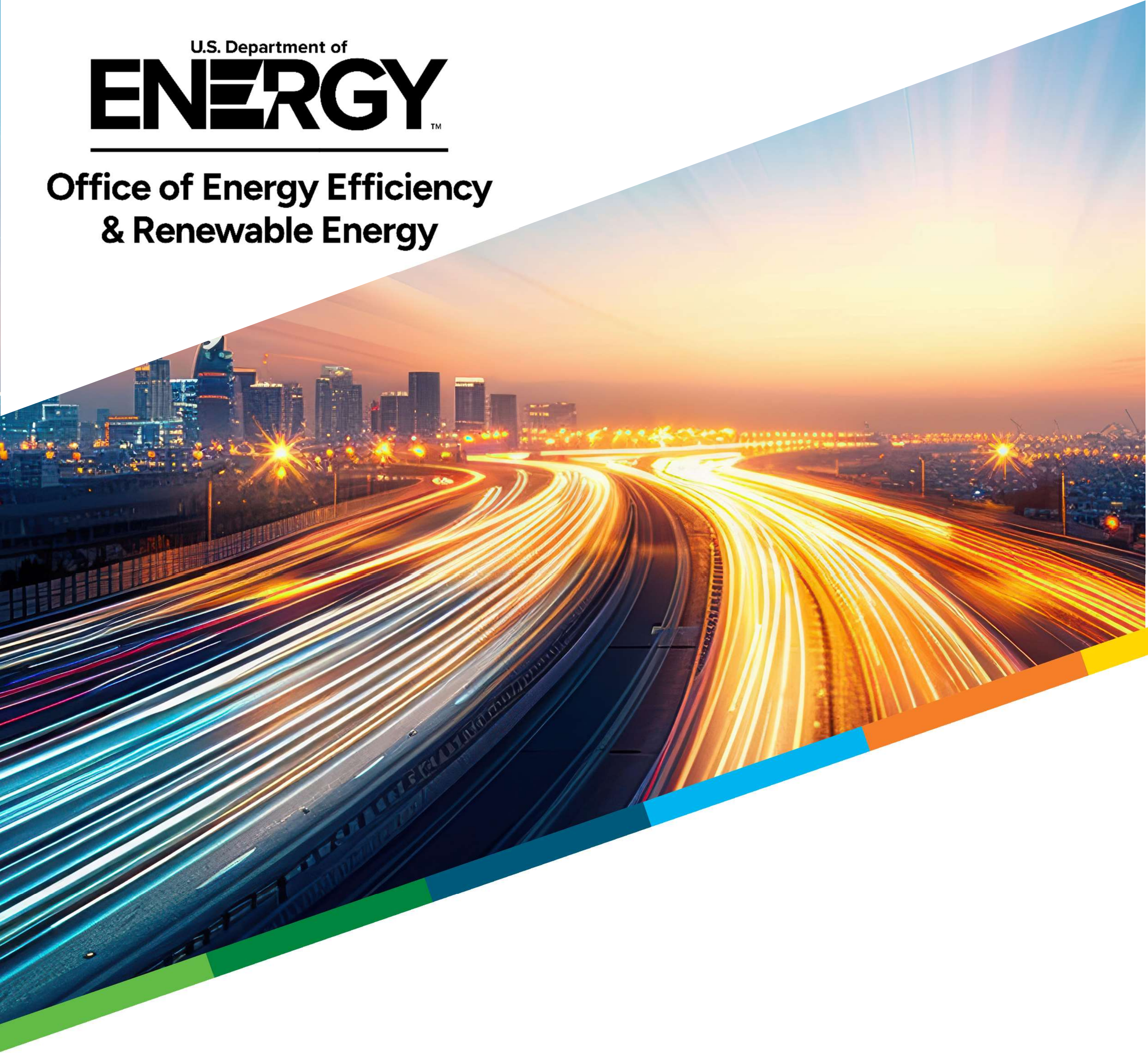
U.S. Department of
ENERGY

Office of Energy Efficiency
& Renewable Energy



2024 Annual Merit Review Vehicle Technologies Office

Results Report

January 2025

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Introduction

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Introduction

The 2024 U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy's (EERE) Vehicle Technologies Office (VTO) Annual Merit Review (AMR) was held June 3-6, 2024, in Arlington, Virginia. The review encompassed work done by VTO: 226 individual activities were reviewed by 218 reviewers. Exactly 888 individual review responses were received for the VTO technical reviews. Each project was reviewed by 2–7 independent reviewers, with a majority of projects having 4–5 reviewers.

The objective of the meeting was to review the accomplishments and plans for VTO over the previous 12 months, and provide an opportunity for industry, government, and academia to give inputs to DOE with a structured and formal methodology. The meeting also provided attendees with a forum for interaction and technology information transfer. VTO technology managers and leadership use the peer review results to inform their oversight of the project and to inform future investments. Project leads receive reviewer scores and comments and are expected to address these comments in their future peer review presentations.

The peer review process followed the guidelines of the Peer Review Guide developed by EERE. Each activity is reviewed every three years, at a minimum. However, VTO strives to have every activity reviewed every other year. 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. Each reviewer was screened for conflicts of interest as prescribed by the Peer Review Guide.

Reviewers provided qualitative and quantitative feedback on VTO projects evaluated during the AMR. Qualitatively, reviewers offered written comments in response to a series of specific project evaluation questions. Quantitatively, reviewers provided numeric assessments for each of the same questions. These scores were organized and analyzed on both a project-level and subprogram-level basis. Tables summarizing the average numeric score for each question, with 4.0 being the highest possible score, by VTO subprogram portfolio are presented below.

Table I-1. Average Project Scores, By VTO Research & Development Subprogram

VTO Subprogram	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
Battery R&D (BAT)	3.43	3.41	3.54	3.33	**3.42**
Electrification (ELT)	3.33	3.32	3.33	3.18	**3.31**
Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA)	3.39	3.38	3.36	3.26	**3.37**
Energy Efficient Mobility Systems (EEMS)	3.29	3.33	3.36	3.19	**3.34**
Materials Technology (MAT)	3.36	3.38	3.28	3.12	**3.34**
Vehicle Analysis (VAN)	3.36	3.38	3.37	3.44	**3.38**

Table I-2. Average Project Scores, By VTO Technology Integration Subprogram

VTO Subprogram	Objectives	Approach	Accomplishments	Collaboration	Energy Equity/ Environmental Justice	Weighted Average
Technology Integration (TI)	3.51	3.36	3.20	3.45	3.29	**3.33**

Evaluation Criteria—Research & Development Subprograms

In the technical research and development (R&D) subprogram sessions, reviewers were asked to respond to a series of specific questions regarding the breadth, depth, and appropriateness of the VTO R&D activities. The technical questions are listed below, along with appropriate scoring metrics. These questions were used for all formal VTO R&D project reviews.

