on. The project implementers truly knew the meaning of the word agility.

The second reviewer commented this project's focus on a corridor made sense, and that the project also considered the economics in the state, including the work with Kennecott Copper Mine, in order to maximize outreach to a growth sector in the state economy.

The third reviewer remarked that the project was able to regroup after some folks dropped out. Another reviewer observed a nice focus on the contracts early on, and an excellent number of partners. The fifth reviewer noted a well-defined action plan and execution of strategy to accomplish goals.



The sixth reviewer observed that the approach focused on doing each required procedure, including contracts, NEPA reviews, etc., and then implemented the project. The reviewer noted that when problems with some stakeholders happened, the project team adjusted to move vehicles to other participants. This reviewer observed that in June 2011, the project team had to retrench, replacing 44% of stations/vehicles with original participants. The project team's strategy was to get a wide range of participants, particularly fleets, many with highly visible vehicles. This was what allowed the flexibility when the project team had to retrench and reallocate vehicles. This reviewer observed that, overall, it took six months to retrench completely, which was pretty good considering the extent to which changes were needed to be made. The project's overall strategy focused on many stations and vehicles resulted in a very high petroleum displacement, which can be built upon in the future.

The seventh reviewer observed that the project aggressively pursued project partners and enlisted a good variety. The project employed a sound strategy to build an alternative fuel corridor along major trucking routes and to deal with contracts and NEPA early in the process. This reviewer observed a good variety of alternative fuels included in the program and a large number of vehicles placed into service.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Generally, the reviewers had positive comments about the project's accomplishments. The first reviewer commented that accomplishments were impressive, and elaborated that one of the more interesting aspects of this project was the establishment of a resale market for vehicles which saw the resale at 10% to 30% higher than OEM vehicles. This reviewer observed that under this grant 19 CNG stations were upgraded, 34 alternative fuel stations developed, and 544 new alternative fuel vehicles deployed with 300 jobs created, and 1 million GGEs a year of petroleum displacement.

The second reviewer was pleased to see that the project had achieved 100% deployment by August 2011. The fact that the project was now having so many station openings was a strong indicator of success.

The third reviewer observed that the project was able to overcome many barriers of partnership and geography.

The fourth reviewer recognized that the project had issues with partners dropping out, but was able to re-connect with UPS for a crucial LNG fleet. The project plan was impressive with corresponding good results. According to this reviewer, the Clean Cities' coordinator's force of will had much to do with the success.

The fifth reviewer observed that project leaders demonstrated excellent planning and management skills to achieve goals, overcome barriers and accomplish project on schedule. Thirty-four alternative fueling stations have become operational and other goals have been achieved. Over 1 million gallons of fossil fuel have been displaced.

The sixth reviewer observed that the project team claims 80% of the project had been completed so far. Ninety percent of infrastructure and NEPA reviews were done now, 85% of AFVs deployed, 25% of training/outreach completed, and 100% of contracts signed with 33 sub-recipients. The project has opened 34 AF stations in total, including 1 biodiesel, 3 LNG, 11 electric charging, and 19 CNG stations along the I-15 corridor. The project also upgraded another 19 CNG stations, and saw much interest in CNG when petroleum prices increased. This reviewer observed that the project was currently displacing 1 million gallons/year of petroleum, higher than proposed, and a base from which more was expected to be added. This was highly impressive displacement, particularly concerning the issues that arose along the way. So far 100 jobs have been retained versus 115 projected.

The final reviewer would like to know how much fuel came from each stakeholder type and/or fuel type.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers saw that the project had many partnerships. The first reviewer observed a large amount of partners and a very complex project.

The second reviewer thought that the project obtained significant cost-share from partners. According to this reviewer, the DOE share was approximately \$15 million, while the recipient share was roughly \$37 million. The project team included 33 partners

overall: fleets, including private and public, plus mining; public stations; and private stations. The reviewer observed that the project even included a petroleum transport company running on LNG, and that universities and school districts were also included, expanding the opportunity for getting the word out on the project.

The third reviewer remarked the project achieved a very extensive array of private businesses, local governments and partners in formulating and executing goals.

The fourth reviewer observed that partnerships included 33 different partners from governments, municipalities, private corporations, universities and school districts. This reviewer believed that by spreading the effort to include a number of different partners, a word of mouth network had been built that would get other partners to join the effort.

Another reviewer thought the level of collaboration was good, especially for a predominantly rural state. The sixth reviewer observed that a variety of partners were enlisted, including a number of school districts. The seventh reviewer observed many partnerships, and liked the diversity.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, future activities certainly build on the work so far. The Fueling the Future educational supplements for schools as well as highway signage for station locations were solid endeavors to help the citizens of Utah work towards greater implementation of AFV vehicles.

The second reviewer thought that future activities seemed appropriate. The third reviewer commented that the project continued tracking success stories, and have planned a good slate of AFV workshop training and highway signage. There were still two stations to install.

The fourth reviewer observed 2 stations and 12 vehicles left to get going.

The fifth reviewer observed that the remaining actions included training and outreach, as well as highway signage. The project team was putting together success stories and tracking data. Nearly all vehicles were in place, but had two stations to go.

Another reviewer thought that sharing success stories and collaborations should be very effective.

The seventh reviewer cautioned that outreach plans seemed a bit thin. This reviewer would like to know plans for keeping the momentum of the vehicle and station users.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers found that resources were sufficient. One reviewer commented that the project's funding share was impressive with recipient share at three times what DOE's share totaled [DOE Program Clarification: Cost share is 2.5 times the Federal share (i.e., \$37 million recipient cost share and \$15 million Federal cost share)]. Another reviewer commented that no problems were identified, and that there was a very high degree of cost-sharing. A third reviewer thought that the project seemed to make good use of resources. The project spread the wealth to a variety of projects and fuels and allowed more sub-recipients to benefit. Another reviewer remarked resources appeared sufficient to achieve goals within the timeline. The final reviewer commented thought that a nice job was done matching funds.

SANBAG - Ryder Natural Gas Vehicle Project: Kelly Lynn (San Bernardino Associated Governments) – arravt044

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer observed a 100% petroleum displacement, and that the reduction of emissions by using a domestic energy source fully supported DOE's objectives of petroleum displacement and energy security.

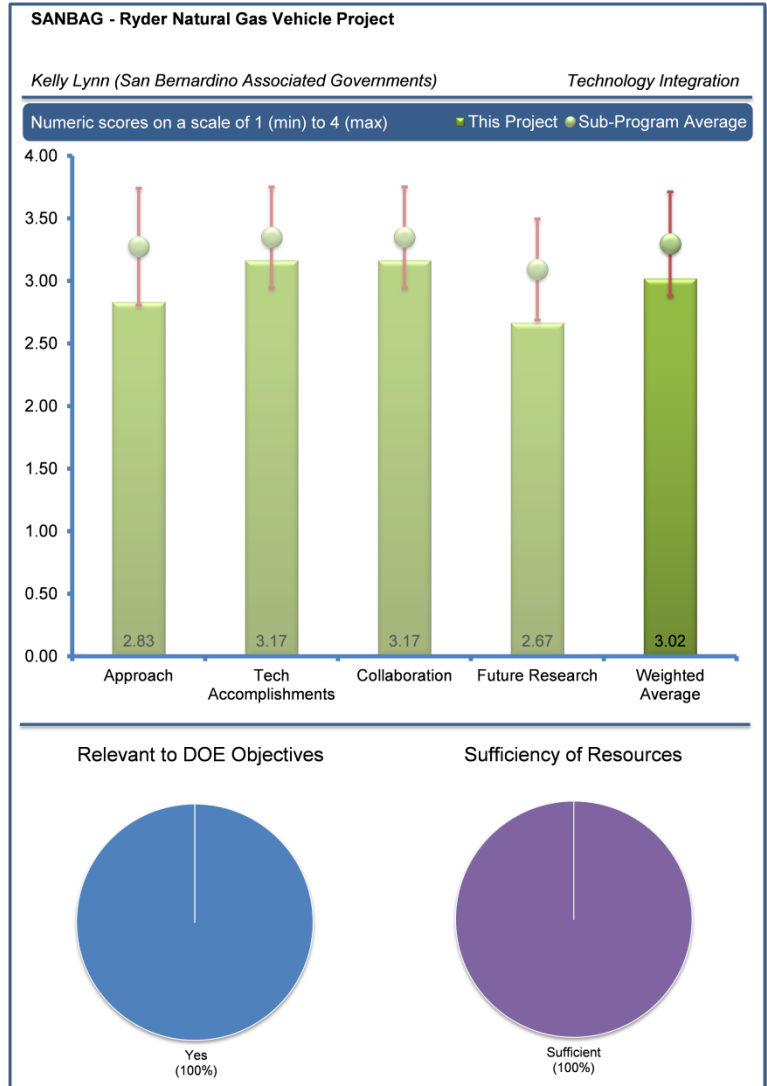
According to the second reviewer, by increasing the use of alternative fuels, this project supported the objective of petroleum displacement. It was estimated the project would directly displace 1.5 million gallons of diesel fuel by introducing 202 heavy duty natural gas vehicles. The project would also decrease particulate matter and NO_x emissions.

The third reviewer indicated that the project was on track to meet the stated goals of 1.5 million gallons of diesel displaced annually and the use of 3 million gallons of LNG used annually.

The fourth reviewer observed that the project would apparently displace approximately 1.5 million gallons of diesel fuel over its four-year project life. However, according to this reviewer, the presentation did not state what timeframe the 1.5 million referred to. Clean Cities Recovery Act applications called for such calculations over four years; however, the presenter did not know. The presentation did not provide any explanation of the estimate but Ryder Truck presumably had a sound basis for making such estimates. However, it must be assumed that the estimates come from Ryder –again there was no explanation, which should have been provided.

The fifth reviewer commented that this was the first and also the largest natural gas truck deployment in commercial leasing and rental operations. This \$20 million project was going to pay for incremental costs of 202 new natural gas trucks and fund the installation of 2 LNG and CNG stations. This reviewer further observed it was part of a larger regional corridor project, the Interstate Clean Transportation Corridor (ICTC), and it was projected to have 400 green jobs. The same reviewer further reported that it was projected to reduce annually 1.51 million gallons of fuels, 4.2 metric tons of GHGs emissions, and 131 tons of NO_x and completely eliminate 2.65 tons of diesel PM emissions from local neighborhoods, but pointed out it was unclear what these metrics were based on. This reviewer questioned whether the metrics were based on purely replacing 202 trucks with diesel with natural gas, and inquired whether this grant funding was accelerating compliance with state environmental policies.

According to the sixth reviewer, this project is expected to displace 1.51 million gallons of diesel fuel. However, it was unclear how the grantee came up with these estimates. This reviewer questioned whether it was based on the 202 trucks or other vehicles as well. The reviewer inquired whether the presenter could provide more explanation. The presenter stated it was the largest commercial leasing fleet in the nation operating on natural gas. This reviewer observed that this project fulfilled the needs of a



large multi-state regional corridor and expected creation of 400 green jobs, which was significant if accurate. The commenter remarked that it would be helpful if DOE asked all the presenters to provide a return on investment for all areas, including jobs and petroleum reduction. This reviewer also observed that the project anticipated 4.194 metric tons of GHG reductions, 131 tons of NO_x reduction, and 2.65 tons of particulate matter PM reduction. These figures were based on 202 trucks. This reviewer understood that the project also installed two to three public stations, but this was a little unclear. The presenter mentioned that Ryder was looking for grants to promote further use. It concerned this reviewer that this project seemed dependent upon future funding for growth. According to this reviewer, the presentation's estimate of 400 jobs created appeared excessive and lacked credibility, particularly if only the net job creation was counted, as it should be. The presenter stated that the estimates had been generated by the project consultant and believed that the project included numerous Ryder employees who would presumably have been employed without the project, irrespective of whatever fuel configuration its trucks were. But this does not impeach the credibility of the fuel displacement estimates for the reasons stated above.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

According to the first reviewer, the technical barriers were relatively low as LNG is an established technology. However, there were economic barriers in terms of capital investment. With the cost of natural gas so low, the timing for this project was excellent.

The second reviewer commented that all 202 heavy duty trucks have been delivered and the plan of where the stations are to be put at the Ryder facilities would fill in the infrastructure needs nicely. A concern of this reviewer was that permitting had been slow in coming for one of the stations. It would be a big plus to the project if the permitting took place by August and November of this year. This reviewer was encouraged that everyone had been impressed with the power provided by the trucks because that was a concern early in the project.

The third reviewer remarked that while it would have been preferable to have included multiple vehicle owners or operators in the project, if a single owner was used, Ryder is one of the best choices because its trucks are leased to multiple businesses, many of which had already committed or expressed a desire to rent the LNG trucks. These businesses can be expected to provide additional visibility to the use of LNG and to provide examples for other regional centers within their companies.

The fourth reviewer observed that the strategy was to pay for the incremental cost of 202 heavy-duty natural gas trucks and to install 2 LNG/CNG refueling stations. The plan was to work with a national leasing fleet, specifically Ryder, with the expectation of future growth. The national partner also had a lot of exposure to private consumers for a good long term outreach strategy. According to the presentation, Ryder has over 1,200 customers. Ryder also has an influence with the OEM based on their purchasing power. This was good for the long-term strength of this project. The reviewer cautioned that although this was a good approach, it would be nice to see Ryder make more of an initial investment in the project, especially if the cost savings were significant to them.

The fifth reviewer observed that the project was going to pay for incremental costs of 202 new natural gas trucks and fund the installation of 2 LNG and CNG stations. This project got slowed down because it had to replace its main commercial partner with another partner. The replacement partner, Ryder, turned out to lend a tremendous amount of credibility to the project because of its AAA access to commercial customers such as Kraft, Staples and CVS. Ryder has over 1,200 customers that will magnify the penetration of the impact of the project. Additionally, because Ryder is a big truck customer it also has the ability to influence the OEMs and Tier and Tier 2 suppliers. The Rancho Dominguez station was completed in May 2011. It was unclear to this reviewer when the Fontaine and Orange stations would be fully operational, but hopefully soon. Two-hundred and two natural gas (CNG and LNG) Peterbilt and Freightliner vehicles were delivered by December 31, 2011. The project was placing stations in gaps along key, West coast corridors. This reviewer noted that the approach had to be altered and appeared to have altered in a constructive manner, but DOE needed to monitor that this project stays on track. No good explanation was supplied about forthcoming data tracking regarding actual numbers of displacement fuels and emissions reductions.

While the sixth reviewer acknowledged that the project was on track to meet stated deployment goals, issues remained with the completion of the City of Orange refueling site. The presenter stated there was an education curve for staff, and that a list of other cities was provided in the Los Angeles metro area that had completed similar projects. Presenting this list and setting up meetings with other city officials could have happened earlier and contributed to quicker completion of the permitting and station construction. This reviewer believed that more information on how Ryder promoted the trucks to their leasing customers would have been helpful in the review.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses. The first reviewer stated that a majority of objectives and goals had been met, save the Orange refueling facility and maintenance shop upgrades.

The second reviewer remarked that having all vehicles delivered and one station built showed good progress. The estimates of fuel savings and emissions reductions were very encouraging but would need to see if these estimates were realized after the operational data was analyzed. The new station locations in this project help to fill in the needed infrastructure in the area.

According to the third reviewer, there appeared to have been some early project restarts as some partners withdrew. However, having a very well established partner like Ryder may have made the project stronger as it provided access to 1,200 potential fleet customers. It appeared that vehicle deployment was predictively on schedule but the refueling stations were seriously behind schedule. The approach Slide map showed three Ryder labels while the text indicated that only two stations were constructed, which was a bit confusing. Also, the exact timing of station openings and vehicle deployment was a bit confusing and it appeared to not be perfectly timed.

According to the fourth reviewer, reasonable progress had been made despite a substantial delay due to the default of the original fleet owner partner, which was not identified nor was any explanation given of what happened. The project schedule shown in the presentation would be only about six months behind what it should have been according to the original Clean Cities ARRA requirements, which was reasonable under the circumstances. This reviewer cautioned that the presenter did not know about data collection on use of the trucks, refueling, and etc., which was required of the ARRA grants. Siting of refueling sites seemed well chosen to fill gaps in the region.

Another reviewer observed that the project was delayed due to partner switch and permitting problems, but these were resolved. The project managers have identified valid locations for its refueling stations to fill in the gaps of natural gas availability along key corridors. NEPA paperwork and permits are done, the Orange County permit is not done yet, but close, and construction will take place this summer. The approach had to be altered and this slowed down progress. DOE would need to make sure objectives continue to stay on track in a timely fashion. According to the slides, the vehicles, including 202 CNG/LNG, were ordered and delivered around the beginning of the year. This reviewer did not know how these vehicles were performing to date. It did not appear that training, such as for drivers or technicians, had been done yet to support these vehicles. This reviewer observed that the Rancho Dominguez facility was completed in May 2011, and that two more stations have yet to be constructed. However, it looked like one more station than was originally proposed would be constructed. It was unclear whether the project was on target to achieve the petroleum reduction goals. This reviewer suggested that DOE needed to continue monitoring this. The reviewer noted that no jobs creation or maintenance data were presented, but 400 were projected. The reviewer suggested that DOE follow-up on this over the course of the project. The DOE grant is paying for incremental costs for the alternative fuel truck expenses, as well as refueling infrastructure, which is not yet done. CEC paid for the trucks, which is complete [DOE Program Clarification: CEC as well as DOE helped to pay the incremental costs of the trucks. The project reports jobs data on a quarterly basis to DOE and supports the jobs data in that report.].

The sixth reviewer noted that this project got slowed down because it had to replace its main commercial partner with another partner. The lengthy permitting process for new LNG and CNG stations has also slowed progress. The Rancho Dominguez station was completed in May 2011. Pursuant to a slide in the presentation, 202 natural gas (CNG and LNG) Peterbilt and Freightliner vehicles were delivered by December 31, 2011. Two more stations have yet to be constructed but would be constructed hopefully

soon. This reviewer suggested that DOE should closely monitor the progress of these two stations and when construction begins. No actual jobs data was tracked other than initial 400 count projections supplied to the reviewers. It was not clear what training for drivers, maintenance workers and service station attendants has been developed and implemented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally perceived strong partnerships. The first reviewer noted that collaboration was very good and the use of SCAG would help get the word out about the project to the community.

While the second reviewer thought the list of project partners was fairly short, it included the necessary players to carry out the project due to Ryder obtaining commitments or interest from numerous lease fleet operators. It would have been preferable to this reviewer to have gotten these entities to commit to becoming partners in the project but, if their interest was as stated in the presentation, their participation would be adequate for the success of the project.

The third reviewer noted that collaboration with the project partners appeared to be sufficient, as the presenter stated many groups within the partners and projects had ongoing collaboration and communication.

The fourth reviewer remarked that this project had some great partners. This was still a good project even though a major national truck partner departed and Ryder was recruited. The replacement partner, Ryder, turned out to lend a tremendous amount of credibility because of its AAA access to commercial customers such as Kraft, Staples and CVS. Ryder has over 1,200 customers that will magnify the penetration of the impact of the project. Additionally, because Ryder is a big truck customer it also has the ability to influence OEMs and Tier and Tier 2 suppliers. This reviewer observed that major partners include CEC, San Bernardino Associated Governments (SANBAG), and Ryder. This was a multi-state highway corridor project and must have required coordination in this regard. This reviewer suggested that SANBAG may want to consider recruiting other partners to use the stations. Two more stations had yet to be constructed but would be done hopefully soon, one each in Fontaine and Rancho.

The fifth reviewer commented that the project management pulled together great partners: CEC and Ryder. In spite of losing a large partner, this project secured another great partner in Ryder. CEC is fulfilling its commitments by providing \$9.3 million for the incremental cost of the vehicles. This reviewer hoped San Bernardino continued to work with Ryder to provide a long-term educational outreach program to continue growth. This reviewer remarked that this would be rated higher if SANBAG secured other fleets to use the retail stations.

The final reviewer stated that while the SANBAG and Ryder partnership appeared strong, there does not appear to be a collaboration with any universities or laboratories, which was probably not needed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed comments pertaining to future activities. The first reviewer remarked that the project seemed to be on track in terms of viable timetable for construction of stations and acquisition/deployment of vehicles despite being behind original schedule. Plans for outreach and monitoring were included as required.

According to the second reviewer, future plans were adequate but success hinged on the successful permitting of the stations. It was not clear to this reviewer exactly what data would be collected and how it would be analyzed.

The third reviewer stated that future plans appeared to be well thought out, though it seemed that the issues with the Orange refueling station have taken the focus off of future marketing, collection, and reporting for the time being.

The fourth reviewer remarked that it was unknown when the Orange and Fontana sites would be developed. [DOE Program Clarification: The presentation on Slide 5 indicated that there will be a Ribbon Cutting Event for a station opening in the Summer of 2012. This station would be the Orange Station.] There was no indication that other fleets will be solicited to introduce additional LNG vehicles. It appeared all 202 vehicles were deployed prior to station construction. Actual monitoring methods were

unknown. Given the deployment of vehicles before fueling infrastructure was installed suggested that the development pathways were not well planned.

The fifth reviewer said that this project still had a long way to go before completion. Milestones include obtaining Orange County's permit, installation of 2 natural gas stations, feedback on how the 202 vehicles were performing, and consumer feedback. The reviewer questioned whether the project was achieving the overall DOE program goals of fuel displacement and jobs created. Additionally, the reviewer inquired about the overall long-term promotion efforts. While the presenter said there was a plan, little information was provided during the presentation. Finally, this reviewer wondered if the future of this project was dependent upon additional grants to continue its success.

The final reviewer questioned why Ryder was only contributing \$642,000 to the project as represented in the budget if the project really was achieving cost savings based on Ryder's contribution [DOE Program Clarification: It should be noted that the cost of the base vehicle by Ryder is not included in the cost share calculation]. Furthermore, the partners had a plan for securing more participation from Ryder going forward but their limited contribution to the total \$20 million budget seemed small. This reviewer observed that two more stations had yet to be constructed but would be done hopefully soon in Fontaine and Orange. The reviewer suggested that DOE closely monitor the progress of these stations and when construction is underway. This reviewer highlighted the need for data collection of the performance of the 202 vehicles, and questioned whether relevant ARRA metrics needed to be supplied. This reviewer would like information on actual job creation. Continued media, communications, education awareness and outreach plan is needed and required. This reviewer suggested developing and implementing training for drivers, maintenance workers and service station attendants, along with the development of a manual for first responders and truck drivers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers indicated that funding was sufficient. The first reviewer commented that resources appeared to be in-line with project needs, and the second reviewer commented that funds were sufficient for this project.

The third reviewer remarked that this \$20 million project was going to pay for incremental costs of 202 new natural gas trucks and fund the installation of 3 LNG and CNG stations, which is 1 more station than proposed. However, it was unclear to this reviewer what DOE's return on investment was as there was no data supplied to track on achieving the goals of job creation, fuels displacement and emissions reduction. It would be helpful to know how much of funds had been spent, and on what portions of the projects money has been spent, as this reviewer could not tell.

The fourth reviewer assumed that the 202 vehicles were operating without the construction of the fueling infrastructure at the Orange and Fontana sites, so this called into question why those were even needed, thus the appearance of possible excessive resources.

Another reviewer remarked that Ryder was said to be contributing \$17-\$19 million of its own, although the recipient fleet owner was only required by the budget to contribute \$600,000, which would have represented a major windfall. It would have been preferable that the presentation explained what the \$17-\$19 million represented. This reviewer questioned whether it was only the base cost of trucks that Ryder would have been purchasing in any event. If that were the case, the resource commitments by the combined federal and state governments could be seen as excessive.

According to the final reviewer, this project seemed to have sufficient funds to accomplish the vehicle deployment and the construction of three stations, which was one more than proposed. But it was unclear whether or not future funding was needed to sustain this program over the long haul. It was still unclear to this reviewer whether or not DOE was getting a good return on its investment because the project was not complete. It appeared to this reviewer that this project might just be using DOE funds to accelerate compliance with state mandates. This was something DOE should take into consideration when funding projects.

Heavy-Duty Natural Gas Drayage Truck Replacement Program: Vicki White (South Coast Air Quality Management District) – arravt045

Reviewer Sample Size

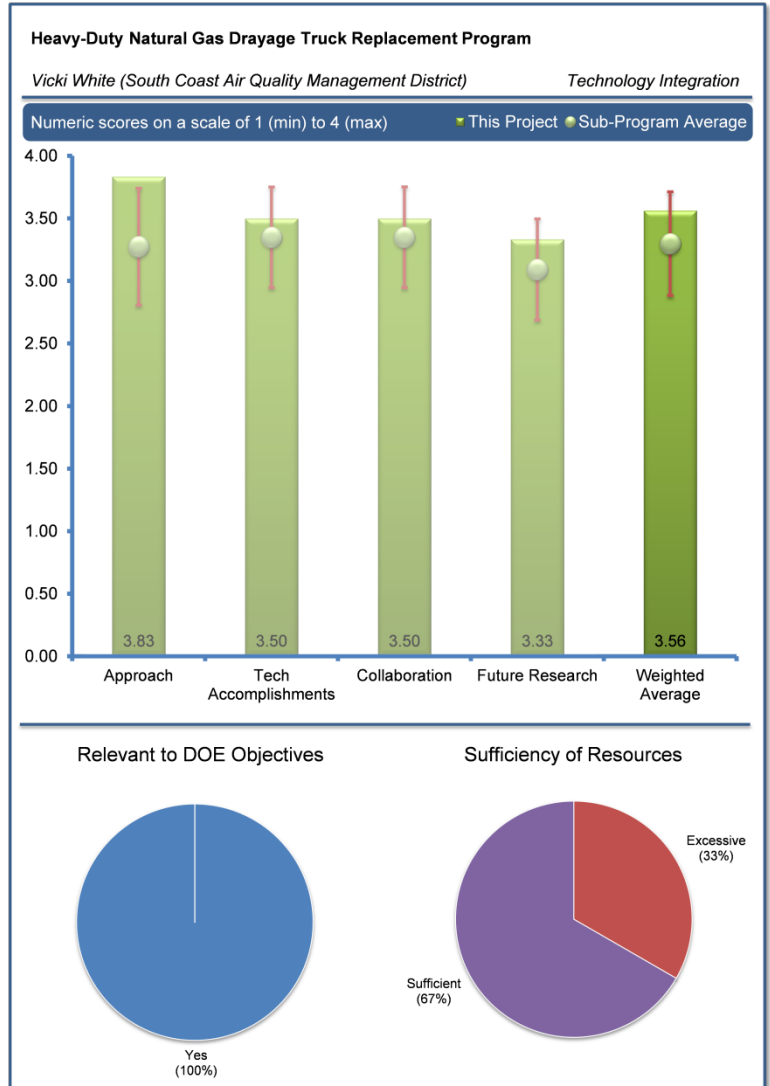
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally agreed that the project met DOE objectives. The first reviewer remarked that this was a great project. The overall project is 88% complete with procurement and deployment. The project expects the rest by the end of the year. This project focused on retiring old trucks and replacing them with natural gas trucks. These vehicles would not have been purchased without the grant. This project was effective in maintaining jobs that would otherwise have been lost due to more stringent environmental standards. This reviewer perceived a double win because of jobs saved and the creation of a new demand for clean burning technologies. Potentially 68 jobs were created but the presenter was a little unclear on how many were actually retained. The presenter indicated that the number of trucks expected to be replaced under this grant would be 219 LNG trucks.

The second reviewer commented that by deploying more than the original estimated amount of LNG trucks that the project has been effective at increasing the amount of petroleum displacement.

The third reviewer remarked that the project scope included replacing and retiring older diesel trucks that serviced the Ports of Los Angeles and Long Beach with natural gas trucks. Originally the scope was for 180 natural gas trucks but due to the successful leveraging of the grant funds, 219 natural gas trucks would be funded. This project increased the use of alternative fuels and reduced the consumption of diesel fuel. State estimates for the 219 trucks were 198 tons a year of NO_x emissions and 9.2 tons of diesel PM emissions annually over the 15 years of the projected useful life of the new natural gas trucks. There was an estimate of a 25% GHG reduction, however, the partners have plans to start tracking the petroleum and emissions reduction more closely and have radio frequency identification tag (RFID) installed in each truck as part of the project. The RFID is used to record trucks' usage in the Ports. Quarterly reports would be submitted by new natural gas truck owners so data is scheduled to be compiled and available to evaluate. This reviewer also noted an estimated 68 jobs created or retained. The project was effective also in retaining operator/owner fleet jobs that may have been lost due to California's new stringent environmental rules. This project was a winner two-fold in that new reliable and effective clean technology was deployed and that there were measureable, economic development benefits to the Ports community.



The fourth reviewer commented that the project would result in the deployment of 219 Class 8 LNG tractor trucks for use in drayage/delivery of freight from ports of Los Angeles and Long Beach. This would displace petroleum accordingly, with an equivalent volume of diesel used for this high fuel use application.

The fifth reviewer commented that it is unknown how much petroleum would be displaced, as the presentation made no mention of petroleum displacement levels. While cleaner exhausts were clearly a positive, DOE's primary focus was on petroleum displacement. However, this project would reduce petroleum use.

The final reviewer affirmed that this project is very relevant to the goals of DOE to reduce the use of petroleum by replacing diesel engines with natural gas trucks. However, the presentation did not make this apparent, and this reviewer does not recall a question about the amount of petroleum displacement being asked.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that project barriers have been successfully overcome allowing the project to move forward nicely. The requirement to have the old trucks scrapped and for the applicant to show a high use pattern would insure that maximum emissions and oil displacement benefit would be realized in the project.

The second reviewer observed that the project appeared very well planned. Solicitations issued resulting in more applications than could be funded so the grantee selected sub-recipients based on cost-effectiveness, fuel use, age or technology of truck being replaced, and etc. Multiple solicitations and awards have been already carried out, and trucks replaced must be scrapped. This reviewer thought that the project was particularly well focused in terms of addressing severe pollution and public health problems from air pollution in the heavily populated, low-income residential areas adjacent to the ports.

Another reviewer indicated that it was fabulous that the grant only paid for incremental costs of new technology and the old technology was scrapped. The reviewer also questioned the incremental cost of \$150,000 per vehicle [DOE Program Clarification: \$150,000 per vehicle is total cost.]. This reviewer also inquired about the expected payback and noted that the presenter indicated this would not be achieved without the grant. The grant managed a solicitation to secure sub-recipients and made sure sub-recipients were operating near the port where there was refueling. Over 1,500 applications were received. This reviewer remarked that the project approach to performing the work was nicely done. The project also did a lot to provide public outreach, and also assisted those who could not fill out the grant application which was nice. The grant developed a list of lenders for a long term sustainable program which was wonderful. The reviewer also commented that the grant included an emissions inspection before scrapping the vehicle under the program. While the reviewer liked this approach, the downtime on the trucks was significant, and there were a lot of mechanical concerns. This reviewer was interested that the grant eliminated trucks that were not otherwise going to be removed. Diesel emissions in this location were identified as high- and at-risk locations. Emissions reduction is key to regional goals at this location. However, this reviewer questioned whether DOE was paying for compliance for a program that would otherwise achieve the same goals without the grant in another year or two.

The fourth reviewer commented that the project partners and managers quickly realized there was an issue with communication and language barriers and implemented a translation program for applicants. Project managers also ensured each applicant had one-on-one assistance with completing their application and information for loan providers and financial opportunities.

According to the fifth reviewer, there are minimal if any technical barriers, as LNG is a well-known technology, so none are being addressed. However, the project is deploying LNG vehicles at a rate that appears to be faster than planned. Given the fairly short distances and near repeatable missions, this was an excellent use of LNG for truck transportation.

The final reviewer observed that this was an RFP process. Several funding opportunities were released, resulting in over 1,500 applicants. This was an impressive and time-consuming project that required one-on-one meetings with all fleet owners that participated. Note that four different foreign language translation services were required and secured as some small business fleet operators were not fluent enough in English to understand program requirements such as technology and financing. The reviewer

observed that the average price of the new natural gas truck is approximately \$150,000 - \$175,000. The average grant award per truck was approximately \$75,000. The gap between the grant funds and purchase price was significant so the project partners worked closely with lending institutions to help small business fleet operators secure loans for the balance of the truck. The project lead and partners' involvement in assisting with financing really was a key component for many of the owner/operators in obtaining funding. These examples of unique community outreach really highlighted some of the great lessons learned from this grant award. This reviewer also observed that originally the scope was for 180 natural gas trucks but due to successful leveraging of the grant funds 219 natural gas trucks would be funded. Each diesel truck that qualified for permanent retirement had to be inspected to ensure compliance with the program. Each new natural gas replacement truck also needed to be inspected to ensure it complied with program goals. Model Year 2007 trucks and newer qualified for benefits. According to this reviewer, the presenter indicated there was limited infrastructure in place. The RFID was used to record trucks use age in the Ports to ensure that the natural gas trucks were being used in the Ports. Quarterly reports would be submitted by new natural gas truck owners so data is scheduled to be compiled and available to evaluate. This reviewer cautioned that it may appear that operators were being incentivized to comply, and this reviewer was unclear if this was an appropriate role.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that there has been a tremendous response to solicitations so this was a very successful project. This reviewer noted that originally the scope was for 180 natural gas trucks but due to successful leveraging of the grant funds 219 natural gas trucks would be funded. One-hundred and sixty natural gas trucks have been funded and on the road and the project is on track to do the balance of the vehicles by the end of the year. Each diesel truck that qualified for permanent retirement had to be inspected to ensure compliance with program. Each new natural gas replacement truck also needed to be inspected to ensure it complied with program goals. Trucks from the Model Year 2007 and newer qualified for benefits. This reviewer remarked that overcoming barriers showed a project's flexibility in adjusting to market factors. This was an impressive and time consuming project that required one-on-one meetings with all fleet owners that participated. Note that four different foreign language translation services were required and secured as some small business fleet operators were not sufficiently fluent in English to understand program requirements, such as technology and financing. The average price of the new natural gas truck is approximately \$150,000 - \$175,000. The average grant awarded per truck was approximately \$75,000. This reviewer remarked that the gap between the grant funds and purchase price was significant so project partners recruited and worked closely with lending institutions to help small business fleet operators secure loans for the balance of the truck. The project lead and partners' involvement in assisting with financing really is another key component for many of the small business owners or operators in obtaining funding. These examples of unique community outreach really highlighted some of the great lessons learned from this grant award. This reviewer observed that state estimates for the 219 trucks are 198 tons a year of NO_x emissions and 9.2 tons of diesel particulate matter emissions annually over the 15 years of the projected useful life of the new natural gas trucks. Estimates of 25% GHG reductions were made, however the partners have plans to start tracking the petroleum and emissions reduction more closely and have RFID tag installed in each truck that was a part of the project. The RFID was used to record trucks usage in the Ports. Quarterly reports will be submitted by new natural gas truck owners so data is scheduled to be compiled and available to evaluate.

The second reviewer noted from the presentation that over 50% of the applications were from small or single operators. This fact made it evident that the project was addressing a need to keep these operators from being able to access the port facilities and continue their business while meeting the clean vehicle requirements of the port.

The third reviewer noted that the project was 88% complete, with 160 of the originally planned 180 trucks already having been acquired and deployed, some of which were deployed immediately after the project contract was executed. This presenter noted that slides show 160 trucks but the presenter updated this to 182 as of the Annual Merit Review, thus meeting the originally planned amount ahead of the 24 month required timetable. According to this reviewer, the grantee correctly did not count as job creation the prevention of truck operators from going out of business since that would not have had any effect on net employment (amount of drayage), just would have moved it to other firms. Only jobs in manufacturing were counted, which was probably

correct. This reviewer noted that the project estimated 68 jobs and 0.31 jobs per LNG truck configuration installed, including the manufacture of any additional equipment.

The fourth reviewer indicated that it was very good that the project already had most of the trucks operating now and that the balance of the trucks would be online by the end of the year. This schedule would allow for at least a year of data collection on all trucks. The fifth reviewer remarked that there were no real technical accomplishments beyond deploying LNG trucks, which the project has done well.

The final reviewer noted that the project goal was to provide 219 trucks (originally scoped 180). This reviewer thought the project did an excellent job leveraging funding to put more vehicles on the road and noted how the project has provided 160 vehicles to date and was on track to do the remaining vehicles by the end of the year. The reviewer also noted that the presentation addressed one technical challenge that arose by adding translators for those applying for the vehicles. Additionally, the project also received a significant number of responses to the two solicitations. This was evidence of getting the word out well and doing a lot of outreach also. This reviewer remarked, "great job." However, this reviewer expressed concern that there was not much justification behind job creations, and that this could be explained further. This reviewer liked that the project worked with lending institutions to sustain this project beyond the grant, and also remarked "outstanding." This project was on track to over-achieve its emissions reduction by placing more vehicles on the road than originally estimated. The reviewer noted 2.68 million gallons per year for the life of the vehicles, which is noted as 15 years, and an estimate that the project would generate 198 tons of NO_x reduction per year and 9.2 tons of PM per year over a 15 year span.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers perceived that the project had significant partnerships across a wide variety of stakeholders, including Clean Cities. The first reviewer thought the collaboration was very good and indicated that having five Clean Cities coalitions involved in the project would ensure that a lot of people would hear about this effort.

The second reviewer also noted that the project included five Clean Cities coalitions as well as array of stakeholders: dealerships, manufacturers, governments, and ports.

The third reviewer noted how the project has both public and private partnerships and secured 15 sub-awards. The reviewer listed Air Quality Management District (AQMD), California Air Resources Board (CARB), the U.S. EPA, the Port of Los Angeles, the Port of Long Beach, California Energy Commission (CEC), and truck dealers as partners. The evaluator noted that the project did a great job getting out in the community to seek applicants and assisted the community in completing these applications, and how nice it was that free translators were provided, and that the project had five Clean Cities coalitions to support this project.

The fourth reviewer remarked that the collaboration and communication with financial partners and community members appeared to be strong throughout the project.

The fifth reviewer noted that the project had public and private partnerships and secured 15 sub awards. The project demonstrated strong community involvement by recruiting lenders and language translators and in the opinion of this reviewer, went above and beyond to make these awards available to the broadest group of recipients, not just the most clever and resourceful applicants. The reviewer remarked impressive partnership and listed CEC, AQMD, CARB, EPA, five Clean City coalitions, and Port of Los Angeles and Port of Long Beach as partners.

The final reviewer remarked that while there was good government collaboration, this was really an all government demonstration with the truck operators not even mentioned as a partner. In addition, this reviewer commented that there was no mention of any university or laboratory collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers generally perceived that planned future activities were satisfactory. According to the first reviewer, the future activities of getting the balance of the trucks operational and collecting and reporting the operational data would satisfactorily complete the project.

According to the second reviewer, the project team was effective at identifying and overcoming barriers that would lead to project success and future replication.

The third reviewer noted that the project would fund 219 trucks, exceeding the project proposal of 180, and that monitoring and reporting was to continue for two years as required.

The fourth reviewer liked that this project did audits to ensure that each truck was used as intended and noted that the project was collecting data on trucks that serviced the ports. This reviewer noted that the project planned on reporting the data, and that the reviewer looked forward to learning more. According to the reviewer, the project worked with local lenders to continue this project into the future, which showed forward thinking. The reviewer also noted that there was limited long-term outreach, as least as communicated in the presentation. However, the reviewer noted that the project would do a few more before completion. This reviewer commented that more could be done with technician training to reduce outreach as a barrier to the project's overall success.

The fifth reviewer noted close coordination with engine and truck manufacturers and dealers to ensure natural gas vehicles were properly maintained and the delivery of future vehicles in a timely manner. However, this reviewer noted that the technician training may be a barrier to long-term success if not addressed. The reviewer also observed that data was collected and monitored on a quarterly basis, that there was long-term planning as evidenced by securing financial institutions, and that only selected cost-effective projects were funded to ensure overall long-term success.

The final reviewer was unsure if each vehicle would be equipped with data loggers to collect mileage and fuel use, if the LNG fueling is limited to a single station, and how the LNG use would be tied to single vehicles. This reviewer remarked that there does not appear to be any technology advancement nor alternative development pathways, which are not needed. However, there would be some type of future monitoring.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Most reviewers perceived resources to be sufficient. One reviewer remarked that project resources were sufficient to meet the original plan and milestones. Considering the high environmental and public health benefits of this project, additional resources might be desirable.

The second reviewer commented the funding seemed sufficient for the project, and remarked that it was very impressive that the cost share for the project was so high.

The third reviewer thought the project did a great job leveraging additional resources to over-deliver on this project and also worked with lenders to sustain this project on the long-term. The project also chose sub-grantees that were most cost-effective at achieving the emissions reduction goals.

The fourth reviewer observed that the project's resources increased after receiving the award. Originally the scope was for 180 natural trucks but due to successful leveraging of the grant funds, 219 natural trucks would be funded. This reviewer also noted how each diesel truck that was qualified for permanent retirement had to be inspected to ensure compliance with program. Each new natural gas replacement truck also needed to be inspected to ensure it complied with program goals. 2007 trucks and newer qualified for benefits. This reviewer perceived that long-term planning was evident by the securing of financial institutions, and observed that only selected cost-effective projects were selected and funded to ensure the overall long-term success of project.

Two reviewers thought that resources were excessive. The fifth reviewer thought that while one-on-one applicant help may seem excessive, the presenter certainly demonstrated the need for such personalized assistance. The sixth reviewer commented that DOE cost share was matched by more than 250% by the other project partners. However, with a total project funding of \$33.74 million and a deployment goal of 219 natural gas trucks, the cost per truck was \$154,064. This reviewer remarked that this seemed to be extremely excessive.

UPS Ontario - Las Vegas LNG Corridor Extension Project: Bridging the Gap: Larry Watkins (South Coast Air Quality Management District) – arravt047

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally agreed that the project fit DOE’s goals. The first reviewer remarked that the project resulted in significant petroleum displacement.