Question 1: Approach to performing the work—How would you rate the degree to which technical barriers are addressed? Is the project well designed, and is the timeline reasonably planned? (Scoring weight for overall average = 25%)

4.0=Outstanding. Sharply focused on critical barriers; difficult to improve significantly.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 2: Technical Accomplishments and Progress—How would you rate the technical progress that has been made compared to the project plan? (Scoring weight for overall average = 50%)

4.0=Outstanding. Sharply focused on critical barriers; difficult to improve significantly.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 3: Collaboration and Coordination Across Project Team—How would you rate the collaboration within the project team? Are there specific contributions made by industry,

national laboratories, or other external entities? Are there areas where more collaboration is needed? (Scoring weight for overall average = 12.5%)

4.0=Outstanding. Close, appropriate collaboration with other institutions; partners are full participants and well-coordinated.

3.5=Excellent. Good collaboration; partners participate and are well-coordinated.

3.0=Good. Collaboration exists; partners are well-coordinated.

2.5=Satisfactory. Some collaboration exists; coordination between partners could be significantly improved.

2.0=Fair. A little collaboration exists; coordination between partners could be significantly improved.

1.5=Poor. Most work is done at the sponsoring organization with little outside collaboration; little or no apparent coordination with partners.

1.0=Unsatisfactory. No apparent coordination with partners.

Question 4: Proposed Future Research—How would you rate the proposed future research? Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets? (Scoring weight for overall average = 12.5%)

4.0=Outstanding. Purpose of future work and likelihood of achieving future work targets clearly stated.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 5: Relevance—Is the project relevant? Does the project support the overall VTO subprogram objectives? (Did not factor into overall weighted average numeric score)

Yes

No.

Question 6: Resources—How would you rate the resources of the project? Are the resources sufficient for the project to achieve the stated milestones in a timely fashion? Did not factor into overall weighted average numeric score)

Excessive

Sufficient

Insufficient.

Evaluation Criteria—Technology Integration Subprogram

Reviewers for the Technology Integration (TI) technical session answered questions tailored to TI's 2024 AMR focus on improving fuel diversity, use of domestic fuel sources, reducing transportation energy costs for businesses and consumers, and enabling energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations. These technical questions are listed below, along with appropriate scoring metrics.

Question 1. Project Objectives— How would you rate this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency? (Scoring weight for overall average = 20%)

4.0=Outstanding. Project Objectives are sharply focused on supporting DOE/VTO/TI objectives. The project has a direct and substantial impact upon addressing barriers; difficult to improve project objectives significantly.

3.5=Excellent. Project objectives are effective and substantially support DOE/VTO/TI objectives; project addresses a significant number of barriers; effectively contributes to program objectives.

3.0=Good. Project objectives are generally effective and support DOE/VTO/TI objectives but could be improved; project addresses some barriers; contributes to program objectives.

2.5=Satisfactory. Project objectives have some weaknesses and support DOE/VTO/TI objectives; project addresses some barriers; project may have some impact in achieving program objectives.

2.0=Fair. Project objectives have significant weaknesses and minimally support DOE/VTO/TI objectives; project addresses few barriers; project may have a small impact on achieving program objectives.

1.5=Poor. Project objectives are minimally responsive to DOE/VTO/TI objectives; project does not address barriers; project is unlikely to contribute materially to achieving program objectives.

1.0=Unsatisfactory. Project objectives are not responsive to DOE/VTO/TI objectives project fails to address any barriers; project is highly unlikely to contribute materially to achieving program objectives.

Question 2. Project Approach— How would you rate this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges? (Scoring weight for overall average = 20%)

4.0=Outstanding. Project approach is sharply focused on achieving project objectives; difficult to improve project approach significantly.

3.5=Excellent. Effective; project approach contributes to achieving the majority of project Objectives.

3.0=Good. Generally effective but project approach could be improved; contributes to achieving some of the project objectives.

2.5=Satisfactory. Has some weaknesses; project approach contributes to achieving some project objectives.

2.0=Fair. Has significant weaknesses; project approach may have some impact on achieving project objectives.

1.5=Poor. Minimally responsive to project objectives; project approach is unlikely to contribute to achieving project objectives.

1.0=Unsatisfactory. Not responsive to project objectives; project approach is highly unlikely to contribute to achieving project objectives.

Question 3. Project Accomplishments and Progress—How would you rate the project's progress and significant accomplishments to date? (Scoring weight for overall average = 40%)

4.0=Outstanding. Project demonstrates significant accomplishments; strong progress toward achieving both project and VTO-TI objectives; difficult to improve progress significantly.

3.5=Excellent. Project demonstrates many accomplishments; very effective progress toward achieving overall project objectives and VTO-TI goals.

3.0=Good. Project accomplishments are generally effective; progress is on schedule to contribute to some project objectives and VTO-TI goals.

2.5=Satisfactory. Project has some accomplishments, but also displays some weaknesses; progress could be improved; contributes to some project objectives and VTO-TI goals.

2.0=Fair. Project has few accomplishments and demonstrates significant weaknesses; rate of progress is slow; minimal contribution to project objectives or VTO-TI goals.

1.5=Poor. Minimal demonstration of accomplishments; progress is significantly behind schedule; unlikely to contribute to project objectives or VTO-TI goals.

1.0=Unsatisfactory. Project demonstrates no accomplishments; limited or no demonstrated progress; not responsive to project objectives.

Question 4. Collaboration and Coordination Among Project Team—How would you rate the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals? (Scoring weight for overall average = 10%)

4.0=Outstanding. Sharply focused on collaboration among project team members; team is well-suited to effectively carry out the work of the project and have strong working relationships; no notable weaknesses.

3.5=Excellent. Effective; team members meaningfully contribute to carrying out the work of the project, are well-suited to effectively carry out the work and have excellent working relationships.

3.0=Good. Generally effective but could be improved; collaboration exists; team members are fairly well-suited to project work and have good working relationships.

2.5=Satisfactory. Has some weaknesses; collaboration among team members is satisfactory for carrying out the work of the project; project partnerships, team members and working relationships could be improved.

2.0=Fair. Has significant weaknesses; little collaboration exists and team lacks effective working relationships.

1.5=Poor. Minimally responsive; little collaboration exists and team lacks effective working relationships.

1.0=Unsatisfactory. Little or no apparent collaboration between team members; project team is lacking critical expertise to effectively carry out the work of the project.

Question 5. Energy Equity and Environmental Justice Project Contribution—How would you rate the contribution of this project to energy equity and environmental justice by ensuring

the project benefits underserved and overburdened communities and does not cause increased burdens to these communities? (Scoring Weight for overall average = 10%)

4.0=Outstanding. Project maximizes the benefits to underserved and overburdened communities and incorporates affected communities in the planning and execution of the project.

3.5=Excellent. Project maximizes the benefits to underserved and overburdened communities and includes some collaboration with affected communities.

3.0=Good. Project will have significant benefits to underserved and overburdened communities.

2.5=Satisfactory. Project will have some benefits to underserved and overburdened communities.

2.0=Fair. Project does not benefit or burden underserved and overburdened communities.

1.5=Poor. Project will have some benefits to underserved and overburdened communities while also causing increased burdens to underserved and overburdened communities.

1.0=Unsatisfactory. Project has no benefits to underserved and overburdened communities while also causing increased burdens to underserved and overburdened communities.

Project Scoring

R&D Subprogram Projects

For R&D subprogram sessions, reviewers were asked to provide numeric scores (on a scale of 1.0-4.0 in one-half point increments, as indicated above) for Question 1 through Question 4 of each formally reviewed activity. For each reviewed project, the individual reviewer scores for Question 1 through Question 4 were averaged to provide information on the project's question-by-question scoring. Scores for each of these four criteria were weighted using the formula below to create a Weighted Average for each project. This allows a project's question-by-question and final overall scores to be meaningfully compared against another project:

Weighted Average* = [Question 1 Score x 0.25] + [Question 2 Score x 0.50] +

[Question 3 Score x 0.125] + [Question 4 Score x 0.125]

**R&D subprogram Questions 5 and 6 were not factored in the Weighted Average Score calculation because their scoring scales were incompatible with Questions 1 through 4.*

Each reviewed activity has a corresponding bar chart representing that project's average scores for each of the four designated criteria. As demonstrated in Figure 1, a bullet and error line are included within the green bars representing the corresponding average and standard deviation of criteria scores for all of the reviewed projects in the same subprogram.

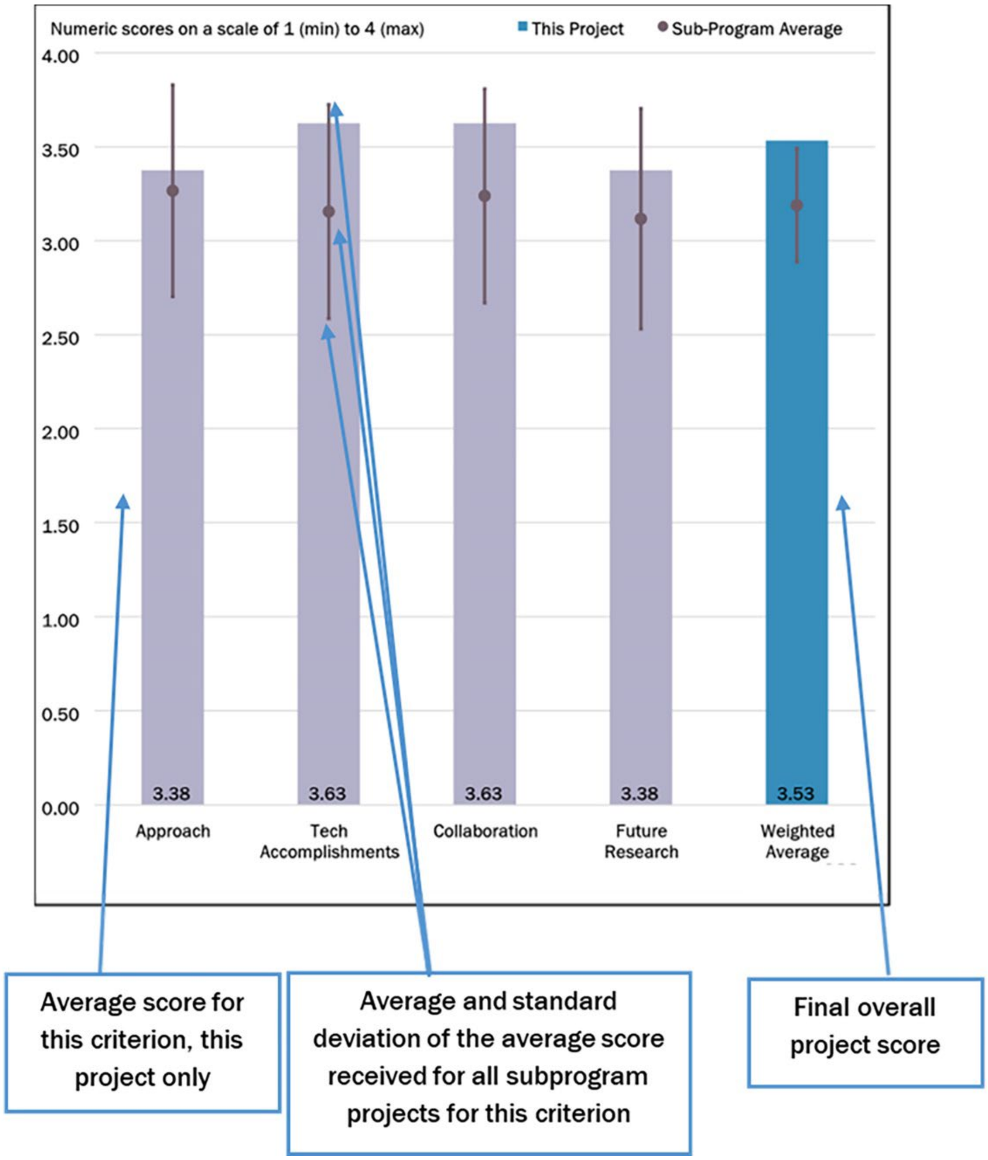

Figure 1. Sample Question 1 through Question 4 score averages, standard deviations, and overall Weighted Average for an R&D subprogram project

Reviewers were also asked to evaluate a given project's relevance and funding through Question 5 and Question 6, which were each scored on a different scale than Question 1 through Question 4. For the R&D subprogram sessions, while Question 1 through Question 4 were rated on a 1.0 to 4.0 scale in one-half point increments, Question 5 was rated on a yes or no scale, and Question 6 was rated on an excessive, sufficient, or insufficient scale. Consequently, Question 5 and Question 6 results were excluded from the Weighted Average calculation (as shown above) because the scoring scales are incompatible.

TI Subprogram Projects

For the TI subprogram session, reviewers were asked to provide numeric scores (on a scale of 1.0-4.0 in one-half point increments, as indicated above) for Question 1 through Question 5 of each formally reviewed activity. For each reviewed project, the individual reviewer scores for Question 1 through Question 5 were averaged to provide information on the project's question-by-question scoring. Scores for each of these five criteria were weighted using the formula below to create a Weighted Average for each project. This allows a project's question-by-question and final overall scores to be meaningfully compared against another project:

Weighted Average = [Question 1 Score x 0.20] + [Question 2 Score x 0.20] +

[Question 3 Score x 0.40] + [Question 4 Score x 0.10] + [Question 5 Score x 0.10]

Each reviewed TI activity has a corresponding bar chart representing that project's average scores for each of the five designated criteria. As demonstrated in Figure 2, a bullet and error line are included within the green bars representing the corresponding average and standard deviation of criteria scores for all of the reviewed projects in the same subprogram.