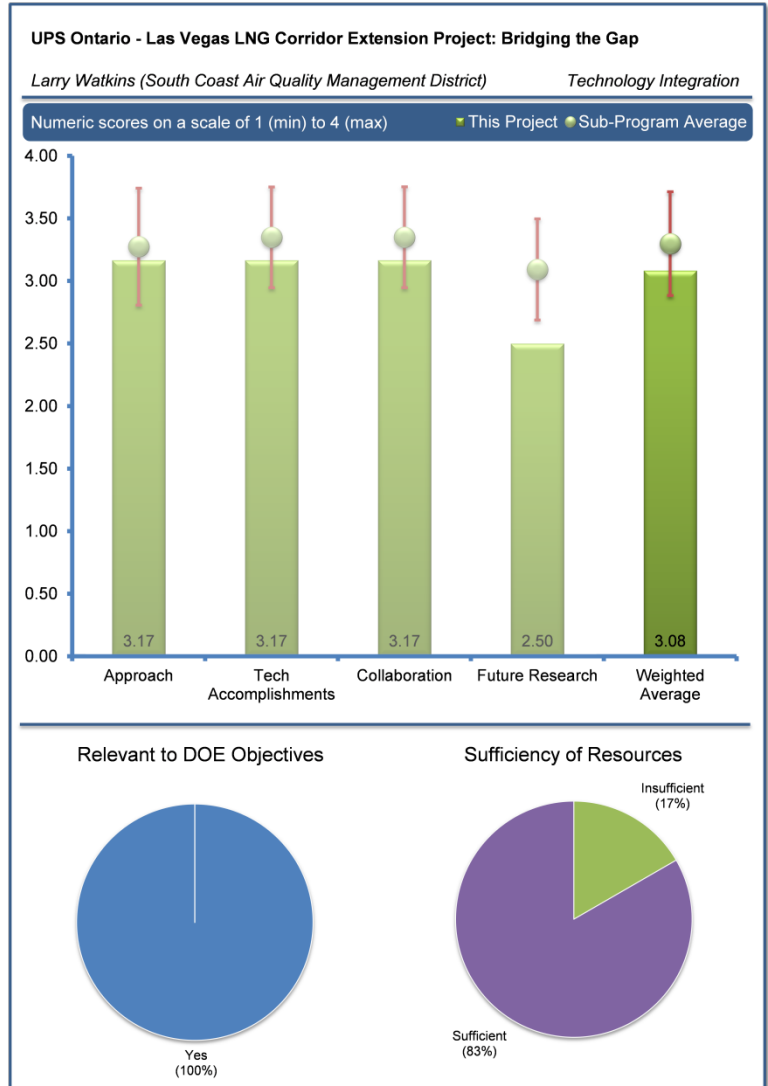
The second reviewer remarked yes, that this project definitely supported the DOE objective of oil displacement. This reviewer noted that this project would help displace oil use of 1.25 million gallons annually by using LNG trucks instead of diesel. In addition, because it would also complete the LNG refueling corridor from Southern California to Utah, it may provide fueling for other projects and thus help displace additional oil.

The third reviewer remarked the project would directly result in 48 new Class 8 LNG tractor trucks for use by UPS but would indirectly result in more than that because it was a catalyst project for UPS, which would replace its Class 8 trucks with LNG trucks according to its normal retirement schedule. The reviewer noted that these were high-mileage, high-fuel use vehicles. The reviewer noted an estimated 1.25 million gallons of diesel to be displaced per year.

The fourth reviewer agreed that this was relevant. The project was proposing to pay for the incremental costs of 48 Class A Kenworth trucks. The reviewer noted that the project planned to install one clean corridor LNG/CNG refueling station in Las Vegas, and that the project expected to displace 1.25 million gallons of diesel annually and reduce emissions by 83.23 tons of NO_x, 1.07 tons of PM and 236 tons of GHGs annually. The reviewer also noted that the project anticipated creating 58.1 jobs including mechanics, maintenance trucks, service stations, and etc.

The fifth reviewer remarked that the estimates of 1.25 million gallons of diesel displaced annually and estimated 1.3 million miles driven would contribute to the original petroleum reduction estimates.

The final reviewer noted that this was the first multi-state, publicly accessible LNG refueling corridor project supporting delivery operations from the Port of Long Beach to Salt Lake City, Utah. The reviewer observed that the project included 48 heavy duty Kenworth trucks for UPS and was putting in a publicly accessible Clean Energy refueling station in Las Vegas, Nevada. The project included 32 trucks in Las Vegas and 16 in Ontario, California. The refueling station would be strategically placed on the ICTC corridor. The reviewer observed a projected displacement of 1.25 million gallons diesel annually and emissions reductions of 83.23 tons of NO_x, 1.07 tons of PM, and 236 tons of GHG annually. This reviewer also noted that this project was projected to create and retain 58.1 jobs without multipliers in the construction, manufacturing and capital reinvestment sectors.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer perceived a simple, straight-forward project that has accomplished deployment on a revised schedule.

The second reviewer commented that the project has been moving along very well and has successfully addressed all of the barriers identified in the project. The project has been well designed and was being implemented successfully.

The third reviewer noted that the project was well designed in terms of bridging the gap in the corridor between Los Angeles and Long Beach, California and Salt Lake City while serving an initial 32 UPS trucks based in Las Vegas. This reviewer observed that the project was delayed by a dispute over the price of trucks and LNG refueling site, and was delayed for 18 months due to location raising issues with the U.S. Department of Homeland Security.

The fourth reviewer commented that SCAQMD picked an experienced team to install a needed LNG/CNG refueling station. This reviewer observed that the station would be managed and owned by Clean Energy and that 32 of the vehicles would be in Vegas and 16 in Ontario, California. The station would have 30,000 gallons of storage. This reviewer noted that the station location was chosen to be on the ICTC clean corridor, which the reviewer thought was good. It was apparent to the reviewer that there was some training to be done, but there was little discussion about it. Furthermore, this review observed little discussion about how this station would be supported outside of UPS. This reviewer believed that DOE should follow up on this with the project managers.

The fifth reviewer noted that SCAQMD pulled together an experienced team to execute this project and divided up the responsibilities. The location of the Las Vegas station was selected as an important mid-point leg in the I-15 corridor linking Southern California with Salt Lake City. This station was planned to have 30,000 gallons of LNG storage and 3 dispensers. The reviewer observed that Clean Energy took the lead in securing and purchasing the site and long lead-time equipment. Clean Energy assumed all responsibilities for the turnkey developer, operator and maintenance. Furthermore, this reviewer noted how UPS took the lead in ordering the 48 T800 LNG heavy-duty Class 8 trucks from Kenworth. UPS also was required to purchase an easement from the Las Vegas Airport, which was still not completed. The reviewer noted that as illustrated in the milestones, all 48 trucks have been delivered, and that training has occurred for mechanics and UPS drivers. The reviewer observed that the refueling station location was selected to be strategically placed on the ICTC corridor. This reviewer noted that this project has encountered some challenges in permitting and siting of the permanent station in Las Vegas, Nevada near the airport. This reviewer understood that there were all sorts of questions that may arise due to transporting goods and services in a delivery truck that was fueled by an airport service station that provided LNG. There was a temporary station that was operational, but this reviewer thought the presentation materials were vague in distinguishing the difference between the temporary and permanent station. However, this reviewer thought the fact that there was a substitute station in operation illustrated the resourcefulness of the project's partners. This reviewer was unclear about what the long-term education, communications, marketing and training outreach plans were.

The final reviewer noted that while the project managers had a clear vision for project success, two main barriers each contributed to a one-and-a-half year delay in project deployment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewers had mixed feedback on technical accomplishments and progress. The first reviewer noted that the project had started collecting data and has already shown 1.3 million miles driven and 250,000 gallons of LNG purchased by UPS.

According to the second reviewer, the project appeared to be back on track despite the initial delays. At the time of the presentation, this reviewer noted that a temporary facility had been created to refuel the vehicles pending the completion of the planned facility, and that trucks have yet to be deployed under the project [DOE Program Clarification: As of the Final 2012 Annual Merit Review Results Report, all 48 trucks had been deployed].

According to the third reviewer, the project had overcome the major barriers that were encountered, but still have one barrier to overcome before the Las Vegas station is developed to its original specifications and functionality.

The fourth reviewer noted that according to the presentation materials, all 48 vehicles were put into service. This reviewer noted that a temporary refueling station was put up at the Las Vegas airport, but that the permanent station has been delayed because of permitting, electric utilities and easement ownership. The presentation indicated 2,500 gallons were being used daily, which according to the reviewer seemed low. This reviewer would like to know how the project expected to grow with more vehicles. This reviewer would like to know the costs for the temporary station and how this factored into the project, and who owed it. Furthermore, this reviewer noted that the station cost \$3 million in Las Vegas, and would like to know if this was on target with what was originally estimated. The reviewer noted that England was another carrier that was going to use this station. However, it was unclear to the reviewer how much. The reviewer cautioned that these seemed like low numbers, and would like to see more long term projections. Furthermore, this reviewer requested hearing more about what was done in the driver training and technical training, including details on how the training went and whether training would be on-going. This reviewer requested a better understanding of the return on investment for the overall project goals, including emissions, petroleum displacement and job creation.

The fifth reviewer observed that according to the presentation materials, all 48 trucks had been delivered to UPS. The reviewer noted that the presenter said the trucks cost approximately \$134,000 and that it required extensive negotiations with the manufacturer to get this cost down. The reviewer observed that UPS exerted a tremendous amount of time and resources to get Kenworth to manufacture the trucks at this cost. This reviewer noted that data tracking for the performance of vehicles and metrics for tracking fuel displacement and emissions reduction was not explained, and inquired if any data tracking was on-going. The reviewer would like to know what data was being tracked. For this reviewer, the presentation was confusing because the presentation stated in the beginning that the station would be a publicly accessible Clean Energy refueling station in Las Vegas, Nevada. However, according to this reviewer, the Technical Accomplishments and Progress section seemed to imply that the station could accommodate UPS and CR England's trucks that have a volume of 2,500 DEGs daily, and could fuel 576 trucks daily. This reviewer would like to know whether the temporary station was just for UPS and CR England or if it was also publicly available. This reviewer became confused when during the presentation it was mentioned that the Las Vegas station was completed but then it was stated in the presentation that a permanent electrical meter needed to be secured from the utility and operation of temporary generator stopped. The reviewer inquired if the generator was used at the temporary station and therefore was not needed at the permanent station. The reviewer questioned how much money it cost to operate the temporary station, and inquired whether the temporary station was close to the permanent station. The reviewer observed that the presenter said the station cost \$3 million, and questioned how this compared to costs projections for this station.

The final reviewer noted that there were not any real technical objectives to overcome as the real burdens were permitting. This reviewer thought that it was odd that the final hurdle was getting the electric utility to energize the meter.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw a strong collaboration with an array of partners. The first reviewer noted that the project had excellent collaboration and was very unique in that a local government like the SCAQMD had been able to coordinate a project that had an impact in other areas of the U.S.

The second reviewer stated that the project partners did well to continue dialogue with the public and private organizations that created the delays, and were able to eventually work through those barriers.

According to the third reviewer, partners in this project were impressive. This reviewer notes participation of SCAQMD, Clean Energy, UPS, two Clean Cities' coalitions, and multiple state governmental agencies and quasi-governmental agencies, including the California Ports and Nevada Airport. The reviewer opines that the project partners appeared to be working together well, that the station as working and UPS had the new 48 LNG trucks. This reviewer noted that at some point CR England became a partner in the project and that this reviewer was not clear what role if any CR England was assuming. The reviewer observed that the presenter said Clean Energy had plans to do 150 more stations in this corridor, which according to the reviewer was fantastic news. The reviewer appreciated a handy map in the presentation illustrating the numerous existing LNG stations in the corridor. It was not clear to this reviewer where or which of these stations were Clean Energy existing stations and/or planned. From the presentation, the reviewer noted that UPS has had such success with this technology that it has purchased extra trucks at the

company's expense because the return on investment was evident. The presenter said that as UPS replaces trucks that UPS will be replacing them with these LNG trucks. The reviewer thought that this obviously was a further sign of a successful project. This reviewer recommended that as the trucks were on the road and data tracking occurred the team should look for opportunities to share lessons learned with stakeholders, industry, and public.

The fourth reviewer believed that the project had good partners. This reviewer detailed state, municipalities, Clean Cities' coordinators, and private partners, specifically Clean Energy and UPS. However, this reviewer would like to hear more about what the private partners were going to do to continue to support this project as the grant comes to a close.

The fifth reviewer believed that project partners seemed to be communicating well and that the success of the project was a reflection of that, as well as the decision to segment deployment responsibilities. There was not any university or laboratory involvement, nor was it obvious why there should be, so this reviewer had to question why this was a review question.

The final reviewer noted that the list of partners/collaborators was short, but included those needed. However, this reviewer cautioned that the collaboration was apparently insufficient in advance to prevent the unforeseen events that had substantially delayed the project. Clean Fuel, shown as a collaborator, was only added to the project by UPS to operate the refueling site. This reviewer also noted that Daimler/Freightliner were only added after price negotiations with the original vendor failed.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the future activities were very adequate and would provide good information about the operation of the trucks and amount of fuel that would be used. The second reviewer commented that the proposed future activities hinged on the completion of the Las Vegas refueling facility and the subsequent marketing to potential users of the site. The third reviewer thought that it was a bit confusing as to why the electric meter was not energized; however, this reviewer assumed that this should not be too difficult to accomplish.

The fourth reviewer would like to see more explanation about what the project managers planned to do to reach out to new fleets, and would like to know what was going to be done to continue to train drivers and mechanics over the long haul. This reviewer remarked that because the Las Vegas site was not yet complete, that it was DOE's job to make sure that this aspect of the project was completed. This reviewer would like to better understand what role UPS and Clean Energy were going to have in the future. The presentation described that Clean Energy was going to install 150 more stations at their own expense. The reviewer emphasized that this was great news, but questions whether this means the project was self-sufficient without additional federal or state funding in the future.

According to the fifth reviewer, the going-forward plan did not explain in detail what the ongoing training and education component was going to be for new drivers and mechanics. With such high-profile partners as UPS and Clean Energy it would be helpful if a media and communications plan was designed and implemented because it seemed like plenty of helpful, interesting and useful lessons learned could be shared with stakeholders. The reviewer noted that the presentation was silent on how the actual tracking of the data collection such as fuels displacement and emissions reductions would occur for sharing with the stakeholders and for public dissemination. The reviewer observed that the presenter said UPS was thrilled with the performance of these new trucks and has already purchased more assuming the cost for the entire new LNG truck. According to the reviewer, this obviously is a sign of a successful project and as the trucks are on the road and data tracking occurs the team should look for opportunities to share lessons learned with stakeholders, industry, and public. This reviewer also believed that there needs to be some clarification on permanent versus temporary Las Vegas station, and clarification about if the Las Vegas station was publically available or just for UPS and CR England.

The final reviewer noted that proposed future activities were essentially to perform the work that was originally scheduled to have been accomplished by now. The follow-up, reporting, etc. that would have been done in the third and fourth year of the project would now not be possible until after the project period has expired.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer opined that resources were insufficient. This reviewer noted that resources could have been realigned to provide more support and motivation to those organizations and agencies that created the project barriers and delays.

Five reviewers thought that resources were sufficient. Specifically, one reviewer commented that resources seemed sufficient. Another reviewer commented that project resources were ultimately adequate due to the emergence of an alternative truck supplier; however, this reviewer commented that resources would have been insufficient if not for this fortuitous development.

The final reviewer noted that it appeared that the project had sufficient budget to complete the tasks outlined. However, this reviewer noted that little information was provided on the breakdown of the budget, and there also seemed to be limited funds allocated to long-term marketing outreach, education and training. This reviewer would like to know who was going to do that in the future. It seemed to another reviewer that the big ticket items had been budgeted for, including the new trucks and new station. However, this reviewer was concerned that there really was no detailed budget data shared. While it appeared that the project was executing according to scope, this reviewer did not have any financial data to confirm that there was enough money to fund the completion of the project, including administration, marketing, media, communications, data tracking and ongoing training for drivers, service attendance and maintenance workers.

**Wisconsin Clean Transportation Program:
Maria Redmond (State of Wisconsin) –
arravt048**

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that this project resulted in 17 alternative fuel refueling stations, including biodiesel, E85 and electricity, being deployed, as well as up to 280 AFVs. The project also included training and outreach components for vehicle operators, technicians, refueling site staff and supervisors and users of refueling infrastructure. According to this reviewer, all of these actions supported the DOE objectives of petroleum displacement.

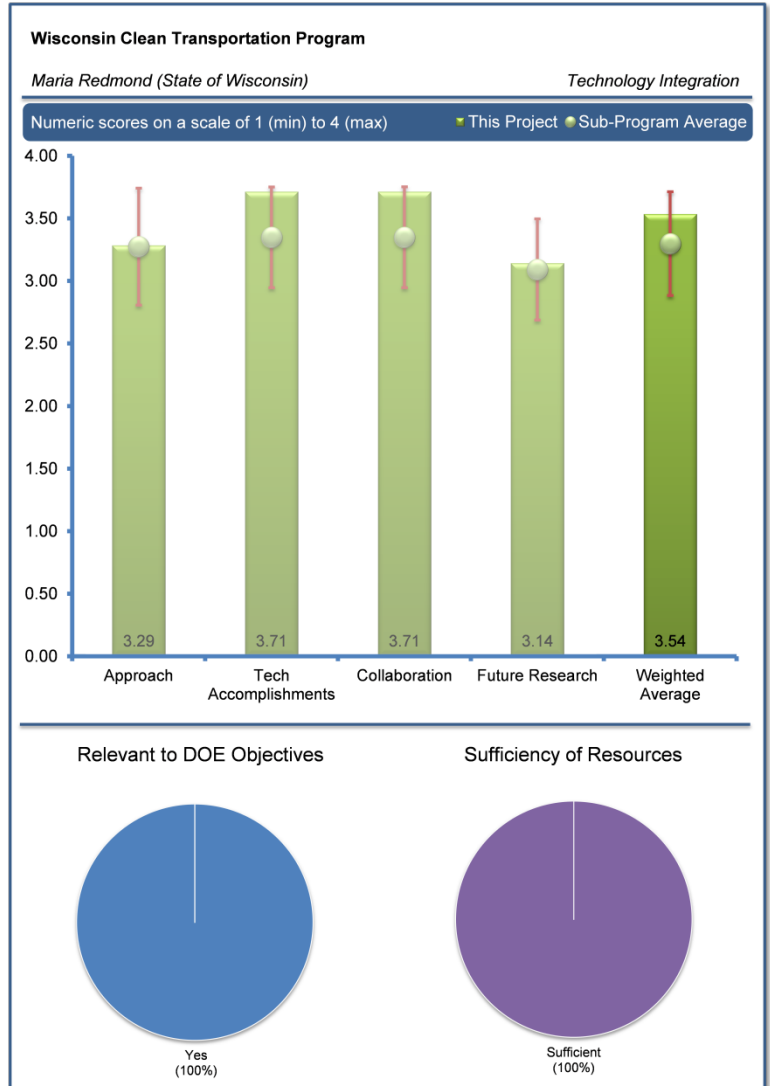
The second reviewer remarked that the project was obviously aimed at deploying alternative fuel vehicles and infrastructure, which would support DOE's objective of petroleum displacement.

The third reviewer noted that fleets would now go beyond because of these purchases. A large number of partners ensures that there is broad potential for future success. This reviewer observed a good depth in utility partners, and excellent breadth and depth to the types of vehicles deployed, from refuse to light-duty and fuel choices including hybrids, plug-ins, and CNG. This reviewer believed that the potential of this project to exponentially grow alternative fuels used in the area is excellent.

The fourth reviewer noted that the project targeted replacement of petroleum-consuming vehicles with other fuels. By building stations and monitoring technical issues with the vehicles the project can feel assured of actual usage of the vehicles. This reviewer wondered if the wide variety of fuel types and vehicle applications may be allowing member fleets to do pet projects that looked good or intrigued fleet managers, rather than fully maximizing petroleum reduction. However, according to this reviewer the project management seemed to believe the variety was a positive as it encouraged fleet managers to embrace a wide variety of technologies in future RFPs.

The fifth reviewer commented that this project addressed a broad spectrum of vehicle and alternative fuel types for petroleum displacement. It also included infrastructure development and Madison Area Technical College fuel system maintenance training.

The sixth reviewer commented that the project was relevant to petroleum displacement goals for DOE, but that the total displacement estimated was not listed specifically, unless this reviewer missed it. According to the seventh reviewer, the objectives were clearly defined as reducing petroleum use, creating jobs, reducing emissions, especially in non-attainment areas, and building an AFV industry. This reviewer noted that no specific numbers were cited as goals, however.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Generally, reviewers thought that deployment activities were effective. According to the first reviewer, the project seemed to be well thought-out, including addressing barriers and tweaking the project design as conditions changed.

The second reviewer thought the strategy for deployment was comprehensive and well thought-out. This reviewer noted that prior approval of vehicle purchases were required, and the team did frequent monitoring and site visits to follow up on implementation. There have been numerous technical difficulties, primarily with heavy-duty hybrids, but the team took action to address them, once the team was made aware of them. The project is working closely with Eaton to resolve technical issues. This reviewer anticipates that the lessons learned from this project should prove valuable in addressing existing mechanical and technical problems and preventing them in the future. This reviewer also thought that the outreach and education, done in conjunction with Wisconsin Clean Cities, was excellent.

The third reviewer observed a straightforward deployment approach with broad reach of technologies including virtually all major alternative fuel and alternative technology options for transportation. This reviewer noted that both light-duty and heavy-duty vehicles were included, and that the project team members made an effort to be at the fleet sites when the vehicles were delivered to ensure success.

The fourth reviewer commented that the team focused on addressing project management issues from the start, setting up comprehensive reporting systems. The project made sure that all vehicles were approved ahead of time and were verified upon delivery. The PI helped fleet partners throughout the process with activities like reviewing technological specifications and evaluating quotes. The reviewer commented that the project similarly helped infrastructure projects with Davis-Bacon compliance, Buy American requirements, and signage, and noted that the PIs worked with a variety of partners to develop and conduct trainings for a variety of AFV types.

According to the fifth reviewer, the project was very well-designed and integrated. The schedule slippage of initial deployment data from December 31, 2011 to June 30, 2012, due to vehicle availability and construction delays, was the only reason the project did not receive an outstanding rating. The reviewer indicated that the project correctly identified the importance of site visits.

The sixth reviewer referenced a prior comment on a variety of technologies relating to petroleum reduction. It also seemed to this reviewer that there was not an initial strategy to deal with technical problems that have delayed the project. However, this reviewer perceived that the project management had adapted and now had an active strategy to push fleet managers to communicate and collaborate when vehicles broke down. Seeing fleet managers incorporate new technologies into unrelated RFPs was a great sign. This reviewer also observed that the project had a tough time getting partner fleets to report technical issues to them. For example, the project implementers did not always find out when vehicles were taken out of service for various reasons, such as mechanical issues, and etc. There had been a couple instances of not finding out for six months. The biggest technical challenges were in the heavy-duty hybrid vehicles, across suppliers and systems. The reviewer observed that the project did a lot of site visits to monitor the vehicles, and that the project made the fleets get approval of purchases before the order was placed. The project was seeing more fleets use this as a stepping stone to buy more AFVs in their fleets, and were adding AFVs to the RFP process.

The final reviewer observed that clearly the project learned early in the process that more monitoring and control strategies were needed, and that using a technical consultant to help address vehicle problems ensured an informed advocate for the fleet other than the PI. The PI indicated partners were sent a stern reminder if the partners did not communicate appropriately, but this reviewer suggested that the PI should consider different tactics that build the partnership and establish good habits of communication. The PI's frustration is understood but this reviewer suggested that a different approach should be taken. This reviewer noted that one of the municipal partners was only now determining how to charge/bill infrastructure users for fuel. This particular portion was poorly planned but it was unclear to this reviewer whether the city provided poor information to the PI about their ability to make their infrastructure available. This reviewer noted that data collection was only now being thought about and a potential state portal was being considered. This reviewer expressed concern that the timing of this activity seemed late considering the number of vehicles that have already been deployed [DOE Program Clarification: This is incorrect and a

misunderstanding of the PI's statement. Data collection and reporting has been completed and complied with on a quarterly basis from all sub-recipients and the prime recipient. The PI was discussing a plan to refine the project team's data collection methods for long-term use beyond the required ARRA reporting templates used now to report to DOE project management.]

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Several reviewers saw that the project had good progress. The first reviewer commented that the project seemed to have made significant accomplishments and progress to date, even dealing with problems outside of the project's control. The reviewer praised that it was good how the project appeared to have moved quickly to redeploy funds from fleets that could not perform as expected to new fleets or projects that could use the funds.

The second reviewer commented that despite early hurdles, the project has made excellent progress and has adjusted methods as needed to complete the project on time and on budget. The project has displayed a clear understanding that to be successful, there was a need to find fleets with near-term order windows and pursue only those partners.

According to the third reviewer, this year the project made good progress by going from 24% to 61% complete. It had a broad spectrum of alternative fuel and vehicle types. The project reported 221 of 280 vehicles deployed, which was 79%, and 12 of 17 fueling sites were completed. This reviewer noted how the project helped support fuel system maintenance training at the Madison Area Technical College.

The fourth noted that deployment was behind schedule, but this was explainable; the causes included vehicle and infrastructure availability, which should be done about six months behind schedule. The project was gaining real-world experience with new technologies, and working on solving problems, especially with hybrid vehicles, in conjunction with manufacturer representatives. This reviewer noted that the renewable natural gas aspect in Dane County was novel and may be of interest to other Clean Cities partners. This reviewer remarked that there appeared to be extensive training and an outreach aspect, including events, to the project as well, which was useful for these new technologies. This reviewer noted that the monthly newsletter to partners was unique and suggested giving consideration to showing a copy of an issue in the presentation.

The fifth reviewer praised that while the program had not been without its challenges, the team has made very good progress in addressing them. This reviewer noted that all 17 stations were up and running, and most vehicle issues were being addressed [DOE Program Clarification: All 17 pieces of fueling infrastructure were not operational at the time of this presentation.]. VTM shuttle buses were described as total failures, which would impact overall petroleum reduction; for this reviewer, it would be interesting to see a case study developed on these vehicles. The reviewer noted that the presentation did not indicate what the goal was for annual petroleum displacement, however, so while the project implementation was going well, it was difficult to know how successful it has been with regard to its impact on petroleum use.

The sixth reviewer noted that the technical breakdowns have slowed technical accomplishments some; however, the project was nearly done and the project has dealt with those set-backs. The reviewer would like to see specific petroleum reduction numbers to be able to judge better, and remarked that the amount of outreach was positive. This reviewer also observed that the project included a non-attainment area so project investigators were targeting a few of the partners to be in that area and increase emissions performance. This reviewer observed that the project originally targeted getting all vehicles in place by the end of last year but this was behind schedule because of vehicle technical issues and ordering delays. However, project implementers now think that completion could occur by June. The reviewer also observed that now 90% of the vehicles were purchased, all stations except one were up and running and doing well, up to 71% of the funding was spent and 16 sites were completed, with 267 vehicles ordered and deployed.

The final reviewer remarked that while the original completion date for deployment has been pushed back, 90% of vehicle purchases have been completed as of the time of presentation, with the remainder to be completed by the end of the fiscal year. All but one of the infrastructure sites were installed, reported this reviewer, and many trainings and events had been conducted. This reviewer also pointed out that all NEPA EQs were completed and approved. Furthermore, added this reviewer, over \$10 million of

DOE money and over \$12 million of cost share had been spent. Finally, this reviewer summarized that a second RFP for replacement projects was recently completed, which was the reason for some of the delay.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Generally, reviewers saw strong collaboration and coordination. The first reviewer remarked that there has been smart partnering on the part of the State Energy Office (SEO), the project lead; the project worked with several utilities, which then entered into contracts with multiple local governments, to reduce the number of contracts the SEO would have to deal with. This reviewer noted very good coordination between SEO, technical consultant, project participants, and industry representatives. The reviewer noted that this was a well-managed project.

The second reviewer noted that the project was led by the SEO with participation from the local Clean Cities coalition. This reviewer observed a good list of fleet partners around the state, and that some fleet partners were able to consider alternative fuel vehicles as a result of this project.

The third reviewer noted that the state energy office has worked very closely with the Clean Cities coalition, a technical consultant, and 36 public and private fleets. There has been frequent contact with the fleets through regular newsletters and site visits.

Another reviewer commented that the 36 partnerships, outstanding training and outreach activities, along with the project's extra effort of site visits gave this project an outstanding rating in collaborating and coordinating with other institutions.

The fifth reviewer commented that the amount of fleets involved meant a great deal of coordination and monitoring. This reviewer was impressed that the project felt comfortable monitoring all vehicle purchases and usage for such a wide variety. This reviewer observed that the project worked with Wisconsin Clean Cities, mainly on outreach and marketing; that the management team was the SEO, Wisconsin Clean Cities, and that there was a technical consultant; the project had a fair amount of fleets that did not spend all of their money so in the past quarter the project took away the extra money and used it for a second round of funding for fleets already in the program that were able to purchase new vehicles in the next couple months; and that the project performed field visits because it helped keep the fleets cognizant that the fleets needed to be reporting issues to the SEO or Wisconsin Clean Cities and not just their dealers.

The sixth reviewer remarked that there were a good number of partners on this project, and the key partners appeared to be collaborating very well. It was less clear to this reviewer how much collaboration was happening outside of the immediate project actors, including with Clean Cities coalitions outside the area who could benefit from what the project has learned.

The final reviewer commented, again, that the project had addressed communication problems with partners but some of it seemed to be the stick approach opposed to the carrot which would build longer term partners. It was unclear to this reviewer why the project was only now looking to train drivers; seemed like that should have been part of the vehicle deployment. This reviewer believed that this piece could be better coordinated.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that the SEO had already initiated a second round of funding, using money that had not been spent, which should result in up to 50 additional vehicles being deployed. The project had operator training and nine outreach events scheduled through June 2012, and would continue collecting data.

The second reviewer noted that the project appeared on track to complete the remaining outreach activities and finish deploying vehicles and infrastructure.

According to the third reviewer, the PI had focused on solutions to problems and barriers and adjusted accordingly. This reviewer noted that the PI was to be commended for overcoming fairly serious vehicle reliability issues, and that outreach and training were proposed as future activities.

The fourth reviewer commented that the future work plan was straightforward, and would close out the project. Additionally, online data submission for reporting would be a useful addition.

Another reviewer remarked that future activities included completion of vehicle acquisition and infrastructure equipment installation. This reviewer commended how the project initiated a Round 2 of funding to purchase by the end of the year, 50 more vehicles with the remaining un-costed funds.

According to the sixth reviewer, the primary focus of future activities was on completing the vehicle and infrastructure deployment and the associated trainings and data collection. Most activities other than the data collection should be complete by June 30. This reviewer noted that Round 2 RFP projects may take a little longer.

The final reviewer commented that the outreach and training plans were great, lots of opportunity there. If at all possible, it would be great to see future work addressing the public/private station conundrum and perhaps building a framework to make it work. According to this reviewer, this was one of the big market barriers, especially for CNG stations, so it would be a great final accomplishment to contribute a solution. The reviewer understood it might be beyond the scope of the project and depended much more on outside decision makers, but it was something to shoot for. It would also be nice to see further plans on addressing some of the technical issues with heavy-duty hybrids, as that is another big barrier that was found by this project. This reviewer also observed that the city of Milwaukee had a CNG station with a public and private side and the city was struggling with how to price the CNG on the public side. The city had to pass a resolution to address it. Milwaukee was not allowed to profit on the sales, so the city has had to price the CNG perfectly so that it addressed all of the maintenance and implementation; or the city could pass a resolution allowing a certain amount of profit, but then the market changes over time so Milwaukee would either be price gougers or not making the approved profit. The private side of the station is up and operational; the public side was planned under the grant but Milwaukee needs to figure out how to price it properly. The reviewer also noted that the project was looking to do more training in the future. The reviewer noted problems with heavy-duty hybrids, specifically Eaton utility trucks. The issues were mostly technical or mechanical issues, some driver and training. The reviewer observed that Eaton had a new regional representative there who has been very helpful and knowledgeable to get performance improvement through software updates. The reviewer also noted that the VTM shuttle buses had been total failures. The hybrid systems have rarely functioned and have not delivered efficiency improvements when the systems do function.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers indicated that resources were sufficient. One reviewer commented that the PI and consultants have adjusted resources to ensure success.

Another reviewer remarked that resources seemed reasonable, given the scope and scale of vehicles implemented. This reviewer observed that there has been \$15 million in funding, plus \$17 million to match; the technical consultant developed a training and outreach program to educate the fleets; the technical consultant was also working with Navistar and Eaton, which are the vendors, to provide onsite training when the vehicles are deployed; and that WPPI/We Energy are the utilities, and the project has partnered with them to reduce the number of contracts.

The third reviewer remarked that the project lead has made good use of the available resources. Although there have been slight delays in deployment of stations and vehicles, the delays have not been significant. The fourth reviewer commented funding should be sufficient for vehicle and fueling station deployment. More vehicles are to be deployed with funds from partner under-spending. This would expand displacement with a logical methodology for choosing projects.

The fifth reviewer noted that because of drop-outs, the project has about \$500,000 remaining in uncommitted funds, but that was being taken care of. To date, the project has spent over \$10 million in DOE funds and \$12 million in cost share, which left about 30% of spending remaining.

The last reviewer noted that the DOE project funding of \$15 million and the \$17 million matching funds are sufficient to reach stated milestones.

Connecticut Clean Cities Future Fuels Project: Carla York (Connecticut Clean Cities Future Fuels Project) – arravt049

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

There were mixed responses for this question. One reviewer stated that this project has shown great results, and that the project team’s tracking system is constantly validating the investment.

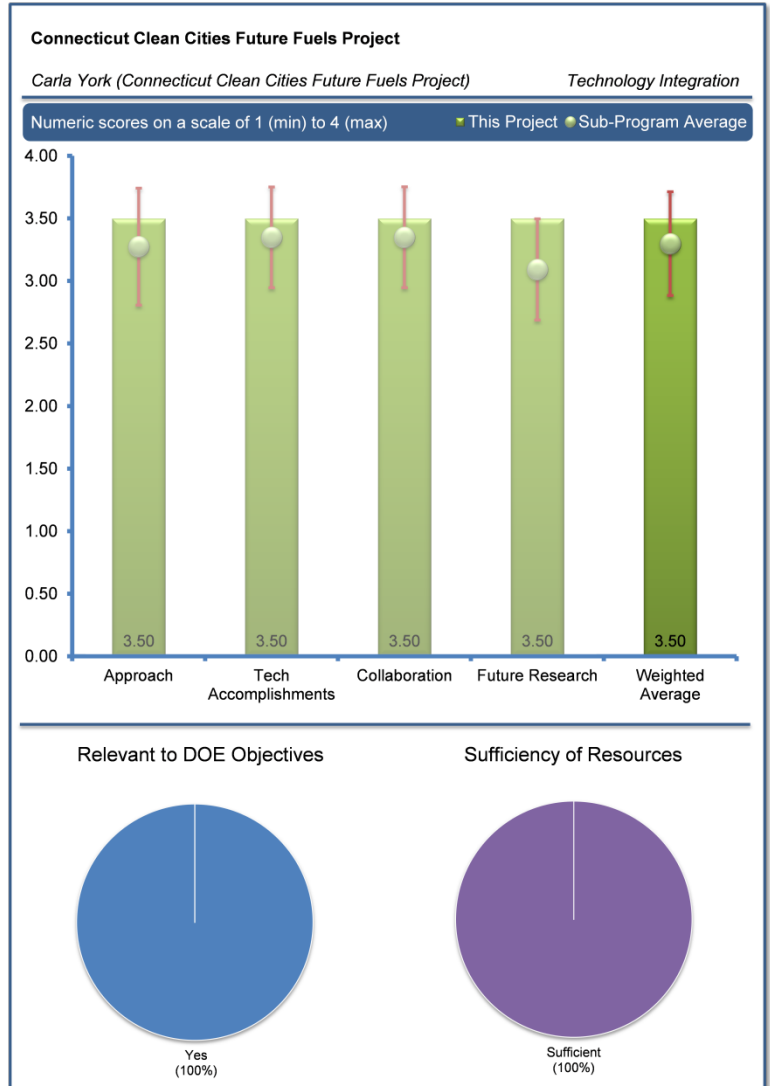
A second reviewer said that jobs are a primary focus as well as economic growth and collaboration to leverage in-project investments. This person commented that this project is focused on new alternative fuel vehicle (AFV) and alternative fuel refueling stations. The same reviewer also said that this project incorporates five fuels, including five hydrogen (H₂)-fueled buses, but did not include E85 and liquefied petroleum gas (LPG). The reviewer then added that the project represents 15 million miles overall traveled over the life of the project.

A third reviewer remarked that the project showed a substantial amount of petroleum displacement.

A fourth reviewer felt that the petroleum and greenhouse gas displacement figures were quite overstated. The reviewer said that eliminating six million gallons of petroleum and 11 million pounds of greenhouse gases with 286 vehicles deployed is most admirable, but that no other program that evaluated by this reviewer even came close to displacing six million gallons of fuel. According to this reviewer’s calculations, each vehicle would use about 20,979 gallons of fuel each year. The reviewer continued to say that if the vehicles mentioned are diesel vehicles with a 10 miles-per-gallon average, then this equates to about 209,790 miles driven per vehicle each year [DOE Program Clarification: It appears that the reviewer mistakenly believes the displacement of 6 million gallons was an annual displacement. However, the 6 million gallons represented the estimated displacement over the four year project period]. This reviewer also pointed out the importance of considering that only 28 heavy-duty (HDV) vehicles are included in the proposed 286 vehicles, which means the light-duty and medium-duty vehicles (LDVs/MDVs) would get better gas mileage. The reviewer suggested that these numbers be investigated. The reviewer further observed that because this is the implementation or building phase, AFV stations would not be constructed for all four years.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments to this question were generally positive. One commenter thought that the researchers did a very good job in working with the first responders and data collection.



A second commenter said that the researchers did a good job getting two taxi companies to commit to compressed natural gas (CNG) and to share an order for the MV1, allowing the para-transport market to expand, and developing an alternative fuel corridor along a major trucking route.

A third commenter also noted that the researchers did a good job on the outreach, and was glad that they highlighted matching locations to fleets. However, this commenter questioned the researchers if there were any work with schools, if the researchers could quantify the amount of usage by the public (or non-partners), if the strategy could have accounted for vehicle delays, or if the researchers have any contingency plans.

A fourth commenter remarked that this is a state-wide project with compartmentalized project implementation, calling for different people managing different parts. This commenter added that the project includes a broad range of fuels and vehicles (LDV/MDV/HDV), and is also focused on a corridor across the state (I-95 and I-91). The same commenter mentioned that the researchers' strategy focuses on target stakeholder groups (public/private fleets, local governments, first responders, State Fire Marshal, etc.), and is designed to leverage additional participants such as AT&T. The commenter continued on to say that the project uses Sabre Technologies data collection system for infrastructure, which provides for real-time data collection. Furthermore, it was pointed out by this commenter that the system also allows immediate notification of issues, that it can be integrated with Geographic Information Systems (GIS) and Google systems, and that data can be received on I-Pad or smart phones. According to the commenter, with all of this data collection capability, the project should be able to report extensive, detailed data when completed, which is key to the usefulness of the project. The commenter concluded that this level of data collection also appears relatively uncommon among these American Reinvestment and Recovery Act (ARRA) projects, but is clearly important.

A fifth commenter felt that the researchers' strategy was solid and that they had achieved much, but did have some issues with the gallons displaced as well as media coverage. The commenter observed that one of the more important issues was that any piece of the project that would have resulted in long delays in being shovel ready was not included. This commenter further emphasized the importance of this idea because this program was designed to facilitate AFV acceptance in everyday use. The commenter praised the researchers' choice of targets and fleet, which has the greatest number of hydrogen buses on the east coast. This commenter also opined that some type of pay off needs to be accomplished to turn back the doubters.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were generally positive. One reviewer applauded the methods that the researchers used to collect data and measure website hits. The same commenter asked the researchers if there were plans to make this available to other Clean Cities coalitions (and other similar projects).

The second reviewer commented that the researchers are making their goals through somewhat difficult times. The third person made note of the fact that all vehicles were ordered, most were delivered, and most stations were online and pumping. This reviewer then mentioned that the project instituted real-time monitoring of fuel use at each station, emissions reductions, etc., and targeted fleets, first responders, and other likely groups. The commenter also stated that there were some delays due to order backlogs for vehicles, but that this is a common problem for all projects. This person then commented that real-time monitoring of fuel use is innovative.

A fourth reviewer claimed that the project is 81% complete, and that most of the fueling stations were complete, with a few exceptions. The commenter remarked that the project team held ribbon-cuttings for all new stations, with local and state officials, in order to provide additional visibility. The reviewer additionally stated that vehicle acquisitions were planned to be completed by the end of May 2012, but that there may be some that are delayed until this summer, and that taxi fleets will be fully deployed by early June. This person followed up by saying that all of the required National Environmental Policy Act (NEPA) documentation had been submitted for all of the vehicles and has been approved by the U.S. Department of Energy (DOE). The commenter noted that the project held 20 events this year, with 1,100 attendees, developed safety materials on new vehicle types for the region, and

conducted safety training. The reviewer also mentioned that the project team anticipates an overall displacement of 6 million gallons of petroleum and 11 million pounds (lbs.) of greenhouse gases over the four-year project.

A fifth reviewer said the researchers seemed more honest and upfront about exposure to their efforts. The commenter explained how the researchers listed a number of 218 million and upwards for possible exposures, but that 20% of that number seemed more realistic. The reviewer commended the station monitoring system that allowed the station to report in automatically when there was a problem. This person said that this should be adopted by all other programs, and that it could potentially save a significant amount of time and money.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers were pleased with the collaboration on this project. One reviewer said that the researchers did a great job in getting a number of non-profit, local government, and private industry partners into the process. A second person was impressed by the project team's work with first responders as well as its measured media market exposures. A third commenter stated that the project received over 50% cost-share – \$13.2 million from DOE and \$16.7 million from recipients. This person then noted that the project partnered with all Connecticut Clean Cities Coalitions, state/local governments, private industry, and utilities/non-profits. The same reviewer pointed out that the hydrogen station had cost about \$3 million in total, including in-kind and the like, half from DOE and the rest from the partners. A fourth reviewer observed that the collaboration fostered between two taxi companies in two cities to make a large order for CNG-fueled MVI para-transport taxis is filling a gaping need.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer responses for this question were generally positive. One reviewer was impressed by the project's opportunity for a data collection platform to be used in the future.

A second commenter stated that the researchers are winding down their efforts with marketing and other outreach events planned, as well as completing manuals for the Emergency Response Program. This person applauded the eight-hour program that gives first responders placards to take with them showing the emergency response critical issues and points for different types of vehicles.

A third person felt that the plan to account for return on investment (ROI) was commendable. This reviewer also asked the researchers how the project planned to maintain usage of the stations after the grant is spent.

A fourth commenter observed that the researchers proposed future training for first responders, a large slate of events, follow-up for tracking fuel use, and reporting of data. The reviewer additionally stated that real-time data tracking of fuel use and money saved seems like it would be a tremendous tool for recruiting fleets to switch over to alternative fuels.