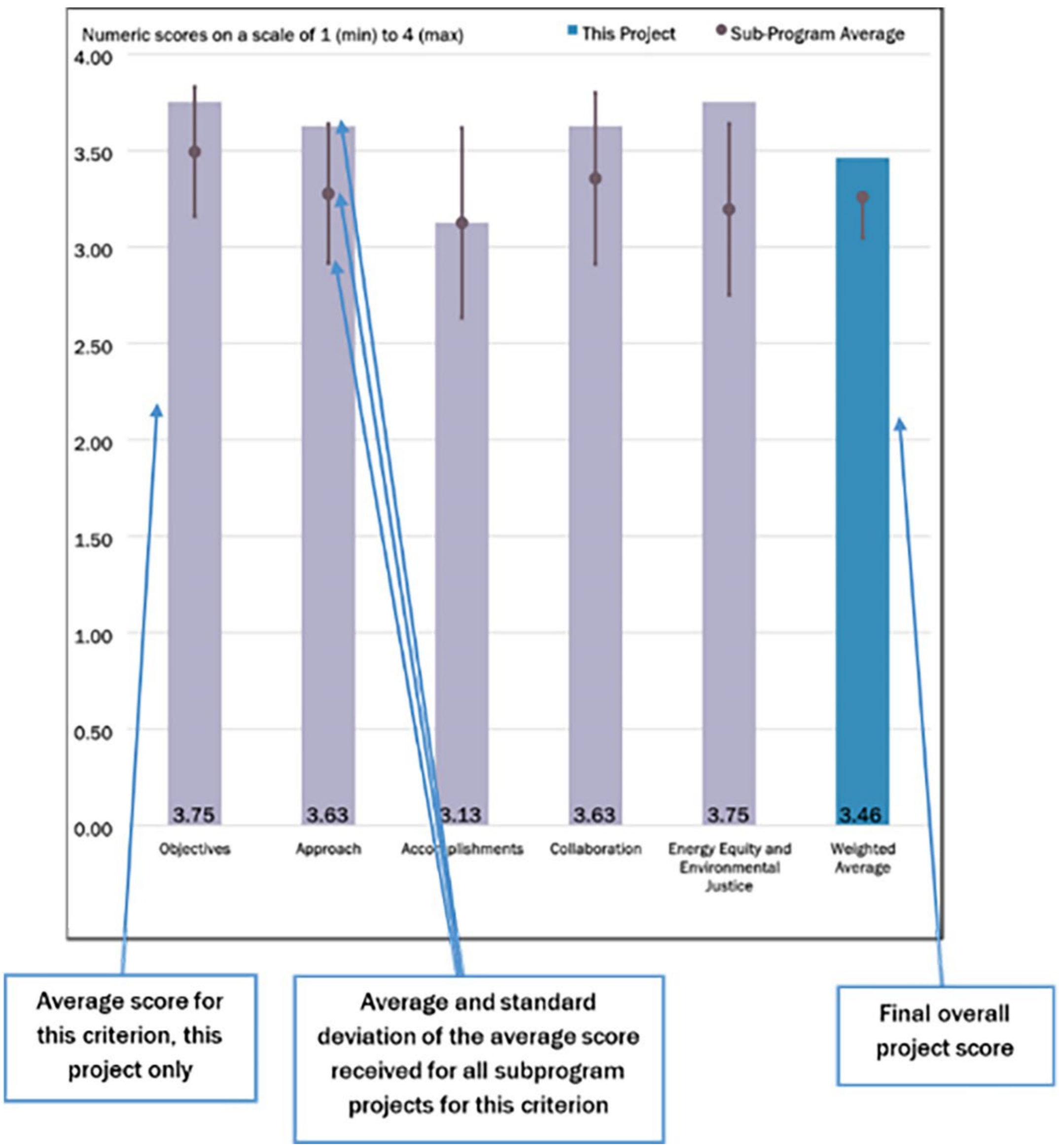

Figure 2. Sample Question 1 through Question 5 score averages, standard deviations, and overall Weighted Average for a TI subprogram project

Reviewer Responses

Text responses and numeric scores to the questions were submitted electronically through a web-based software application, PeerNet, operated by Oak Ridge Associated Universities (ORAU). Database outputs from this software application were analyzed and summarized to collate the multiple-choice, text comments, and numeric scoring responses and produce the summary report.

Responses to the questions are summarized in this report, with summaries of numeric scores for each technical session, as well as text and graphical summaries of the responses for each individual technical activity. For each project, the reviewer sample size is identified.

Each reviewed activity is identified by Presentation Number, followed by the Presentation Title, the Principal Investigator (PI), and the PI's organization. For each subprogram area, reviewed activities are ordered numerically by project number. Figure 3, below, provides an example project title.

Presentation Number: DORMA020

Presentation Title: Sustainable Aviation Fuel (SAF) Contrail Modeling

Principal Investigator: Matt McNenly (Lawrence Livermore National Laboratory)

Figure 3. Sample project title with Presentation ID, Presentation Title, PI, and PI organization

For each project, in addition to the PI, the presenter at the AMR is identified, along with the reviewer sample size. For some projects, the presenter at the AMR was a project team member rather than the PI.

Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that for each question the order of reviewer comments may be different; for example, for each specific project the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc. Not all reviewers provided a response to each question for a given project.

The report is organized by technical subprogram area. Each technical area section includes a summary of that subprogram, a subprogram activities score summary table (and page numbers), project-specific reviewer evaluation comments with corresponding bar graphs, and a list of acronyms and abbreviations.

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1. Battery R&D

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Batteries subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, national laboratories, and industry covered under the Energy Storage Grand Challenge key priority and four distinct crosscuts including: Critical Materials, Grid Modernization, Advanced Manufacturing, and Energy Sector Cybersecurity.

The subprogram supports early-stage R&D of high-energy and high-power battery materials, cells, and battery development that can enable industry to significantly reduce the cost, weight, volume, and charge time of plug-in electric vehicle (PEV) batteries. This activity is organized into three sub-activities: advanced battery materials research, advanced battery cell R&D, and battery recycling R&D. Advanced battery materials research is coordinated with the Critical Minerals Initiative and includes: early-stage research of new lithium ion (Li-ion) cathode, anode, and electrolyte materials (currently accounting for 50% to 70% of PEV battery cost) and the development of "beyond Li-ion" technologies, such as lithium (Li) metal anodes, solid-state electrolytes (SSEs), and sulfur-based cathodes, that have the potential to significantly reduce weight, volume, and cost reduction of over 80% 2008 baseline, with a target of $60/kWh.

Advanced battery cell R&D includes early-stage R&D of new battery cell technology that contains new materials and electrodes that can reduce the overall battery cost, weight, and volume while improving energy, life, safety, and fast charging. Battery recycling R&D includes the development of innovative battery materials recycling and reuse technologies, and the Lithium-Ion Battery Recycling Prize, both of which aim to assure sustainability and domestic supplies of key battery materials and minerals.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 1-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT085	Interfacial Processes†	Robert Kostecki (Lawrence Berkeley National Laboratory)	1-8	3.50	3.33	3.17	3.50	3.38
BAT091	Characterization and Modeling of Lithium-Metal Batteries First-Principles Modeling and Machine Learning†	Kristin Persson (Lawrence Berkeley National Laboratory)	1-12	3.50	3.38	3.38	3.33	3.41
BAT183	In Situ Spectroscopies of Processing Next-Generation Cathode Materials	Feng Wang (Argonne National Laboratory)	1-16	3.50	3.57	3.43	3.29	3.50
BAT287	Advanced In Situ Diagnostic Techniques for Battery Materials†	Xiao-Qing Yang (Brookhaven National Laboratory)	1-23	3.50	3.17	3.67	3.33	3.33
BAT309	Electrode Materials Design and Failure Prediction†	Venkat Srinivasan (Argonne National Laboratory)	1-27	3.38	3.25	3.63	3.50	3.36
BAT360	Cathodes Beyond Lithium Nickel Manganese Cobalt Oxide (NMC) 811	Arumugam Manthiram (University of Texas at Austin)	1-31	3.70	3.80	3.40	3.40	3.68
BAT361	Understanding and Improving Lithium Anode Stability	Yi Cui (Stanford University / SLAC National Accelerator Laboratory)	1-36	3.50	3.63	3.75	3.25	3.56