A fifth reviewer mentioned that the focus for going forward is getting recent deployment in place and on-going data collection. This person then pointed out that the researchers expect to conduct remaining station openings by the end of June for one and the end of September for the other. This reviewer remarked that it seems like some effort on detailed data analysis should be made, although exactly how much was a bit unclear. The commenter also responded that the project was designed to have the capability for detailed analysis, so it is expected that it will occur, but that it simply did not appear to be an area of emphasis in the future plans.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the commenters agreed that the resources were sufficient. The reviewers generally did not see any problems with the project's resources. One reviewer reported that the resources were spent wisely for maximum impact, but indicated a need for a bigger budget in order to install more hydrogen fueling points. This person then noted that the funds were used to address a previously unmet civic need in para-transport and to create synergy with other funded projects, like the hydrogen buses.

**State of Indiana/Greater IN Clean Cities
Alternative Fuels Implementation Plan:
Patrick Flynn (State of Indiana) – arravt050**

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All six reviewers responded positively to this question.

The first reviewer remarked that the project is obviously aimed at deploying alternative fuel vehicles and infrastructure, which will support DOE’s objective of petroleum displacement.

The second reviewer noted that the project displaces petroleum through vehicle and alternative fuel infrastructure deployment (1.4 million gallons displaced annually), and is thus relevant to DOE goals.

The third reviewer reported that the project will displace over 1.4 million gallons of petroleum annually and create more than 200 jobs.

The fourth reviewer stated that the project supports a fuel neutral approach for displacing petroleum.

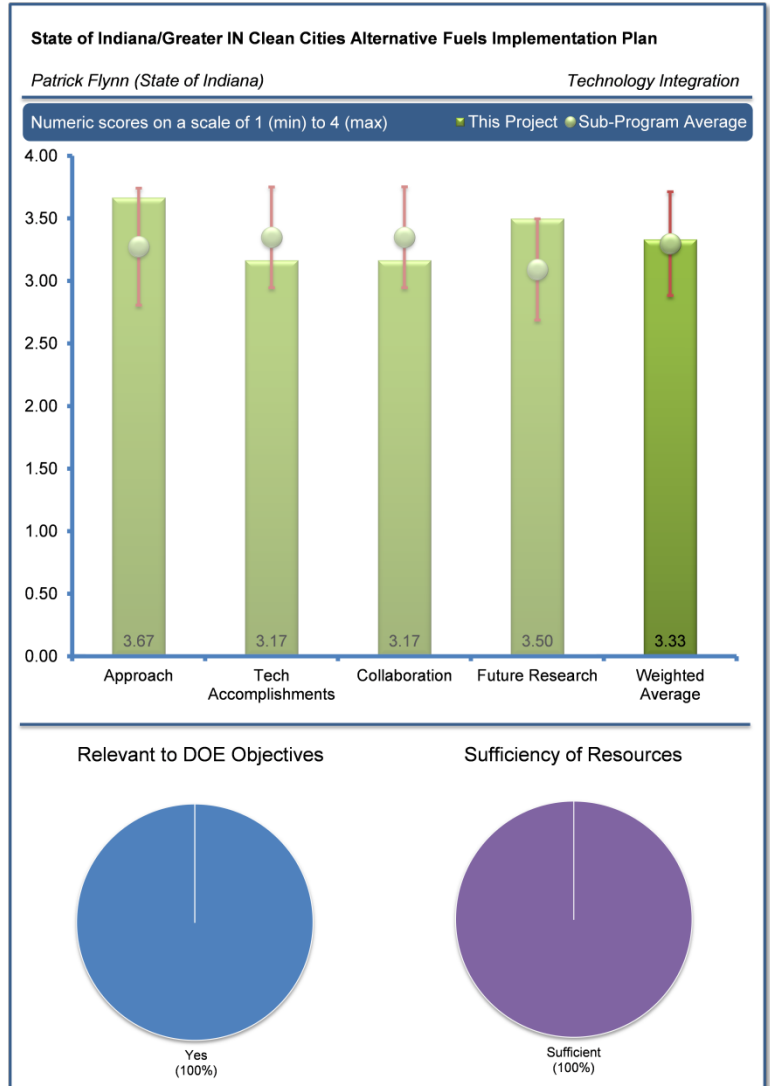
The fifth reviewer commented that the project had an excellent mix of vehicle types and fuel types, as well as excellent additional displacement. This person mentioned that the project deployed 369 vehicles and 122 infrastructure sites with 1.4 million gallons displaced annually, and that partner fleets spanned the state. The commenter also noted that there was quick additional growth at the Indiana Department of Transportation (INDOT) of \$2.5 million in additional funds to convert 357 more vehicles to autogas. This person then said that Sysco hybrid tractors were deployed in nine states impacting petroleum use in a broad geographic area. The same reviewer pointed out that the researchers added Tippecanoe School Corporation as a partner when funds became available.

The sixth reviewer claimed that by helping public and private fleets replace petroleum vehicles with alternative fuels that best fit their duty cycle, the project team maximized reduction potential. This person went on to say that the large amount of stations and vehicles (especially the significant focus on the state fleet and autogas) meant a great deal of implementation. The reviewer then stated that the goal of the project was to take Clean Cities fuel neutrality and apply it to the implementation, incorporating all fuels except biodiesel (BD). According to the reviewer, the way the funding opportunity announcement (FOA) was structured in a way that limited interest in biodiesel.

The sixth reviewer claimed that by helping public and private fleets replace petroleum vehicles with alternative fuels that best fit their duty cycle, the project team maximized reduction potential. This person went on to say that the large amount of stations and vehicles (especially the significant focus on the state fleet and autogas) meant a great deal of implementation. The reviewer then stated that the goal of the project was to take Clean Cities fuel neutrality and apply it to the implementation, incorporating all fuels except biodiesel (BD). According to the reviewer, the way the funding opportunity announcement (FOA) was structured in a way that limited interest in biodiesel.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments in this section were quite positive. One commenter stated that the project appears to have just taken U.S. DOE’s strategy for deploying the ARRA funds and replicated the process at the state level. This person explained that the project had



some good strategy at its core, but that it is unclear if there is a strategy to really facilitate the market development around some of the vehicles/fuel that the presenters claim is likely to happen. A different reviewer felt that the researcher's plan for expansion was excellent because the INDOT infrastructure was placed with growth in mind. This person cautioned that the project's only barrier appears to be that INDOT had to rewrite some vehicle specifications, but went on to say that the barriers seemed to be addressed in a timely manner with successful outcomes.

A third commenter was impressed by the way the project helped partners solve some of the problems that could have occurred in implementing technologies on their own (e.g. additional E85 stations to let a police department fully run their vehicles on E85). This person then mentioned that it seemed like the researchers really targeted ways to maximize fuel switches that would not have functioned well on their own. This reviewer said that by using the federal grant scoring metric, the presenters stayed true to the project goals. Additionally, the reviewer stated that the researchers essentially used the federal grant scoring to make their own FOA to choose fleets to use and scored them that way. This person observed that INDOT put in 115 stations with the grant and retrofitted some vehicles; because of the infrastructure INDOT was able to go out on their own and retrofit 404 Ford Rangers. Finally, the reviewer is waiting to see results from this year as it is the first time the vehicles are fully being fueled with the new technologies.

A fourth commenter emphasized that the researchers used a very logical and appropriate strategy (using DOE FOA scoring and logic on project strength and contribution to petroleum displacement) to identify projects and partners to be funded. This person then added that the project contained broad fuel neutral approach spanning the entire state of Indiana.

A fifth reviewer commented that the project addressed the key barriers of expanding infrastructure and providing training to first responders through a wide range of partnerships, and that the partners were selected through a Request for Proposals (RFP) process. This person made note of the fact that when fully deployed, the project will be a major push for acceptance of AFVs and will help catalyze further market action. According to the commenter, the Principal Investigator (PI) found that there are particular applications for AFVs that are particularly relevant to the Indiana economy, especially with dairy and agriculture vehicles.

A sixth reviewer pointed out that the project encompassed the majority of available alternative vehicle types, had clear milestones and met them on schedule, and was selected by considering various criteria including job creation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most of the reviewers' responses for this question were positive. One reviewer indicated that the researchers have made excellent progress, used an excellent model, and formulated a nice plan to build the infrastructure, make it bigger, and make it a good experience that will grow business for the local supplier. The reviewer then pointed out that PI found new partners when funding freed up. This person said that first responder training through NAFTC was completed, and that NAFTC is doing more this year so the researchers are clearly expanding the funded project already. The same commenter applauded the researcher's proactive work to easily make the infrastructure available to other fleets. This person noted that the investigators have addressed the problem of the propane association not being happy with INDOT selling fuel opposed to propane marketers. The commenter then added that by using INDOT to attract fleets, the project has the potential to grow exponentially. The reviewer added that with the dairy partner, the researchers took what the project was doing and made it better by growing infrastructure on the routes that the dairy partner used, like a roadmap for the dairy industry. This person remarked that when the price of hybrids and conversion costs went down, that cost went into first responder training and more vehicles. The commenter said that the researchers reacted quickly to identify additional projects when the funds were available.

A second reviewer said that the project had a large amount of stations and vehicles, showed significant petroleum reduction and nearly complete vehicle and station implementation, and was done in ways that solved problems the presenters' partners were facing. Additionally, the commenter noted that the investigators had basically finished implementation last fall (98% spent), so the next year and a half are focused on data collection. This person reported that the presenters created new bid specifications in organizations to fit Davis-Bacon, and that the jobs mentioned are hard jobs the researchers have counted at the primary level vendors. The same reviewer also stated that the Fort Wayne police fleet is now fueling E85 basically 100% of the time; it was at

50% initially but then the fleet partnered with a petroleum marketer to install three more stations in the heart of the city. Finally, the commenter described that the savings that funded the last-stage LPG school buses in Tippecanoe County came from fleets seeing lower costs when vehicles were purchased than was expected when submitting bids.

A third reviewer mentioned that the project had significant infrastructure and vehicle counts (121 fueling sites and approximately 369 vehicles). This commenter confirms that fueling site deployment (propane) enabled INDOT to expand their propane vehicle fleet by 400 vehicles beyond the 245 funded by the project. This person added that virtually all vehicles have been deployed, enabling nearly two full years of data collection. The reviewer also indicated that Renewable Dairy Fuels project (renewable natural gas) was already showing expansion beyond stations funded by the project, which could be a potential pattern for the dairy industry for reducing greenhouse gases. The commenter concluded that the E85 police fleet (Fort Wayne) is enabled by strategic ethanol infrastructure, and is reducing fleet fueling costs.

A fourth commenter affirmed that the project was substantially completed by last fall, with all deployments completed by April 2012, and that currently, the only activities that remained included reporting, outreach, and administrative tasks. This person stated that the project deployed 115 LPG stations for government use, first responder trainings, and a bio-methane CNG station, among other projects.

A fifth reviewer mentioned that the project initiated support for a new project of recovering bio-methane from dairy for fuel for a class eight milk delivery truck, assisted in the establishment of a CNG corridor on interstate I-65, and is displacing 1.4 million gallons of gasoline annually.

A sixth commenter expressed that the project had definitely made good progress and accomplished quite a bit, but that it was unclear to the commenter if the investments in some areas would really result in leveraged and/or long-term benefits given the one-off and very diverse nature of the work funded with grant money.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer comments in this section were positive for the most part. One reviewer stated that the project has ten partners consisting of government, private and public institutions.

A second reviewer said that the researchers' partners included the State Energy Office, Clean Cities coalition, and major fleets (like Sysco), who are all pursuing novel projects as a result of this work.

The third commenter elaborated that INDOT was a key partner for propane infrastructure, the Energy Office did the contracting, and the Clean Cities Coalition did the field work.

A fourth reviewer felt that the researchers had great partnerships with the implementing fleets. It seemed to this person that the investigators chose to go for off-the-shelf technologies, and thus avoided the types of partnerships with academia/industry that would have been natural in aggressively pursuing more advanced technologies. However, the reviewer commented that this was unimportant as the payoff was obviously quicker and the implementation cleaner. In addition, this commenter suggested that perhaps there could have been more safety training, testing of technology, etc. Additionally, this person recalled that the researchers have been working to train INDOT and other technicians so that incidents could be responded to on their own fleet without outside help. The reviewer emphasized that INDOT CNG/propane stations were designed to be open to other government entities; none have taken them up on it yet but some are looking and INDOT has the contracts ready. This person went on to say that INDOT stations are getting some pushback because local propane dealers want to be the ones selling it, but INDOT believes it will work out fine. The commenter specifies that INDOT stations will seed it and get fleets to invest, at which point the propane dealers can come in and build a station of their own volition. The reviewer also made note of the fact that the presenters tried to retrofit Indianapolis prisoner transport vans to CNG because those run a regular route. However, the reviewer explained that the vans do have to go outside of the loop occasionally, so there were worries about a dedicated CNG vehicle, which is why the researchers ended up going with propane. This same person pointed out that the investigators are looking at putting in more stations down the corridor so the project could use those trucks to make runs all the way down to Florida, which is a model that

can then be taken throughout the country. According to the reviewer, CNG allowed them to address their greenhouse gas (GHG) emissions in a significant way (even more if bio-methane could be used). This person concludes that the researchers hope to be running solely on bio-methane after Labor Day.

A fifth commenter recounted that the KAKCO station upgrade supported both their fleet and AT&T so it would demonstrate the viability of the station configuration. This person then offered that the presenters could possibly communicate dairy project success more within industry.

A sixth reviewer remarked that it was unclear how much collaboration happened outside of the project manager and individual grantees, and also if there is a mechanism to gather and share lessons learned from this project more broadly than just the identified partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All the reviewer responses for this question were favorable. A couple reviewers said that the project appears to be on track to complete future activities, and that there is not much left to do. One of those reviewers added that the project recently added five propane buses to the Tippecanoe School District, and that getting the last two or three of those will completely finish the vehicle implementation. Another commenter stated that the project plans well for the future, particularly the growth of LPG vehicles and infrastructure. This person also pointed out that savings due to fuel price will help retain city jobs. A different reviewer remarked that the future work seems appropriate to close out the project, and that mostly outreach events and data collection/analysis are implemented at this stage. The reviewer complemented the researchers on their use of a computer kiosk to display information about the project at outreach events. An additional commenter recounted that many of the fleets have been buying additional AFVs beyond what was required in this project. This person mentioned that the PI planned to conduct more trainings, events, and outreach in the future and is looking to replicate the CNG project with other dairies. The same commenter concluded that the LPG stations can eventually catalyze more interest and generate private investments in more LPG infrastructure and vehicles.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers unanimously agreed that the project's resources were sufficient. All of the comments in this section were positive. One reviewer summarized that the amount of vehicles and stations suggested that the resources were used very well. This person noted that the project started in 2009, used \$10.125 million from DOE, and was matched \$12.415 million. The reviewer made note of the fact that the total cost of INDOT propane and E85 stations was around \$3 million for 115 stations, although there was access to the infrastructure tax credit of 30% up to \$30,000 through their vendor, and the average cost was \$35,000-40,000 installed, though INDOT has had to do some later work on their own. A different reviewer stated that 98% of the DOE and cost share money has been spent. This commenter specifies that the researchers were able to add partners with some of the unspent funds and the projects seem to have had reasonable prices for the infrastructure projects.

NJ Compressed Natural Gas Refuse Trucks, Shuttle Buses and Infrastructure: Chuck Feinberg (New Jersey Clean Cities Coalition) – arravt051

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Evaluators were overall supportive of this project. The first reviewer stated that this project would displace over 2 million gallons of petroleum annually and reduce emissions of criteria pollutants and GHGs by over 900,000 lbs. per year.

The second reviewer remarked that the project has jump-started the use of CNG in heavy duty vehicles in New Jersey, and would have a major impact on petroleum displacement in the state, with nearly 300 heavy duty vehicles deployed and six refueling stations that would be open to the public.

A second commenter explained that the project is obviously aimed at deploying alternative fuel vehicles and infrastructure, which will support DOE's objective of petroleum displacement.

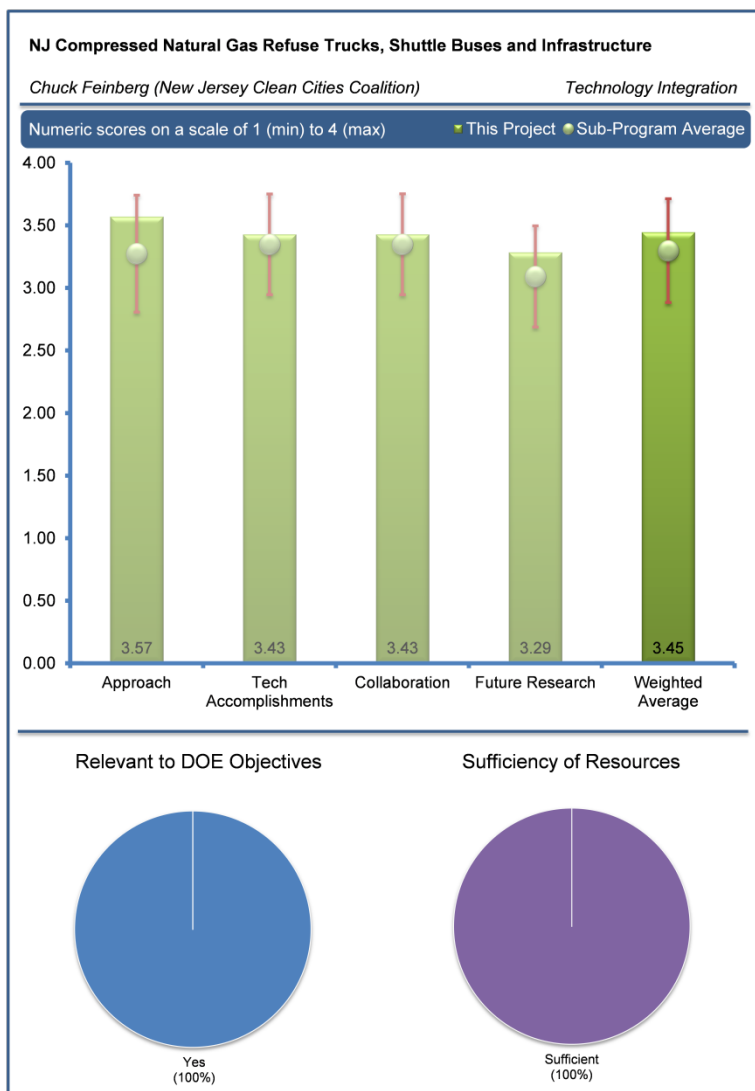
The third reviewer indicated that the project is obviously aimed at deploying alt fuel vehicles and infrastructure, which will support DOE's objective of petroleum displacement.

The fourth reviewer observed that both leveraging and visibility of wrapped refuse haulers were excellent. The commenter noted that this CNG project attracted diverse participants with high volume, high visibility applications to have the biggest effect on petroleum reduction and emissions. This person said that the HD portion in particular had significant fuel and emissions savings. The commenter also mentioned how wrapped jitneys transport casino patrons among casinos and drivers talk about their vehicles being natural gas. According to the reviewer, both are excellent support of the broad petroleum displacement goal.

The fifth reviewer noted that the project will reduce a relatively large amount of petroleum consumption by targeting a large amount of high-fuel consuming vehicles. The sixth reviewer reported that the project has high relevance to DOE objectives because the project will displace a significant amount of petroleum (i.e., approximately two million gallons per year). The seventh reviewer affirmed that the project supported reducing petroleum dependence by focusing on developing the infrastructure for compressed natural gas refuse haulers and shuttle buses.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All reviews were positive for this section. One reviewer stated that the project was well-designed and straightforward, focusing on the deployment of vehicles and refueling stations using one alternative fuel, CNG. This person mentioned that the vehicles selected



for the project are all high fuel use, high visibility, and high impact. The same commenter pointed out that deployment activities occurred throughout the state, and will have a widespread impact in terms of petroleum displacement and community awareness. It was the reviewer's opinion that the project integrated well with Waste Management's (WM) introduction of natural gas to its fleets across the country, and fit with the growing interest in the use of natural gas vehicles by the waste hauling industry in general.

The second reviewer claimed that the project had a very good strategy of focusing its efforts on one particular fuel and making sure that it was successful with what it did with that fuel, and continued to look for ways to leverage that work for even greater benefit. The third commenter reported that technical problems included a design issue with jitneys (tank over cab was knocked off at an overpass), which was quickly addressed and resolved. The person also stated that the root cause (lack of training, substitute drivers) of some problems was quickly solved. According to the reviewer, the PI implemented a solution that was appropriate and did not overreact. This person acknowledged that the high visibility of these projects have already brought interest from other fleets and policy-makers.

The fourth commenter applauded the strategy of targeting one technology and applications that are both highly consuming and highly visible because it targets petroleum reduction much more than niche technologies. Additionally, this person described that the researchers' strategy was to limit the project to one technology (CNG) and fleets with high fuel use and visibility. The reviewer highlighted that the goal was to have a big impact on emissions reduction and outreach, and to create jobs and get the technologies out to the public. The commenter brought to light that even though the project did not use a large number of fleets, that the project was designed to use ones that would prove to the public that alternative fuel infrastructure was available.

The fifth expert pointed out that the investigators used strategic locations for fueling sites around the state to serve these fleets, with some public access. This person also mentioned that this was the first statewide alternative fuel project for New Jersey. The sixth reviewer remarked that the selection process focused on partners that were capable of following through on their commitments. The reviewer observed that this keep it simple approach has seemed to work well, although the City of Newark had to drop out but the PI brought in new replacement partners. The seventh commenter summarized that the strategy of the project was to create a critical mass of NGV activity to sustain continued development of the technology, and overcome the deployment barrier in New Jersey for NGV(s).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The general reviewer response was that excellent progress and petroleum displacement had been made on this project. One reviewer commented that the lack of any significant problems with the stations or vehicles was a testament to the project's good up-front planning and implementation. This person went on to say that the project has already resulted in an increase in interest in all alternative fuels in the state, the opening of several other CNG stations, and the deployment of additional, privately-funded vehicles. The reviewer indicated that one original participant dropped out due to cost-share issues, but that the setback was quickly overcome, and probably resulted in a stronger project overall.

Another commenter mentioned that three remaining CNG stations have been awarded and can be completed in a timely manner. The person stated that the high fuel use and emissions benefits of this project have already contributed significantly to DOE's goals. The reviewer also commended the researchers on their excellent progress and collaboration on solving problems. The commenter concluded that the revised energy master plan for New Jersey now included alternative fuels because of the success of this program.

A third expert noted that most of the stations had been built (some with public access), and that most of the vehicles are on the road and documenting petroleum savings. The reviewer expressed that it is hard to fully evaluate the project without data on the amount of money spent, timeline, and etc. According to this person, addressing permitting issues is the one issue that sounds like it still needed work. Additionally, the commenter stated that there are four stations in operation currently, one in construction, one in local permitting process, and approximately 300 vehicles (trash trucks and shuttles) as well as six stations that will be open to the public in the future. This person pointed out that the local permitting process was one of the unexpected hurdles the researchers found, and that it is still being dealt with to a certain extent. This reviewer then reported that the WM site in Camden has two

public quick fill pumps as well as 88-time fill posts for the WM trucks. The expert emphasized that the time fill kept the cost of the station much lower than it would have been, and that WM is using the station design as a model for those elsewhere. The reviewer concluded that another public station has deployed 500,000 gasoline gallon equivalents (GGEs) since August 2010.

The fourth reviewer noted that the project planned the deployment of 300 natural gas refuse haulers and shuttle buses, of which 35 refuse haulers and 202 shuttle buses have been purchased and deployed to date. The commenter also mentioned that the project also supports six compressed natural gas fueling stations, of which three are operational, two will be open soon, and one is in the permitting process. Currently, observed this reviewer, the project has an annual displacement of 2 million gallons of petroleum per year, which equates to 900,000 pounds of pollutants and greenhouse gas emissions eliminated.

The fifth reviewer indicated that the project has made great progress and appears to have achieved all appropriate accomplishments to date.

The sixth reviewer reported that over 230 vehicles had been deployed in six fleets, and three stations (of six) were operational. This reviewer further noted that actual fuel displacement numbers were not listed in the presentation, but would have been useful information to gauge project success. The same reviewer presumed high displacement given the number of vehicles. This reviewer remarked that it was good to see stations spurring additional demand (specifically, private waste haulers interested in CNG as a result of the Newark station). Because there was not much discussion in presentation about data collection efforts, this reviewer questioned what was being done (or will be done) to track these vehicles to assist in quantifying project success.

The seventh reviewer stated that four of the six CNG stations were complete, one is under construction, and one is stuck in permitting. The same reviewer also noted that over 235 CNG vehicles had been deployed to date, with more to follow, and that many of the projects have enabled other fleets to buy CNG vehicles. This reviewer acknowledged that some of the reporting has been difficult, but the PI was working with partners to address this challenge. Furthermore, continued this reviewer, the project was a bit behind schedule, but is making progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer praised the researcher's collaboration among partners, both public and private. The commenter reported that the project involved coordination with multiple gas utilities and state agencies to the degree necessary.

The second reviewer applauded the project's list of partners and said it appeared to be doing its best to spread the word on its work beyond these partners within the region. The same person recommended that the project manager consider distilling the project's lessons learned and key takeaways to share the good work from this project with Clean Cities Coalitions around the country.

A third reviewer stated that the project has a high industry partner collaboration and has stimulated a range of discussion about alternative fuels. This person noted that the impact of the project has the opportunity to grow CNG in New Jersey significantly and that WM is using it as a model for other facilities to do the same. The commenter remarked that fleet operators are now committing to NG vehicles because of the refuse recycling facility, and that the town that mandated CNG will influence and assist other cities who are doing the same. The same expert mentioned that the Jitney association consisted of independent owner operators that serve Atlantic City casinos and specialize in transportation between the casinos and the airport. The reviewer described that the vehicles that were 15 years old were replaced, and that the newer vehicles were used to showcase NG while transporting casino patrons between sites.

A fourth commenter criticized that the breadth of partners is somewhat limited, but that is dictated by the specific focus of the project. This reviewer was very impressed with the buy-in that the investigators got from the refuse haulers and jitney association. In addition, this person questioned the need for more collaboration within the state to publicize and spread CNG adoption, but noted that it sounded like there was some effort there. Additionally, this commenter recalled that the project had 11 partners, and that it did not go through the state government at all (only Clean Cities is running it). Secondly, the reviewer stated that Essex county facility services many trucks in New Jersey and even 200 in New York City. The expert described that this proved to fleet operators working out of there, that fleet operators could buy trucks because there would be a station at the facility where drop-offs

are made. This person reinforced that this station is letting the presenters get fleets to buy trucks outside of grant funding. Thirdly, the reviewer acknowledged that the Atlantic City site has 190 shuttle bus operators and that those are all independently owned. This person went on to say that the association opened a new fueling station which would also be open to the public, which is a good exposure for CNG because it would be so visible in a tourist destination. Lastly, the commenter noted that the researchers worked closely with the board of public utilities [kind of public utilities commission (PUC) combined with a state energy office (SEO)], and that their new energy plan has a transportation component for the first time and looks to CNG.

The fifth reviewer pointed out that the project was led by the Clean Cities coalition, and noted connection with 11 fleets in the state. This reviewer further remarked that the New Jersey Board of Public Utilities (including the state energy office) is not a direct partner, but is involved as a collaborator, and that gas utilities are also involved.

The sixth commenter felt that the partners represented a wide range of sectors and fleet types. The expert then said that there has been no direct state involvement, but that the Clean Cities Coalition has worked closely with the New Jersey Board of Public Utilities (BPU), New Jersey Transit, New Jersey Department of Environmental Protection (DEP), Port Authority, and utilities. This same person remarked that some of the partners, like the Atlantic City jitneys, have been extremely enthusiastic about the project and intended to continue developing their CNG capabilities.

The final reviewer reported that the project has 11 public and private partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer pointed out that future work is well-planned and already well underway. This person described that the lessons from initial phases of the project would clearly be used to accomplish the remaining work. Another reviewer noted that future work is logical to complete the project.

The third reviewer supported this assertion and noted that the project appeared to have a good plan to accomplish what it needs to for its future work. A third reviewer also agreed, indicating that the future work is logical to complete the project.

The fourth reviewer explained the project has \$500,000 remaining, which will be used to deploy additional natural gas vehicles, although few specifics were provided. This reviewer added that the project lead would continue with training for fueling and maintaining vehicles, outreach to the public and policy makers, and marketing campaigns for the new stations.

Another reviewer reinforced the statements made by the previous reviewer and stated future activities are completing vehicles deployment and start-up of the last fueling station. This reviewer indicated that the project also includes the continued training and outreach activities to the project completion date of December 14, 2013.

The sixth reviewer agreed stating that the first priority is completing the deployments and continuing trainings. This reviewer mentioned that now that much of the infrastructure is in place, the PI is looking to expand the use of CNG in New Jersey further, although additional funding may be necessary. The same commenter affirmed that the interest is primarily in CNG, but that there may be opportunities to do LNG as well.

The seventh reviewer pointed out that there is not a lot left to do, but that it would be nice to see more details on the outreach and first responder training. Additionally the reviewer noted that one of the big grant partners in the proposal ended up backing out because the partner could not meet the cost share and had some other issues. The commenter noted that this freed up funding for new partners, observed this is still being worked on (\$500,000 in federal money still available), and expressed a decision on that is still being considered. The expert then stated that the researchers needed to finish the construction of stations as well as outreach and first responder training. This person lastly affirmed that the Atlantic County Utilities Authority (ACUA) is collecting methane for electricity generation onsite, and said that Essex County burns it, so no biomethane goes through these facilities.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the commenters agreed that the resources were sufficient. The first commenter indicated that resources were well matched to project needs. Another commenter was very impressed with how well the project team leveraged funds (i.e., \$15 million in Federal funding and \$32 million in leveraged, non-Federal funding). This commenter noted that because the project team focused on one fuel and two implementations, it enabled leverage of a significant number of fleets and diesel reductions. A third commenter remarked that project resources were sufficiently planned to enable the successful completion of the project. The fourth commenter offered that money has not been the main obstacle to date, though permitting and construction delays have been obstacles. The same commenter added that the project has had no trouble meeting the cost share requirements and has approximately \$500,000 remaining to reallocate to other projects. A fifth commenter opined that the \$14,500,000 in DOE funding and the \$31,672,444 match are sufficient funding to reach stated goals. The final commenter stated that resources should be sufficient given the scope limitation to CNG only.

Promoting a Green Economy through Clean Transportation Alternatives: Rita Ebert (Greater Long Island Clean Cities Coalition)
– arravt052

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One expert commented that the petroleum fuel displacement was substantial.

The second reviewer remarked that this project absolutely supports the overall DOE objectives, highlighting that this is another poster child program for DOE, and explaining that matching funds exceeded DOE’s investment. The reviewer also commented it was admirable that 1,633,389 gallons of diesel fuel have been displaced so far. According to this person, 135 heavy-duty CNG AFVs, 11 light-duty, and 5 CNG stations have either been developed or are being developed. The expert felt that the presentation was well thought out and presented the facts clearly, however this person remarked that the presenter read the slides instead of encapsulating what was on them.

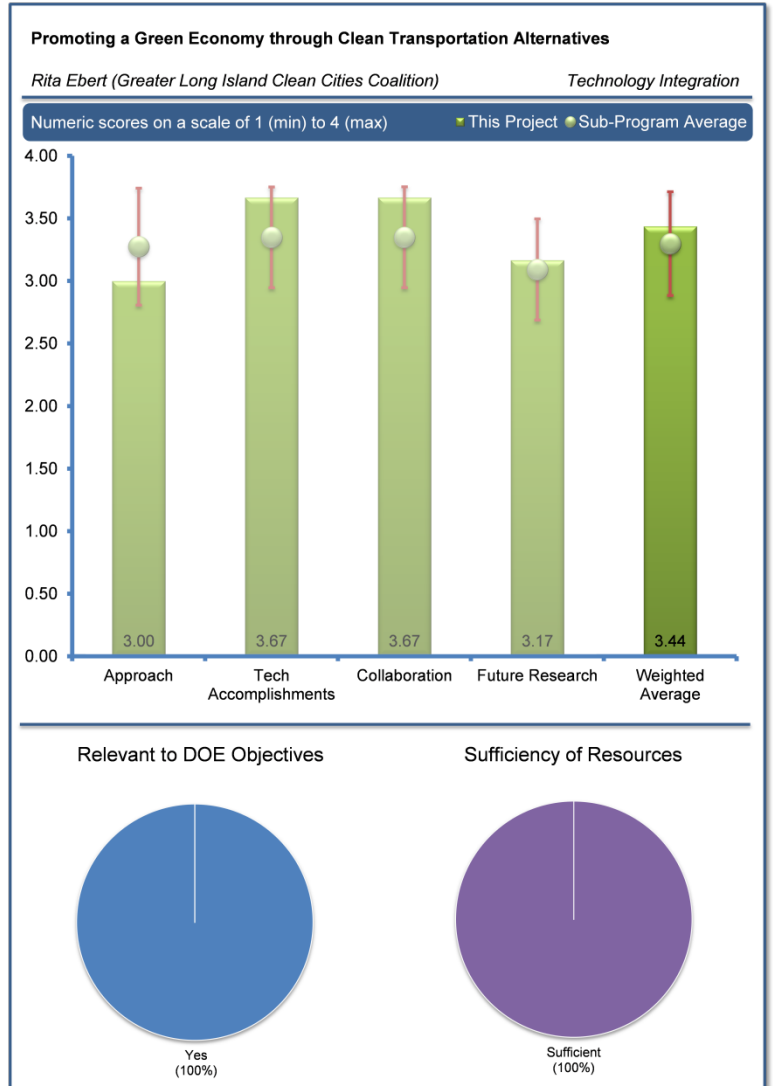
A third evaluator mentioned that the project called for more than 150 AFVs plus 6 refueling stations to strengthen a refueling corridor and the alternative fuel industry, and also includes conducting outreach and training. This person noted that the researchers are also focused on creating jobs for the local economy based upon clean technologies.

The fourth reviewer highlighted that the project targeted a wide geographic area, key points along the LIE corridor, and commercial, municipal fleets for immediate impact. This person observed that the presenters chose to concentrate locally rather than participate with other New York coalitions that might have watered-down the impact in this area.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter judged the strategy to be good because of what the project had accomplished in the end, despite the overall strategy not being described in the slides. The reviewer added that the best strategy information was contained on Slide 19 where the approach was described.

A second evaluator observed that the investigator’s strategy was built upon successful approaches and projects that had already been completed. This person noted that most of the vehicles were MD/HD, which resulted in significantly more fuel displacement (roughly 11,000 gallons per vehicle). The reviewer indicated that the project was focused on key leverage opportunities, and a number of participants also had CMAQ or other funds, which could not be applied to this project. But the commenter said that



those partners will acquire additional CNG vehicles to locate nearby at the same locations as vehicles under this project, and thus be able to share the alternative fuel infrastructure. This person felt that this was a very useful way to stretch the project's funding to create even more petroleum displacement.

The third reviewer praised the researcher's strategy, the fleets chosen, and the accessible locations chosen for the stations. This reviewer also noted that the project includes many MDVs and HDVs.

A fourth expert indicated that CNG was targeted heavily based on availability and interest, and because other fuels/technologies were not as accessible on Long Island. This person described the strategy to leverage local needs and availability as smart. The commenter applauded the clear criteria for choosing which projects to fund, and noted good advance planning as well as the backup plan to replace dropped-out projects. This person stated that the investigators overcame political budget-wrangling by local officials.

The fifth evaluator summarized that the project used one fuel, created less barriers, and did not use a huge number of vehicles. The sixth commenter felt the project was successful and liked that it included heavy and light duty vehicles, but questioned if it should consider other strategies beyond just CNG.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that, whatever the formal strategy was, the bottom line was that the project has made significant achievements since 2009. It seemed to a second reviewer that the work done on the project was very competent.

The third person reported that four out of five stations were open and accessible to the public, and liked that the investigators conducted training for all grant awardees.

The fourth commenter felt that the issues were primarily non-technical, and that there were a lot of issues to overcome surrounding the partner continuity. However, this person applauded how the presenters established partner ratings. The fifth evaluator claimed that there were not a huge amount of barriers to overcome.

The sixth expert noted that there were 129 NGVs in place, with 4 stations open (with last one by July 1) so far. This person mentioned that the researchers' approach was to build a corridor along Long Island Expressway, and in addition, they tried to make the project vehicles visible. The reviewer added that significant barriers resulted in a few delays, and local elections meant new officials changed budgets (Nassau County), plus there were backlogs on getting vehicles. However, the expert pointed out that the project team had other projects planned, so it reallocated using those. This person then mentioned that Nassau was the site for the one station that did not get done.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally observed multiple collaborations. The first evaluator was impressed by the number and diversity of partners that the researchers have enlisted for support, which included Long Island townships, and private project partners. A second reviewer was impressed by the project's management and oversight of the funding provided to its diverse partners. A third commenter described that the large number of partners turned out to be critical when changes to the project were needed due to a partner backing out. In addition, this person said that the partners brought more than 50% of the funding. Specifically, continued this reviewer, DOE funding was \$15 million, with a local match of \$21.4 million. A fourth expert complemented the presenters on their collaboration with municipalities to fund the deserving programs. A fifth person indicated that the researchers did a great job keeping partners on schedule. A sixth reviewer did not think the investigators had a huge amount of partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter opined that the investigators are on the downhill slide with a number of vehicles yet to be deployed and one CNG station remaining to be finished. This person was glad that the researchers apparently front-loaded the project, and got to work early getting things done. The same evaluator acknowledged that the presenters should also be commended for the ability to work through the political election change over and the redistribution of funds without de-voiding any goals or objectives.

The second reviewer described proposed future activities as appropriate. The third commenter stated that there are 18 vehicles and 1 station to go at this time. This person continued on to say that most of the remaining efforts will focus on doing more outreach and events, plus reporting/documentation. The reviewer specified that the researchers will also continue to reach out to new fleets to use stations built under this project, and expect to generate an on-going need for training.

The fourth expert felt that the investigators have a good handle on completing what is left to finish. This reviewer noted that the project will be reaching out to new fleets.

The fifth reviewer noted that the project intends to complete all installations and deployments, and reach out to new fleets to increase use of stations installed under the Program. The project will continue training to reach new employees and new fleets/partners.

The final reviewer thought proposed future activities were good, but this reviewer did not see any concrete plans of how the researchers would accomplish the outreach and evaluation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers were in agreement that this project's funding is sufficient. The first commenter observed that with the project's matching funds the investigators appear to be well funded, and the fund investment from DOE appears to be sufficient. A second evaluator heard no mention of an issue, but stated that the presenters did raise the subject of a penalty for partners for withdrawal from a project to identify/encourage commitment, or at least help to fund the re-allocations that were necessary. A third reviewer remarked that the resources were adequate for the needs of the area and scope of this project. This person confirmed that the project had wide-reaching impact on the community. According to a fourth evaluator, it looked expensive to focus the project on all on heavy duty vehicles, but seemed like the right choice for that community. This commenter would like to see that reasoning/differentiation spelled out explicitly in the presenter's report(s).

New York State-wide Alternative Fuel Vehicle Program for Vehicles and Fueling Stations: Patrick Bolton (New York State Energy Research and Development Authority) – arravt053

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project absolutely met DOE objectives. This reviewer further added that the project team’s deployed vehicles have driven 3 million miles and the displacement of fossil fuel was considered substantial with 372 out of 382 vehicles deployed.

The second commenter was impressed at the scale of this project. This person added that they seemed to have made an impact across a broad sector and a large geographic area.

The third expert commended the amount of petroleum fuel displacement for this project. The fourth evaluator claimed that the project hit all the key points.

The final reviewer highlighted the project’s impressive reductions in petroleum usage and emissions and big emphasis on electric vehicle charging stations, but not on deployment of EV vehicles. The commenter continued on to say that the researchers alluded that a different project was deploying EVs, so this was a great way to support that initiative.

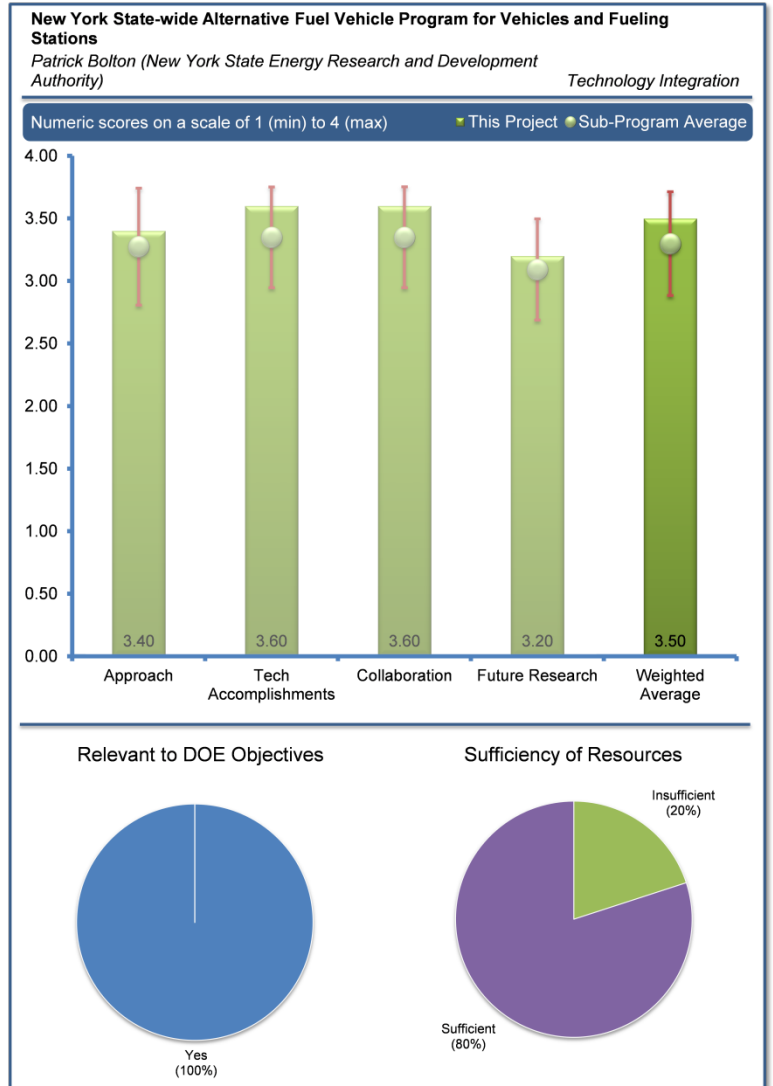
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had varied feedback on deployment. One expert was impressed that this project worked with diverse sectors and seemed to offer solutions that were appropriate to the partners. A second commenter noted that the project is expanding infrastructure in key geographical areas.