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT362	High Capacity S Cathode Materials	Prashant Kumta (University of Pittsburgh)	1-41	3.50	3.50	3.38	3.38	3.47
BAT364	Synergistic Effects of Electrode and Electrolyte Materials for High Energy Lithium Cells	Jihui Yang (University of Washington)	1-45	3.50	3.50	3.63	3.38	3.50
BAT365	Stabilizing Lithium Metal Anodes by Interfacial Layer and New Electrolytes	Zhenan Bao (Stanford University/ SLAC National Accelerator Laboratory)	1-49	3.60	3.70	3.90	3.40	3.66
BAT366	Manufacturing and Validation of Lithium Pouch Cells	Mei Cai (General Motors)	1-54	3.50	3.50	3.38	3.63	3.50
BAT367	Multiscale Characterization Studies of Lithium Metal Batteries	Peter Khalifah (Brookhaven National Laboratory)	1-59	3.38	3.38	3.75	3.25	3.41
BAT368	Full Cell Diagnostics and Validation to Achieving High Cycle Life	Eric Dufek (Idaho National Laboratory)	1-65	3.40	3.30	3.50	3.40	3.36
BAT369	High Energy Rechargeable Lithium-Metal Cells Design Fabrication and Testing	Jie Xiao (Pacific Northwest National Laboratory)	1-69	3.33	3.33	3.67	3.33	3.38
BAT402	Improving Battery Performance through Structure-Morphology Optimization	Venkat Srinivasan (Argonne National Laboratory)	1-74	3.75	3.75	3.67	3.42	3.70

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT496	Silicon Consortium Project Advanced Characterization of Silicon Electrodes	Robert Kostecki (Lawrence Berkeley National Laboratory)	1-80	3.33	3.50	4.00	3.50	3.52
BAT497	Silicon Consortium Project Electrochemistry of Silicon Electrodes	Christopher Johnson (Argonne National Laboratory)	1-83	3.38	3.13	3.88	3.50	3.33
BAT498	Silicon Consortium Project Next-Gen Materials for Silicon Anodes	Nathan Neale (National Renewable Energy Laboratory)	1-87	3.38	3.25	3.75	3.25	3.34
BAT499	Silicon Consortium Project: Mechanical Properties of Silicon Anodes	Katherine Harrison (National Renewable Energy Laboratory)	1-91	3.00	3.00	3.75	3.25	3.13
BAT501	Integrated Modeling and Machine Learning of Solid-Electrolyte Interface Reactions of the Si Anode	Kristin Persson (Lawrence Berkeley National Laboratory)	1-95	3.50	3.38	3.63	3.50	3.45
BAT523	Development of Long Life Lithium and sulfurized polyacrylonitrile (SPAN) Cells	Ping Liu (University of California-San Diego)	1-99	3.67	3.17	3.83	3.17	3.38
BAT524	Advanced Electrolytes for Lithium Metal Batteries	Chunsheng Wang (University of Maryland, College Park)	1-103	3.50	3.50	3.67	3.50	3.52
BAT536	Polyester-Based Block Copolymer Electrolytes for Lithium Metal Batteries	Nitash Balsara (Lawrence Berkeley National Laboratory)	1-106	3.67	3.67	3.67	3.67	3.67

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT538	Ion conductive high Li+ transference number polymer composites for solid-state batteries	Bryan McCloskey (Lawrence Berkeley National Laboratory)	1-110	3.75	3.75	3.25	3.75	3.69
BAT539	3D Printing of All-Solid-State Lithium Batteries	Jianchao Ye (Lawrence Livermore National Laboratory)	1-113	3.33	3.33	3.17	3.00	3.27
BAT540	Synthesis of Composite Electrolytes with Integrated Interface Design	Sanja Tepavcevic (Argonne National Laboratory)	1-116	3.50	3.67	3.83	3.50	3.63
BAT541	Substituted Argyrodite Solid Electrolytes and High Capacity Conversion Cathodes for All-Solid-State Batteries	Jagjit Nanda (Stanford University / SLAC National Accelerator Laboratory)	1-119	3.17	3.17	3.50	3.17	3.21
BAT542	Polymer Electrolytes for Stable Low Impedance Solid State Battery Interfaces	Chelsea Chen (Oak Ridge National Laboratory)	1-123	3.50	3.50	3.67	3.17	3.48
BAT543	Integrated Multiscale Model for Design of Robust 3D Solid-state Lithium Batteries	Brandon Wood (Lawrence Livermore National Laboratory)	1-127	3.17	3.17	3.33	3.17	3.19
BAT553	Understanding solid electrolyte interphase (SEI) reactions in Lithium metal and Lithium-Sulfur batteries	Perla Balbuena (Texas A&M University)	1-130	3.50	3.63	3.63	3.63	3.59
BAT587	Earth-abundant Cathode Active Materials for Li-Ion Batteries Theory and Modeling†	Hakim Iddir (Argonne National Laboratory)	1-134	3.17	3.33	3.17	3.00	3.23

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT590	Lithium Halide-Based Superionic Solid Electrolyte and High-Voltage Cathode Interfaces	Robert Sacci (Oak Ridge National Laboratory)	1-137	3.38	3.50	3.50	3.25	3.44
BAT591	High-Conductivity and Electrochemically Stable Thioborate Solid-State Electrolytes for Practical All-Solid-State Batteries	Yi Cui (Stanford University / SLAC National Accelerator Laboratory)	1-141	3.30	3.50	3.50	3.30	3.43
BAT599	Fluorinated Glyme Solvents to Extend Lithium-Sulfur Battery Life	Taylor Xu (Navitas Systems)	1-146	3.20	3.10	3.10	3.10	3.13
BAT600	Liquid Electrolytes for Lithium-Sulfur Batteries with Enhanced Cycle Life and Energy Density Performance	Gaind P. Pandey (Giner Inc)	1-151	3.08	3.17	3.08	3.08	3.13
BAT601	Development of Functional Electrolytes for Lithium Sulfur Battery Cells	Donghai Wang (Penn State University)	1-157	3.75	3.75	3.50	3.50	3.69
BAT602	Extending the Operating Range and Safety of Li-Ion Batteries with New Fluorinated Electrolytes	Suresh Sriramulu (Koura)	1-161	3.40	3.30	3.40	3.30	3.34
BAT603	Fluorinated Ester Local High Concentration Electrolytes for Operation of Li-Ion Batteries under Extreme Conditions	Esther Takeuchi (Stony Brook University)	1-166	3.42	3.33	3.25	3.00	3.30

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT604	Novel Organosulfur-Based Electrolytes for Safe Operation of High Voltage Li-Ion Batteries Over a Wide Operating Temperature	Meinan He (General Motors)	1-171	3.30	3.50	3.30	3.20	3.39
BAT605	Silicon Consortium Project Next Generation Electrolytes for Silicon Anodes	Gabriel Veith (Oak Ridge National Laboratory)	1-176	3.30	3.10	3.80	3.00	3.23
Overall Average				3.43	3.41	3.54	3.33	3.42

† Denotes a poster presentation.