A third evaluator indicated that the investigators attempted to cover the whole state, involve 5 Clean Cities coalitions and 42 fleets, include schools, municipalities, private fleets, and universities. This person added that the project is regimented in keeping tabs on each sub-project, and the project management plan is clear. The reviewer also reported that the project included a big push for propane school buses, education on AFVs in general, and matching projects with the most appropriate alternative fuels for each one, not just pushing one type of fuel for all.

A fourth commenter applauded the project’s numbers, spread of technologies, and quick start in 2010.

A fifth expert felt that the presenters have a very sound strategy for deployment. However, the reviewer had concerns with the area of first responder training. This person explained that when people say first responder in and around these programs in general



they are speaking about Fire and EMT personnel and little consideration, if any, is given to police who usually show up first at the scene of an accident. The expert added that it is police personnel that file the accident report and maintain the accident experts. This person also mentioned that any type of hazards including hazmat that include automobiles, trucks, and/or buses that could pose a threat to first responders needs to be addressed for police as well. The reviewer reinforced that while the first responder training was truly staged by fire folks with their mobile training vehicle, an outreach to police must be started. However, outside of the first responder training, this reviewer considered the project's approach to be outstanding.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first evaluator expressed that the project is a great piece of work. This person described that the researchers moved quickly and constructed a word of mouth network that is attracting other potential AFV adopters. The expert felt that one of the more interesting aspects that should be looked at is the project's cost comparison data comparing AFV cost of ownership to standard vehicle ownership. The reviewer hoped that this takes into account all the costs including cost to repair the AFV vehicles.

A second evaluator was impressed that the investigators doubled many of their original goals and have sparked continued purchases beyond original partner commitments.

A third commenter remarked that the presenters did a great job getting ownership cost calculation done and written up in the paper.

A fourth expert noted that 99 EV charging stations have been installed, most of which will be publicly accessible, and that 7 CNG/LNG fuel station installations have also been installed. This person pointed out that the project leveraged funds to help spur other grants aimed at EV vehicles.

A fifth reviewer remarked that the project included many different fuels and infrastructure, which are creating barriers to deployment.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought the investigators' collaboration and coordination was wonderful, with 42 various agencies, groups, organizations, counties, and cities. This person expressed that this is really an example of what cross boundary collaboration should look like. A second evaluator was pleased to see that this project appeared to be focused on offering locally appropriate solutions. A reviewer acknowledged that the project had a nice spread of partners with which to deal. Another expert stated that the project had collaboration with five Clean Cities Coalitions and many fleets. The final reviewer liked the pie chart of stakeholders and thought it was a nice spread.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter observed that the investigators will continue their marketing and outreach efforts and reporting of fuel usage and fuel dispensed, with the lion's share of the work completed in 2011. A second reviewer said that data collection could be useful for the future. A third evaluator noted that future activities include data collection and reporting, and finishing deployments. The fourth expert commended the project's proposed future activities, but questioned how the project plans to maintain usage of the stations after the project.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer thought resources were insufficient. The remaining reviewers felt the project's resources were sufficient. The first reviewer felt that compared to other projects, this state-wide initiative is daunting given its funding resources in a state that is so population dense. The second commenter voiced that the resources appear to be sufficient as most of the heavy lifting was accomplished in 2011 and 15% of the budget remains at this point in time. A third evaluator stated that the resources were a very large award, spread out over a large number of projects. This person was impressed by the impact and stimulated significant

private investment. A fourth expert felt that this project produced a lot of good for the amount of resources provided. This person observed a little imbalance of EVSE, but was glad the researchers were making a strong showing.

The Ohio Advanced Transportation Partnership (OATP): Cynthia Maves (Clean Fuels Ohio) – arravt054

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first expert noted that this project supports diverse alternative fuel types, and encourages the deployment of vehicles and alternative fuel infrastructure. This person added that the CNG and LNG stations, in particular, should contribute to increased petroleum displacement.

The second commenter affirmed that the project is obviously aimed at deploying alternative fuel vehicles and infrastructure, which will support DOE's objective of petroleum displacement.

The third evaluator applauded the project's diversification among fuels and vehicle types. This person claimed that projects with this breadth and depth require an excellent PI in order to be successful. According to this reviewer, the Clean Fuels Ohio's ability to assist fleets in analyzing optimal fuels would be best ensured success. The commenter also felt that there was excellent petroleum displacement potential for this project and for growth beyond the funded work.

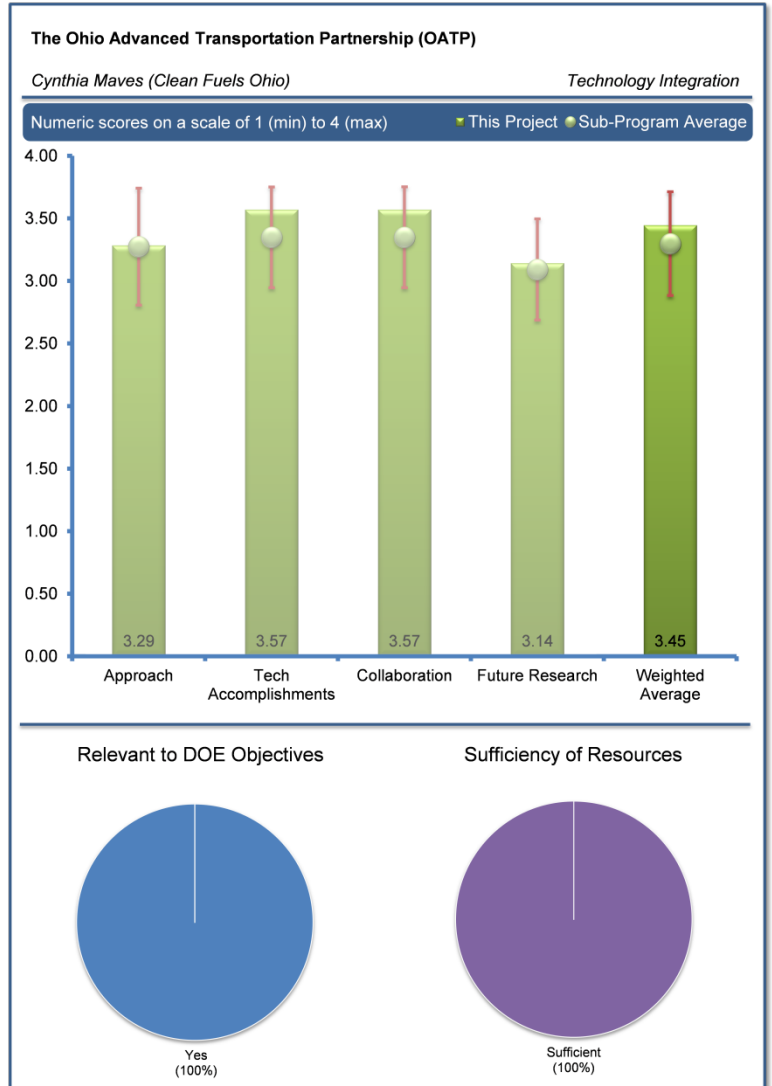
The fourth expert highlighted that by introducing non-petroleum vehicles into Ohio, it allows fleets to displace petroleum consumption. The fifth expert remarked that the project reduced dependency on imported petroleum through deployment of alternative vehicles, construction of charging and fueling stations, and public outreach.

Another reviewer remarked that the project is relevant because it is estimated to displace 875,000 gallons per year. This project is focusing on job creation as well. This commenter recounted that the researchers want to keep Ohio up to date in automotive technology with initiatives like vehicle conversion centers.

The seventh reviewer noted that the project will reduce petroleum use by about 875,000 gallons per year and will result in significant emissions reductions and job creation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally had positive input on the deployment strategy, and some reviewers also noted barriers that have been overcome. One reviewer reported that the project had a diversified fuel and technology portfolio with the deployment of 292 vehicles (natural gas, hybrid, propane, and electric) and 75 fueling stations (natural gas, propane, and electric). This person also mentioned that the researcher's balance of fuels met local needs and their clearly-defined marketing campaign seemed poised for success. The expert added that the team is shaping the projects to maximize use of grant funding.



A second person said that the approach the PI took was to deploy a diverse set of fuels in a wide range of fleets, both big and small. This commenter observed that the focus was on creating a statewide network of stations from Cleveland to Columbus. The evaluator also indicated that the PI has been very inclusive, bringing in a large number of partners with both local and national presences.

A third evaluator acknowledged that the researchers identified a clear milestone approach for completing vehicle deployment, installing fueling infrastructure and outreach activities.

A fourth reviewer noted that the economic recession impacted the project's partners at the start. This person highlighted that additionally, the equipment was in short supply so there was insufficient competition among vendors. Also, the commenter highlighted that the Clean Fuels Ohio experienced some delays because of that, but has overcome a number of barriers to find success, and said that their forthrightness about the barriers they encountered makes them excellent PIs. This person pointed out that the investigators have clearly learned from managing the project and will use that knowledge moving forward. The evaluator made note of the fact that an excellent growth result of the project was the interest in a conversion center for LPG vehicles in Ohio, as well as natural gas. This person highlighted that companies see there is a market in Ohio for conversions which may also draw parts suppliers. The commenter thought it was commendable that a driver was hesitant about CNG and completely turned around after using the vehicle. The reviewer remarked that the Owens Corning portion of the project was built on a similar successful project in Texas, and concluded that every part of the project was well integrated and planned for [DOE Program Clarification: The partner in the sub-project to whom the reviewer is referring is Dillon Transport. Owens Corning is not an official partner in this project.].

A fifth expert felt that the deployment strategy was admirable in addressing a wide variety of technologies and applications. This reviewer certainly could see the value of putting EVSE in areas where it will have educational impact, but questioned how it could actually address technical barriers without a plan for follow-up and gathering feedback. This person also thought that factoring in the state's auto parts strength was a great idea, but did not feel like there was much of a structure for using it to address technical barriers. Additionally, the evaluator mentioned that the researchers aimed for a portfolio as diversified as possible. Secondly, the commenter said that Ohio is the second biggest supplier of auto parts and needs to stay competitive in that, and staying on the cutting edge with alternative fuel technologies is something the presenters think is an essential part of that. Thirdly, the expert noted that the outreach strategy is really focused on fleet managers much more than the general public because that is who the researchers see using the stations, but the EV infrastructure will be more public oriented. Fourthly, this person recounted that the still-to-come EV infrastructure was focused on areas where it will have a large educational and public impact, such as universities, city governments, museums, etc., and all will be public access. This reviewer noted that Bowling Green has them installed and free to use. Lastly, the reviewer confirmed that the investigators did provide some technical assistance to fleets in determining which fuel choice would be best for them.

A sixth person stated that the project appears to be quite well designed although there appears to have been a significant number of problems that developed after the grant was awarded, which raised questions.

A seventh commenter brought to light that the project faced several notable barriers: the recession and budgetary concerns caused some local governments to drop out, a lot of equipment was in short supply, and there was insufficient competition among vendors. The evaluator added that Clean Fuels Ohio was able to replace the original partners that dropped out. This person continued on to say that the project originally started with 20 partners and is now up to 43 and growing, but that more partners does not necessarily mean a better project. The expert stated that the fuels addressed were CNG, LNG, propane, EVs, renewable natural gas, and hybrids. This person speculated that it may have made more sense to focus on fewer fuel types and fewer partners. The reviewer concluded by stating that Clean Fuels demonstrated good forethought by helping fleets analyze their duty cycles during the early stages of the project to help them determine which technology would work best for them.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had a broad range of responses regarding the technical accomplishments. The first commenter observed that the project had a deployment of 117 vehicles, and about half of the stations seemed to this person to be a bit behind schedule given the 2013 end date, but the team plans to catch up by October. The evaluator added that petroleum displacement is already significant but will hopefully accelerate as more vehicles come online. This expert would like to see some examples of the media outreach materials when they are completed, and commented that these should be included in the presentation.

A second reviewer reinforced that the progress has been slower than expected (the project is about 60% complete) because of a lot of turnover in sub-recipients. This person mentioned that only about 100 of the vehicles are deployed, but most of the infrastructure is in use, including the LNG station and the 10 LNG trucks, which will be part of an LNG corridor from Chicago to Pennsylvania. The commenter noted that the presenters have hosted trainings for fire marshals and building inspectors, and have hired a marketing firm to develop a marketing plan. The reviewer said that the EVSE will be public and will be in educational and municipal settings.

A third evaluator felt that the project has been a little slower than some others in reaching objectives, but that it also started later. For this reviewer, it would be useful to see more concrete documentation of the vendor/technology obstacles encountered and how they were overcome because it would give future parties a blueprint to follow. The expert pointed out that the project is now at around 60% deployment, and researchers had some partners pull out because they could not cover the cost share. This person mentioned that the investigators saw some problems because there were not enough/approved vendors for some vehicles, for example, there were specific vehicle functions that were not available or had not been EPA certified yet. The evaluator also indicated that the Clean Energy CNG stations have unused capacity now so more usage is expected to come up. The reviewer reported that the project includes 292 vehicles (114 CNG) and 57 stations (42 EV, 6 CNG), and one renewable natural gas station (Quasar bio-digester) at the end; about 120 vehicles put in so far. According to this commenter, the presenters had Senator Brown speaking at a CNG station opening recently with two more in Cleveland coming online in August. This person then stated that a Frito Lay EV charging project was almost \$100,000 in cost due to length of conduit required because of station location because the project had to be set back from the street a fair amount and ran a lot of conduit.

A fourth reviewer mentioned that the project experienced only modest progress this year in meeting milestones by going from 30% to 43% completion [DOE Program Clarification: PI presented that the project was 60% complete at the time of the review]. The project calls for 292 alternative vehicles, 42 charging locations, and 15 other fueling stations. This person remarked that the project had 50 marketing activities, media events, education activities, and completed natural gas station training for fire marshals and building inspectors.

A fifth expert observed that some projects have come in under budget or down scoped so the investigators are constantly adjusting. This person said that the project's success is clearly the result of excellent work by the PI with partners. The commenter elaborated that the researchers identified a technical assistance need very early on and were smart to ask for assistance. Again, according to this reviewer, clearly overcoming the barriers and managing the constantly changing landscape of the project could only be done with a knowledgeable and outstanding PI.

It appeared to a sixth reviewer that the project has made good progress and accomplished good things in terms of vehicles and infrastructure. The person was unsure of how to rate the marketing campaign piece given the amount of information provided both in the presentation and verbally. The commenter said that this is likely fine, but it is hard to say for sure.

The seventh evaluator felt that it was unclear from the presentation how the 60% completion compares to the initial projections. This person noted that two CNG stations, six propane stations, and some EVSE have been completed, and five CNG stations are 50% complete. The commenter stated that the presenter indicated that the amount of petroleum displaced may be higher than estimated because Clean Energy stations have greater capacity than original vendor. However, the person pointed out that although the number of locations for EV charging increased from 2 to 42 when compared to earlier projections, the number of CNG, propane and hybrid vehicles to be deployed decreased by 10-20%, so that may negatively affect total displacement. The

expert noted that delayed openings of the remaining CNG stations may also have a negative impact on overall petroleum displacement, when compared to original estimates. The reviewer concluded that some projects came in under cost, and noted a good use of this funding by issuing a second RFP in March 2012.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Many commenters complimented the researchers on their variety and depth of local and national partnerships. One reviewer mentioned that the increase from the original 20 partners to 43 meant more coordination was required to implement all projects.

The second evaluator noted good partnerships with industry, and acknowledged that the presenters' media campaign will bring a lot of benefit to the project and the partners, and the focus on fire marshals and building inspector training will ensure future projects for any fleet are barrier-free. This person noted that the PIs used a national laboratory for technical assistance early in the project and were communicative with their partners about the level of assistance that was available without cost to the project team and what was not. The reviewer claimed that the investigators clearly navigated the situation successfully and formed good partnerships with municipalities. This person voiced that focusing the EV project on cities will ensure high visibility.

A third person offered that the Ohio Advanced Transportation Partnership is an outstanding example of the power of partnerships.

A fourth commenter stated that the project's partnerships were a balance of government, non-profit, and private partners. This person mentioned that the team saw a significant increase in the number of partners since their initial proposal, including several major companies (Frito Lay, Scotts Miracle-Gro).

A fifth expert noted that there is a great variety and depth of partnerships, and that there are 43 partners, all sub-grantees. The project started out with 22 so it has grown dramatically. This reviewer pointed out that the investigators had a major partner drop out in 2010 so they issued a new RFP with that funding and got a lot of new partners through that. This person mentioned that the researchers held a well-attended fleet education workshop after a station dedication this spring, as well as a CNG workshop for Fire Marshalls and inspectors recently. According to the evaluator, the project team hired a marketing firm to work with the project, conducted a fleet manager survey by phone to use in implementation, and was currently focusing on free media. This person added that the Columbus CNG station will have credit card public access, which the city will build two more of in the future, with or without grant money.

Another reviewer noted that a lot of partners have dropped out, but the total number of partners has increased from 22 to 43. Partnerships include a wide range of local and national partners in the public and private sectors.

The final reviewer observed that there are a good number of partners on this project, and there appears to be good coordination between the project manager and the sub-awardees. It is less clear to this reviewer how much collaboration is happening outside of these interactions, including with Clean Cities coalitions outside the area who could benefit from the project's learnings.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the future activities have heavy emphasis on marketing and outreach, training, meetings, workshops, data collection, and reporting, which seems reasonable for this stage of the project.

A second commenter agreed that the project appears from the information provided to be on track to complete the future work required.

A third person voiced that the project was a catalyst for more CNG vehicles being acquired by partners. This expert was highly confident that the PI will translate this project into more for the state of Ohio because the PI has a clear plan for future work to be completed in a timely manner. This person affirmed that the majority of barriers have already been addressed and future risk has been mitigated already.

A fourth evaluator summarized that the detailed future work plans are sufficient to complete the project objectives.

A fifth reviewer highlighted that the plans include strategies to catch up on progress, completing NEPA reviews and installations by October, and conducting marketing events for the CNG stations. This person claimed that trainings will continue and marketing activities will accelerate. The commenter added that Clean Fuels Ohio is working with the Columbus transit authority to see if they can make their CNG stations public.

A sixth expert commented that the project continues to December 2013, but has no future activity listed past December 2012.

A seventh person reinforced that the future plans were ambitious with a lot of potential. This reviewer would like to get more of a concrete goal in what that EVSE will do and what barriers it addresses beyond just putting it in the public sphere. This person expected that partner contributions will increase because the investigators are seeing CNG station costs come in higher than expected, and reported that the partners will cover the cost. The reviewer pointed out that the presenters were about to issue contracts from a new RFP that was funded by cost savings from other parts of the project. This person recounted that the researchers want to finish EV station ordering and installation by the fall, and emphasized that is one of the big areas needed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agreed that the resources provided to this project are sufficient. One evaluator affirmed that the economic issues that caused a number of original partners to drop out could not have been predicted, and Clean Fuels Ohio was able to replace them with new partners. A second reviewer indicated that a large portion of the remaining work is media events, meetings, and training. This person felt that the PI was clearly well-prepared to be successful. Two reviewers noted that funds consist of \$11,041,500 in DOE funds and \$18,275,000 in partner contributions, with one of these reviewers commenting that these funds are sufficient to achieve the stated milestones, and a second noting that the project is run by the Clean Cities coalition in Ohio. A fifth person highlighted that the project team had second round of RFPs for additional projects with available funding. A sixth reviewer reported that some money still remains from projects that dropped out, which will be reassigned to more awards. It seemed to this person that the project has expended plenty of cost-share.

**RECOVERY ACT -- CLEAN ENERGY
COALITION MICHIGAN GREEN FLEETS:
Sean Reed (Clean Energy Coalition) –
arravt055**

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Many reviewers were in agreement that this project supports DOE's objective of petroleum displacement. One evaluator mentioned that the project is deploying over 500 alternative fuel vehicles, 20 CNG and 7 propane refueling stations, and 33 EV recharging stations, consistent with overall DOE petroleum displacement goals.

The second commenter noted that the project will create significant petroleum reduction across fuels, and pointed out that despite a shaky start when a major partner bowed out, this project has found a lot of success. The expert said that the researchers are taking the time to identify the right fuel for each partner to ensure longevity with the change to alternative fuels. This person applauded the investigators' mix of CNG and LPG and a lower number of vehicles on HD hybrids and HDVs.

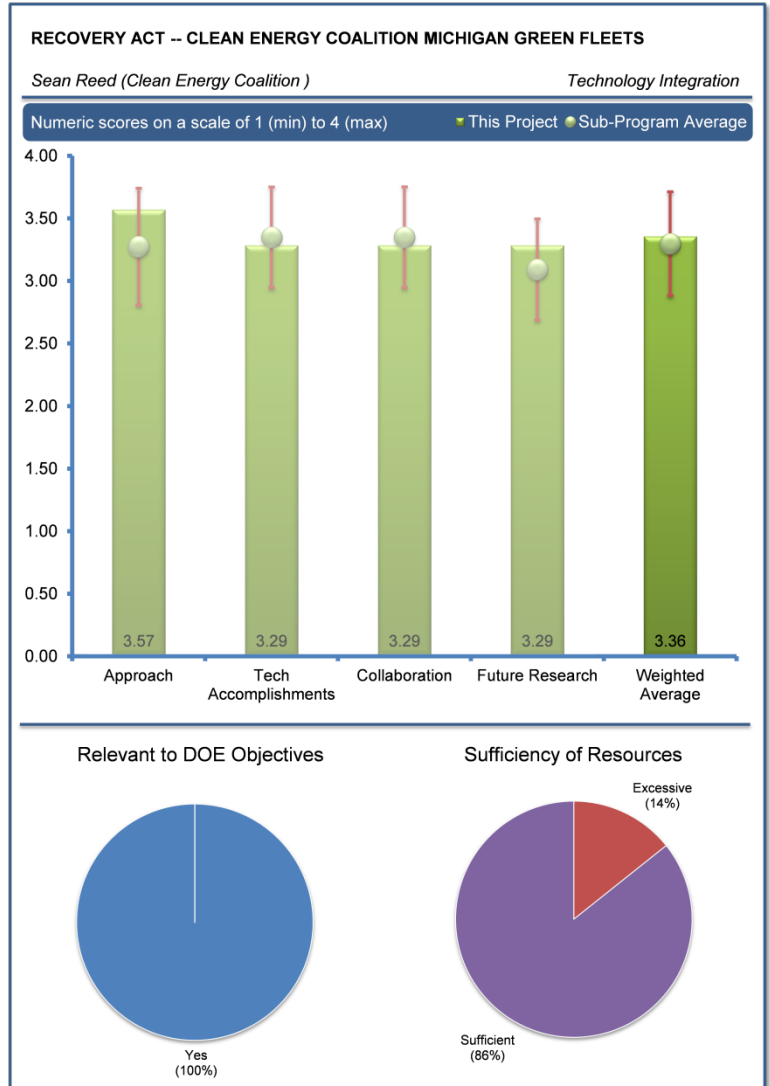
A third person summarized that the project converts or purchases vehicles to run on non-petroleum fuels, thus displacing petroleum use. According to the fourth reviewer, the project is obviously aimed at deploying alternative fuel vehicles and infrastructure, which will support DOE's objective of petroleum displacement.

The fifth reviewer stated that the project will reduce 1.2 million gallons of petroleum use per year or more. This person highlighted that jobs are a critical part of this project as well, as Michigan was particularly hard-hit by the recession. According to this commenter, the other objective was to build fleet partnerships and infrastructure.

The sixth reviewer noted that the project is focusing on petroleum reduction, and expects to exceed the goal of 1.2 million gallons of displacement per year, which is relevant to DOE objectives. The seventh reviewer observed that the project adopted a fuel neutral approach for displacing petroleum with alternative fueled vehicles, and building the infrastructure necessary to support these vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One expert claimed that the project had a good selection process that prioritized displacement potential and project readiness, and ensured that vehicles and infrastructure were readily available commercially. This person noted that the project includes first responder and technician training and ongoing assistance to partners to maximize their displacement. The evaluator remarked that



the strategy includes developing technology and application-specific case studies and summary reports for each partner. The reviewer complimented the investigators on their partnering with the Michigan Economic Development Corporation, and that the project includes a manageable number of partners.

A second commenter mentioned that the job creation was crucial in Michigan. This person also remarked that each fleet gets emissions savings and economic savings. The reviewer reported that the project team explains to their management what the real world savings are for them. This person pointed out that the fuel-neutral approach allows the best fuel to be identified for a broad spectrum of user types. The evaluator acknowledged that the case studies are completed for each project and reviewed via a conference call. This person observed that the researchers are capitalizing on local work to speak to corporate people about the project. The commenter commended the researchers on addressing the CNG infrastructure barrier when one jurisdiction was not friendly to CNG being public, and noted that they quickly identified that a contiguous jurisdiction was friendly. This person explained that politics suddenly became very important, which was not something the investigators expected. This person described that the presenters replaced a major partner with another who would displace an equal amount of petroleum, which was a big barrier that they successfully overcame. This reviewer mentioned that the investigators identified a recycling company who converted 18 trucks to CNG plus added 2 CNG stations, and also brought in Frito Lay to do propane. The expert pointed out that the project successfully addressed a barrier when installing LPG infrastructure. This person indicated that the researchers received contradictory guidance from two code officials (fire marshal and an OSHA official) about where to put a station, and that the project had to negotiate carefully. The commenter concluded that 100% of projects should be done by June 2012.

A third evaluator felt that the strategies seemed cognizant of the realities facing fleet management, which that person thought was great. The reviewer would like to see more of a focused strategy in terms of what vehicles/fleets to target and how that will overcome technical barriers and allow further adoption. This person liked the idea of doing partial conversions and providing data on results, to encourage fleets to do further adoption on their own if it works. The expert pointed out that because of municipality budget restrictions, it was a big sales point to reduce operating expenses for the fleets. This person claimed that the investigators targeted fleets for partial conversion to increase market penetration and visibility of technologies and also want to leverage economies of scale. The evaluator indicated that the presenters really want to get concrete data on usage and costs so that they can demonstrate the metrics very clearly. The reviewer explained that the researchers stayed fuel neutral to get in to a broad spectrum of vehicle classes, and are focusing on private fleets a lot because they are allowed to consider long-term cost savings.

A fourth person remarked that the presenters' approach is very detailed to maximize fuel displacement for each participating fleet. This person emphasized that the project's broad use of technologies, including natural gas, propane, and hybrids (with hydraulic hybrids). The evaluator commented that the use of data collected from the project to provide partners with case studies and ongoing consulting to maximize fuel savings is unique among these projects, and shows value to partners beyond just giving access to DOE funding. The reviewer pointed out that it is important to present results of the projects to high-level decision makers in these companies, to build further petroleum displacement. The commenter mentioned that the investigators helping fleets think about how to use operating budget savings to supplement capital budgets is a value-add component.

A fifth expert stated that the presenters' strategy is to provide significant relief in promoting increased market penetration of alternative vehicles, where the approach is to be fuel neutral, letting the application determine the fuel type.

A sixth reviewer pointed out that because of limited budgets, higher than expected costs, and limited infrastructure, the project tried to cast a wide net and work with a variety of providers in-state and try a number of different fuels for different applications to provide budget relief for its partners. According to this reviewer, one solution to information barriers is to create technology and application-specific case studies for each fleet showing the fuel savings and GHG reductions.

A seventh evaluator noted that the project appears to have gotten off to a slow start for reasons not entirely under the project partners' control. This person said that the significant delay, especially on the infrastructure work, seemed to indicate that the project strategy was not as well developed or designed at the outset as it could have been.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Several reviewers noted that the project has overcome barriers. One evaluator expressed that excellent progress had been made despite significant hurdles. The commenter observed that the presenters' creativity and thoughtful approach ensured success. This person stated that even as the cost of conversions came up over time and made the budget a challenge, the researchers found solutions and willing partners. The expert added that all vehicles are either in place or ordered and all infrastructures have begun construction.

A second reviewer was encouraged by how the investigators had identified barriers along the way and put in programs to overcome them (i.e., the hybrid training by Eaton). This person made note of a slight delay in accomplishing some objectives, but stated that the project still seemed to be on track. The commenter remarked that one of the goals was to create and sustain local markets, but did not see much information on how that was going in the presentation. The expert commented that the presenters provided reports to fleets demonstrating deployment cycles and what they paid/would have paid in fuel comparing the new and standard fuel type. This person claimed that this was done after the first full quarter to show the expected annual savings and environmental impacts (at full deployment). The reviewer noted that there had been training provided to first responders, and mentioned that the investigators had run into some permitting issues (four months for one fleet to get a permit for propane with two jurisdictions giving contradictory advice). The commenter noted that the researchers expect a baseline of 1 million GGE displacement per year. This person confirmed that the presentation gave a lot of details on the data, savings, jobs, etc. The evaluator offered praise that the presenters were honest about the low job creation of the project because fuel changes are not usually more labor intensive (post-conversion). According to this person, the researchers put Eaton hydraulic hybrids into garbage trucks in Ann Arbor but had not seen a level of savings near what was expected from the systems. The commenter continued to say that Eaton thinks that this may be largely due need for driver training and is going to come in and educate drivers on how to use the systems. The expert explained that the investigators are going to put some in place in another city soon and Eaton will train at the same time so there is not a lag.

A third commenter said that this project is similar to several others but that the pace of deployment is slower than expected. This person further offered that the deployments of vehicles and stations are still good. The reviewer commended the researchers on their outline of accomplishments (numbers of vehicles, stations, and gallons of petroleum in clearly defined graphs) in the presentation, and opined that this helped the reviewer understand the project more easily. According to this reviewer, the addition of details on how the project dollars were used within Michigan supplements a good data presentation.

A fourth evaluator affirmed that the accomplishments of the project have been the deployment of 159 vehicles and installation of a CNG station. This person claimed that this represents progressing from 30% completion last year to 75% completion this year.

A fifth reviewer noted that the project is about 80% complete, and brought to light that 35% of the partners dropped out and had to be replaced, which created a major setback. The expert remarked that at this point, over 430 vehicles are deployed and some EVSE remain to be installed. The evaluator mentioned that the presenters have conducted trainings around the state, and all vehicles and infrastructure are expected to be deployed by the end of June 2012.

A sixth commenter recounted that the project had encountered a number of technical barriers, but had overcome or is in the process of overcoming them. This person indicated that 4 of 11 original partners dropped out, but new partners included 2 high fuel usage fleets (i.e., Frito-Lay and UBCR recycling company) whose vehicles will have a large impact on petroleum displacement. The expert confirmed the project encountered some permitting issues that were resolved. This person explained that vehicle deployments are on target, but station deployment is somewhat behind schedule. The evaluator acknowledged that hydraulic hybrid numbers have been lower than anticipated, but the researchers are working with Eaton to address driver training issues. This person stated that most of the stations to be deployed are EVSE, but was not clear how much petroleum displacement is expected from EVs. The reviewer concluded that the petroleum displacement goal was originally 1.2 million GGEs, and now it is expected to exceed that amount.

A seventh commenter reiterated that the project seems to have gotten off to a slow start, although much seems to be underway now. This reviewer felt that the project should make decent progress, assuming that the work that is underway is completed in a timely manner. Given the amount of money the project has received, it did not appear to this person that this project has accomplished as much as some other projects at similar funding levels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally observed effective collaboration. One person remarked that the project appears to be very well coordinated. The commenter noted that the project also includes ongoing collaboration with partners to ensure maximum petroleum displacement, and a good mix of government, industry, and higher education participants.

A second evaluator applauded the project group's industry interaction. This person claimed that the researchers have identified strong, willing partners, and further noted that partners are well-coordinated, and communication from the PI to partners is excellent.

The third evaluator witnessed a good usage of partners; the project worked hard to bring in new partners when original ones dropped out. According to this reviewer, providing data to the partners is an excellent use of funding. This reviewer also noted that the project is partnering with Michigan Economic Development Corporation (MEDC) (which operated the SEO) as well as Greater Lansing Clean Cities. The project had 11 original partners in the proposal and 4 of them dropped out in the first year, including a grocery store chain converting Class 8 trucks that was one-third of the program and a huge emissions reduction. The project ended up identifying a recycling fleet that converted all 18 of their trucks to CNG and put in 2 CNG stations (as of January); each tractor travels 120,000 miles per year. This reviewer observed that Frito Lay piloted propane in the state, converting over half of their fleet. The same reviewer reported that the project is having potential issues with one fleet that is looking to sub out all of their vehicles and thus would not be able to take alternative technologies. This reviewer would like to know if the project has considered getting Penske/other big nationals to take on the technology. The reviewer noted that the project has tried to get other fleets to put pressure on a jurisdiction that does not want to open up a station to the public; the other fleets are interested in using that station though if it was made public.

According to a fourth reviewer, the collaboration was good between the implementing partners (Clean Cities and Michigan Energy Office) and the 12 award recipients, which consisted of city governments (Ann Arbor & Detroit), industry and universities.

The fifth reviewer noted that the project is a collaboration of the Michigan Economic Development Corp and the Clean Cities Coalition, plus about a dozen sub-recipients of all different types. The reviewer further observed that the project also tried to engage local manufacturers in particular.

The sixth reviewer observed only two main partners with CEC (Clean Cities Lansing and MEDC), but a number of sub-recipients. This reviewer reported that several major fleets were included (Frito Lay, FedEx, Schwans) along with the University of Michigan. The same reviewer thought the project did good work in identifying a replacement for major supermarket that dropped out of the project to keep displacement up.

The final reviewer commented that the project has a few partners, but the collaboration appears relatively limited. This is particularly true of public sector participation. It was unclear to this reviewer how project lessons will be shared, if at all, outside of the immediate project partner for whom the information on case studies is prepared.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers generally saw effective planning of future work. The first reviewer found that the project has outstanding planning of future work. All the remaining work can be accomplished within the project timeframe. Collecting data from partners should be seamless because of the excellent work by the PI. According to this reviewer, the PI clearly understands how to grow the project with partners.

The second reviewer noted that first responder training coming up in July. This reviewer concluded that following up with first responder trainings and trainings by Eaton on the hybrids is a great set of future goals. This reviewer also liked that they are continuing to provide partners with the data reports and looking at doing case studies with them. This reviewer noted that the project expects 100% of vehicles and stations to be implemented by this June (originally was December 2011), that the project will continue to do training (especially first responder) even though they have exceeded milestones, because the project finds them very useful. The project is putting in most of their vehicles this year, and has a lot of EVSEs left to put in (mostly in Ann Arbor and Western Michigan University campus). The project is now down to about 30 vehicles and 13 stations left to deploy, and wants to be able to use the case studies they do for the partners to benchmark the various technologies and their savings to help others determine what technology might be useful.

According to the third reviewer, future work will include training, ongoing consulting to project partners, as well as deployment of remaining vehicles and infrastructure. The fourth reviewer noted that the project will finish deploying vehicles and stations; work already underway. According to this reviewer, continuing the project partner case studies is very good.

The fifth reviewer commented that the project will deploy the remaining 30 vehicles and 13 stations, continue training sessions and data reporting, and conduct driver training for the hydraulic hybrid trucks. The sixth reviewer observed that the future activity is offering consulting to project partners until 31 December, 2013. That is the closing date of the project.

The final reviewer commented that, again, given what appears to have been a slow start to the project, it is difficult to have very strong confidence in the project team's ability to complete the future work. Hopefully, everything will be completed on time as they say, but, according to this reviewer, it is hard to be sure about that.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Six reviewers found that resources are sufficient, and one reviewer found resources are excessive. The first reviewer opined that a lot will be accomplished with the funding received. The second reviewer observed a good use of federal dollars, and that the sub-recipient match is higher than originally anticipated. A third reviewer commented that sufficient resources are planned to execute the remaining portions of the project successfully and in a timely manner. A fourth reviewer reported that funds include \$14.9 million from DOE and \$26 million in matching funds. The fifth reviewer observed over \$11 million of DOE funds spent to date and over \$30 million in cost share. According to this reviewer, this represents approximately two-thirds vehicles, and one-third infrastructure. The same reviewer observed that the project seemed to have been able to do even more than originally expected with the amount of money it has. A sixth reviewer remarked that the \$15 million in DOE funding and the \$26.5 million in matching funds are sufficient resources to reach the stated goals. The seventh reviewer who found resources are excessive reiterated that compared to other projects, this project seems to be using more government funds per project benefits than other projects.

Midwest Region Alternative Fuels Project: Kelly Gilbert (Metropolitan Energy Information Center) – arravt056

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer absolutely found that the project met DOE objectives. This reviewer noted that the project deployed 301 vehicles, or 85% of project objective, with orders for 328 vehicles with an overall 365 due to be deployed by end of project. The reviewer also observed 215,000 gallons of petroleum fuel displaced. Additionally, the project's AFV stations are 75% complete. This reviewer described the work as admirable.

The second reviewer saw a good number of vehicles deployed or ordered with a corresponding number of stations. The reviewer saw an ambitious project covering a wide geographic area.

The third reviewer liked the project's diverse strategies to offer options.

The fourth evaluator noted that the project included targets of 333 AFVs and 36 stations over a three-state region, plus maintaining/creating jobs. This included roughly 300 natural gas vehicles (NGVs), 40 hybrid-electric vehicles (HEVs), and 6 EVs in the project. As for stations, this reviewer noted there were plans for 15 EVSE, 10 CNG stations, 7 E85 stations, and 1 biodiesel station, not including 3 stations planned for E85 sites.

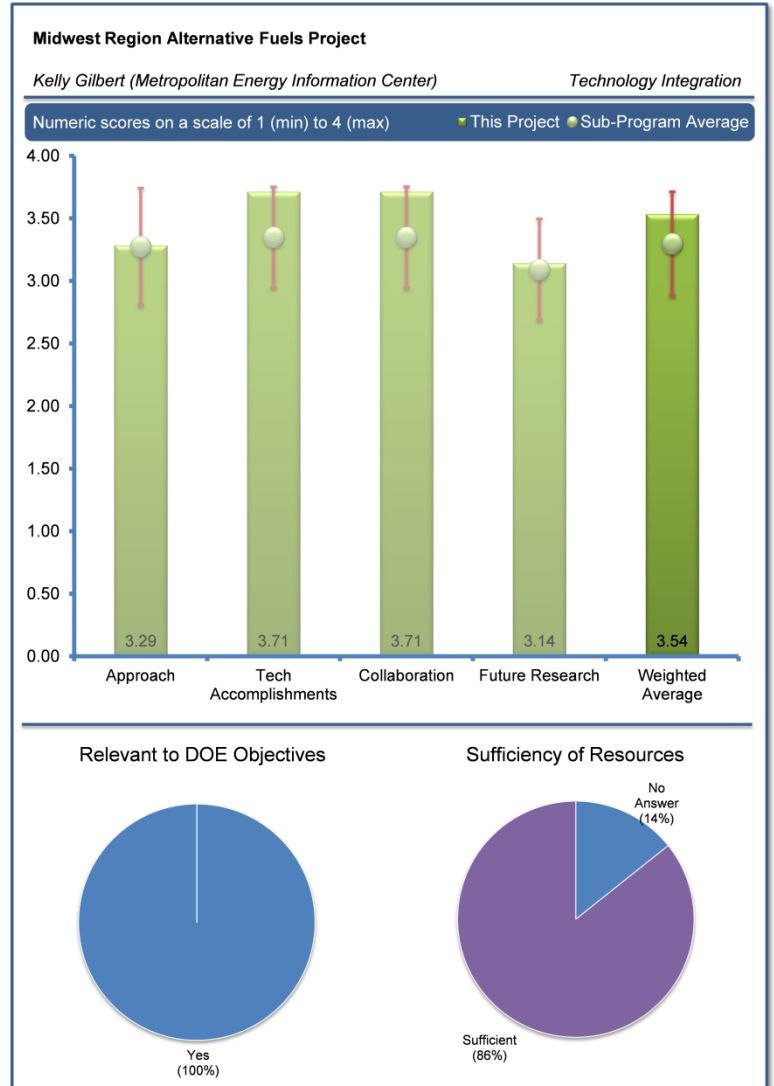
Another reviewer found this project supports DOE's goal of reducing dependence on foreign oil and gasoline by deploying 365 AFVs and 36 new alt fueling stations in 3-state region.

The final reviewer remarked that there was going to be a fair amount of fuel displaced.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed input on project deployment. According to the first reviewer, while the project's approach is not spelled out, it obviously works. The reviewer elaborated that each partner became a lead for each organization, creating a collaborative hub for the movement of information and funds. Moreover, as projects came in under budget, the project added partners.

The second reviewer noted that the project focused on marketplace transformation in Missouri, Kansas, and Nebraska. The project tried to have a relatively strong focus on jobs, and significant outreach activities were included as critical elements. The project's strategy also included involving nearly all of the local partners necessary not only to make the project succeed, but also to provide options as new opportunities arose. According to this reviewer, most of the project focused on light-duty vehicles, or at least lower



fuel use larger vehicles, such as school buses, which is why the overall petroleum displacement is lower than other projects with fewer (but heavy-duty) vehicles. The project's focus was largely on partners with shovel-ready projects, which appeared to contribute to much of the project being accomplished on time.

The third reviewer liked that the project was able to increase the numbers due to cost decreases. This reviewer also noted a wide area for deployment.

According to the fourth reviewer, the project seemed to have been flexible in overcoming any barriers, e.g., different budget cycles among some partners and choosing projects with ready partners. The presentation by project leaders demonstrated good knowledge and skills in completing project goals, said the reviewer.

Another evaluator commented that the project focused on deploying a large number of vehicles with a variety of fuel types, and that it tried to establish a sustainable alternative fuel market.

The sixth reviewer observed that there were some delays on implementation that could provide insight for future efforts.

It was unclear to the final reviewer what barriers were overcome. This reviewer noted there was not much discussion of barriers.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses to this question. The first reviewer commented that project implementers have achieved much in their project, which originally targeted 333 vehicles for introduction, but this number has increased to 365, so this reviewer said that the original program goals have been exceeded. The project has created 36 AFV fuel stations at 19 locations with 85,000 gallons of alternative fuel dispensed so far. Seven bio-stations are in the works but were delayed by a project revision. This reviewer perceived that this was another poster child program that DOE could use to underscore the success of these efforts.

The second reviewer noted that currently, the project is reported to be more than 80% complete. The reviewer pointed out that some projects came in at lower cost than planned, so the project team was able to use the savings to add activities, and increase displacement. The project also had some acquisitions where costs came down during the project, particularly in hybrid areas. The reviewer recognized that project implementers expected 100% of vehicles in place by the end of June, with 90% currently in place and 100% ordered, but some might be delayed to September due to delays in getting stations in place. The stations delayed were biofuel stations, said the reviewer. Overall, 75% of stations are in place, and have pumped 250,000 GGE to date. This reviewer noted that the CNG station in Omaha is attracting attention from non-project participants resulting in follow-on/leveraged displacements, and that the project included lots of highly visible outreach events throughout the region. Overall, according to this reviewer, there were a few delays, but the project team appears to have responded quickly and appropriately.

The third reviewer noted that it appears the project is on target. Another reviewer noted that the project appears to be on goal at anticipated levels. This reviewer observed a good array of media events but this reviewer had difficulty discerning how effective they were.

The fifth reviewer observed that there have been some delays due to partner budgets and backlog in supply chain for vehicles. The CNG tanks are for vehicles primarily, noted the reviewer. One project component with seven fueling stations is on hold. This reviewer perceived a low deployment rate compared to other projects.

The final reviewer recommended that although difficult, it is important to quantify the effects of the project on employment. This reviewer was sure that the project was selling itself short by dismissing employment from its presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers saw effective collaboration and partnerships. The first reviewer thought that including 19 partners, and 6 municipalities or counties is commendable. This reviewer noted that partnerships extended across multiple disciplines, organizations and

interests. The second reviewer thought the project had done a nice job with first responder training. This reviewer loved that the project is working so closely with the schools.

According to the third reviewer, this project does a good job of integrating diverse stakeholders, ranging from fueling stations to metropolitan governments, as well as schools and fueling stations for more rural areas.

The fourth reviewer noted that overall, the project included 19 partners over 3 states, including 6 municipalities and 4 utilities, plus private companies. The reviewer pointed out that many events were held with the partners. The partners also brought over a 50% cost-share consisting of \$12.2 million DOE versus \$18.5 million cost-share. According to this reviewer, having a strong network of partners also helped when some activities came in less expensive than planned, and the project team easily had partners willing to sign on for additional activities while bringing additional, unplanned cost-share. Thus, the project is accomplishing more than was planned in some areas due to these successful partnerships.

The fifth reviewer perceived that the 19 project partners appeared to represent a very wide and varied cross section of the communities served.

The sixth reviewer observed a well-organized partner team, with each partner having a team lead. This reviewer noted a good number and variety of partners over a wide geographical area, and that the project showed good planning. The final reviewer observed numerous partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the project's future activities seemed appropriate and that the project was addressing the delays with the fueling station. According to this reviewer, those delays seemed outside the scope for the project implementers to control, and seemed understandable given the economy.

The second reviewer observed that most of the remaining events yet to be completed included media outreach and marketing efforts to create more awareness of the program. Additionally, the project is wrapping up the bio-stations, vehicle introduction and AFV station work.

The third reviewer commented that most of the remaining activities are outreach, training, data collection, events, and reporting, plus that the biofuels stations still need to be completed.

According to another reviewer, the future work proposed for training administration and technical work was reasonable and workable.

The fifth reviewer observed that the project would continue outreach and training, and is waiting for final vehicle deliveries and completion of stations. The sixth reviewer perceived that there was still a fair amount to be completed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer noted that resources were sufficient for the project as planned, and that the project was able to add partners when some projects came in under budget. The second reviewer pointed out that one of the best parts of this program was that when funds became available, implementers sought out new partners rather than just let the funds sit there without dedication to a particular end goal. The third reviewer commented that the reported resources appeared consistent with project goals and timeline, and the final commenting reviewer conveyed that there was no indication of any issues on funding.

North Central Texas Alternative Fuel and Advanced Technology Investments: Lori Clark (North Central Texas Council of Governments) – arravt057

Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

According to the first reviewer, this project took a portfolio approach to deploy vehicles and infrastructure using natural gas, propane, ethanol, biodiesel, and electricity to displace petroleum. The reviewer noted that estimated petroleum reduction was 870,000 gallons per year, and that extended over the life of the vehicles. The project has also resulted in petroleum reductions beyond project partners due to fuel use at installed infrastructure.

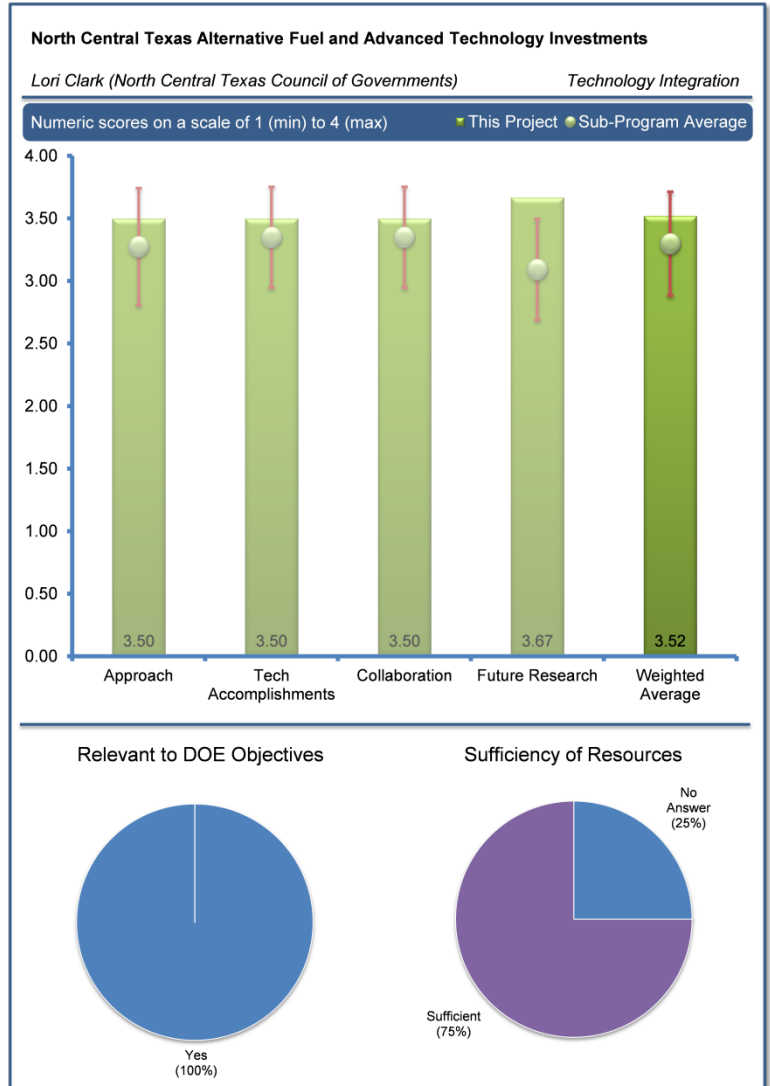
The second reviewer commented that this project would support petroleum displacement by increasing the use, availability, and awareness of alternative fuels and advanced technology vehicles. The reviewer observed that the project would deploy 284 vehicles including CNG, electric, and hybrid, and would develop 11 refueling stations for CNG, electric, ethanol, and biodiesel. The reviewer also noted that the project anticipates 872,847 GGEs to be displaced annually.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally perceived good progress. According to the first reviewer, the project was well designed in its strategy for deployment. The fuel neutral approach to vehicle deployment and infrastructure development would spur further advancement in multiple alternative fuel vehicle and advanced technology vehicle markets. The partners were identified prior to submitting the application to DOE and contingency projects were used as needed when projects were withdrawn. The marketing, outreach, and training campaign complemented the deployment efforts, stated the reviewer.

The second reviewer commented that project leaders have pursued appropriate solutions to overcome barriers, both technical and non-technical barriers. For example, one project partner has suspended additional electric vehicle orders because the partner is not getting the anticipated range of the two vehicles purchased; project leaders plan to investigate this issue and ensure the proper time and training resources are dedicated. This reviewer also observed that efforts of project partners have been integrated with efforts of organizations outside of the project, e.g., coordinating partnerships for refueling infrastructure.

The final reviewer perceived that the program has made good progress. This reviewer noted that the team has adapted well to changing boundary conditions, such as high turnover with a city government, partners dropping out, and etc.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw very good progress. According to the first reviewer, of the 284 vehicles, 232 were deployed and 38 were ordered as of March 16, 2012. With 95% of the vehicles deployed or ordered, this project has made significant progress towards its goals. The reviewer noted that of the 11 refueling stations, 6 were operational and 1 had site work started. This reviewer perceived good progress on the refueling stations. The reviewer also noted that the PI addressed barriers stemming from working with many project partners, vehicle lead times, and infrastructure NEPA clearance.

For the second reviewer, the information presented clearly showed progress between the project's beginning to 2011 and now to 2012. Appropriate plans are in place to continue this momentum. Further, there has been progress made beyond the project partners, specifically because of new shared refueling infrastructure, which contributes to overall accomplishments and DOE goals.

The final reviewer perceived good progress, and good stewardship of tax dollars. The reviewer observed that the program is changing plans on the fly to deal with half-hearted partners dropping out or other issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed strong partnerships and collaborations. The first reviewer noted that project partners included public, private, and nonprofit entities. These partners are invested stakeholders, evident from their proactive response to an initial solicitation from the North Central Texas Council of Governments, remarked the reviewer. There was also coordination between project partners and other organizations to facilitate increased use of private access refueling infrastructure.

The second reviewer observed that the PI collaborated with eight private or nonprofit organizations for 44% of the DOE funds and nine public organizations for 56% of DOE funds. The reviewer noted that this collaboration brought a variety of players to the table and ensured a diverse impact of the project. It was necessary for all partners to participate in selecting vehicles, purchasing vehicles, identifying fueling sites, and building fueling stations. For this reviewer, the progress made on this project would not have been possible without outstanding collaboration with other institutions.

The final reviewer perceived numerous collaborations, and thought the project did a good job reacting to some partners that backed out late in the game.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer perceived that planned future work is appropriate, logical, and has the potential to be very effective with regard to petroleum and emissions reduction. In particular, the training for natural gas and hybrid vehicles, as well as the marketing and outreach campaign, are likely to have far-reaching impacts, noted the reviewer. The development of a separate contingency list of projects to be approved for use as needed demonstrates a strong commitment to the consideration of barriers and mitigating risk. The second reviewer noted that the PI has considered barriers to the realization of the proposed technology, such as vehicle lead times, infrastructure NEPA clearances, reallocating funds, and sub-recipient internal procurement processes. This reviewer thought the project had effectively planned how it would complete the deployment of vehicles, construction of infrastructure, and technology training.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers thought that project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer commented that resources were sufficient for the remaining deployment and training activities. According to the second reviewer, ARRA presented an unusual funding opportunity. This reviewer noted that parties appear to be using funds consistent with the program goals.

Texas Propane Vehicle Pilot Project: Dan Kelly (Railroad Commission of Texas) – arravt058

Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers observed that the project met DOE’s objectives. According to the first reviewer, the estimated petroleum displacement for this project is approximately 865,000 gallons per year. This project put vehicles and infrastructure in place to contribute to continued alternative fuel use and petroleum displacement. Likewise, the second reviewer noted that this project would reduce dependency of petroleum by approximately 12 million GGEs through deployment of natural gas and propane vehicles, propane fueling stations, and education program.

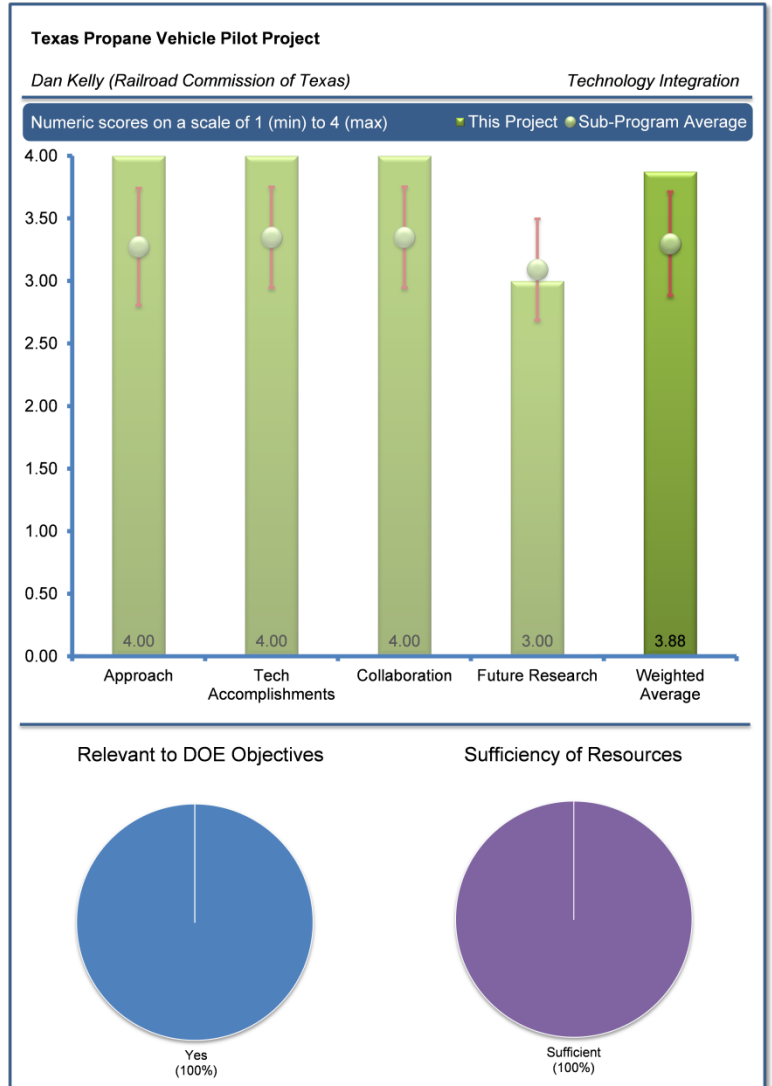
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented the project is leveraging pre-existing relationships with key industry players to address technical barriers, such as vehicle availability. The reviewer indicated that the project is feasible and builds upon similar past successes. The training used some existing materials and would also result in new materials for use by others. This reviewer observed that project leaders are ensuring that fleets integrating propane or natural gas for the first time have access to other fleets that have been through the same process.

The second reviewer added that this project addressed the technical challenges of deploying alternative fuel school buses. The project addressed the barrier of vehicle availability by pulling together necessary stakeholders to encourage the development of a propane powered school bus. Through education and outreach to school districts regarding the benefits of propane vehicles, key decision makers signed on to use this new technology, said the reviewer. The reviewer identified that the project had a comprehensive strategy which included public education, driver training, emergency responder training, and mechanic training. The reviewer noted that this comprehensive strategy would ensure the successful use of the deployed vehicles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Both reviewers observed that the project has had good progress. According to the first reviewer, the project is on schedule and is projected to meet deployment and installation goals. The reviewer noted that the training program is comprehensive in that it touches drivers, refuelers, first responders, and mechanics. According to this reviewer, these training materials would be used beyond the timeline and scope of the project. Similarly, the funded fleet loan program has the potential to influence other fleets not participating in the project, resulting in future petroleum displacement. The second reviewer observed that the project has



successfully deployed 481 propane school buses, pickups and other vehicles, and is making excellent progress towards the objectives. The public education program has exceeded its targets in the quantity of events, media coverage, and number of fleets reached. This reviewer concluded that creating demand for propane school buses, and thus spurring the vehicle availability, will support the DOE goals of petroleum reduction by setting the example for other areas of the country to use this new technology. The reviewer noted how the PI is addressing barriers of partners who cannot meet the timeframe or provide matching funds leaving the project. This reviewer emphasized that the replacement fleets have been identified and new contracts are being issued to address this change.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally observed multiple collaborators. The first reviewer noted that in addition to close coordination with project partners, the project also leverages connections with other fleets to help support those just beginning to implement propane and natural gas vehicles. The project's utilization of tools such as webinars, blog posts, and other outreach further ties the project and industry partners together. In addition, the project includes coordination with OEMs and fuel providers, as well as Clean Cities coalitions.

The second evaluator noted that the project interacted with vehicle manufacturers, infrastructure providers, school districts, cities, counties, the Propane Education and Research Council, and the Central Texas Clean Cities coalition. Close collaboration with these institutions are necessary to arrange the vehicle deployment, infrastructure development, and education efforts. This reviewer commented that the project could have done a better job of incorporating other DOE-funded first responder training curriculum rather than spending resources developing its own emergency responder training.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, future plans are logical and appropriate. For this reviewer, a particular strength of the project is that it has enabled an administrative structure to allow for further deployment, if funding is available. Also, the project included an evaluation period related to public education and training, which would allow for changes if warranted. This reviewer noted that continued lack of vehicle availability may still be a problem in the future; the project includes plans for communication with OEMs and other industry partners.

The second evaluator observed that the project had clear plans for future activities that would complete the project's objectives and expand future petroleum reduction. The reviewer noted that the vehicle and infrastructure would be completely deployed by January 2013, public education and training will be continued, and vehicle and infrastructure data would be collected and reported quarterly. This evaluator remarked that the PI will build upon the success of this project by seeking additional funding for partners on the waiting list.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers thought that the funding was sufficient. One reviewer thought the project has sufficient resources to complete deployment and outreach goals.

Development of National Liquid Propane (Autogas) Refueling Network, Clean School Bus/Vehicle Incentive & Green Jobs Outreach Program: David Day (Texas State Technical College) – arravt059

Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that the project supported the DOE objective of petroleum displacement by installing alternative fuel infrastructure, deploying alternative fuel vehicles, and providing alternative fuel technician training. The second commenter stated that this project will deploy fueling infrastructure and provide workforce training to contribute to petroleum displacement. The third evaluator criticized that the project needed a better method for ensuring that planned refueling stations are actually utilized in the long term.

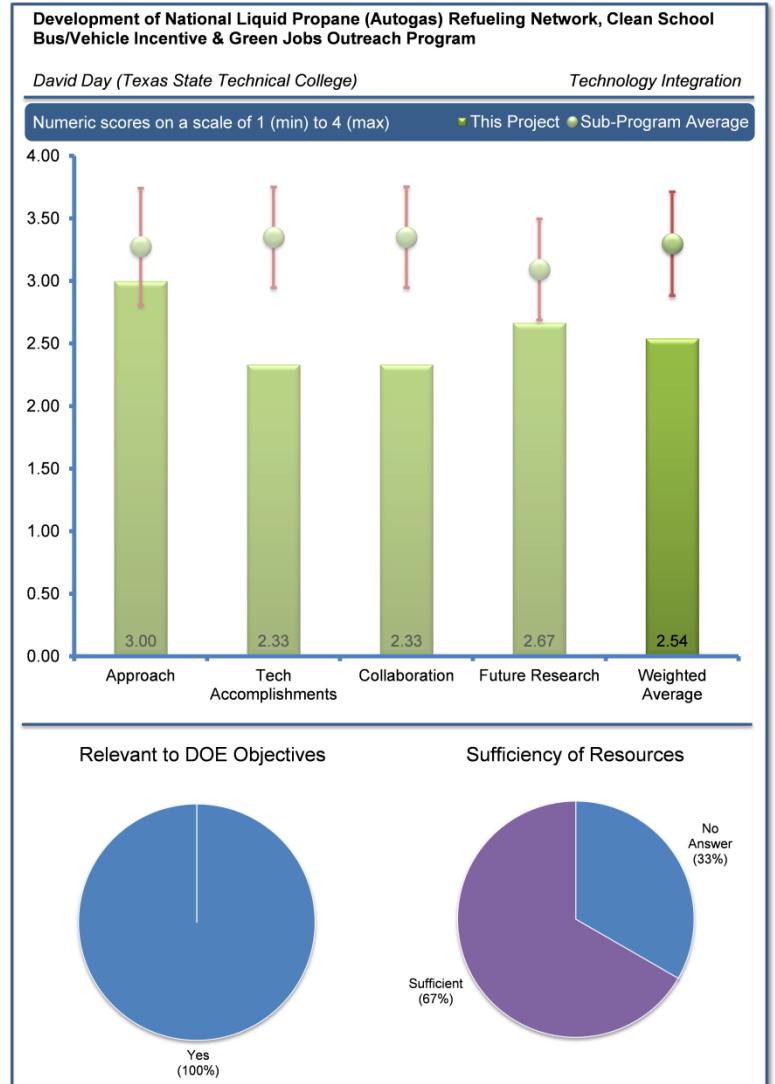
Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts? Multiple experts confirmed that the project had a generally effective strategy for deployment of propane vehicles by addressing the needed infrastructure, vehicles, mechanic training, and outreach. One commenter pointed out that the design of the project became well-integrated with other alternative fuel vehicle deployment efforts by addressing mechanic training in areas that are deploying propane vehicles.

Another reviewer mentioned that while the strategy has changed from the original project, it was feasible and generally effective. This person highlighted that there is some room for improvement, such as reconsidering the role of certain fuel marketers in propane infrastructure development, but that the current and future deployment efforts were generally well-designed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One evaluator noted that at approximately 50% complete, the project is somewhat behind others with regard to progress at this time. This person elaborated that significant changes to the original plans have contributed to this delay. The reviewer observed that while the original plans indicated a strong project, the changes may actually contribute to a more well-thought-out project overall, one that ensures that infrastructure is being sited where vehicles exist.

A second commenter claimed that the project has been on target with the goal to train ASE-certified technicians to service propane vehicles by training 150 technicians. This person reported that the project successfully deployed 90 propane school buses in Los Angeles. However, the expert pointed out that progress has been slow to address a significant project barrier regarding developing



propane fueling stations. The reviewer indicated that when a project partner pulled out of the committed 100 fueling stations, the PI was slow to address that issue and determine a different course of action.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One person explained that the project includes collaboration with fleets, technical institutions, and Clean Cities coalitions. In addition, the evaluator reported that the project was using resources (i.e., training curriculum) that already existed and modified it for their use. This person voiced that the project's partners seemed fairly well coordinated, though the presentation pointed out several challenges having to do with relationships among the partners that may be contributing to the delayed progress. The commenter recounted that the role of Rush Truck Centers, while referenced briefly during the presentation, was not clear.

A second reviewer mentioned that the project consisted of collaboration with CleanFUEL Holdings, Public Solutions Group, Rush Truck Centers, and Clean Cities Coalitions. Based on the information provided, it appeared to the reviewer that the collaboration among those groups has been insufficient to meet the original objectives of the project. According to this expert, Texas State Technical College appeared to be pursuing the propane training for mechanics while technology deployment aspects of the project would benefit from improved collaboration with other project partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter explained that future plans that take into consideration the challenges and barriers encountered to date, are logical and appropriate given the project's progress thus far, and leaves room for additional adjustments as needed. The evaluator remarked that the project had plans to use any remaining funding left from the reduced number of station installations. Furthermore, the expert said that the project planned to expand and change training programs to accommodate different/additional vehicle offerings.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers agreed that the resources for this project are sufficient. It was mentioned by one commenter that it may be challenging to find partners interested in purchasing propane school buses and to deploy the vehicles in a timely fashion, but that there should be sufficient resources to do so if the PI provided adequate commitment to managing this effort.

DeKalb County/Metropolitan Atlanta Alternative Fuel and Advanced Technology Vehicle Project: Don Francis (DeKalb County) – arravt060

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One commenter remarked that all vehicle technologies would contribute to petroleum reduction as would infrastructure projects.

Another evaluator said that the project would be installing alternative fuel infrastructure (six to seven refueling stations) and would operate over 200 vehicles which would support the objective of displacing oil.

A third expert stated that the project would displace some 240,000 gallons per year of petroleum fuels with CNG, including some made from landfill gas (LFG).

A fourth reviewer affirmed that each of the aspects of the project met or exceeded the estimated petroleum reduction numbers, primarily from the heavy throughput expected with the Dekalb County station.

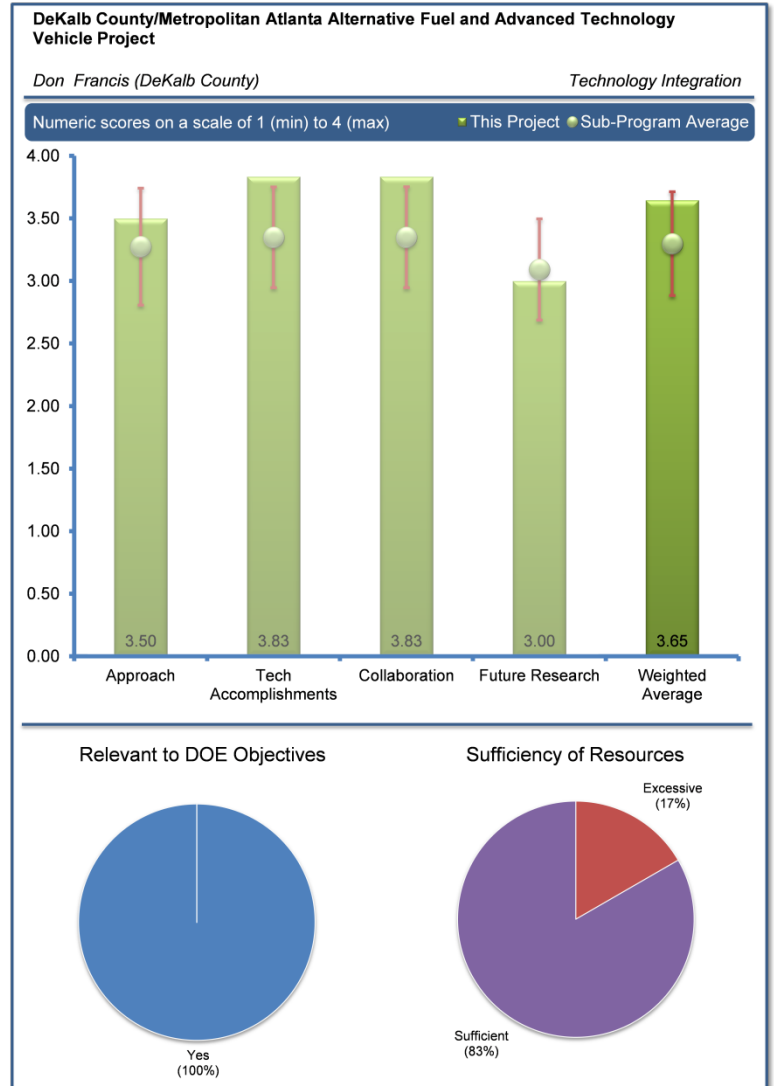
A fifth person claimed that the project leveraged assets and large employers in Atlanta to create a very interesting and effective renewable fuels story.

According to this reviewer, the investigators creatively repurposed the landfill to supply seven stations and renewable natural gas. The evaluator then mentioned that this project increased CNG in the region exponentially, and that there was only one station prior to this project. The reviewer described that the job creation numbers and air quality matters were not addressed in the presentation. The commenter remarked that the reduction in petroleum fuels seemed like it should be yielding more savings. The expert then observed that this project was 33% complete based on project goals but only started in March 2010 and ended in March 2015. The reviewer wondered what the long term realistic projections were based on the ARRA goals.

A sixth evaluator noted that this was a big project and had high expectations to displace fuel, but that the cost is significant also (almost \$15 million in DOE funding). To this person, the job benefit was unclear. The commenter voiced that there is not much to use in order to compare this project against others because air quality was given very little attention in the presentation. The reviewer then brought to light that the presentation indicated that the project has displaced 239,642 gallons, which the reviewer said was quite low for the dollars invested. The evaluator contemplated what the realistic long-term projections were of this project based on ARRA goals (jobs, emissions reductions, and fuel displacement).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person noted that this project clearly makes monitoring of the project an objective in order to measure project success. This reviewer observed that vehicle deployments are straightforward with no technology challenges, but speculated the landfill gas



(LFG) to renewable natural gas (RNG) technology may provide challenges. The commenter confirmed that the time lines for permitting, approvals, and bidding all seemed appropriate.

A second reviewer commented that the project had progressed very well and addressed the barriers as evidenced by the number of stations and vehicles already in operation.

A third evaluator summarized that the project is on track for meeting milestones and the deployment strategies built into the project, and that all vehicles and stations were deployed on schedule.

A fourth commenter claimed the investigators were on target to have their vehicles and have an impressive list of fleet participation including Coke, Marriott, UPS, airport shuttles and the City of Atlanta. This person expressed that training users and public relations (PR) and media outreach plans sound promising, wished further details were provided.

A fifth expert explained that the project's approach includes the installation of a landfill natural gas to CNG refueling station. This person noted that the natural gas would otherwise likely be used for electric power generation. The reviewer questioned whether or not there was a net GHG benefit, and suggested that DOE include this in its evaluation in the future. However, the commenter asserted that this station does meet the need for CNG refueling in the area. The reviewer stated that the researchers are on target but a little behind schedule, and have a great variety of users, which will help with project sustainability and expansion. This person pointed out that the investigators plan to install an additional six stations in metro Atlanta, and planned to decrease petroleum usage by deploying 200 CNG and diesel, hybrid, and hydraulic hybrid vehicles. This evaluator also mentioned that the presenters planned to train the users and educate the community, and would like to learn more about what this plan includes because little detail was provided. The reviewer went on to say that the investigators also planned to collect data and report the success of the project. Overall, the commenter agreed that the project's approach seemed reasonable.

A sixth expert remarked that the project combined eight CNG refueling stations with some 170 CNG vehicles, HD hybrid vehicles, and electric charging stations [DOE Program Clarification: Since the Annual Merit Review, EVSEs are no longer a focus of this project.]. The reviewer stated that the project implored an aggressive outreach to spur deployment of additional CNG vehicles, as needed to make the refueling stations viable. This person noted that all of the alternative fuel/technology vehicles in the project will have been deployed by June of 2012, meeting the schedule required by the ARRA grants, despite some reported delays due to EPA certification/availability issues. The evaluator noted that more parking shuttles and more Coca Cola trucks are being deployed than had been anticipated. The reviewer added that approximately 200 vehicles were included, many, but not all, of which are high fuel use vehicles. The expert remarked that the training is to be completed by July 2012 and outreach is to be underway for completion, per project requirements, by December 2012 but will continue after that. However, this person brought to light that with the exception of the refueling station at the county landfill, the LFG-NG project does not really relate to transportation. The commenter emphasized that the county has been recovering the gas and using it to generate electricity. According to this reviewer, other than the station at the landfill, the gas may only be put into the Atlanta Gas pipeline and distribution system. The evaluator further opined that any gas extracted from the system for CNG would not be the LFG and found it difficult to identify a direct relationship between putting LFG into the system and using CNG in transportation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer observed that the progress in the project has been excellent. This person supported their previous statement by saying that any vehicles and stations are in operation and data has been collected to show the amount of gallons of petroleum fuel that has been reduced.

Another commenter recalled that deployment of vehicles and training is being completed on schedule, construction of stations is only a few months behind schedule, and outreach is on track to meet schedule. A third evaluator noted that the project appears to have met, or will soon meet all technical and programmatic goals. The fourth reviewer pointed out that the project's goal to build and operate is going very well. This person also mentioned that demonstrating LFG to RNG may present technical challenges; however, the project's focus seemed to be on petroleum reduction technologies.

A different commenter acknowledged that the researchers had the 2009 Vehicle Technology DOE rules as barriers and have addressed these technical problems. According to the expert, this created delays and lost a partner but the investigators were able to regroup and put together a revised scope. This evaluator explained that the availability and location of the planned CNG stations may not be enough for the response received from public fleet demand. This person said that the presenters were slow to order the vehicles but were confident that data could be tracked for two years. The reviewer said that in general, the proposal was silent on tracking data for vehicle performance, emissions reduction, and petroleum replacement.

The seventh reviewer claimed that a problem for this grant was that vehicle technology needed to be commercially available (based on the grant restrictions) in 2009. This person stated that the technology had changed and was no longer available, which created delays and caused the project to lose some sub-recipients. The commenter suggested that DOE review this in the future to resolve their future solicitations and that DOE should stipulate using commercially ready technology at the point of implementation. The reviewer also pointed out that the availability of sufficient CNG stations continues to be a challenge for the overall success of this program. The evaluator added that with more stations, the vehicles deployed would be better received. The expert criticized that this project addresses technical barriers but more is still needed. The reviewer commented that the price of CNG and petroleum is a factor in the long term payback of this project. The person said that according to the presenter, the investment payback on the landfill gas facility would be longer because the price of CNG has dropped and there would be a smaller margin as a result. However, the commenter remarked that CNG costs are so low that it is attracting more users, which is a good thing. The evaluator highlighted that the project has had some delays in ordering the vehicles. The reviewer indicated that the researchers will continue to collect data for two years after deployment, regardless. The commenter reported that all vehicles are expected to be deployed by June 2012, which DOE will need to verify.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One expert voiced that the project's partners seem to be working together well, but that there is no university and lab participation, which may not be needed. A second reviewer explained that the collaborations and partners in this project have contributed to the early success of the project. A third commenter reinforced that collaboration and communication appeared to be strong between the project lead and the associated public and private partners. This person specified that the outreach and education plans are well-developed and efforts thus far have resulted in an increased demand for the technologies being deployed under the project. A fourth evaluator mentioned that the list of collaborators is reasonable and adequate, while apparently not comprehensive (as regards technology suppliers for LFG project). Multiple reviewers acknowledged that the project has outstanding partners that include the DeKalb County's Landfill Gas facility, Coke, Marriott, UPS, and airport shuttles. Although, the same experts claimed that more discussion of long term community outreach, media, and education would be helpful.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter noted that a goal was to monitor the project to measure success, and emphasized that the project appears to be progressing in a reasonable manner and pace. A second reviewer summarized that given the current progress and planned future work, the project appeared to be on track to be successfully completed.

The third expert stated that outreach is to be completed per ARRA grant milestones by December 2012 but is to continue aggressively so as to generate enough users to make CNG stations viable. This person added that reporting is to continue through 2014 as required.

A fourth evaluator reinforced that future education and outreach plans have been developed for ongoing efforts, as is the plan for data collection on deployed vehicles. This person observed that due to the success of the project, there is additional interest from local partners to deploy similar vehicles and take advantage of the new refueling infrastructure.

The fifth commenter noted that the researchers are completing deployment and making sure everything is operational. This person questioned what the investigators are doing to continue to do outreach on this project, and what the return is on investment based on the ARRA goals. The reviewer pointed out that the county owns the facility, and that the payback on the vehicles from the

diesel fuel saves \$5 million per year. The expert recounted that the presenters planned to put out 50-100 electric vehicle (EV) charging stations, and hoped to put an RFP out on that shortly. The evaluator remarked that it would be helpful to have more information on this and about how the researchers are promoting the technology. The person also questioned this strategy [DOE Program Clarification: Since the Annual Merit Review, EVSEs are no longer a focus of this project.].

The sixth reviewer observed that job creation and data tracking strategies were not shared in the presentation and should be explained. This reviewer remarked that training users and PR and media outreach plans sound promising. Furthermore, continued the same reviewer, it would be helpful if further details were provided.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Most reviewers felt the funds were sufficient for this project, but one felt that it was excessive. One expert mentioned that the resources appeared appropriate and that the cost share from non-DOE sources was excellent. A second evaluator commented that the resources were apparently sufficient as the milestones appeared to be met. A third commenter agreed that the researchers more than met the 50% cost share required by the grant guidelines. A fourth reviewer concluded that the total budget grant match appeared to exceed the 50% threshold and was reported as \$24,682,387, while the DOE share was \$14,983,167.

Chicago Area Alternative Fuels Deployment Project (CAAFDP): Samantha Bingham (City of Chicago, Department of Environment) – arravt061

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

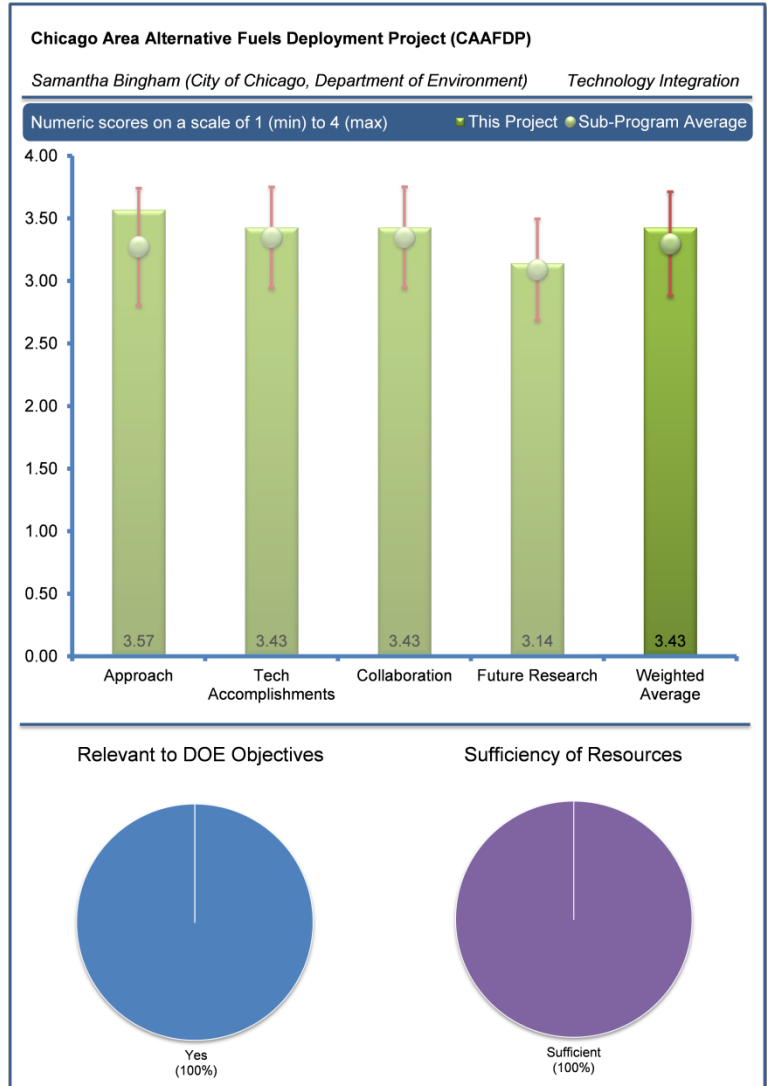
All reviewers were in agreement that this project should be allowed to proceed. One reviewer stated that this project would greatly increase the amount of petroleum displacement in the region. This person mentioned that the researchers are already seeing snowball effects, with additional alternative fuel vehicles being deployed by other companies that have seen savings being realized by project participants.

A second expert noted that this project is obviously aimed at deploying alternative fuel vehicles and infrastructure, which would support DOE's objective of petroleum displacement.

A third commenter asserted that the project highly supports the overall DOE objectives. The reviewer noted that the project anticipates three million gallons of displacement per year, and is assisted by a variety of partners. This person recalled that a variety of fuels, vehicle types, and partners are included so the span of influence of this project is very wide. The reviewer went on to say that there has already been the snowball effect and more vehicles have been ordered because the ARRA projects started the snowball rolling. The commenter mentioned that upgraded pressure at CNG stations means there is room for future growth and it is more than a one off project. The person then claimed that the project is further supported by the Chicago Climate Action plan which calls for a 10% increase in alternative fuel use in Chicago by 2020. The reviewer remarked that the project contains a mix of private and public fleets, and that fueling is highly desirable for DOE projects.

The fourth reviewer explained that the project is relevant to petroleum displacement goals and noted that the three million gallons per year will nearly reach the goals for alternative fuel use set forth in the local Chicago Climate Action Plan.

The fifth expert explained that the project hit both sides of displacement by installing stations and adopting vehicles, and its goal is a huge amount of displaced GGEs. The sixth person stated that the project would reduce criteria pollutants by 400 tons per year, GHGs by 7,500 tons per year, and create 77 jobs. The seventh reviewer described that the project supported petroleum displacement by increasing the deployment of alternative and hybrid vehicles, and by developing fueling and charging infrastructure in the six county region surrounding the City of Chicago.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer expressed that the project anticipated potential permitting, construction, and equipment availability issues. This person remarked that the researchers have a good mix of public and private sector partners; not an overwhelming number of partners. The person pointed out that the researchers had a sensible strategy of shared refueling by municipal partners, and private sector participants using publicly accessible refueling infrastructure. The commenter felt that upgrading existing local government CNG stations to 3,600 psi made good use of existing infrastructure that was underutilized. The expert claimed that focus on medium and heavy duty vehicles would maximize petroleum displacement. The same reviewer noted that the addition of E85 availability at city facilities and locking out E85 vehicles from gasoline usage ensures ongoing alternative fuel usage by those vehicles, and will increase E85 usage from 500,000 gallons per year (gpy) to 1.2 million gpy.

A second expert observed that the researchers had a great strategy in making big impacts in both vehicles and infrastructure. This person commented that the targeting areas deemed essential [e.g., the low-hanging fruit for CNG, and direct current (DC) fast chargers for EVs] really drive the technology and address barriers rather than just trying to get money out the door. The reviewer also felt that the regional cooperation was great to see as well, and helped to look at the city as part of a whole system. The expert liked that the investigators aimed at areas that are not incentivized by other programs but still can be potential game-changers commercially. Additionally, the same reviewer noted that the project is run by Chicago Clean Cities, which is run out of the City's Department of Transportation. This person stated that the city of Chicago was the only municipality to receive funding to do this, that the goal was for a 10% increase in Chicago use of alternative fuel, and that this project alone almost gets them there. The reviewer indicated that it was not just a city-aimed project; the presenters see all of their initiatives as regional because the city is part of a larger region. The expert added that the researchers wanted to grow infrastructure and increase adoption because there was only one CNG station in the region before this (at GTI). This person pointed out that the previous efforts in municipalities had died off when original equipment manufacturers (OEMs) did not offer vehicles, so the project was targeted at shared use to make the finances work so that there would be enough demand beyond the host fleet. The reviewer mentioned that the vehicles were CNG and various hybrids, but that the project built a number of EVSE (including 73 DC fast charging). The expert stated that having the big waste haulers (WM, Groot) converting to CNG has really persuaded the smaller ones to convert to CNG, and with the infrastructure in place, diesel would not be bought anymore. The commenter mentioned that the presenters saw the DC fast chargers as being essential because they allowed one-third of the population that lived in multi-unit dwelling to access the EV market. Finally, this person noted that the researchers are looking at ways to dis-incentivize usage of the DC chargers at peak demand in rush hour/early evening.

A third reviewer reinforced that the city has worked with a number of expert contractors to help overcome permitting and construction delays. The expert remarked that the project has helped change city policies to be more favorable to AFVs, and that the investigators have worked with fleets of all shapes and sizes, from taxis to garbage trucks.

A fourth commenter confirmed that the strategy of the project was to combine the Chicago Climate Action Plan with federal support funds, and that it supported the Green Taxi Program, new electric charging stations, and public/private natural gas fueling stations for both light and heavy duty vehicles.