Presentation Number: BAT085
Presentation Title: Interfacial Processes
Principal Investigator: Robert Kostecki, Lawrence Berkeley National Laboratory

Presenter

Robert Kostecki, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

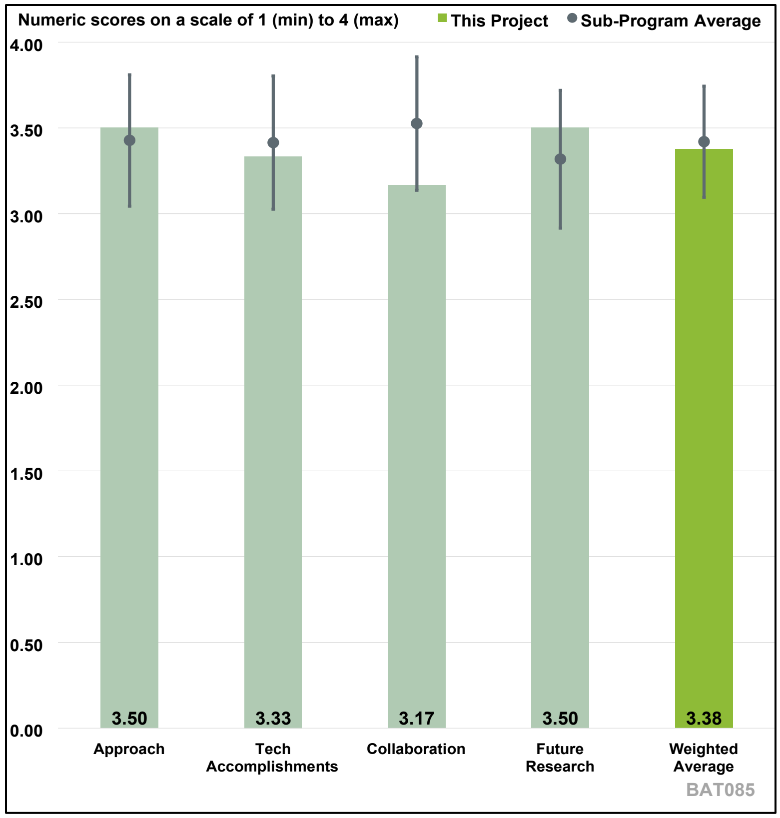

Figure 1-1. Presentation Number: BAT085 Presentation Title: Interfacial Processes Principal Investigator: Robert Kostecki, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked the proposed technique, in-situ nano-Fourier transform infrared spectroscopy (FTIR), is a very powerful and less studied technique to study the solid-electrolyte interphase (SEI) formation on a lithium (Li)-metal anode. The project is well designed, and the timeline is reasonably planned.

Reviewer 2

The reviewer said this project focuses on addressing the major barriers of the inadequate energy and power density, calendar/cycle lifetimes of Li-metal and Li-ion batteries for plug-in hybrid and electric vehicle (EV) applications. The team explored the origin of the high cell/electrode/interface impedance that limits power and affects the system safety. To find the fundamental cause of these barriers, the reviewer noted the investigators developed near-field nano- FTIR spectroscopy to analyze the spontaneously formed SEI layer on a Li surface in a novel localized high-concentration electrolyte (LHCE). The work is featured by four coherently connected milestones. Accomplishment of these four milestones will provide insights for finding the path to address the barriers. The reviewer said the project is well designed and the timeline of completion of the proposed work is adequate. It appears that a theoretical modeling will be beneficial for the interpretation of the results of the present work.

Reviewer 3

The reviewer said the project utilized ex situ spectroscopy (nano-FTIR) to characterize the chemistry fingerprints of SEI on a Li surface. Ex situ spectroscopic data were collected for a baseline Gen2 electrolyte and a LiTFSI/DME/TTE LHCE. The technique is powerful to reveal vibrational signal of SEI component with a very high spatial resolution. The reviewer remarked the proposed technique is somewhat biased towards organic species, and a supplementary characterization tool biased towards inorganic species is crucial for a comprehensive understanding of SEI.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said great two-dimensional vibrational data were collected using nano-FTIR. It is interesting to see the difference among different LHCEs, as well as the comparison between high concentrations version to low concentration versions.

Reviewer 2

The reviewer said the technical progress is well matched with what has been proposed. The reviewer summarized the team first developed a spectro-electrochemical cell for in situ nano-FTIR studies of the SEI. The team used a model material of graphene to study the in-situ formation of SEI layer. Subsequently, the team used ex situ nano-FTIR to study the SEI layer on Li in a Gen2 electrolyte. The researchers reveal that after Li has a short exposure to the Gen2 electrolyte, the Li surface immediately becomes highly inhomogeneous on nanometer scale and rich in Li organic carbonates. The technical progress up to date follows what has been proposed. The reviewer remarked these studies provide insight as how electrolytes react with the Li-metal surface to form SEI layer. Integration of theoretical modeling will be great for enhancing the interpretation of the results.

Reviewer 3

The reviewer remarked using FTIR, the project provided important insights in understanding the reaction mechanism for the SEI formation on Li-metal anodes in different liquid electrolytes. Current studies on the Li SEI are primarily ex-situ. The in-situ study of the SEI formation is done on single-layer graphene. The reviewer asked if there is a particular challenge that prevents in-situ study of SEI formation on a Li-metal anode.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented the project encompasses wide-board collaborations within the United States and internationally of both experiments and theoretical modeling. In particular, the collaboration team has different experimental techniques, which will provide complementary information across different scales. The reviewer recommended a baseline material should be selected for a cross-scale study.

Reviewer 2

The reviewer said the project involves collaborations with multiple national laboratories and encouraged industrial collaboration to validate the results from the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked the investigator is very ambitious for the proposed future research, which covers time-resolved methodology, ranging from pico-second to second, under the in-situ and operando condition of the battery cell. The techniques developed in this project will be extended to X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS). The proposed research aligns well with what is going on in this field of research. The reviewer noted that integrating a theoretical component should be beneficial for this project.

Reviewer 2

The reviewer commented in situ experiments are proposed to follow the change of SEI during electrochemical processes.

Reviewer 3

The reviewer said the project is more than 80% done. The proposed future research to observe the changes in SEI of Li at different states of charge is reasonable. It is unclear to the reviewer whether that would be done in-situ or ex-situ.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented developing advanced characterization technique is important to provide insights for interfacial design of Li-metal batteries. The proposed research also support VTO's overall objective of developing high performance batteries for EV applications.

Reviewer 2

The reviewer said performance of rechargeable batteries is critically controlled by the interfacial process, which is simultaneously formed upon battery operation. The proposed research of probing into the interfacial process in rechargeable batteries will gain insights for tackling the key technical barriers for enhancing the performance of battery. Therefore, this project is very relevant for the VTO subprogram objective.

Reviewer 3

The reviewer said the effort supports VTO's efforts in developing high energy density Li-metal based batteries for transportation applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the resources that the principal investigator's (PI's) lab possessed are adequate for carrying out the proposed research. In particular, the in-situ technique developed by the PI in Lawrence Berkeley National Laboratory. In terms of both resources and time scale, the resources and instruments can meet the stated milestone of the proposed research. The reviewer pointed out that integrating theoretical modeling will be useful for this project.

Reviewer 2

The reviewer said resources of the project look reasonable.

Presentation Number: BAT091
Presentation Title: Characterization and Modeling of Lithium-Metal Batteries First-Principles Modeling and Machine Learning
Principal Investigator: Kristin Persson, Lawrence Berkeley National Laboratory

Presenter

Kristin Persson, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

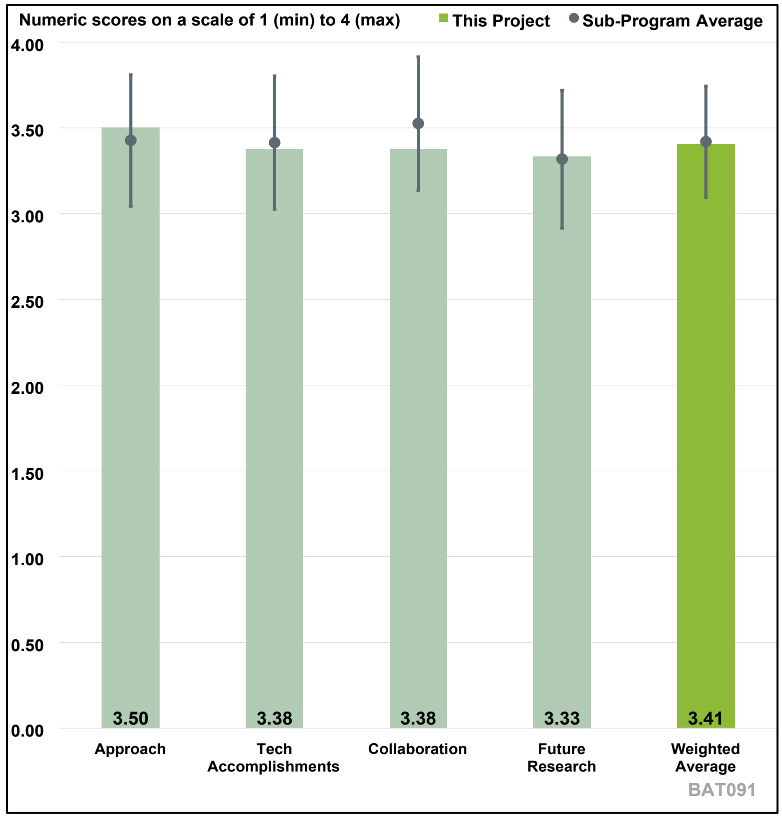

Figure 1-2. Presentation Number: BAT091 Presentation Title: Characterization and Modeling of Lithium-Metal Batteries First-Principles Modeling and Machine Learning Principal Investigator: Kristin Persson, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said this is a very well-designed project that, with modeling, aims to understand and develop quantification metric for solid-liquid (lithium hexafluorophosphate, $LiPF_6$) and solid-solid interfacial reactivity and decomposition at Li-metal anode. The reviewer said the timeline is reasonably planned and proposed milestones were delivered with great depth. Note that amorphous coating milestones cover work from the first and second quarters of 2023.

Reviewer 2

The reviewer said the approach appears promising to address individual issues, and a cohesive final goal that unifies the objectives of the 3 approaches would be useful.

Reviewer 3

The reviewer remarked the project’s goal is to design interphase/coatings in Li-metal batteries for EV applications. It provides fundamental insights to address the technical barrier (Cost, Performance, and Safety). The computational approach is well-designed and leverages multiple data infostructures

(Materials Project, atomate, and Maggma). The reviewer said the project seems to touch many different areas for Li-metal batteries, e.g., coatings on cathodes, SEI on Li-metal in both liquid and solid electrolytes. It could be more focused on solving more specific technical barriers quickly.

Reviewer 4

The reviewer said the project is on track to address the proposed technical barriers including cathode coating development, SEI formation in liquid electrolyte, transport and stability of organic electrolyte and interfacial design of solid-state batteries. Computational study on these surfaces are particularly challenges due to the absence of a particular crystal structure and usually a mix of multiple phases. The project provides many important insights with relatively high throughput computations. One technical comment the reviewer provided for the cathode coating development is that many coating materials actually react with the cathode during coating or cycling. However, the chemical stability between the coating material and the cathode is not considered in the computation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said this computational work beautifully connects with experimental (in-situ XPS) and thermodynamic predictions on solid-solid interfaces to reveal reaction kinetics and interface morphology.

Reviewer 2

The reviewer remarked the theoretical results from the project’s previous work tested experimentally by internal and external collaborations is interesting and useful. It would be useful to compare oxygen diffusion in actual coating conditions (thickness; extent of amorphous state) with the predictions for similar lithiation condition. Solid-solid interfaces are very complex and usually kinetically slow. The reviewer said the ab initio molecular dynamics (AIMD)-driven machine learning interatomic potentials (MLPs) are a reasonable attempt for the description of the longer time evolution, but the 10 ns shown seem too short. Generating appropriate interfacial configurations is another bottleneck. It is mentioned but not sufficiently explained. It is unclear how the kinetic data is predicted via MLPs. Are the MLPs trained with experimental or theoretical data? If from AIMD, are the data obtained close to the Li-metal anode, i.e., close to the electron source? Various tools for solvation and transport analysis mentioned but their use not explained, except for the solvent effects on the dielectric constant. Besides fundamental understanding of solvation, what is the practical knowledge expected from this part of the research? In other words, how are solvation structures, speciation, coordination, related to the battery performance under cycling conditions?

Reviewer 3

The reviewer stated that the project provided multiple important insights for the interphase design for enabling nickel manganese cobalt oxide (NMC) cathode, Li-metal anode, and solid-state batteries. The computational result on the thickness of the interphase formed between Li-metal and sulfide electrolyte seems to be much thinner compared with the experimental results (4.8 nm versus 200 nm) based on Janek’s study. The reviewer suggested more detailed study on the transport property, particularly electronic transport, of the interphase to predict its growth behavior.

Reviewer 4

The reviewer remarked simulations did a very nice job of predicting oxide coating predictions that were experimentally validated. This is largely because the design objectives for the coating on the cathode are very clear. In comparison, the SEI design objectives on Li-metal electrodes are not very clear. So far, the simulation tools have been built to show amorphous SEI formation. The reviewer said the desired SEI layer and how to form it are still not clear.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said there are great internal collaborations within Lawrence Berkeley National Laboratory (LBNL) and University of California-Berkeley, as well as with some external related companies.

Reviewer 2

The reviewer remarked this team work together very effectively and complement each other.

Reviewer 3

The reviewer noted good collaborations with different experimental groups.

Reviewer 4

The reviewer said the project listed a couple of collaborations from CoreShell, Sandia National Laboratories, and LBNL, and that more details of these collaborations should be provided.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that with about a quarter remaining at the time of the review, the proposed future research looks reasonable.