A fifth commenter pointed out that the project included the deployment of almost 400 vehicles across six counties in Chicago, with more than 300 alternative fuel refueling stations (including charging stations). The expert recounted that the researchers are seeking to develop more public/shared infrastructure to keep access open even if the host fleet dropped out of the alternative fuel market. This person criticized that there is a somewhat limited reach of technology (only natural gas and hybrids), which the reviewer speculated could be a result of the participation of GTI.

A sixth commenter stated that project barriers include permitting issues, construction delays, equipment availability and all have been mitigated in a timely manner that keeps the project on track. This person affirmed that the project is well integrated with Chicago's Climate Action Plan, and that a mix of taxi fleets will provide high fuel displacement. According to the reviewer, the fact that the investigators have been successful in identifying and negotiating shared fueling among municipal partners is an excellent accomplishment.

A final reviewer mentioned that the presentation did not provide much information on project strategy, and felt it was difficult to assess the quality of the strategy because the researchers spent most of their time on the introductory slide. This person remarked that the project appeared to have taken the shotgun approach of many others whereby funds are made available for all alternative fuels and technologies based on evaluation factors but not designed to have a comprehensive impact on significant transformation of the system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer pointed out that the project targeted several areas that will result in large petroleum displacement (taxis, waste haulers, and other medium duty and heavy duty vehicles), which are all high visibility, high fuel use partners. This person commended the researchers on their progress toward vehicle and station deployment. The expert mentioned that the development of nearly 200 EV charging stations and partnership with two-car sharing companies will make possible the introduction of EVs to the general public at a reasonable cost. The commenter said that E85 has been introduced to all 11 city-operated fueling stations and E85 vehicles are locked out from using gasoline. The reviewer continued to say that through this project, the presenters have shown that alternative fuels can be economically feasible, resulting in an additional WM station near the airport and introduction of 50 AT&T CNG vehicles that were not part of the project.

A second reviewer expressed that excellent progress has been made to date, and that a high number of vehicles and refueling/charging stations have been deployed. This person highlighted that despite the variety of applications and fuels and vocation types, the researchers have overcome barriers and the ARRA-funded portion of the project has led to additional deployments not funded by ARRA.

A third commenter felt the presenters did a great job addressing the problems that mattered and created barriers, rather than just buying vehicles indiscriminately. The reviewer voiced that there is still further work to go, but that progress is great given the barriers being addressed. Additionally, the expert noted that the investigators upgraded city CNG stations from 3,000 psi to 3,600 and also built E85 infrastructure at all 11 city stations so that it guaranteed E85 use by flex fuel vehicles. This person stated that all police vehicles are flex fuel and now use E85, elaborating that usage went from 500,000 gallons per year to 1.2 million gallons and growing. The reviewer pointed out that a large amount of the funding allowed municipalities that already had CNG stations to make them available to the public. The commenter remarked that the researchers were unsure what sort of reception would be received from taxi fleets because most of them were individual or small owners and cannot afford to convert a ton of vehicles without some risk. However, the reviewer said that many taxi fleets are now going out on the road with hybrids or natural gas vehicles (NGVs) without grant funding now. The expert mentioned that the researchers did an RFP with \$1 million of Clean Cities and \$1 million of city money to install and maintain public EVSE. The commenter went on to say that level two stations (207 in total) are mostly built out and are free, and the DC fast charging (73 in total) are getting there and can be accessed by buying a card. The expert then noted that the EVSE project was essential because none of the OEMs were initially planning on using Chicago as a launch market for EVs but it brought them in, and that the project also allowed car share fleets to invest in EVs and offer that as an option. The reviewer pointed out that the investigators hit an initial barrier in installing the DC chargers because there was potential of being a \$10,000 fee from the utility for each station because of the voltage upgrade. However, the commenter clarified that the utility has been a big partner in the project and decided the stations could be labeled as new customers, thus the utility could cover the fee. The person added that the station essentially is a new customer even though it is installed under an existing meter and customer. The reviewer mentioned that the engine in the cement mixers is the Cummins 8.9L but that there have not been any issues with under-power (maybe because of Chicago's landscape). The expert remarked that the presenters have 14 mixers as part of the grant and are looking to get more.

A fourth person said that there are more than 350 vehicles and 223 stations deployed to date (26 being DC fast charging), and that 1.6 million gallons of petroleum have already been displaced. The reviewer indicated that several waste haulers (WM and Groot) will be purchasing only CNG trucks in the future because of the infrastructure installed as part of this project. The commenter described that some alternative fuel taxis are being purchased outside of this project now, as a result of project activities. The expert also confirmed that several other fleets are considering alternative fuel programs on their own as a result of the project

activities, which the reviewer attributes to good leveraging of DOE funding. The commenter was also amazed how the electric vehicle charging brought the Leaf to Chicago a year early.

A fifth reviewer commented that the project advanced from 25% completion last year to 77% complete this year, attracted a nearly two- to-one match in private to federal funds, displaced three million gallons of gasoline annually, and influenced city policy changes in respect to green taxis.

The sixth reviewer acknowledged that given the information provided both electronically and verbally, it is hard to gauge progress too well. This person recalled that the project appeared to have made some good progress on vehicles and infrastructure in certain areas, but questions remained in other areas. The commenter felt that in particular, the deployment of electric vehicle charging stations was not well explained and appeared to be seriously ambitious given the resources devoted to that piece of the project. Additionally, this person reported that there was brief mention of marketing but not enough information provided to assess this piece's effectiveness.

The seventh reviewer reported that the project is about 80% complete, with over 350 vehicles deployed and over 200 Level 2 and 70 Level 3 EVSE deployed. This reviewer acknowledged that the project team had overcome some issues with the utility on these installations. The same reviewer noted that the project team has taken cost-effective approaches to infrastructure deployment (e.g., upgrading a CNG station to 3600 psi and including E85 at city gas stations, which has doubled the city's fleet use of E85). Furthermore, continued this reviewer, the project team has also worked with car sharing and taxi fleets, which facilitates introducing the public to AFVs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted good partnerships with GTI, 350 Green, and City of Chicago Fleet & Facilities Management. This reviewer added that the city has released a RFP for a green airport fueling station as a result of the project's successful taxi component. The second reviewer observed excellent coordination across all technologies and a good partnership with GTI.

The third commenter reported a wide variety of fleets and regional participation. Further, this reviewer elaborated that combining the city and GTI is a great idea, as is incorporating outside efforts interested in installing EVSE. The reviewer described that getting the EV-makers to use Chicago as an early-release market is a great success. Additionally, the commenter noted that the investigators are working closely with Gas Technology Institute (Ted Barnes is co-presenting it), who developed the application for the project. The expert observed that Chicago CC identified the fleets, other government entities worked on permitting and deployment, and that private companies worked on technical issues and training. This person mentioned that GTI manages a large amount of the sub-grants. According to the commenter, the presenters have also aimed at private industry that can use public infrastructure to fuel, mainly NGV. The expert specified that some of these (for example, a small pizza fleet) have received a great deal of publicity for doing NGV conversion. The reviewer pointed out many snowball effects: others investing in alternative fuel vehicles outside of grant efforts; the EV-makers coming to the market; and AT&T jumping on a CNG station whenever it is built.

The fourth expert noted that the project had the partnership between the City of Chicago and GTI for project leadership. This person said that there were a total of 16 partners, which were a mix of local government and private fleets. The commenter also recounted that there was a separate initiative with 350 Green for EV infrastructure, and that a major national fleet (WM) was included.

The fifth reviewer explained that the city has worked with GTI, the Clean Cities Coalition, and other city and state entities. Additionally, this reviewer reported that the researchers have worked with over a dozen other partners of all types, many of whom had not worked with AFVs before. This reviewer also indicated that the project team included the utilities in its work as well.

The sixth expert stated that the project has 13 partners, and promoted the Green Taxi Program. This person brought to light that the program enlisted small independent taxi operators, and currently consists of 55 independent taxi companies that operate 70 NGV(s) and 50 hybrids.

The seventh commenter stated that coordination seems to be happening between the project manager and sub-awardees, but questioned the level of collaboration beyond that. In addition, this person affirmed that the brief mention of continuing to market current efforts is not clear about exactly what is going to happen to bring in additional partners and participants. The reviewer suggested efforts should be made to gather and share lessons learned through the national Clean Cities network.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert commented that the project's future activities' focus on completing deployment of vehicles and infrastructure, collecting data, and continuing marketing efforts. The second reviewer reported that future activities consist of continuing current efforts, data reporting, and marketing.

The third reviewer remarked that the majority of the presenter's hurdles have been overcome, and that future work is well-planned and can be accomplished successfully. The reviewer elaborated that future plans incorporate the right decision points and have the potential to grow the project even further.

The fourth expert noted that the data from the EVSE will be very valuable and is a great way to focus future efforts. This person would be interested to see the success with smaller private fleets as well. Additionally, the commenter observed that there was a large amount of potential in private fleets that have undergone small conversions and are looking at doing their larger fleets soon (airport shuttle, handicapped mobility vehicles). Furthermore, the reviewer confirmed that the researcher would have more information available on EV charging rates, plans, and data once the EVSE gets completely built out.

The fifth reviewer reinforced that the future work was clearly laid out and should complete the project. The sixth expert recalls that the project will wrap up deployments later in 2012 and that training, reporting, and marketing would continue. This person said that the project helped push other waste haulers toward CNG and many of the fleets have bought more than expected. It has also gotten the attention of automakers to bring their products to Chicago for sale. The seventh reviewer mentioned that with little detail provided in the presentation and little time to discuss this topic in the review meeting, it is hard to rate this piece with much confidence.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agree that the resources for this project are sufficient. A couple reviewers summarized that the project is very well planned and that sufficient resources remain to successfully complete the work in a timely fashion. One commenter felt that the project should yield a good return on dollars invested, in terms of petroleum displacement. Another person noted that the project had \$15 million in DOE funding and \$24.6 million from elsewhere.

Kentucky Hybrid Electric School Bus Program: Tom Stratton (Kentucky Department of Education) – arravt062

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

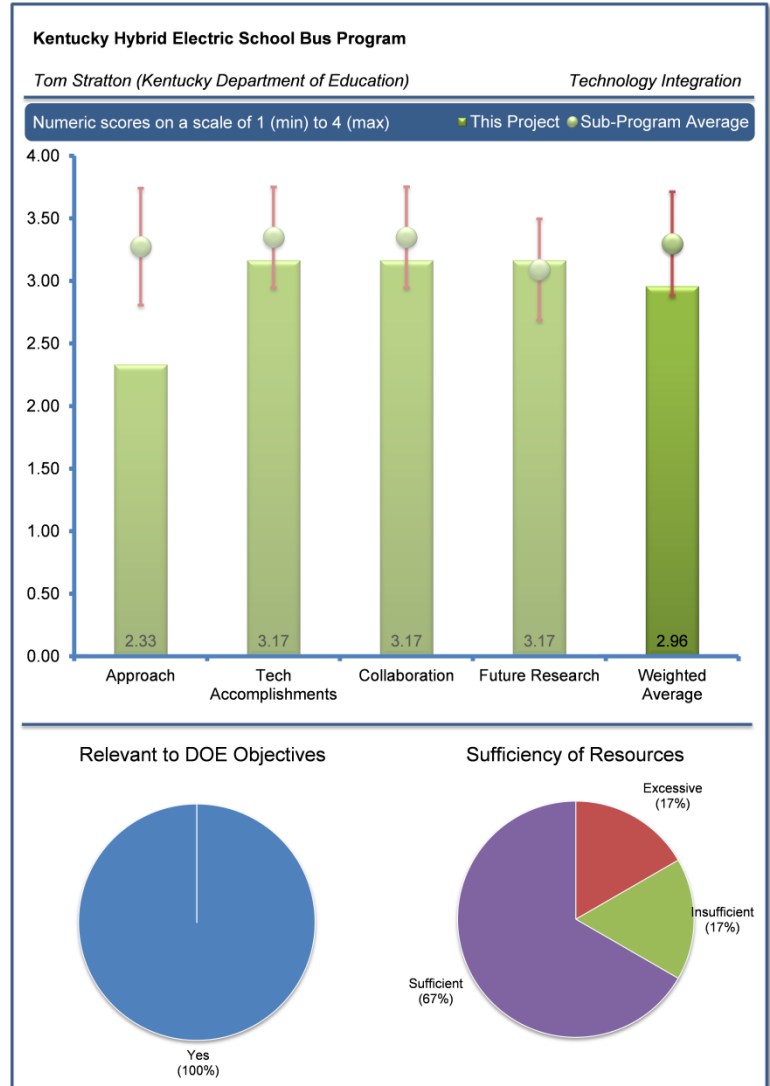
The first reviewer asserted that this project clearly demonstrated petroleum displacement. The second reviewer noted that the project was 75% through for deploying vehicles and that the project would be finished in December 2012. This reviewer added that hybrid electric buses were a targeted area for DOE.

The third reviewer stated that the project definitely supported the objective of oil displacement as shown by early data of a 33% fuel economy increase using the hybrid school bus over the conventional diesel bus.

The fourth reviewer stated that it would reduce petroleum fuel use, but only marginally, based on the reported 44,000 gallons saved between January 2011 and February 2012, and the projected 140,000 gallons saved over the four year life span of the project. This reviewer also indicated that to date, the average fuel economy only increased from 6.3 to 8.4 miles per gallon (mpg) i.e., 2 mpg and that school buses were not heavy fuel users compared to other heavy-duty vehicles, nor were most of them high-mileage vehicles.

Another reviewer indicated that although the project is not displacing large amounts of petroleum, it is doing so in a good application and demonstrating good results.

The sixth reviewer opined that the driver, technical and first responder training were very good and that the future curriculum being developed would have a sustaining impact. The same reviewer indicated that this project was the largest fleet of hybrid electric buses in the country. While these hybrid buses increased fuel economy by approximately 33%, the average bus was getting 8.4 mpg with a baseline of 6.31 miles per gallon. The project goals were to displace 44,000 gallons per year and emissions reductions were not accurately measurable at this time. From January 2011 through February 2012, 494 tons of CO₂ emissions were saved, approximately 44,000 gallons per year were displaced, and emissions were reduced. In the future, this reviewer would like to see more detail regarding data collection methods. The reviewer noted that while this project was achieving its stated goals, it was questionable why so much federal money was invested in this project to begin with as it did not ever seem like it was going to be a project that would either reduce petroleum usage, emissions and/or create jobs. The reviewer continued to add that this project seemed more like a R&D project than deploying commercially available technology. The reviewer noted in the first instance, that the data collection technology appeared to be very expensive and so were the batteries for the buses [DOE Program Clarification: There is no specific, unique, data tracking equipment associated with this project.]. The reviewer pointed out that apparently the batteries in the Kentucky buses cost \$20,000 each and the presenter told the reviewers that the price to replace these batteries was now \$8,000 each. The reviewer also commented that the data tracking of drivers routes and bus performance was



helpful but again that this data seemed like it would help the manufacturers more than it would the grant recipients, as petroleum and emissions reductions and job creation goals were very modest to begin with. It also seemed like the data collection technology was not consistent throughout the fleet. While the reviewer applauded Kentucky for trying to use hybrid buses, the reviewer said that it did not appear that the return on investment would ever be realized going forward.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that the barriers had been met since the project was well on its way towards a successful completion.

Another reviewer noted that the project partners had a good strategy for selecting the most effective routes and drivers for the hybrid busses and noted that the selection was based on a thorough evaluation of the vehicle data.

The third reviewer pointed out that the use of Thomas Built and IC as manufacturers was an excellent strategy that would help ensure a successful project, versus using a small start-up conversion company with insufficient resources. The reviewer added that the technical barriers seemed to be more human in terms of acceptance and data collection.

The fourth reviewer criticized that the deployment of vehicles to date had been done according to whatever school district requested funding, and was not related to fuel use, mileage or cost effectiveness. This reviewer also mentioned that some buses reported only getting 6.64 mpg, which was barely greater than the reported average fuel economy of Kentucky conventional school buses.

The fifth reviewer agreed that the project succeeded in accomplishing its goals, but still questioned why DOE funded the project. The reviewer stated that the project did very little to reduce petroleum for the dollar invested. The reviewer added that the project may have been good at getting press coverage for Clean Cities but did little to achieve the overall goals. The reviewer continued to state that this seemed to be a strategy for reducing hybrid technology costs rather than using commercially ready technology. The reviewer also pointed out that there were some inconsistencies in the number of buses ordered. The reviewer explained that the project had 164 buses ordered as of September 2011. The reviewer acknowledged that the project did do technician and first responder training and commended the project's good job on this effort. The project did follow-up with driver training to increase petroleum reduction/performance, added the reviewer, but again that it seemed like R&D.

The sixth reviewer stated that while the project was very creative and an ambitious use of grant funds, there appeared to be too much dependence on one vehicle. Two vehicles were part of the effort but project leads determined early on that one of the vehicle's technologies was not suitable for the project [DOE Program Clarification: ThomasBuilt and IC Bus (International) are the manufacturers of the buses participating in this project.]. The presenter told the reviewers that Kentucky replaces buses every 14 years and sells them to another state after 14 years. The reviewer commented that it seemed like this project just augmented a State procurement program that was already in place and that it was debatable if petroleum displacement, emissions reduction, and job creation goals were ever considered when DOE approved the project. One of the reviewers stated that the only negative would be the lack of cellular communications for data downloading from the buses.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer was impressed with the progress of getting vehicles on the road and the collection and reporting of the data of the fuel saved in this project. In addition, the reviewer commented that the training and information provided to the public has helped to meet the objectives of the project.

Another reviewer agreed that the improvement to the fuel economy was 33% which was right on target to the projections, and that it was good that the project was achieving its goals. The reviewer did question why so much funding was invested for so little return (44,000 total gallons of diesel fuel saved from January 2011 - February 2012) and hoped that this played out over the course of the overall project. The reviewer went on to question how the 448 kg/494 tons of CO₂ emissions saved compared. The reviewer added that data was being used to compare schools and technology and to make comparisons. More questions needed to be asked

to see more information on what this data was showing, as data was not being collected the same way per vehicle and the reviewer wanted to know why. The reviewer also noted that the reduction in the price of the battery technology went from \$22,000 to \$8,000 and that this was good progress as a result of this project.

The third reviewer reiterated the previous commenter by saying that the 33% increase for average hybrid mpg was excellent and that it was excellent that the project was quantifying the mpg benefits. The reviewer also noted that deployment seemed to be on track.

The fourth reviewer said the project was well on its way to completion as the project partners expected to deploy the remainder of the buses during the upcoming RFP (#5).

The fifth reviewer judged the project most favorably by seeing it as a learning experience—the first project of this nature/scale for school buses on a state-wide basis - largely making the mistakes for others to learn from. Project sponsors had been generating and evaluating good data and apparently learning from mistakes - noting wide differences in results between different school districts routes, and etc., as well as differences in quality of data collection modules between bus manufacturers. The reviewer noted that this should enable some adjustments to remedy low effectiveness/cost effectiveness of some deployments. Unfortunately, the reviewer stated, the project deployment was already 75% completed, and such adjustments may not be made effective before the end of project deployment. The reviewer went on to add that the high vehicle cost, low cost-effectiveness may limit or prevent additional deployments beyond the project.

The final reviewer opined that the driver, technical, and first responder training were very good, and that the future curriculum being developed would have a sustaining impact. This reviewer summarized that the project was the largest fleet of hybrid electric buses in the country. While these hybrid buses increased fuel economy approximately 33%, the average bus was getting 8.4 miles per gallon with baseline of 6.31 miles per gallon. The project goals were to displace 44,000 gallons per year and emissions reductions were not accurately measurable at this time. From January 2011 to February 2012, 494 tons of CO₂ emissions were saved, approximately 44,000 gallons per year were displaced, and emissions were reduced. In the future, this reviewer would like to see more detail regarding data collection methods. The commenter added that the data tracking of driver's routes and bus performance was helpful but again, that this data seemed like it would help the manufacturers more than it would the grant recipients as petroleum and emissions reductions and job creation goals were very modest to begin with. It also seemed like the data collection technology was not consistent throughout the fleet. While the reviewer applauded Kentucky for trying to use hybrid buses it did not appear that the return on investment would ever be realized going forward. The reviewer concluded that if the project were going to the effort and expense to collect data it appeared that it was being shared with DOE and partners monthly so that the project could use to use this data.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed responses to this question. The first reviewer felt that the inclusion of the first responder training was an excellent part of the project, and that using bus original equipment manufacturers (OEM) and component OEMs significantly increased the likelihood of the project's success.

Another reviewer indicated that the project partners were working well together and that there was a demonstrated effective communication between all partners and the schools/communities that were receiving the vehicles.

The third reviewer felt that the collaboration with all of the school districts even though some did not use hybrid buses would help give information about the overall success of the project.

The fourth reviewer commented that the list of collaborators included those required for the project but most were departments of the Kentucky State government involved administratively, the school district potential beneficiaries, and the equipment providers. This reviewer thought that the ineffective deployment pattern could be seen as a failure of adequate coordination with the school districts, the State agency administering/selecting recipients, or the lack of a planning consultant.

The fifth reviewer reiterated that the project had partners through the supply chain including manufacturers, distributors, fleet managers, county executives, educators (NEED), and etc., and that 300 people were trained under the program.

The final reviewer claimed that coordination seemed to be good but it should be noted that there were not that many partners in the project. The partners seemed to collaborate but really only included mainly one Clean Cities group, the Kentucky State Department of Education, four other state agencies, and less than a handful of U.S. manufacturers. This reviewer also claimed that it was not readily clear from the presentations supplied from the Kentucky Clean Fuels Coalition and Kentucky Department of Education reviewers how many total buses were going to be a part of this project. In one of the presentations it stated 164 buses had been purchased and that the project was 75% complete but there were only financial data for the 164 buses purchased which equaled \$9,966,570; the total project budget was over \$28 million. The project overview stated 174 Kentucky school districts are part of the project but based on the information supplied there are discrepancies between what percentages of the project as complete and how many total buses had been deployed. One presentation said a total of 213 buses were going to be purchased and that the project was 47% complete with only 101 buses deployed within 53 school districts. The reviewer continued that it was reported in the presentation that there had been many media stories about this project.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the researchers presented a good plan to continue to collect data from bus controller area network (CAN) per the American Reinvestment and Recovery Act of 2009 (ARRA) requirements. The reviewer added that the production of drivers' experience would help future adaption. Another reviewer added that the future activities of collecting additional data and holding public relations activities would help move the project to successful completion. The third reviewer agreed that the development of future curricula as a result of this project as well as holding public relations activities would have a sustaining impact.

The fourth reviewer noted that future data would help stakeholders understand real world applications, and added that if the project was going to the effort to collect data under the project, that the results received would at least be communicated to industry partners and manufacturers. The reviewer also added that it would be helpful to know how much displacement each vehicle was getting and how that looked over the course of the project.

The fifth different reviewer repeated that the project partners had developed a plan to continue to collect data and provide education and outreach on the projects. More detailed comments were received from one reviewer who pointed out that the project sponsors had been quite candid about the problems of effectiveness and are learning and doing what the researchers could to remedy them - noting that mileage of school buses within the state ranged from 600 to 5,000 miles per month. While the latter figure seemed higher than accurate (at least excluding some possible few very exceptional instances), the substantial differences may provide some potential to remedy the problems, though the differences were probably greatest between different school districts. Better training may also help remedy the problems and the project sponsors were engaged in providing that. The researchers were also talking to the equipment providers about lowering costs and improving performance.

The sixth reviewer noted that it was not readily clear from the two presentations supplied from Kentucky Clean Fuels Coalition and Kentucky Department of Education how many total buses were going to be a part of this project. In one of the presentations it stated that 164 buses had been purchased and that the project was 75% complete, but there was only financial data for the 164 buses purchased which equaled \$9,966,570.00. The total project budget was over \$28 million. The reviewer went on to say that in this presentation, the project overview stated 174 Kentucky school districts were part of the project but based on the information supplied, there were discrepancies between what percentage of the project was complete and how many total buses had been deployed. One presentation said a total of 213 buses were going to be purchased and that the project was 47% complete with only 101 buses deployed within 53 school districts. The data tracking of driver's routes and bus performance was helpful but again this data seemed like it would help the manufacturers more than it would the grant recipients as petroleum and emissions reductions and job creation goals were very modest to begin with. It also seemed like the data collection technology was not consistent throughout the fleet. While the reviewer applauded Kentucky for trying to use hybrid buses, it did not appear that the return on

investment would ever be realized going forward. The final reviewer continued to suggest that if the researchers were going to the effort and expense to collect data it appeared that it was being shared with DOE and partners monthly so that the project could use to use this data with other bus fleet customers and industry. The final reviewer again commented that the driver, technical and first responder training were very good and that the future curriculum being developed would have sustaining impact.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four out of six reviewers felt that the resources were sufficient for the project. One reviewer commented that the resources appeared to be sufficient. Another reviewer remarked that resources appear to be at the proper level and observed good cost sharing. The third reviewer asserted that funds for this project are sufficient.

The fourth reviewer would have liked to see the State make some investment in the hybrid technologies rather than have the whole burden fall to the DOE. The reviewer went on to questions where the investment was from the state as it looked like the state was taking credit for vehicles that would have been bought by the State anyway.

The fifth reviewer thought the resources were excessive, stating that the cost per fuel volume reduced was high and that if fewer funds had been provided that the project might have been more focused on the districts/routes that would be taking advantage of the technology effectively- high mileage routes with substantial per mile savings, using training to maximize effectiveness, and etc.

The last reviewer noted insufficient resources based on a lack of information to make an informed response. The reviewer explained that it was not readily clear from the two presentations supplied from Kentucky Clean Fuels Coalition (KCFC) and the Kentucky Department of Education how many total buses were going to be a part of this project and how many had been deployed. In one of the presentations, it stated that 164 buses had been purchased and that the project was 75% complete but there was only financial data for the 164 buses purchased which equaled \$9,966,570.00. The total project budget was over \$28 million. In this presentation KCFC, the project overview stated 174 Kentucky school districts were part of the project but based on the information supplied there were discrepancies between what percentages of the project was complete and how many total buses had been deployed. One presentation said a total of 213 buses were going to be purchased and that the project was 47% complete with only 101 buses deployed within 53 school districts.

Maryland Hybrid Truck Goods Movement Initiative: Christopher Rice (Maryland Energy Administration) – arravt063

Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the use of heavy-duty hybrid trucks, with proper driver training should increase petroleum displacement consistent with DOE goals. The second reviewer indicated that petroleum displacement was achieved by deploying a fleet of electric hybrid and hydraulic vehicles. The third reviewer stated that the project was obviously aimed at deploying alternative fuel vehicles, which would support DOE’s objective of petroleum displacement. The fourth reviewer pointed out that heavy duty trucks were the highest-consuming segment of the vehicle fleet and successful hybrids would lower their consumption and displace petroleum.

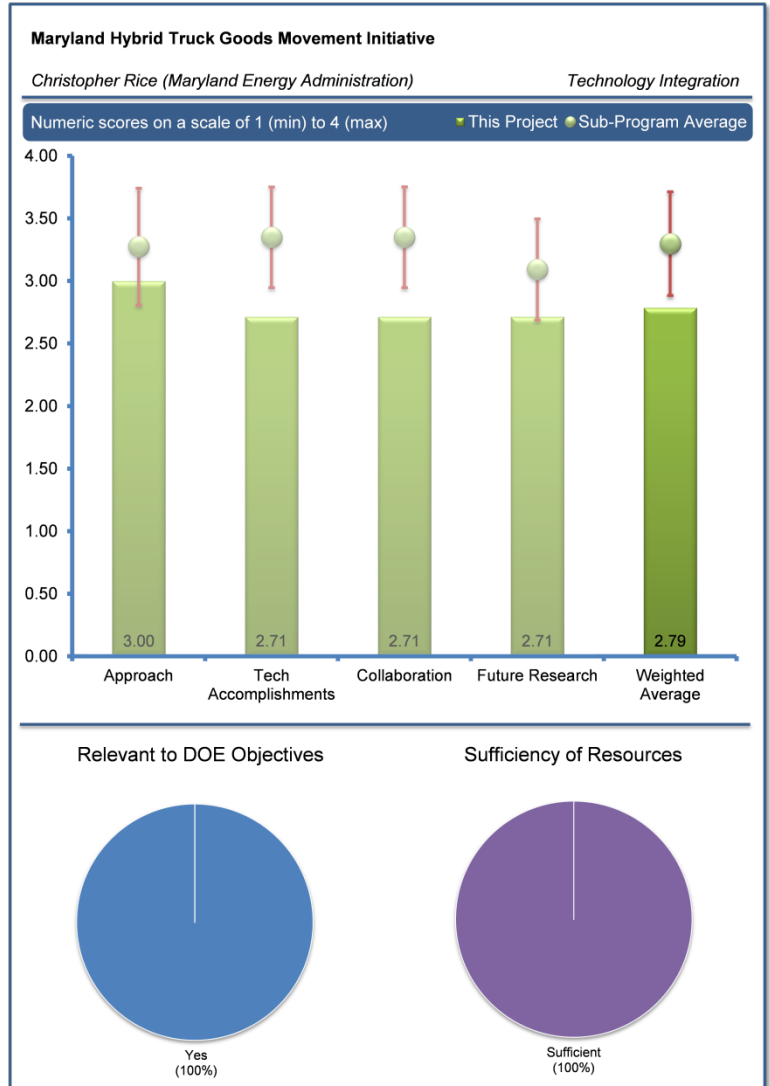
The fifth reviewer stated that the project met DOE and ARRA program goals of petroleum reduction through deployment of advanced technologies as well as maintained focus on jobs per ARRA goals. This reviewer also claimed that developing these technologies could potentially reduce the cost of hybrid trucks to enable a better business case for fleet purchases, further expanding petroleum reduction potential (difficult to quantify).

The final reviewer stated that the project would displace over 130,000 gallons of petroleum per year, reduce greenhouse gases (GHG) emissions by over 600,000 pounds (lbs.) per year, and create 68 jobs. The final reviewer included that there would be 143 heavy duty hybrid diesel vehicles to replace existing vehicles, and that the savings seen were clear but cumulatively were not highly significant.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer identified that the project involved a reasonable number of partners and vehicles, the supply chain issues involved with delayed deployment were correctly anticipated, and the project vehicles varied in size, duty cycle and freight types which should provide a good range of data for analysis.

Another reviewer indicated liking the focused strategy and that its focus was on a segment of the market that consumed huge amounts of fuel and was ripe for technological innovation. This reviewer proposed spreading the project out around the country as another creative idea.



The third reviewer commented that the deployment of one type of vehicle (hybrid trucks) with a relatively small number of partners was beneficial to the focus of work. This reviewer added that the project was a multi-state project, but that there were no clear details on how many vehicles went to which states.

The fourth reviewer felt that despite the number of challenges with the supply chain and technologies, that the PI had worked with the sub-recipients and OEMs to try to address the problems and improve the products to get them fully operational and deployed. The strategy was reiterated by the final reviewer who stated that the strategy was to introduce in the Maryland region 143 heavy duty hybrid and hydraulic trucks in order to show feasibility for this emerging truck technology. The barrier was associated with expected start-up problems on minimally tested technologies.

The fifth reviewer noted that the project targeted HD vehicles only (143) with hybrid technology; saw some differences in usage because of the types of freight being hauled/duty cycle; and had seen some technical issues with the hybrids in the first part of deployment. The project was having Freightliner work with the fleets to overcome the technical issues, as they could actually see a negative marginal mpg with some of the vehicles due to driver usage. The project needed to work more to educate the drivers on how to drive the vehicles properly, but the project expected that the hydraulic hybrids would take the driver out of the equation- if the efficiency gains were not as expected, that it would be a mechanical issue and not driver related.

The sixth reviewer felt that it was hard to gauge the strategy of the project. The reviewer stated that it appeared to be mostly a pass-through of grant funds to private fleets to buy hybrid trucks to be deployed wherever. This was not necessarily all bad, but it was not much of a strategy other than to benefit the participating fleets. The reviewer noted that the presenter did not develop the idea, but was approached by a third-party to submit the proposal for others.

The final reviewer noted that the project design did not integrate with other programs, projects or partners. The reviewer questioned whether the PI was not sufficiently invested in the project's success or was taking the role of a middle man. The reviewer continued that a barrier with partners not meeting their original commitment led to other initial partners receiving more vehicles. This reviewer felt that the PI demonstrated no interest in understanding the impact of the project in other states where vehicles were deployed. With regards to hydraulic hybrids – the commenter noted that the project threw warning lights early in the deployment phase, causing downtime, and a lack of driver confidence. The reviewer acknowledged that this was addressed but could have potentially been avoided with driver training. The reviewer added that driver training for getting maximum effectiveness was needed. Effectiveness of hybrid technology could be challenging if drivers were not trained appropriately. Partners have very different duty cycles - cube out versus weight out. The reviewer acknowledged large national partners - UPS, Sysco, Nestle, Aramark (uniform delivery side).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that good progress toward DOE goals had been made. All vehicles were hybrids, including hydraulic hybrids, and no infrastructure was included. The reviewer added that there was a very low likelihood that the project would not succeed simply because of its narrow scope.

Another reviewer stated that the project experienced strong accomplishments this year by going from 38% to 85% in vehicle deployment which was responsible for nearly 1,700,000 miles driven, and which identified the need for driver training on hybrid and hydraulic vehicles to achieve targeted improvements in fuel economy. On top of this, the reviewer identified that the current hydraulic trucks were unacceptably noisy, yet the project created 68 jobs.

A different reviewer noted that over 80% of the vehicles had been deployed, and that the remainder was some of the hydraulic hybrids that had many problems. Some of the projects had to reduce the number of vehicles, but the reviewer noticed that other partners stepped up and bought more. This reviewer reported that the trucks are deployed across the country, range in size from box trucks to Class 8 trucks, have been driven over 1 million miles to date, and are averaging a 25% fuel economy increase.

The fourth reviewer was unable to determine from the presentation which duty cycles and/or vehicle sizes were performing best, or what the annual petroleum displacement goal was. The reviewer noticed the Aramark and Sysco vehicles increased petroleum use for a short time based on the lack of driver training at that point in the project, as well as the slight problems with the hydraulic hybrids that Freightliner was attempting to resolve. The same reviewer stated that there was up to a 60% increase in efficiency from these hybrids once the vehicles were deployed, and claimed the presentation was light on data and other information that could have given a better sense of project success or failure.

The fifth reviewer noticed that it appeared that the trucks were being deployed, although there were issues that slowed the project down. The reviewer added that the project manager stated that there were issues with driver education that had to be addressed to get the project back on track.

The sixth reviewer stated that it was great to see that the project had quickly recovered from the fleets dropping commitments, and that a more structured plan to deal with technological problems would be good because the goal of the funding was to address technological barriers. The reviewer went on to suggest that more data and backing in the presentation would be helpful to give a better idea of whether or not it was successful. Some of the details the reviewer noted included: that the project had seen issues on fleet downtime as the researchers had implemented technologies that had not been tested much; most orders were placed by last July, but some of the fleets rescinded them due to economic conditions, and the remaining fleet partners were willing to pick up more demand and took the remaining vehicles; the vehicles supported were deployed all over the country (out to CA, down to FL); all vehicles deployed so far had been electric hybrids with the Eaton system, which saw about 25% fuel efficiency improvement; the project estimated 134,000 gallons diesel reduction annually (seen over 30,000 gallons thus far); the researchers have seen noise issues with the hydraulic hybrids to prevent them from being deployed, but Freightliner was working on that though Freightliner was not originally a cost-share partner; and the project is collecting fuel and mileage data quarterly.

Another reviewer claimed that the project had deployed 83% of vehicles to date, which was reasonable given the difficulties with the deployment of these hydraulic hybrids, and that the fleet training for the vehicles was very important to maximize hybrid fuel economy benefit, as the project showed. The reviewer was disappointed in the data collection activities, as it was noted that the activities did not seem as robust as would be expected. The reviewer continued that more details would be appreciated on how detailed the data collection was, and how the data would be used. The performance of the new hydraulic hybrid vehicles would be of interest to DOE, and real-world performance would assist in understanding the real potential for this technology. Quarterly fuel use data would not necessarily be sufficient to characterize this technology—other data collection efforts should be considered, as this was one of the largest deployments of hydraulic hybrid technology in the country.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers were split in regards to the collaboration and coordination of this project. The first reviewer indicated that project partners appeared to be fairly well coordinated. The second reviewer noted that the project had partnerships with both regional and national trucking firms. The third reviewer noted that MEA had worked with Clean Cities and a number of national fleets and OEMs, particularly Freightliner, and that some of the partners had been more eager to go further than others.

The fourth reviewer reported that collaboration appeared to be sufficient, and that participation from vehicle OEM (Daimler Trucks) to solve problems is a positive collaboration contribution. This reviewer added that involvement of major partners like Sysco and Nestle is a plus.

The fifth reviewer indicated that working with partners across state lines was great to see and was admirable. However, continued this reviewer, it did not seem like there was much effort to incorporate other partners beyond the few fleets using the truck and the OEMs. The reviewer then suggested that perhaps bringing in other partners to publicize or study the data would be useful. This reviewer also noted the following from the presentation: working with private fleets to get the hybrids into HD fleet; working with companies across the nation with wide-scale deployment; the project team was sought out for the national deployment and was approached by Gladstein, Neandross and Associates (GNA) who had done the legwork in finding the fleets and could help sell it to the governor's office; the government is very interested in EVs/hybrids and saw the value in letting people kick the tires on these across the U.S.; and UPS buying the hydraulic hybrids from Freightliner made it very easy to get Freightliner to invest in-

kind. The same reviewer opined that UPS was such a big customer that Freightliner was going to make sure they got everything right.

The sixth reviewer observed very little interaction with any groups or even among the groups in the project. The seventh reviewer remarked that there did not appear to be much collaboration at all. This reviewer indicated that work was done at the level of the individual participating fleets, but not much else was clear from the presentation. The same reviewer asserted that lessons learned on these trucks, especially the importance of and ways to address driver education, should be shared through the national Clean Cities network.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer was confident that the future work plan was reasonable to complete the project, but asked if there would be sufficient time during the next year to complete the activities listed before the end of the contracts (i.e., outreach, technology evaluation). The second reviewer noted that there was a ribbon-cutting planned for August, additional driver trainings were planned, and the rest of the vehicles should be deployed later this year. Further, continued this reviewer, outreach and reporting would continue. The third reviewer reported the project's future work involved final technical and activity reporting. The fourth reviewer explained that future efforts involve deploying the remaining vehicles, training, outreach, data collection and evaluation. The fifth reviewer agreed that it was difficult to tell how exactly the future work that was listed would be accomplished, and/or accomplished on time.

The sixth reviewer commented that the supply chain barriers seemed to have been solved by OEMs but that the PI did not make it sufficiently clear. This reviewer added that whether technology barriers had been overcome was not sufficiently addressed. The same reviewer noted that the proposed future work was vehicle deployment and training. However, this reviewer noted that the training seemed too little too late if the majority of the vehicles were already deployed and the lack of training had already been identified as a barrier as well.

The last reviewer noted that more detailed ideas on what to do with data collected and how to do outreach would be nice. The reviewer also asked if there was any planning to take this experience and use it to get more vehicles in other fleets. The reviewer then noted that: the remaining vehicles were largely hydraulic hybrids for UPS - expect a huge efficiency increase of 60% or more from them; expect to see additional cost share from Freightliner to get the hydraulic hybrids right for UPS; hired GNA to do the outreach; the hydraulic hybrids were going to be in the DC metro area since more stops equaled quicker payback; and asked if the hydraulic system was Parker Hannafin.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All of the reviewers agreed that the resources appeared to be sufficient. One reviewer noted that the resources appeared to be adequate to meet project objectives and that the anticipated petroleum displacement of 134,000 gallons per year seemed modest, given the resources provided. Another reviewer observed sufficient resources to complete the project, collect data, and successfully execute. The third reviewer noted that DOE contributed \$5.9 million with a cost share of \$10 million. The fourth reviewer stated that project funding of nearly \$6 million from DOE and \$10 million in matching funds was sufficient to achieve the stated milestones. Another person said that the funds appeared sufficient to cover the incremental cost of the hybrid vehicles being purchased. The sixth respondent pointed out that about 78% of the money had been spent, and the partners have contributed extra cost share including Freightliner, which was an unexpected contributor of cost share.

**Carolina Blue Skies & Green Jobs Initiative:
Kathy Boyer (Triangle J Council of
Government) – arravt064**

Reviewer Sample Size

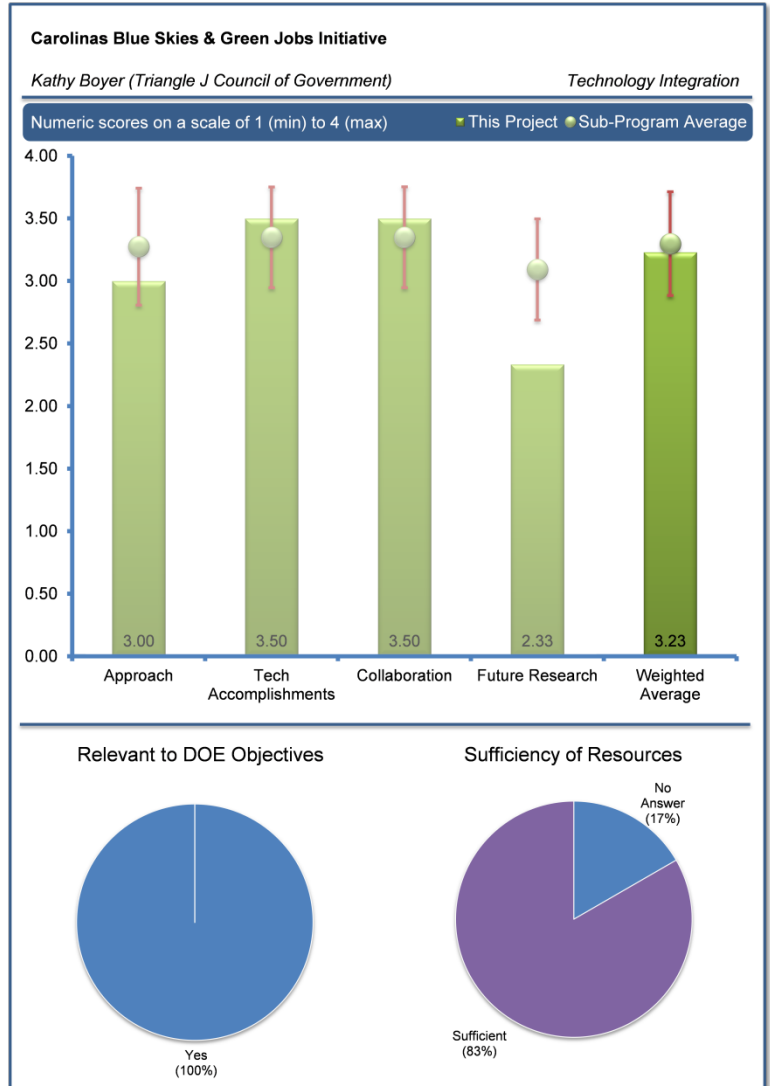
This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer asserted that the use of electric vehicles (EVs) helps petroleum displacement and that this project supports the DOE goal of oil displacement as well as estimated displacement of nearly 3.7 million gallons of gasoline gallon equivalent. The second reviewer mentioned that the current use of alternative fuels appeared to be in line with petroleum displacement goals. The third reviewer detailed that the project reported 325,000 gallons of petroleum fuel displaced to date by LPG, CNG, biofuels, electric, and etc., and that the project would ultimately deploy over 500 alternative fuel vehicles (AFVs) and EVs, approximately 90 alternative refueling stations, and 220 electric vehicle recharging stations.

A different reviewer stated that the project was expected to generate over a hundred jobs (the project has created 19.3 FTE based on actual FTEs) and convert about 200 vehicles to an alternative fuel, and that the project had already displaced 325,000 gallons of gasoline over 18 months. This reviewer would have liked to see if the project was on target to displace the expected 3 million plus gallons annually as the researchers had estimated, and how far off the project was, but that overall the project was very relevant and ambitious.

The fifth reviewer stated that this was a very ambitious and comprehensive plan that included four, state Clean Cities coalitions and tried to include all forms of renewable and alternative fuels. The reviewer added that the project scope underestimated fuels displacement and the project plans to exceed 3.7 million gallons of gasoline annually but did not explain how the project was going to achieve this metric. The original project scope was amended to reflect the demand for various fuel projects. The difference between the original plan and the current plan were the reduced number of stations: specifically 6 fewer biodiesel stations, 10 E85 stations and 2 EV stations as well as an additional 1 LPG station for a total of 8 biodiesel, 5 CNG, 9 E85, 110 EV, and 5 LPG stations. This reviewer continued to say that the vehicle deployment count increased from the original scope of 503 to a total of 528, with the majority of the vehicles being liquefied petroleum gas (LPG) with some NEV, HEV and CNG. The additional vehicles were the result of lower-cost projects and a reallocation of funds. It appeared that the EV stations were being installed with the hope that users would follow because currently there is not enough demand to support 110 charging stations, stated this reviewer. The same reviewer mentioned that there were twenty jobs retained with 63 lives touched through this ARRA funding, as well as the 43 sub-recipients, 88 vendors and 5 investigative leads that were part of the economic development benefit of this project. The reviewer concluded that it was exciting to see a lot of EV stations being installed but that there is no evidence to support this demand. The reviewer asked if the current technology was going to be compatible with the EV cars when



they got deployed to the United States. The reviewer recounted that the presenter made a comment that there was not a tremendous amount of EVs in the United States, but adhered to the theory that once stations were installed, EV cars would come.

The final reviewer asserted that the use of EVs helps petroleum displacement, but LPG does not.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Mixed reviews were encountered regarding the project's approach to performing the work. One reviewer indicated that the project had been able to address the barriers identified for the project and that the mix of vehicles in this project would help make this project successful.

Another reviewer indicated that that all aspects of the project deployment appeared to be going well, but that there were several delays and issues with verification of conversion technologies.

The third reviewer commented that the project must have spent a lot of time herding cats as there appeared to be too many organizations (5 investigative leads, 43 sub-recipients, and 88 vendors) to effectively manage, and it was difficult to tell what the exact deployment strategy was as it had shifted. This reviewer noted that some things were curious, such as deployment of 222 EV chargers when Slide 9 suggested less than 25 NEVs would be deployed.

The fourth reviewer identified that there was no specific strategy identified in the presentation, that the project was a diffuse grouping of sub-projects covering almost all of the alternative fuels described as being fuel neutral, which could be seen as unfocused. This reviewer also added that a large number of sub-recipients were said to have delayed deployment considerably, resulting in the project being substantially behind schedule.

The fifth reviewer detailed how the project was a lot of work and how it was hard to find sub-recipients. The reviewer noted that the project had 44 sub-grants and 88 vendors and believed that there may be simpler ways of doing this. The reviewer asked how DOE was going to continue to fund these types of projects or if there were better methods for introducing this technology. This project had a strong outreach component and the reviewer wanted to know how it would be sustained. The reviewer was also concerned with the presenter's comment that the EV stations were being installed without fleets to support them today. The reviewer quoted that everyone was hopeful but asked if this was an effective strategy and remarked if the vehicle and the stations should go hand-in-hand. The reviewer concluded that if the overall project did achieve its goals it would displace a significant amount of petroleum, generate long term local business, and support alternative fuels in the region.

The final reviewer felt that given the complex nature of this project, including the 43 sub-recipients, 88 vendors, and 5 investigative leads and the all-inclusive fuels deployment technology that the project was behind schedule. However, that it appeared the project team altered the scope of the project given the economic factors affecting demand and lack of demand for certain types of alternative vehicle stations. The original project scope was amended to reflect the demand for various fuel projects. The difference between the original plans and the current plan was a reduced number of stations, specifically 6 fewer biodiesel stations, 10 fewer E85 stations, and 2 fewer EV stations, as well as an additional 1 LPG station for a total of 8 biodiesel, 5 CNG, 9 E85, a110 EV, and 5 LPG stations. This reviewer also added that the flexibility, team work and breadth of alternative vehicle technologies included in this project by incorporating various types of alternative fueling stations, alternative fuel vehicle deployments, and an extensive list of partnership members was remarkable.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Most of the reviewers were satisfied with the results to date. The first reviewer stated that there was very good progress, with over 325,000 gallons of gasoline displaced through operating over 200 vehicles at the 59 fueling stations that are operational. The second reviewer commented that the project partners had done well to overcome and work through the deployment barriers, especially the conversion delays as barriers arose.

The third reviewer reported that the project is 53% complete and noted that this was not unusual based on the number of collaborators involved. This reviewer added that given the extensive partners, sub-recipients, contractors, five Clean Cities, and two State governments), as well as the complexity of the environmental review process required for this project, it is behind schedule but on track. The same reviewer noted that the PIs identified problems meeting timelines and worked with partners and subcontractors to revise accordingly. This reviewer added that investigators surveyed sub-recipients to identify training needs and determined that three categories were needed including Operator, Maintenance and First Responder. It was suggested by this reviewer that DOE track the training barrier that the investigator identified. This reviewer explained that reporting was occurring on the fifth day after the quarter ends. It was unclear to this reviewer, however, what data was being collected and shared. Going forward, continued the reviewer, this project should track metrics of petroleum replacement and emissions reduction in a manner that is user friendly to the public so lessons can be learned from this project. In addition, this reviewer emphasized that this is a robust and comprehensive project to design and implement and a tremendous amount of work was required on the front end to create this initiative. Forty percent of Federal funds have been spent and the project is expected to be completed by the end of this summer. Accordingly, the same reviewer suggested that this Program begin to focus on education, lessons learned, and tracking petroleum and emissions reduction. This reviewer remarked that the project scope underestimated fuels displacement and the project's plan to exceed 3.7 million gallons of gasoline annually, but did not explain how the project team was going to achieve this metric.

The fourth reviewer stated that the project is 53% done. Although the project team claimed to be on track, this reviewer recommended that DOE continue to watch if the project team continues to progress because they are running behind, which is not unusual based on the number of collaborators involved. The reviewer detailed that the project had a total of 137 stations and 528 vehicles. The reviewer liked that the project supported a variety of technologies and asked if the police were really doing their own conversion. The reviewer wondered what assurances were available that the American Academy of Applied Forensics conversions were being done safely and if the PIs could further explain if training continued to be a barrier. The presenters projected to over-deliver on fuel displacement of 3.7 million gallons but only had 325,000 displaced to date, noted the reviewer, and asked how the project was going to get to 3.7 million gallons annually. The presenter attributed this shortfall to pulling back on the B20 and E85 stations, and the reviewer questioned how this new approach was going to achieve these goals. The reviewer observed that the project team was working hard to train sub-recipients. This reviewer also asserted that maintenance and first responder training was needed, and acknowledged that the project team was working on it. The same reviewer queried what was meant when the statement was made that the project team was reviewing to make sure it was done right.

One reviewer reported that only 203 of 1,031 planned vehicles were deployed and 59 alternative fuel stations were operational. The reviewer pointed out that this may be misleading because many of these were single EV charging units, which should not qualify as stations.

Another reviewer stated that only 53% of the funds were expended to date, with delays blamed on problems with Environmental Protection Agency certification, backlogs of tank orders, and loss of biofuels tax credits, etc. While this reviewer acknowledged that there was some validity to this, the project was well behind schedule across the wide range of its sub-projects. The same reviewer noted that project sponsors had made some adjustments, particularly in refocusing on providing more training, as well as substituting HD CNG vehicles for biofuels spending, attracting new fleets, etc.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments on the project's collaboration and coordination were mixed. One reviewer felt that the collaboration between project partners appeared to be effective. The second reviewer felt that there was an extraordinary amount of collaboration and coordination within this project.

The third reviewer stated that the list of participants (including four Clean Cities coalitions) was much too long. The reviewer identified that too many participants without adequate structure and coordination mechanisms set up in advance was probably one of the reasons the project was delayed.

The fourth reviewer asked why five personal investigators were needed, as it appeared that the only collaboration with industry partners was buying vehicles and infrastructure.

The fifth reviewer added that there were four Clean Cities coalitions and one local university doing this work in two states and guessed that the huge list of collaborators was really difficult to manage. The reviewer questioned if the model of this massive list for future reference was effective or not, but in general liked seeing the coordinators working together.

The final reviewer stated that this project of 43 sub-recipients, 88 vendors and 5 investigative leads and the all-inclusive fuels deployment technology must have required extensive collaboration, coordination and team work to design on the front-end. The reviewer noted that this was a very ambitious and comprehensive plan whose scope included four Clean Cities coalitions and one local university. The same reviewer observed that the project tried to include all forms of renewable and alternative fuels vehicles and charging station deployments. The reviewer noted that two states, North Carolina and South Carolina, were part of this program requiring two State governments and a number of local and governments involved government involvement in decision making and permitting, and also that the Carolina Blue Skies and Green Jobs Initiative should be commended for its inclusive technology and partnership involvement. The final reviewer also asked if this model was effective and liked seeing the coordinators work together and so many local companies being a part of the project. The reviewer was hopeful that in the long-term that local businesses would benefit.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the proposed future work of getting all the vehicles and infrastructure in place this year should allow for the project to meet its oil displacement goals.

Another reviewer inquired about the deployment schedule of the rest of the vehicles and stated that the project needed to take 22 months to deploy the first 50% of the vehicles; therefore the plan to deploy the remaining 50% in three months was questionable. In addition, the reviewer noted that there was no identified data collection and/or monitoring plan offered.

A different reviewer said that the future plans appeared to be well developed, except for the plans and roll-out for the technician/first responder training activities.

The fourth reviewer stated that although the project was only 53% done, the researchers claimed that the project would be finished with deployment by August and that DOE should continue to monitor this. The reviewer noted that the researchers have modified their approach to achieve the overall goals and that this was good. The reviewer hoped that the researchers planned to continue the key responder and technician training into the future. The reviewer added that the researchers should also comment on how the project would be sustainable in the future. The reviewer stated that it was exciting to see a lot of EV stations being installed, but questioned how the stations were being used. The reviewer went on to ask if the current technologies would be compatible with future technologies and also if the project manager could explain more about what the long term communications included.

The fifth different reviewer reiterated that the project appeared to be on track to deploy vehicles and stations by the end of the summer but that data tracking, training, education and communications and media plans were less clear. The reviewer explained that there was some training referenced for sub-recipient projects but it was not clear about how all the partners (four Clean Cities Coalitions, two State governments, DOE and numerous local governments) were going to become aware of lessons learned from this interesting project. The reviewer added that the researchers had modified the approach along the way to accommodate partners dropping out and new recruitment of new partners and it seemed to the reviewer to be a very attractive model but was curious if this was an effective model. The reviewer was excited to see many EV stations being installed but lacked the evidence to support this demand; also would need to determine if the current technologies would be compatible for when EV cars get deployed to the United States.

The sixth reviewer indicated that the proposed future activities were mainly those that were scheduled to have been completed by the end of the second year of the project. Data gathering and etc., which would have been the activities of the second two years, would now probably be pushed outside of the ARRA project period.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers determined that the resources for this project were sufficient. The first reviewer stated that resources appeared to be sufficient.

Another reviewer mentioned that partners have failed to come through on this project early on and that the project managers have had to seek alternative support. This reviewer also said that the speaker indicated that they have reallocated funds and pursued additional partners to address this, and that DOE should follow up and make sure this actually happens to keep this project on track for completion. The reviewer then added that if overall goals were achieved, that this would be a great project.

The third respondent stated that based on the fact that project scope was revised to accommodate more alternative energy vehicles and fewer stations it appeared that there was close monitoring of these budgeted items, however, what was less clear was what the balance of budgeted funds available for administration, data collection tracking and reporting, communications and media awareness, training and education efforts was. The reviewer then concluded that the changing out of partners (dropping out and recruitment of new ones) may have affected the overall budget, so DOE should confirm that the budget was indeed on track.

The fourth reviewer reiterated this comment, indicating that the resources should be more than enough, but with so many hands in the pot, that it was difficult to judge.

Southeast Propane AutoGas Development Program: Al Christopher (Virginia Department of Mines, Minerals and Energy) – arravt065

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer found that this project estimates oil displacement of 4 million total gallons at the conclusion of the project and already has displaced 1 million gallons of gasoline.

The second reviewer also noted that 1 million gallons of petroleum fuel have already been displaced, and an estimated 4 million gallons per year to be displaced when project is complete based on 1,200 vehicles.

The third reviewer remarked that the petroleum displacement numbers are high, and will increase above preliminary estimates as more vehicles have been deployed than the initial estimates.

The fourth reviewer remarked that this project is the largest propane gas project in the country and far exceeded its initial goals and will be converting at least 1,200 vehicles from many various public and private fleets. It is projected to displace 4 million gallons of gasoline a year.

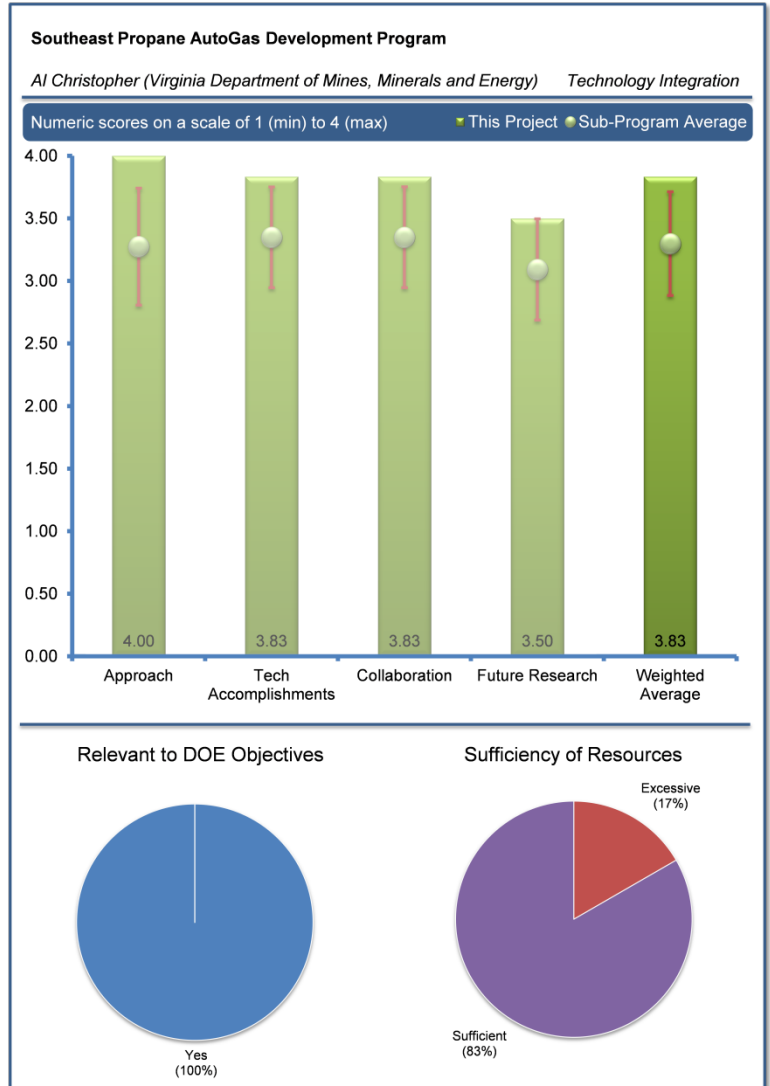
Another reviewer also noted the displacement of 4 million gallons of fuel, and would like to know whether the project is achieving these projections. This reviewer noted the 1,200 conversions, and would like to know how many are done. The reviewer also noted 35 stations.

The final reviewer remarked that it somewhat helps petroleum displacement if the LPG is made from natural gas instead of petroleum. However, according to the reviewer, this is unknown.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mostly positive feedback on the approach. The barriers identified have been addressed and the strategy for deployment was very good, stated one reviewer. This reviewer said that the project was unique based on the fact that the project was deploying vehicles over the entire southeast region.

The second reviewer claimed that there were no real technical barriers, but instead organizational in trying to get fleets to add these vehicles. However, this appears to be going very well.



Another reviewer observed 35 stations throughout the Southeast to service 34 participating fleets (up from 14 originally planned), 1,200 vehicles (up 138 from planned). This reviewer observed that a contractor provides both the conversion of all the vehicles at a center established for the project and installs the refueling equipment/trains operators etc. Deployment has proceeded at a strong pace even while expanding the scope of the project with additional non-DOE resources. This reviewer also noted an aggressive marketing and outreach to expand even further in the future using model of autogas usage in Europe which is much greater than in the United States.

The fourth reviewer mentioned that there would be ten Clean Cities coalitions impacted by this project. The project should be done with deployment by August and is on target for completing the project on time. This reviewer likes the road show concept to further promote long-term sustainability.

The fifth reviewer commented that the strategy and execution has been well-planned and developed.

According to the sixth reviewer, the project appeared to leverage the DOE Clean Cities funding almost four-to-one, which was truly impressive [DOE Program Clarification: The formal government cost share value is \$8.6 million and the recipient cost share is \$10.4 million.]. This reviewer also stated that there were 35 propane stations donated for this effort, and the partners reached out to fleet customers all over their geographic footprint and appeared to be really successful at including any group that was willing to retrofit their vehicles. It was mentioned that the partners' presentation testimonial video and education materials including the road show in ten Southeastern states and national media coverage would further recruit other fleet owners to choose to convert their vehicles to propane.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers were pleased with the progress of this project. According to the first reviewer, the program is deploying vehicles at a fairly good pace. The second reviewer remarked that the progress in this project has been excellent. There are nearly half of the vehicles already put into service and the project has displaced over 1 million gallons of gasoline. The third reviewer observed that there were several major barriers early in the project, but project partners have done a good job overcoming those barriers.

The fourth reviewer noted that the project would be over 60% completed as of AMR compared to the original scope of the project as approved for grant by DOE. This reviewer stated that even with the expansion of the project, deployment is apparently on track for completion by August 2012, only two months behind ARRA's overall deadline and the original project milestone in the application. Despite expansion from 14 to 34 fleets and despite delays relating to EPA certification of conversions and addition of additional vehicle platforms, the project sponsors were able to meet substantially increased stations and fleet deployment by first setting up stations for private use and addressing issues for public access afterwards, which was a reasonable adjustment/accommodation.

The fifth reviewer noted that the project is on target for accomplishing goals by August 2012. This reviewer liked the video of users that show the success of running fleets on propane, but it could have had more data to support their statements. The reviewer also noted that the project has 35 stations, that 1,200 vehicles should be deployed by August 2012, and suggested following up to verify this happens. The reviewer noted that the project currently is at 60% completion. The project is also encouraging fleets to make their own investments over the course of the grant, and that 13 to 34 fleets are now involved in the project. The project has over-delivered on matching funds. The matching funds do the installation of stations, while grant funds just pay for procurement of conversions.

The final reviewer mentioned that the Southeast Propane Autogas Development Program project has increased the number of cars the grant originally was funded to convert. Additionally, the team creatively leveraged the federal grant funds to achieve more vehicles being eligible to be converted. Recruiting 35 service stations to support this initiative was very aggressive, and the reviewer also noted impressive participation from partners. The testimonials from police officers were very powerful and had a high level of integrity.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented that the collaboration and coordination has been excellent. Having the project go through the entire Southeast corridor is outstanding. The second reviewer noted many collaborating entities from the appropriate fields including 11 Clean Cities coalitions, 34 fleets, numerous state and local governments, etc. The reviewer noted that the project is essentially on-track despite having 36 sub-recipients. The third reviewer observed a great list of partners and good media coverage. According to the fourth reviewer, the Southeast Propane Autogas Development Program has partners from universities, municipalities, the private sector and over ten Clean Cities coalitions. It appears that the partners have all worked together to leverage the grant funding to creatively and aggressively expand the project scope and participation. The fifth reviewer noted that the project partners have done well to communicate the success of the project and will continue to do so. According to the final reviewer, the project is working well with their deployment partners, but there is not any university or lab data analysis.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer observed that the plan is to continue deploying vehicles. According to the second reviewer, the future activities call for all of the vehicles to be deployed in 2012 and should allow the project to meet its goal of 4 million gallons of oil displacement. It will be exciting to see the results of the detailed data that is being collected in the project. The third reviewer remarked that future activities will complete deployment by a projected date of August 2012, and that the project will continue aggressive outreach and marketing, opening up private stations to public access, and increase focus on data collection. The fourth reviewer noted several more Road Shows to further promote stations and the net savings for these stations to get them to procure more vehicles and more fuel savings and long term sustainability. This reviewer concluded by commenting that this is a great overall project. The fifth reviewer found that future plans are well developed. The sixth reviewer mentioned that the educational materials, testimonials video, media launch and roadshow into ten Southeastern states would enable taxpayers to learn about commercializing and deploying propane fleet technologies and related petroleum displacement, greenhouse gas elimination and cost savings.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Five out of the six reviewers found that the resources that were provided were sufficient. One of the reviewers noted that the project over-delivered on matching funds, and praised the project on the outstanding job of its resource management [DOE Program Clarification: The formal government cost share value is \$8.6 million and the recipient cost share is \$10.4 million.]. Another reviewer commented that the resources in this project are sufficient. According to the third reviewer, resources apparently are sufficient judged by progress and expansion of project. A fourth reviewer commented that resource use appears to be sufficient. The fifth reviewer found that funds are excessive. This reviewer said that the Southeast Propane Autogas Development Program team appeared to have leveraged their grant funds in a manner to optimize the highest and best use for this award. It appeared to this reviewer that the team was very resourceful and created a program that researched and recruited strong contributing members to be able to execute and grow such an ambitious project [DOE Program Clarification: The formal government cost share value is \$8.6 million and the recipient cost share is \$10.4 million.].

California Low Carbon Fuels Infrastructure Investment Initiative: Robert Bowen (California Department of General Services) – arravt082

Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

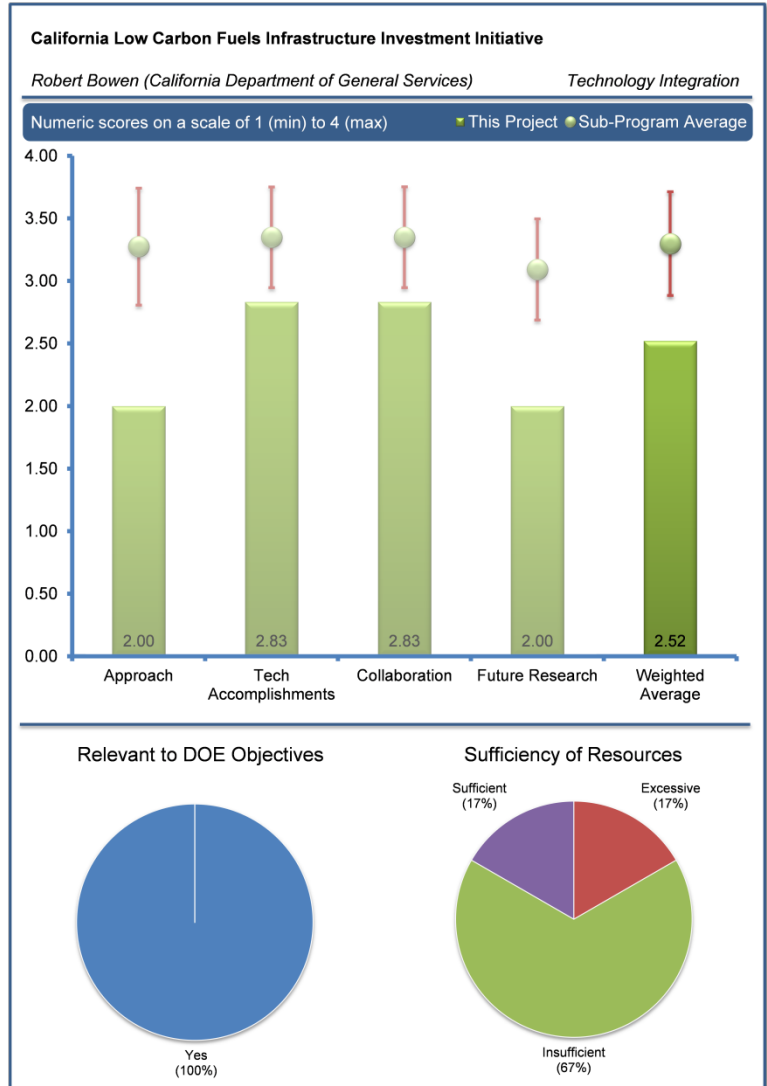
According to the first reviewer, this project estimated that it would displace 66 million gallons of gasoline and diesel fuel and so far has displaced over 2 million gallons of fuel.

The second reviewer remarked that although only 16 of the 75 stations have been constructed, over 500,000 gallons of biodiesel and 1.75 million gallons of E85 have been dispensed, providing support for much greater annual petroleum reduction as more stations are completed.

The third reviewer agreed that the project meets DOE objectives, but notes that there are still questions about E85 and petroleum reductions in the full cycle. The fourth reviewer commented that the project will displace petroleum with E85 if the project ever proceeds towards objectives, which is questionable.

The fifth reviewer observed that 50% cost share is provided by Propel, who did not have funds and therefore caused the project to stall. This reviewer cautions DOE that the project is already out 40% of funds on 16 stations yet there are 59 stations left to be installed. This reviewer also mentioned that the project would create 108 jobs, has already displaced 528,000 gallons of biodiesel and 1,744,000 gallons of E85, and has 21,000 tons of CO₂ equivalent reductions.

The final reviewer stated that the project supports the overall DOE objectives of petroleum displacement, but the execution of the project has been stalled of late. This reviewer recognized that while this project initiative is aggressive and impressive in so far as California did not permit this type of vehicle technology, biodiesel, until this year, it is unfortunate timing given the expiration of the ethanol federal tax and financing challenges the cost share applicant has encountered. The reviewer also mentioned that the private cost share was to be provided by Propel and that they would know soon if some of its financing can be secured. Obviously, these financing challenges have prevented this project from achieving its stated goals of 75 stations as only 16 were completed, and only 1 of the 16 were completed this year. The reviewer also noted that Propel has had tremendous success securing contracts for over 130 retailers so that provides Propel tremendous site flexibility if the financing comes through and may enable this project to catch-up. This reviewer also observed that the project’s job creation is reported as 108. The project displaced petroleum with 528,000 gallons of biodiesel, and 1,744,000 gallons of E85 over the past 12 months. The reviewer also observed that the project has displaced 21,000 tons of CO₂ in a recent 12 month period and the total project was estimated to displace 187,000 tons of CO₂ annually.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer mentioned that many barriers have been addressed given that there are 130 signed contracts and over 100 California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) approvals. Also, a major barrier was private company cost share which had not been met yet and had caused major delays.

The second reviewer agreed that the strategy was sufficient, but that the ethanol industry has been hit by the loss of its federal tax credit. This has stalled the market while retailers and Propel look at whether or not there is still a market. Financing has proven to be difficult. However, this reviewer observed that the project has over 130 signed contracts with retailers, and this is promising. The reviewer pointed out that Propel is in the process of securing financing, which should help get them back to building stations. This reviewer cautioned DOE not to give out funding until that is secured.

The third reviewer expressed a concern that the cost of the stations themselves appeared high at \$430,000 each, which was way out of line with anything seen anywhere else on any other project. The reported costs from successful station installers, etc. has held up the project, possibly along with problems siting stations. This reviewer commented that this should have been foreseen and the deployment strategy should have been different or at least included other contingencies. Additionally, this reviewer noted that contracts are said to exist on 130 potential location sites as contingencies, yet the project is way behind schedule. The reviewer concluded by stating that the project plan and report have been long on hype, short on specifics and short on performance.

According to the fourth reviewer, the project partners did have a strategy for finding additional project partners when Propel had to cease station construction. However, there appears to be no other organization that can provide the same services as Propel, keeping the project stalled for a long time frame.

The fifth reviewer expressed confusion as to what stations and alternative fuel infrastructure will be built. Only 16 of 75 stations have been completed.

The final reviewer noted that given the financing obstacles, state regulatory challenges and federal tax credit expirations, it seemed like this strategy was very risky and should have been altered once these hurdles were apparent. According to this reviewer, while this project initiative is aggressive and impressive in so far as California did not permit this type of vehicle technology, biodiesel, until recently, and it is unfortunate timing given the expiration of the ethanol federal tax, once these facts, including the financing challenges the cost share applicant has encountered, were known, a revised strategy should have been developed. Given that Propel is responsible for the 49% cost share and has these contracts with high-profile and well financed retailers, it might be worth researching if Propel could leverage these retailers and get them financially engaged in some of the station's construction costs. Finally the reviewer identified that it was estimated that a station would cost approximately \$316,000 and the costs appeared closer to \$450,000. Again, once it was discovered that the costs of the stations were higher than projected, it would have been advisable for the strategy to have been revised to reflect the higher costs along with other hurdles identified.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the progress has been slowed due to the lack of funding from Propel, but once the funding is provided, there is a good plan to get stations online fairly quickly. The second reviewer noted that only 16 of the project's 75 stations have been completed as of May-June 2012, the deadline for deployment under ARRA conditions. This reviewer thought that the reasons for the delays were readily anticipatable, and that the deployment schedule now would not allow for the two-year data collection and reporting required by the ARRA grants.

The third reviewer commented that B20 is now available in California, which was not available a few years ago. The project has less than 25% of stations completed. This reviewer observed that all 16 existing stations are privately owned; in the past Propel leased stations. Now they are purchasing the stations outright. This reviewer is not sure if this is a trend or not. For this reviewer, the technical problem is really related to financing and not the ability to install stations.

The fourth reviewer observed that while early progress was going well, the project has been stalled for some time as Propel looks for additional funding to complete the remainder (59) of the stations. Similarly, the fifth reviewer noted that only 16 of 75 stations have been completed due to funding problems. It appeared to this reviewer that matching funding was never in place at project inception.

The final reviewer observed that Propel has excelled at securing 130 contracts with high-profile retailers for stations. At this stage, the project has 108 jobs associated with it and initially projected 450 when entire 75 stations completed. Also, this was an aggressive project scope given California's late acceptance of this vehicle technology. The reviewer noted that the project was heavily dependent on one private cost share company that has encountered financing problems. According to this reviewer, this technology, biodiesel, may not be cost-effective at this time given the over capacity of natural gas but it is necessary for long term diversification, but may explain some of the unexpected financing problems. Propel hopes to learn about securing some additional financing soon and hopefully this will work out. However, this reviewer suggested that DOE needs to monitor this project closely because it has reimbursed approximately 42% of project costs and Propel has only invested approximately 31% of costs. This reviewer noted that CEC is a partner in this project also and they have contributed approximately 18% of costs. It seemed to this reviewer that infrastructure costs are way too high. This total project funding of approximately \$21.5 million was for 75 stations, only 16 have been constructed, and only 1 station was constructed in 2012. It does not seem like there will be enough funding for the 75 stations unless costs for the station technology, permitting, construction labor, etc. comes down drastically. This reviewer concludes that it does not appear that much progress towards overcoming these barriers have been mitigated, and the success of rescuing as much of this project as possible should be determined soon and is heavily dependent on Propel securing its outside private funding.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

According to the first reviewer, in spite of the project delays, which were out of the control of the PI, the project clearly demonstrated the recognition and ability to communicate progress/barriers to all project partners and interested parties. The second reviewer perceived that the number of suppliers, site operators and government agencies in the project shows very good collaboration and coordination. The third reviewer commented that there have been lots of agreements but not much progress, so it is difficult to weight the value of the agreements. Similarly, the fourth reviewer noted a reasonable list of collaborating participants, but it has been insufficient to carry forward the project, obtain permitting in timely way, obtain financing for applicable station costs, etc. The fifth reviewer found that the project has great partners. But the project needs to leverage these partners to provide funding and reduce Propel's investment. This reviewer cites 7-Eleven, Quizno's and Circle K as a few examples of partners.

The final reviewer mentioned that the collaboration on this project was quite good. Propel secured high-profile national partners such as 7-Eleven, Quizno's, Circle K, Zipcar, ADM, Cargill, and Tesoro just to name a few. According to this reviewer, it would be worth Propel's effort (if it has not been done already) to see if these companies would be able to help finance some of the station costs at their facilities to try and move this project forward. Quite possibly these partners may have other assets that could be contributed, that could enable stations to be built and reduce Propel's expenditures. Additionally, this reviewer added that Propel has secured 130 contracts in 5 major markets of California including: San Francisco, Sacramento, Los Angeles, Orange County and San Diego, and acknowledged that collaborating with all these companies and local governments required a tremendous amount of coordination and collaboration. This reviewer observed that a lot of work has been done on the front end of this project and due to reasons stated above of late, the project has been stalled. Propel is hopeful that it has secured additional funding to complete the project but in the meantime this reviewer recommended that Propel compile all the relevant summary information for DOE on the contracts, sites, partners, municipal government offices worked with, and points of contact information, etc. in a user friendly summary manual format, should DOE want to reference it in the future.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers expressed concern about future activities. According to the first reviewer, the future activities hinge on Propel coming up with the funds necessary to complete their cost share. If Propel obtains the funds, the project should be able to install many of the planned stations. The second reviewer noted that proposed future activities hinge on the ability of Propel to secure additional project funding, especially since no replacement/alternative partners have been found. The third reviewer found that the project is significantly behind schedule and it appears the industry partner has come up with needed capital, making the future of this project shaky at best. The fourth reviewer remarked that proposed activities are merely to complete the project two years behind schedule on the new model, taking on faith that it will get on (the new) track soon in the future.

The fifth reviewer cautioned that the project has a lot of work to still do. The project is less than 22% done based on the original proposal, and is waiting for funding or financing to continue work. This reviewer cautioned DOE not to expend more funding.. There have been discussions of looking at other partners to replace Propel or to use the funds differently. But right now the project is still with Propel. This reviewer would like to better understand how Propel is promoting the E85 and biodiesel, and would like to know how the volume estimates compare to the actual volumes.

The final reviewer remarked that it does not seem like the project has incorporated the set-backs that have been encountered during the first few years of the grant. According to this reviewer, it seems highly unlikely that the project will be completed and 75 new stations will be built. This reviewer recognized that recent regulatory approvals have been secured, but they have taken a long time and it does not appear that there are contingency plans to make up for this lost time. The reviewer pointed out that this is an aggressive project scope given California's late acceptance of this vehicle technology. Additionally, it is heavily dependent on one private cost share company that has encountered financing problems. This technology, biodiesel, may not be cost effective at this time given the overcapacity of natural gas but it is necessary for long term fuel diversification but may explain some of the unexpected financing problems. Propel hopes to learn about securing some additional financing soon and hopefully this will work out. However, the reviewer recommended that DOE monitor this project closely because DOE has reimbursed approximately 42% of project costs and Propel has only invested approximately 31% of costs. This reviewer noted that CEC is a partner in this project and they have contributed approximately 18% of costs. It seemed to this reviewer like the infrastructure costs are way too high. This total project funding of approximately \$21.5 million was for 75 stations and only 16 have been constructed, and only 1 station was constructed in 2012. It did not seem to this reviewer like there will be enough funding for the 75 stations unless costs for the station technology, permitting, construction labor, etc. come down drastically. The scope of this project should be evaluated to see if it is financially feasible to accomplish by June 2014. It does not appear that much progress towards overcoming these barriers have been mitigated, and the success of rescuing as much of this project as possible should be determined soon and is heavily dependent on Propel securing its outside private funding. The reviewer advised that this project team needs to have some education outreach materials and reference materials (if not already compiled) supplied to DOE should this project not be completed in its entirety. It would be a waste to lose all the good work that has been done on this project if it is not completed because so much work has been done to get it to the stage it is at now.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four reviewers considered the project to have insufficient resources, one reviewer considered the resources sufficient and one reviewer considered resources to be excessive. For those reviewers who considered the project funding to be insufficient, one reviewer commented that DOE funds are sufficient, but partner funds are very insufficient. A second reviewer commented that obviously, financing is a key issue to this project that has been a problem. The project needs to get that under control. A third reviewer stated that programmatic resources appear to be sufficient, but the funding availability from the main project partner has obviously been insufficient. This reviewer would be interested to know whether there was any discussion to set up a different reimbursement process at the beginning of the project. It appeared to a fourth reviewer that the resources are insufficient to complete the whole project in a timely manner. Cost overruns, financing challenges and regulatory hurdles have slowed the project down tremendously. It appeared to this reviewer that even if Propel secures the funding, it will not be enough to build the 75 stations. This reviewer is hopeful Propel can get its financing and revise scope to execute on this award. Again, if Propel can work

with any of its strong partners to see if they would be willing to contribute to the station costs in order to drive their expenditures down that too seems like another option worth investigating. The reviewer who found that funds are sufficient remarked that funds are sufficient if Propel comes up with the funds needed to complete the project. The reviewer who found that funds are excessive remarked that although insufficient financing is supposedly a key excuse for the delays to date, the costs being allowed are way out of line compared to any costs seen anywhere for E85 installations, even allowing for the greater number of pumps, cost differentials for state of California, and Davis Bacon differentials. The reviewer questioned the distribution and timing of public versus matching contributions. The reviewer also expressed concern about having a single station developer.

National Alternative Fuels Training Consortium (NAFTC) Clean Cities Learning Program: AI Ebron (West Virginia University) – ti017

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer found that the project supports individual and institutional awareness and knowledge of alternative fuel and electric-drive vehicles, and thereby encourages purchases of these vehicles. Greater market penetration of these vehicles will reduce petroleum use.

A second reviewer added that the program is designed to educate various audiences about the introduction, and changing vehicle landscape that now includes AFV's so from this perspective it does the job expected.

Another reviewer added that the training, education, outreach and awareness activities such as these are of value in providing AFV literacy to the public, as well as providing specific training to the workforce sector, thus accelerating mass market introduction and penetration of AFVs, resulting in the DOE objectives of petroleum displacement.

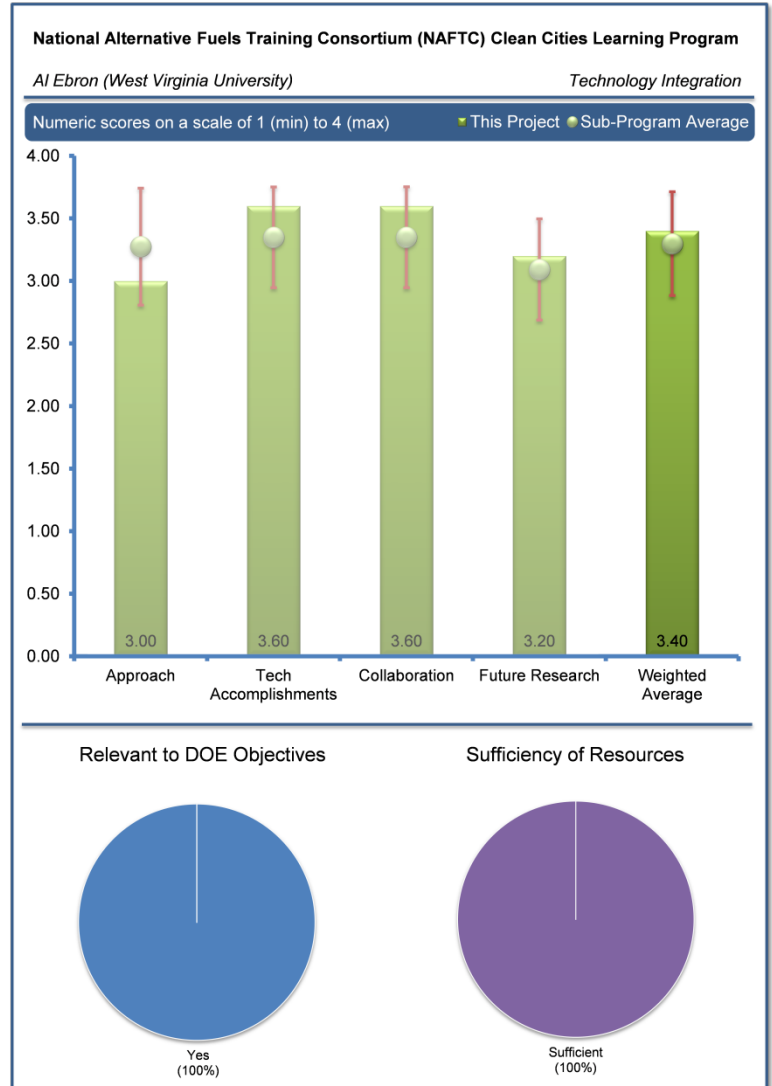
According to the fourth reviewer, the scope of the outreach program is large and has the potential to train many individuals, fleet managers, policy makers, first responders, about alternative fuels and advanced technology vehicles in multiple cities throughout the nation.

The final reviewer found that this project will not directly displace petroleum by putting vehicles on the road, but it will definitely help meet the displacement goals by educating and making people aware of alternative fuels.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer described the strategy this project has to educate and train people as excellent. This reviewer added that information about alternative fuels will be distributed effectively around the country through face-to-face workshops, marketing material, and train-the-trainer activities.

Another reviewer indicated that the strategy for deployment appears sound and workable with both first responder training and National AFV Day completed. The Petroleum Reduction Technologies workshops are ongoing, continued this reviewer, and include a number of different modules that take time to develop. But the reviewer also pointed out that the project appears to be behind schedule considering that the program has been ongoing since 2009.



The third reviewer observed that training is being provided for both trainers and first responders, and that direct public outreach, the website, and the online toolbox will reach potential vehicle purchasers.

The fourth reviewer expressed that the materials have been and are being reviewed by numerous parties, but questioned whether the communications strategy was such to promote wide acceptance of the modules. This reviewer inquired about how NAFTC would know the impact of the petroleum reduction manuals, and queries if there is a tracking system to know which communities, schools, etc., have used one or more of the modules. This reviewer assumed that an evaluation has been developed. Further, the same reviewer noted that the instructor guides do not have talking points, and queried how the training will reach greater audiences at high success rates if the instructors do not have clear instructions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the project has made solid progress to date but do appear to be a bit behind on the introduction of Petroleum Reduction Course. The program has been ongoing since 2009 and would have been close to completion, but additional funding to revise and update specifically for vehicle recovery operation and salvage yard workers in regards to AFVs has pushed it back until 2013. This is the first responder part of the grant, not part of the petroleum reduction technologies program.

Another reviewer added that the training materials that have been prepared and the training through workshops and webinars including first responder training show very good progress for this project. A third reviewer noted that the project has delivered numerous workshops and webinars, first-responder training, and an AFV Odyssey Day report. The reviewer also observed a long list of publications and presentations. The final reviewer observed that the technical materials developed are extensive, peer reviewed, and meet the objectives of the grant.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers noted good collaboration across a wide range of stakeholders. The first reviewer stated that the project has very good collaboration with a variety of training centers, Clean Cities coalitions, and industry partners. A second reviewer added that the project has numerous partners that span a number of organization types and this is a very strong component of the program. The third reviewer also noted that the project is collaborating and coordinating with multiple community colleges, Clean Cities coalitions, and relevant industry partners.

A fourth reviewer noted that the project has collaboration with 12 NAFTC universities, 10 industry partners, and 12 Clean Cities. Additional collaboration is also underway with first responder associations, national educational associations at high schools and beyond who could help them benefit from the modules. According to this reviewer, the communications plan is currently being developed and could take care of reaching multiple audiences, and collaboration with OEMs is not extensive. This reviewer inquires if there was review by OEMs on the first responder manual.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer remarked that the planned future activities that will continue to educate the public through workshops and webinars will continue to make this project a success.

The second reviewer observed an appropriate continuation of existing outreach, education, and training activities. This reviewer added that recovery and salvage workers are suitable future targets for outreach, education and training.

A third reviewer found that the increased funding requires more time to finish the project and calls for more trainings.

According to the final reviewer, future activities include offering additional first responder training. This reviewer would like to know how additional revenue streams will be developed to pay to upgrade to the extensive modules. Much effort and resources

have gone into the modules for both the first responder and petroleum reduction training so it would be unfortunate if the materials could not be distributed far and wide and updated as appropriate.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers found resources to be sufficient. One commenter indicated that the increased scope required additional funds but that the existing resources appeared to be sufficient to finish the jobs required.

Another reviewer added that milestones are being met on a timely basis, but that the program is multifaceted and complicated. It was not clear to this reviewer that the modules would be promoted to a wider audience for greater use. This reviewer is not sure why the communications plan is being developed late in the grant cycle. It may be difficult to complete 38 workshops, 8 webinars, and 6 additional first responder trainings and an Odyssey Day Event by the end of FY 2013.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
ACUA	Atlantic County Utilities Authority
AFV	Alternative Fuel Vehicle
AMR	Annual Merit Review
APU	Auxiliary power unit
AQMD	Air Quality Management District
ARRA	American Recovery and Reinvestment Act
ASE	Automotive Service Excellence
B20	Biodiesel blend of 20% neat biodiesel
BD	Biodiesel
BPU	Board of Public Utilities
CAN	Controller Area Network
CARB	California Air Resources Board
CC	Clean Cities
CCSF	City College of San Francisco
CEC	California Energy Commission
CEC	Clean Energy Coalition
CEQA	California Environmental Quality Act
CMAQ	Congestion Mitigation and Air Quality Program
CNG	Compressed Natural Gas
CO2	Carbon dioxide
CTE	Career and technical education
DC	Direct Current
DEG	Diesel equivalent gallons
DEP	Department of Environmental Protection
DOE	Department of Energy
E85	85 percent Ethanol blend with gasoline
EFG	EV quick reference guide
EMS	Emergency medical services
EMT	Emergency medical technician
EPA	Environmental Protection Agency
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
FCV	Fuel cell vehicles
FOA	Funding Opportunity Announcement
FTE	Full time equivalent
GATE	Graduate Automotive Technology Education
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gases

Acronym	Definition
GIS	Geographic Information Systems
GM	General Motors Corporation
gpy	Gallons Per Year
GTI	Gas Technology Institute
GVPD	Global Vehicle Development Process
H2	Hydrogen
HD	Heavy-Duty
HDV	Heavy-Duty Vehicle
HEV	Hybrid Electric Vehicle
IACP	International Association of Chiefs of Police
ICTC	Interstate Clean Transportation Corridor
INDOT	Indiana Department of Transportation
KCFC	Kentucky Clean Fuels Coalition
Kg	Kilogram
L	Liter
LDV	Light Duty Vehicle
LFG	Landfill Gas
LIE	Long Island Expressway
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MD	Medium-Duty
MDV	Medium-Duty Vehicle
MEDC	Michigan Economic Development Corporation
MPG	Miles Per Gallon
MV1	A para-transport Vehicle Model
NAFTC	National Alternative Fuels Training Consortium
NEED	National Energy Education Development
NEPA	National Environmental Protection Agency
NEV	Neighborhood Electric Vehicle
NFPA	National Fire Protection Association
NGV	Natural Gas Vehicle
NOx	Oxides of Nitrogen
OEM	Original Equipment Manufacturer
PEV	Plug-in electric vehicle
PI	Principal Investigator
PM	Particulate matter
PR	Public relations
PUC	Public Utilities Commission
R&D	Research and Development
RFID	Radio Frequency Identification
RFP	Request for Proposal

Acronym	Definition
RNG	Renewable Natural Gas
ROI	Return on Investment
SANBAG	San Bernardino Associated Governments
SCAQMD	South Coast Air Quality Management District
SEO	State Energy Office
SME	Subject Matter Expert
UM	University of Michigan
UPS	United Parcel Service
VT	Vehicle Technologies
VTP	Vehicle Technologies Program
WM	Waste Management
WVU	West Virginia University

9. Acronyms

The following list of Acronyms cited within the report is provided as a reference for readers.

Acronym	Definition
1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional
3-DEP	Three Dimensional Engineered Preform
A123	A123 Systems
ABA	Anion Binding Agents
ABR	Advanced Battery Research
ABRT	Advanced Battery Research for Transportation
AC	Alternating Current
A/C	Air Conditioning
ACEC	Advanced Combustion and Emissions Control
ACUA	Atlantic County Utilities Authority
ADA	American with Disabilities Act
ADT	Accelerated Durability Test
AEC	Advanced Engine Combustion
AEV	All Electric Vehicle
Afm	Alumina, ferric oxide, monosulfate phase
AFRL	Air Force Research Laboratory
AFV	Alternative Fuel Vehicle
Ah	Ampere-hour
AHSS	Advanced High Strength Steel
Al-12Fe	High-temperature Aluminum Alloy Composition
Al-8Fe	High-temperature Aluminum Alloy Composition
Al	Aluminum
ALD	Atomic Layer Deposition
AlF3	Aluminum Fluoride
AlN	Aluminum Nitride
Al2O3	Aluminum Oxide
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
APE	Advanced Power Electronics
APEEM	Advanced Power Electronics and Electric Machines Program
API	American Petroleum Institute
APRF	Advanced Powertrain Research Facility (ANL)

Acronym	Definition
APS	Advanced photon source
APU	Auxiliary Power Unit
AQMD	Air Quality Management District
ARPA-e	Advanced Research Projects Agency-Energy
ARRA	American Recovery and Reinvestment Act
ASE	Automotive Service Excellence
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASIC	Application-Specific Integrated Circuit
ASTM	American Society for Testing and Materials
Au	Gold
AVFL	Advanced Vehicle/Fuel/Lubricant Committee
AVFL-19	Project 19 under Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council
AVX	AVX Corporation
AWG	American Wire Gauge
AZ31	a Magnesium alloy
B20	Biodiesel blend of 20% neat biodiesel
B100	Biodiesel blend of 100% neat biodiesel
B4C	Boron carbide
BASF	a chemical company
BATT	Batteries for Advanced Transportation Technologies
BD	Biodiesel
BDMS	Battery Database Management System
BES	DOE Basic Energy Sciences
BET	Brunauer, Emmett, and Teller
BEV	Battery Electric Vehicle
BMEP	Brake Mean Effective Pressure
BMS	Battery Management System
BNL	Brookhaven National Laboratory
BOPP	Bi-axially Oriented Polypropylene (film)
BPU	Board of Public Utilities
BSFC	Brake-specific fuel consumption
BTE	Brake Thermal Efficiency
C	degrees Celsius
C	Carbon
CA	Commercially Available
CAEBAT	Computer-Aided Engineering of Batteries
CAFE	Corporate Average Fuel Economy
CALCE	Center for Advanced Life Cycle Engineering (UMD)
CAN	Controller Area Network
CARB	California Air Resources Board
CB	Carbon Black

Acronym	Definition
CC	Clean Cities
CCSF	City College of San Francisco
C_d	Coefficient of Drag
CE	Coulombic Efficiency
CEC	California Energy Commission
CEC	Clean Energy Coalition
CEQA	California Environmental Quality Act
CF	Carbon Fiber
CF8C-Plus	A type of cast austenitic stainless steel
CFD	Computational Fluid Dynamics
CFF	Cell Fabrication Facility (Prototype)
CI	Compression Ignition
CIDI	Compression-ignition Direct-injection
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CMAQ	Congestion Mitigation and Air Quality Program
CMC	Carboxymethyl Cellulose
CNG	Compressed Natural Gas
CNT	Carbon Nanotubes
Co	Cobalt
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COP	Coefficient of performance
CR	Coefficient of Rolling Resistance
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CSI	Current Source Inverter
CSCG	Core-Shell with Concentration Gradient
CSTR	Continually Stirred Tank Reactor
CTE	Career and technical education
Cu	Copper
CVD	Chemical Vapor Deposition
DADT	Developmental & Applied Diagnostic Testing
DBBB	2,5-di-tert-butyl-1,4-bis(2-methoxyethoxy)benzene
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DC	Direct Current
DEG	Diesel equivalent gallons
DEP	Department of Environmental Protection
DERC	Diesel Engine Research Consortium
DFT	Density Functional Theory
DISI	Direct Injection Spark Ignited

Acronym	Definition
DOC	Diesel oxidation catalyst
DoD	Depth of Discharge
DOD	Department of Defense
DOE	Department of Energy
DoE	Design of Experiment
DOT	Department of Transportation
DPF	Diesel Particulate Filter
DSC	Differential Scanning Calorimetry
DSRC	Dedicated Short-Range Communications
DTNA	Daimler Trucks North America
E85	85 percent Ethanol blend with gasoline
EADPF	Electrically-Assisted Diesel Particulate Filter
EAR	E-A-R Thermal Acoustic Systems
EATS	Exhaust Aftertreatment System
EB	Electron Beam
EC	Ethylene Carbonate
EC	European Commission
ECI	Electronic Concepts, Inc.
ECN	Engine Collaboration Network
ECS	Emission Control Systems
EDAX	Energy Dispersive Analysis X-Ray
EDV	Electric-Drive Vehicle
EFG	EV quick reference guide
EGR	Exhaust Gas Recirculation
EIS	Electrochemical Impedance Spectroscopy
EISA	Energy Independence and Security Act
EMA	Engine Manufacturers Association
EMC	Ethyl Methyl Carbonate
EMC	Epoxy Molding Compounds
EMI	Electromagnetic Interference
EMS	Emergency medical services
EMT	Emergency medical technician
EO	Engine Out
EOL	End of Life
EP	Extreme Pressure
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPRI	Electric Power Research Institute
ERC	Engine Research Center
ES124	DOE Energy Storage Program (advanced prognostics modeling tool)
ESCA	Electron Spectroscopy for Chemical Analysis

Acronym	Definition
ESL	Equivalent Series Inductance
ESMS	Energy Storage Monitoring System
ESR	Equivalent Series Resistance
ESS	Energy Storage System
ETM	Electro-Thermo-Mechanical
EU	European Union
EUCAR	European Council for Automotive R&D
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
EVSP	Electric Vehicles Standards Panel
EXAFS	Extended X-ray Absorption Fine Structure
FACE	Fuels for Advanced Combustion Engines
FCHEV	Fuel Cell Hybrid Electric Vehicle
FCV	Fuel Cell Vehicle
FE	Finite Element
FEA	Finite Element Analysis
FEC	Fluorinated Ethylene Carbonate
FEM	Finite element method
FFRL	Fatigue and Fracture Research Laboratory
FMEP	Friction mean effective pressure
FMVSS	Federal Motor Vehicle Safety Standards
FOA	Funding Opportunity Announcement
FOM	Figure of Merit
FPE	Free-piston engine
FST	Fast Summation Transformation
FSW	Friction Stir Welding
FTE	Full time equivalent
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal Year
GATE	Graduate Automotive Technology Education
GEN2	Generation 2
GDI	Gasoline Direct Injection
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gases
GHS	Greenhouse
GIS	Geographic Information Systems
GITT	Grid Integration Tech Team
GM	General Motors Corporation
GOSS	Grain-Oriented Silicon Steel
GPRA	Government Performance and Results Act

Acronym	Definition
gpy	Gallons Per Year
GSA	General Services Administration
GTI	Gas Technology Institute
GVPD	Global Vehicle Development Process
H2	Hydrogen
HAN	Home Area Network
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HCS	Harmonic Compensated Synchronous Detection
HD	Heavy-Duty
HDD	Heavy-duty diesel
HDV	Heavy-Duty Vehicle
HECC	High Efficiency Clean Combustion
HEV	Hybrid Electric Vehicle
HEXRD	High-Energy X-Ray Diffraction
HF	Hydrofluoric acid
HFPP	Hexafluoro-iso-Propyl Phosphate
HHV	Hydraulic Hybrid Vehicle
HK30-Nb	A type of stainless steel alloy
HNEI	Hawaii Natural Energy Institute
HPLB	High-pressure, lean burn
HSG	Hybrid Starter Generator
HSLA	High Strength Low Alloy Steel
HTML	High Temperature Materials Laboratory
HV	High Voltage
HVAC	Heating Ventilating and Air Conditioning
HWCVD	Hot-Wire Chemical Vapor Deposition
HX	Heat Exchanger
IACP	International Association of Chiefs of Police
IC	Internal Combustion
ICA	Interface Control Additives
ICE	Internal Combustion Engine
ICME	International Computational Material Engineering
ICTC	Interstate Clean Transportation Corridor
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated-Gate Bipolar Transistor
IL	Ionic Liquid
IIHS	Insurance Institute for Highway Safety
IMB	Impedance Measurement Box
INDOT	Indiana Department of Transportation

Acronym	Definition
INL	Idaho National Laboratory
IP	Intellectual Property
IPM	Interior Permanent Magnet
IR	Infrared
IRS	Internal Revenue Service
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
JCI	Johnson Controls, Inc.
JFET	Junction Gate Field-Effective Transistor
JMI	John Marvin, Inc.
K	Potassium
K	Temperature in degrees Kelvin
KCFC	Kentucky Clean Fuels Coalition
KEMET	KEMET Electronics Corporation
Kg	Kilogram
KH-ACT	Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence model
ksi	Thousand pounds per Square Inch
KW	Kilowatt
L	Liter
LBL	Lawrence Berkeley National Laboratory
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LCD	Liquid Crystal Display
LCO	Lithium Cobalt Oxide (LiCoO ₂)
LD	Light-Duty
LDD	Light-Duty diesel
LDV	Light-Duty Vehicle
LED	Light-Emitting Diode
LEESS	Lower-Energy Energy Storage System
LEM	LEM, Inc.
LES	Large Eddy Simulation
LFG	Landfill Gas
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
LFT	Long Fiber Thermoplastics
LG	LG Chem
LH	Long-Haul
LHFZ	Laser Heated Floating Zone
LIB	Lithium-Ion Battery
LIE	Long Island Expressway

Acronym	Definition
LiBF4	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalato)borate
LiFOP	Lithium tetrafluorooxalatophosphate $\text{LiPF}_4(\text{C}_2\text{O}_4)$
LiFSI	Lithium bis(fluorosulfonyl)imide
LiMn2O4	Lithium Manganese Oxide
LiMO2	Lithiated transition metal oxides
Li2MnO3	Lithiated transition metal oxides
LiPF6	Effective electrolyte salt for lithium-ion battery
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LLC	Layered Lithium metal oxide Cathode
LLFC	Lean Lifted Flame Combustion
LLNL	Lawrence Livermore National Laboratory
LMNO	Ni-substituted manganese spinel oxides
LMO	Lithium Manganese Oxide
LMP	Lithium Metal Polymer
LMR	Lithium Manganese Rich
LNG	Liquid Natural Gas
LNT	Lean NOx Trap
LPG	Liquefied Petroleum Gas
LSAM	Lanthanum-aluminate based oxides
LSM	Lanthanum Strontium Manganite
LTDI	Lithium 4,5-dicyano-2-(trifluoromethyl)imidazole
LTC	Large Tapered Crystal
LTC	Low Temperature Combustion
MAX	Layered ternary carbides, nitrides, and carbonitrides consisting of “M”, “A”, and “X” layers
MCMB	Mesocarbon Microbeads
MD	Molecular Dynamics
MD	Medium-Duty
MDV	Medium-Duty Vehicle
MECA	Manufacturers of Emissions Control Association
MEDC	Michigan Economic Development Corporation
MERF	Materials Engineering Research Facility (Argonne National Lab)
MENA	Magnesium Electron North America
MFERD	Magnesium Front End Research and Development
Mg	Magnesium
MgO	Magnesium oxide or Magnesia
MGI	Materials Genome Initiative
MIT	Massachusetts Institute of Technology
MLCC	Multilayered Ceramic Capacitor
MMLV	Multi-Material Lightweight Vehicle
Mn	Manganese

Acronym	Definition
Mo	Molybdenum
MO	Carbon and oxides (MO=SiO, SiO ₂ , SnO ₂ , MoO ₃ , GeO ₂)
MOSFET	Metal-Oxide-Semiconductor Field-Effective Transistor
MOU	Memorandum of Understanding
MOxST	Metal Oxygen Separation Technologies, Inc.
MPG	Miles Per Gallon
MPGe	Miles Per Gallon equivalent
msi	Million Pounds per Square Inch
MSRP	Manufacturer Suggested Retail Price
MSU	Michigan State University
MSU	Mississippi State University
MV1	A para-transport Vehicle Model
MXene	Exfoliated MAX phases (2D structures)
MYPP	Multiyear Program Plan
N	Nitrogen
NAFTC	National Alternative Fuels Training Consortium
NASA	National Aeronautical and Space Administration
NBB	National Biodiesel Board
NCSU	North Carolina State University
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	See NMC
NDE	Non-Destructive Evaluation
NG	Natural Graphite
NEC	Net Energy Change
NEED	National Energy Education Development
NEG	Nippon Electric Glass Co., Ltd.
NEPA	National Environmental Protection Agency
NETL	National Energy Technology Laboratory
NEV	Neighborhood Electric Vehicle
NFC	Novel Flux Coupling
NFPA	National Fire Protection Association
NGV	Natural Gas Vehicle
NHTSA	National Highway Traffic Safety Administration
Ni	Nickel
NiMH	Nickel-Metal Hydride
NIST	National Institute of Standards and Technology
NMC	Nickel Manganese Cobalt oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NO	Nitric Oxide
NOx	Oxides of Nitrogen

Acronym	Definition
NO2	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NTRC	National Transportation Research Center
NY	New York
NYC	New York City
NY-BEST	New York Battery and Energy Storage Technology Consortium
OCV	Open Current Voltage
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OTR	Over The Road
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAH	Polycyclic Aromatic Hydrocarbon
PAN	Polyacrylonitrile
PBA	Planar Bond All
PbSe	Lead selenide or lead(II) selenide
PC	Propylene Carbonate
PCB	Printed Circuit Boards
PCCI	Premixed Charge Compression Ignition
PE	Polyethylene
PED	Power Electronic Device
PEEM	Power Electronics and Electric Machines
PEI	Polyethyleneimine
PEO	Polyethylene Oxide
PEV	Plug-in Electric Vehicle
PF6	Hexafluorophosphate
PFOP	Polyfluorene Polymer
PGM	Platinum group metal
PHEV	Plug-In Hybrid Electric Vehicle
PHEV10	Plug-In Hybrid Electric Vehicle with a 10-mile range on a single charge
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PLC	Programmable Logic Controller
PLIF	Planar Laser-Induced Fluorescence
PLZT	$Pb_{1-x}La_xZr_yTi_{1-y}O_3$
PM	Particulate Matter
PM	Permanent Magnet
PM	Project Manager
PMEP	Pumping mean effective pressure
PNNL	Pacific Northwest National Laboratory

Acronym	Definition
POL	Pilot Oxidation Line
PP	Polypropylene
PPAP	Production Part Approval Process
PPC	Partially premixed combustion
PPG	Pittsburgh Plate Glass Company
Ppm	Parts per Million
PR	Public relations
PRIMET	Primet Precision Materials, Inc.
PS	Polystyrene
PSD	Particle Size Distribution
Pt	Platinum
PTC	Positive Temperature Coefficient
PUC	Public Utilities Commission
PV	Photovoltaic
PWB	Printed Wiring Board
QC	Quality Control
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid Compression Machine
R&D	Research and Development
RE	Rare Earth
RF	Radio Frequency
RFID	Radio Frequency Identification
RFP	Request for Proposal
RFQ	Request for Quotation
RNG	Renewable Natural Gas
ROI	Return on Investment
ROMP	Ring Opening Metathesis Polymerization
RPI	Rensselaer Polytechnic Institute
RPM	Revolutions Per Minute
RS2	Redox Shuttle-2
RSW	Resistance Spot Welding
SA	Spark assisted
SACI	Spark assisted compression ignition
SAE	Society of Automotive Engineers
SANBAG	San Bernardino Associated Governments
Sb	Antimony
SBR	Styrene Butadiene Rubber
SCAQMD	South Coast Air Quality Management District
SCCI	Stratified charge compression-ignition
SCP	Spherical Carbon Particles
SCR	Selective Catalytic Reduction

Acronym	Definition
SEI	Solid Electrolyte Interface
SEM	Scanning Electron Microscope
SEO	Poly(Styrene-block-Ethylene Oxide)
SEO	State Energy Office
SES	Triblock Co-polymers (polystyrene-block-polyethylene-block-polystyrene)
Si	Silicon
Si3N4	Silicon nitride
SIC	Single Ion Conducting
SiC	Silicon Carbide
SI	Spark ignition
SIDI	Spark Ignition Direct Injection
SiO2	Silicon Oxide
SMC	Sheet Molding Compound
SMC	Soft Magnetic Composites
SME	Subject Matter Expert
Sn	Tin
SNL	Sandia National Laboratory
SOA	State Of the Art
SOC	State Of Charge
SOE	State Of Energy
SOFC	Solid Oxide Fuel Cell
soh	State of Health
SOIC	Small Outline Integrated Circuit
SOM	Solid Oxygen Ion Membrane
SOP	Standard Operating Procedures
SPS	Strategic Polymer Sciences, Inc.
SSRL	Stanford Synchrotron Radiation Light Source
SUNY	State University of New York
SW	Software
TCM	Technical Cost Modeling
TCO	Total Cost of Ownership
TCR	Thermochemical Recuperation
TE	Thermoelectric
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscope
TFSI	Bis(trifluoromethane)sulfonimide - [(CF3SO2)2N]-
TGA	Thermogravimetric analysis
THF	Tetrahydrofuran
Ti2C	Type of MXene (HF treated Ti2AlC)
TM	Transition Metal
TMS	Tetramethylsilane

Acronym	Definition
TR	Time-Resolved
TRB	Transportation Research Board
TRU	Trailer Refrigeration Unit
TSFI	Bis(trifluoromethane)sulfonimide [(CF ₃ SO ₂) ₂ N]
TTT	3,5-triallyl-1-[1,3,5]triazinane-2,4,6-trione
UCSD	University of California San Diego
UHC	Unburned hydrocarbon
UHEM	Ultra-High Energy Ball Milling Machine
UHMW	Ultra-High Molecular Weight
UK	United Kingdom
UK	University of Kentucky
UL	Underwriters Laboratories
ULSD	Ultra-Low Sulfur Diesel
UM	University of Michigan
UMTRI	University of Michigan Transportation Research Institute
UPA	Unit Production per Annum
UPS	United Parcel Service
UQM	UQM Technologies, Inc.
URI	University of Rhode Island
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
USABC	U.S. Advanced Battery Consortium
USAMP	U.S. Automotive Materials Partnership
USC	University of Southern California
USCAR	U.S. Council for Automotive Research
USPS	U.S. Postal Service
UTRC	United Technologies Research Center
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
V	Volt
VC	Vinylene Carbonate
VCT	Variable camshaft timing
V2I	Vehicle-to-Infrastructure
VDA	Verband der Deutschen Automobilindustrie or Association of German Automobile Manufacturers
VEHMA	Vehma International
VT	Vehicle Technologies
VTP	Vehicle Technologies Program
VVA	Variable valve actuation
VVT	Variable valve timing
W	Watt
WBG	Wide Bandgap
WEG	Water Ethylene Glycol

Acronym	Definition
WHR	Waste Heat Recovery
WM	Waste Management
WPT	Wireless Power Transfer
WVU	West Virginia University
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XPS	X-ray Photoelectron Spectroscopy
XRF	X-Ray Fluorescence
XRD	X-Ray Diffraction (Crystallography)
YSZ	Yttria-Stabilized Zirconia
YTZP	Yttria-stabilized Polycrystalline Tetragonal Zirconia

10. Cross-Reference of Project Investigators, Projects, and Organizations

Cross Reference, Sorted by Project Investigator

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1-74	Abdullah Bazzi; Chrysler LLC. Advancing Plug In Hybrid Technology and Flex Fuel Application on a Chrysler Mini-Van PHEV DOE Funded Project (Vehicle & System Simulation)
1-8	Abdullah Bazzi; Chrysler LLC. Advancing Transportation Through Vehicle Electrification - PHEV (Vehicle & System Simulation)
2-97	Ahmad Pesaran; National Renewable Energy Laboratory. Overview of Computer-Aided Engineering of Batteries (CAEBAT) and Introduction to Multi-Scale, Multi-Dimensional (MSMD) Modeling of Lithium-Ion Batteries (Energy Storage)
8-129	Al Christopher; Virginia Department of Mines, Minerals and Energy. Southeast Propane AutoGas Development Program (Technology Integration)
8-5	Al Ebron; West Virginia University. Advanced Electric Drive Vehicle Education Program (Technology Integration)
8-137	Al Ebron; West Virginia University. National Alternative Fuels Training Consortium (NAFTC) Clean Cities Learning Program (Technology Integration)
6-12	Alan Luo; General Motors. Magnesium Front End Development (AMD 603/604/904) (Light-Weight Materials)
3-26	Allen Hefner; National Institute of Standards and Technology. Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters (Advanced Power Electronics)
1-137	Andreas Malikopoulos; Oak Ridge National Laboratory. Autonomous Intelligent Electric Vehicles (Vehicle & System Simulation)
1-96	Andreas Malikopoulos; Oak Ridge National Laboratory. The Meritor Dual Mode Hybrid Powertrain CRADA (Vehicle & System Simulation)
2-42	Andrew Jansen; Argonne National Laboratory. Fabricate PHEV Cells for Testing & Diagnostics (Energy Storage)
8-21	Andrew Klock; National Fire Protection Association. Electric Vehicle Safety Training for Emergency Responders (Technology Integration)
7-13	Andrew Wereszczak; Oak Ridge National Laboratory. Thermoelectric Mechanical Reliability (Propulsion Materials)
7-19	Andy Wereszczak; Oak Ridge National Laboratory. Improved Organics for Power Electronics and Electric Motors (Propulsion Materials)

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2-131	Anne Dillon; National Renewable Energy Laboratory. Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes (Energy Storage)
2-144	Anne Dillon; National Renewable Energy Laboratory. Development of Industrially Viable Battery Electrode Coatings (Energy Storage)
2-141	Anthony Burrell; Argonne National Laboratory. Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials (Energy Storage)
2-86	Austen Angell; Arizona State University. Electrolytes and Separators for High Voltage Li Ion Cells (Energy Storage)
3-60	Ayman El-Refai; General Electric Global. Alternative High-Performance Motors with Non-Rare Earth Materials (Advanced Power Electronics)
1-94	Aymeric Rousseau; Argonne National Laboratory. Hydraulic HEV Fuel Consumption Potential (Vehicle & System Simulation)
6-66	Ba Nguyen; Pacific Northwest National Laboratory. Engineering Property Prediction Tools for Tailored Polymer Composite Structures (Light-Weight Materials)
1-52	Barney Carlson; Idaho National Laboratory. Electric Drive and Advanced Battery and Components Testbed (EDAB) (Vehicle & System Simulation)
8-37	Beth Baird; Idaho Petroleum Reduction Leadership Project. Idaho Petroleum Reduction Leadership Project (Technology Integration)
4-142	Bill Partridge; Oak Ridge National Laboratory. CRADA with Cummins on Characterization and Reduction of Combustion Variations (Advanced Combustion)
4-81	Bill Partridge; Oak Ridge National Laboratory. Cummins/ORNL-FEERC CRADA: NO _x Control & Measurement Technology for Heavy-Duty Diesel Engines (Advanced Combustion)
4-36	Bill Pitz; Lawrence Livermore National Laboratory. Chemical Kinetic Research on HCCI & Diesel Fuels (Advanced Combustion)
5-13	Bill Pitz; Lawrence Livermore National Laboratory. Chemical Kinetic Modeling of Non-Petroleum Based Fuels (Fuels Technologies)
5-4	Bob McCormick; National Renewable Energy Laboratory. Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends (Fuels Technologies)
5-2	Brad Zigler; National Renewable Energy Laboratory. Fuels for Advanced Combustion Engines (Fuels Technologies)
2-70	Brett Lucht; University of Rhode Island. Development of Electrolytes for Lithium-ion Batteries (Energy Storage)
3-77	Brian Peaslee; Magna E-Car Systems of America, Inc.. Electric Drive Component Manufacturing Facilities: Magna E-Car Systems of America, Inc. (Advanced Power Electronics)

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3-40	Burak Ozpineci; Oak Ridge National Laboratory. Integration of Novel Flux Coupling Motor and Current Source Inverter (Advanced Power Electronics)
8-25	Carl Anderson; Michigan Technological University. Recovery Act – An Interdisciplinary Program for Education and Outreach in Transportation Electrification (Technology Integration)
8-69	Carla York; Connecticut Clean Cities Future Fuels Project. Connecticut Clean Cities Future Fuels Project (Technology Integration)
2-84	Chris Johnson; National Energy Technology Laboratory. Progress of DOE Materials, Manufacturing Process R&D, and ARRA Battery Manufacturing Grants (Energy Storage)
2-54	Chris Orendorff; Sandia National Laboratories. Evaluation of Abuse Tolerance Improvements (Energy Storage)
2-157	Chris Pupek; Argonne National Laboratory. Process Development and Scale up of Advanced Electrolyte Materials (Energy Storage)
4-156	Chris Taylor; GMZ Energy Inc.. Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery (Advanced Combustion)
2-102	Christian Shaffer; EC-Power. Development of Cell/Pack Level Models for Automotive Li-Ion Batteries with Experimental Validation (Energy Storage)
2-95	Christopher Johnson; Argonne National Laboratory. Novel Composite Cathode Structures (Energy Storage)
4-27	Christopher Powell; Argonne National Laboratory. Fuel Injection and Spray Research Using X-Ray Diagnostics (Advanced Combustion)
8-120	Christopher Rice; Maryland Energy Administration. Maryland Hybrid Truck Goods Movement Initiative (Technology Integration)
3-35	Christopher Whaling; Synthesis Partners. Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets (Advanced Power Electronics)
8-76	Chuck Feinberg; New Jersey Clean Cities Coalition. NJ Compressed Natural Gas Refuse Trucks, Shuttle Buses and Infrastructure (Technology Integration)
5-6	Chuck Mueller; Sandia National Laboratories. Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies (Fuels Technologies)
4-102	Chuck Peden; Pacific Northwest National Laboratory. Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials (Advanced Combustion)
4-71	Chuck Peden; Pacific Northwest National Laboratory. Degradation Mechanisms of Urea Selective Catalytic Reduction Technology (Advanced Combustion)
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4-133	Corey Weaver; Ford Motor Company. Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development (Advanced Combustion)
6-48	Curt Lavender; Pacific Northwest National Laboratory. Non-Rare Earth High-Performance Wrought Magnesium Alloys (Light-Weight Materials)
8-87	Cynthia Maves; Clean Fuels Ohio. The Ohio Advanced Transportation Partnership (OATP) (Technology Integration)
2-46	Dan Abraham; Argonne National Laboratory. Diagnostic Studies on Lithium Battery Cells and Cell Components (Energy Storage)
4-33	Dan Flowers; Lawrence Livermore National Laboratory. Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines (Advanced Combustion)
4-88	Dan Greenbaum; Health Effects Institute. Advanced Collaborative Emissions Study (ACES) (Advanced Combustion)
6-28	Dan Houston; USAMP/ACC. Advanced Materials and Processing of Composites for High Volume Applications (ACC932) (Light-Weight Materials)
8-102	Dan Kelly; Railroad Commission of Texas. Texas Propane Vehicle Pilot Project (Technology Integration)
2-72	Daniel Scherson; Case Western Reserve University. Bifunctional Electrolytes for Lithium-ion Batteries (Energy Storage)
1-10	Darren Gosbee; Navistar, Inc.. Advanced Vehicle Electrification (Vehicle & System Simulation)
6-10	Dave Warren; Oak Ridge National Laboratory. Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers (Light-Weight Materials)
6-6	Dave Warren; Oak Ridge National Laboratory. Carbon Fiber Technology Facility (Light-Weight Materials)
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6-56	Dave Warren; Oak Ridge National Laboratory. Improving Fatigue Performance of AHSS Welds (Light-Weight Materials)
6-51	Dave Warren; Oak Ridge National Laboratory. Low-Cost Magnesium Sheet Production using the Twin Roll Casting Process and Asymmetric Rolling (Light-Weight Materials)
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8-104	David Day; Texas State Technical College. Development of National Liquid Propane (Autogas) Refueling Network, Clean School Bus/Vehicle Incentive & Green Jobs Outreach Program (Technology Integration)
7-15	David J. Singh; Oak Ridge National Laboratory. Thermoelectrics Theory and Structure (Propulsion Materials)
4-107	David Koeberlein; Cummins. Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks (Advanced Combustion)
2-148	David Wood; Oak Ridge National Laboratory. Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes (Energy Storage)
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1-85	Dominic Karbowski; Argonne National Laboratory. Optimal Energy Management of a PHEV Using Trip Information (Vehicle & System Simulation)
8-106	Don Francis; DeKalb County. DeKalb County/Metropolitan Atlanta Alternative Fuel and Advanced Technology Vehicle Project (Technology Integration)
1-46	Don Karner; ECotality North America. Advanced Vehicle Testing Activity & Evaluation (Vehicle & System Simulation)
1-5	Don Karner; Electric Transportation Engineering Corp.. Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation (Vehicle & System Simulation)
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6-16	Edgar Lara-Curzio; ORNL/HTML. Supporting Vehicle Weight Reduction Through Characterization (Light-Weight Materials)
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1-135	Erik Rask; Argonne National Laboratory. Defining Real World Drive Cycles to Support APRF Technology Evaluations (Vehicle & System Simulation)
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8-34	Gerald Bernstein; City College of San Francisco. Electric Vehicle Service Personnel Training Program (Technology Integration)
3-46	Gilbert Moreno; National Renewable Energy Laboratory. Two-Phase Cooling Technology for Power Electronics with Novel Coolants (Advanced Power Electronics)
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3-51	Greg Smith; General Motors, Advanced Technology Center. Next Generation Inverter (Advanced Power Electronics)
3-4	Gui-Jia Su; Oak Ridge National Laboratory. A Segmented Drive Inverter Topology with a Small DC Bus Capacitor (Advanced Power Electronics)
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2-56	Guoying Chen; Lawrence Berkeley National Laboratory. Overcharge Protection for PHEV Batteries (Energy Storage)
4-136	Hakan Yilmaz; Robert Bosch. Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles (Advanced Combustion)
4-85	Harold Sun; Ford Motor Company. Advanced Boost System Development for Diesel HCCI/LTC Application (Advanced Combustion)
1-48	Henning Lohse-Busch; Argonne National Laboratory. Advanced Technology Vehicle Lab Benchmarking - Level 1 (Vehicle & System Simulation)
1-79	Henning Lohse-Busch; Argonne National Laboratory. Evaluation and Adaptation of 5-Cycle Fuel Economy Testing and Calculations for HEVs and PHEVs (Vehicle & System Simulation)
2-113	Herman Lopez; Envia. Electric-Vehicle Battery Development (Energy Storage)
7-17	Hua-Tay Lin; Oak Ridge National Laboratory. Low-Cost Direct Bonded Aluminum (DBA) Substrates (Propulsion Materials)
8-28	Huei Peng; University of Michigan. Recovery Act—Transportation Electrification Education Partnership for Green Jobs and Sustainable Mobility (Technology Integration)
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1-56	Jeffrey Gonder; National Renewable Energy Laboratory. Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis (Vehicle & System Simulation)
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3-66	Judith Gieseking; General Motors. US Electric Drive Manufacturing Center (Advanced Power Electronics)
1-42	Julie D'Annunzio; Ford Motor Company. Ford Plug-In Project: Bringing PHEVs to Market (Vehicle & System Simulation)
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8-5	West Virginia University; Al Ebron. Advanced Electric Drive Vehicle Education Program (Technology Integration)
8-137	West Virginia University; Al Ebron. National Alternative Fuels Training Consortium (NAFTC) Clean Cities Learning Program (Technology Integration)
6-32	Zoltek; George Husman. Development and Commercialization of a Novel Low-Cost Carbon Fiber (Light-Weight Materials)

11. Project and Program Statistical Calculations Overview

A numerical evaluation of each project within each subprogram area and a comparison to the other projects within the subprogram area necessitates a statistical comparison of the projects utilizing specific criteria. For each project, a representative set of experts in the project's field were selected to evaluate the project based upon the criteria indicated in Section 1. Each evaluation criterion's sample mean and variance were calculated utilizing the following formulas respectively:

$$\bar{x}_{j,k} = \frac{1}{n} \sum_{i=1}^n x_{i,j,k}$$

$$s_{\bar{x}_{j,k}}^2 = \frac{1}{(n-1)} \sum_{i=1}^n (x_{i,j,k} - \bar{x}_{j,k})^2$$

where $x_{i,j,k}$ is an individual reviewer's score for that criterion and n is the number of reviewers for the given project who answered the question¹. The index i represents an index over the reviewers assigned for the project; the index j represents an index over the projects in that specific subprogram area; the index k represents an index over the questions asked. The sample mean for each project criterion is represented in the graph by their respective bar graph value. These calculations were performed for the numeric values supplied by the reviewers for questions 2 through 5 (those questions indicated with weight values in Section 1).

The above values $\bar{x}_{j,k}$ and $s_{\bar{x}_{j,k}}^2$ can be used to extend the evaluation to the entire subprogram. In order to calculate the variance of each subprogram criterion, the sample variances must be propagated to the calculated variance of each subprogram criterion score. The subprogram area mean and variance for each evaluation criterion are then calculated as follows:

$$\bar{X}_k = \frac{1}{m} \sum_{j=1}^m \bar{x}_{j,k}$$

$$Var(\bar{X}_k) = \sigma_{\bar{X}_k}^2 = \frac{1}{m^2} \sum_{j=1}^m s_{\bar{x}_{j,k}}^2 = \frac{1}{m} \sum_{j=1}^m \bar{x}_{j,k}^2 - (\bar{X}_k)^2 + \frac{1}{m^2} \sum_{j=1}^m s_{\bar{x}_{j,k}}^2$$

where m is the number of projects in a subprogram area. This method of calculation allows each project to weigh evenly on each evaluation criterion of the subprogram area. The criteria means and average of the project variances values for each subprogram area (e.g., Hybrid and Vehicle Systems Technologies, Advanced Combustion Engine Technologies, Technology Integration, etc.) are represented on each project graph as the Program Area Average bullets and the red error bar ranges, respectively for each question. In some sense, the red error bars provide a range by which projects can be evaluated by their criteria with respect to an entire subprogram area's performance. The error bar calculation has changed from the previous year where the expectation of the sample error was the value calculated for the error bars. This change was made so that the error bar provides a more relevant comparison for the criteria measurements of the projects to the subprogram averages.

Each question's score is assumed to be independent of the others for a given project (that is, for example, the question of the quality of the future research should have no bearing on the current accomplishments). Each project's weighted average score can then be calculated as follows²:

¹ If all of the reviewers do not answer all of the questions, the value of n will be different for some questions for a project.

² There is no need to calculate a variance for this value since it is not displayed, and it has no bearing on any future calculated value in the analysis

$$\bar{x}_j = \frac{\sum_{k=2}^5 w_k * \bar{x}_{j,k}}{\sum_{k=2}^5 w_k}$$

where w_k is the weight that question k has on the overall score of the j^{th} project average \bar{x}_j . The value above, \bar{x}_j , is indicated in the graphics by the Weighted Average bar. As was done for each individual project, each question's score is assumed to be independent of the others for a given subprogram. Each subprogram's weighted average score and weighted variance can then be calculated as follows:

$$\bar{X} = \frac{\sum_{k=2}^5 w_k * \bar{X}_k}{\sum_{k=2}^5 w_k}$$

$$Var(\bar{X}) = \frac{\sum_{k=2}^5 w_k^2 * Var(\bar{X}_k)}{\sum_{k=2}^5 w_k^2}$$

These values represent the Program Area Average bullet and its red error bar in the Weighted Average column.

The answers to questions 1 and 6 are represented by pie charts below the combination bar/line graph.