Reviewer 2

The reviewer said the project will end in September 2024 and the last two milestones are in progress. The reviewer asked if this high-throughput tool for predicting electrolyte transport, solvation and stability can be developed to be used for developing polymers (for example, linear poly(ethylene) oxide [PEO]/bis(trifluoromethysulfonyl)imide [TFSI] or crosslinked PEO/TFSI) and ultimately composite polymer electrolytes.

Reviewer 3

The reviewer referenced a prior comment. A unified view that connects the individual goals among themselves and with the actual battery performance and lifetime would be useful.

Reviewer 4

The reviewer noted that proposed future research, “Develop quantification metrics for solid-state interfacial reactivity and decomposition product formation for solid-solid interfaces at the Li-metal anode,” will address the reviewer’s question on the SEI design criteria for Li-metal. It will be highly appreciated by the research community as well. The other future research milestone, “Identify thermodynamically and kinetically favorable mechanisms of ethylene carbonate (EC) oxidation on model cathode materials”, can be better aligned with the most advanced electrolytes for Li-metal batteries (e.g., multiple electrolytes projects related to Li-metal electrodes). The reviewer noted it is known that EC is not a good electrolyte for Li-metal. The cathode material and surface states should be well-defined in the research task/milestone.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked the proposed research on computational study of the interfacial processes is relevant and support the overall VTO goal to develop high-performing batteries.

Reviewer 2

The reviewer commented the project supports VTO objectives of developing fundamental understanding of battery materials and their interactions that can lead to an improved practical design.

Reviewer 3

The reviewer agreed that developing new machine learning potentials to predict and understand solid electrolyte interface reactions is a very important topic to achieve overall VTO objective for solid-state batteries. Similarly, identifying solvation environments, viscosity, and conduction mechanisms in nonaqueous electrolytes, and proposing changes to solvent/salt compositions to improve active ion conductivity, are valuable contributions to Li-ion batteries.

Reviewer 4

The reviewer said this project builds computational approaches that can accelerate battery design, achieving the Batteries program objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

For a project with so many different tasks on various cell chemistry, the reviewer thought the resources are not sufficient to reveal all the insights covering cathode coating in liquid electrolyte, liquid electrolyte development, solid-state battery interface, and SEI formation. The proposed research can potentially be divided into a few different projects, in this person’s mind.

Reviewer 2

The reviewer said resources are sufficient.

Reviewer 3

The reviewer commented the resources are sufficient for the project to achieve milestones in timely fashion.

Reviewer 4

The reviewer found that the overall budget is well aligned with the tasks in the projects.

Presentation Number: BAT183
Presentation Title: In Situ Spectroscopies of Processing Next-Generation Cathode Materials
Principal Investigator: Feng Wang, Argonne National Laboratory

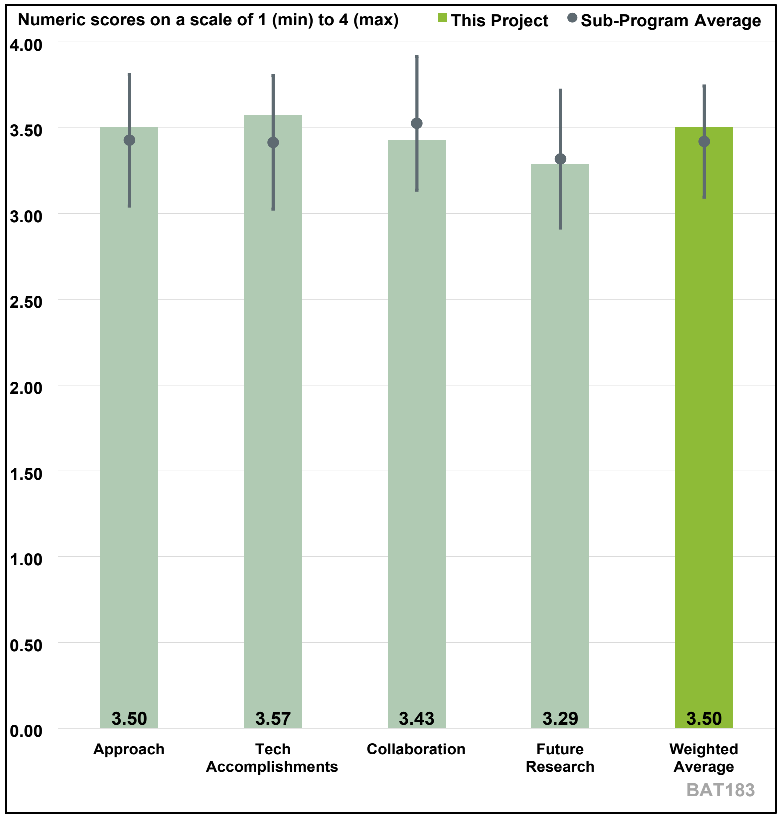

Figure 1-3. Presentation Number: BAT183 Presentation Title: In Situ Spectroscopies of Processing Next-Generation Cathode Materials Principal Investigator: Feng Wang, Argonne National Laboratory

Presenter

Feng Wang, Argonne National Laboratory

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said these researchers have demonstrated over several years that their approach to understanding the effect of synthesis conditions on the structure of the final product and its performance is outstanding.

Reviewer 2

The reviewer remarked the project focuses heavily on the first and second barriers, cathode materials performance, and corresponding structure change. The project is well designed, and the structure analysis is phenomenal.

Reviewer 3

The reviewer said battery precursor and cathode synthesis processes are well established in the battery industry, but there are still fundamentals about the process that are not fully understood. This project is focusing on investigating this area using various in-situ techniques. This will help researchers understand and improve the established process and benefit new chemistry development.

Reviewer 4

The reviewer said the approach of this project is excellent. A combination of in situ synchrotron X-ray spectroscopies, such as in situ X-ray diffraction (XRD), pair-distribution function (PDF), and X-ray absorption near edge structure spectroscopy (XANES) were utilized to gain insights into predictive process design and synthesis and provide input for modeling and process development/scale-up for cobalt (Co)-free nickel (Ni)/manganese (Mn)-based cathode active materials (CAMs). Strategies for cathode processing to improve performance and safety were developed through tuning Li-stoichiometry during cathode calcination and through tuning transition metal (TM) stoichiometry in the bulk and locally via coating/doping. The reviewer said this is an innovative approach.

Reviewer 5

The reviewer said the project is well designed and the timeline is reasonably planned. Current achievements provide an in-depth understanding of the processes and reaction kinetics/thermodynamics underlying the synthesis and processing of cathode active materials.

Reviewer 6

The reviewer remarked the objective of the work is to develop processing science and technologies to enable the scalable production of next-generation industrially relevant cathode materials. The approach to use in situ spectroscopy for real-time tracking of the phase progression and structure evolution was novel and provided insights and strategies for cathode processing to improve performance. But it is not applicable to scaling up as discussed by the researchers.

Reviewer 7

The reviewer detailed that the project’s overall objective is to use in-situ spectroscopic methods and modeling to analyze synthesis and processing procedures for cathode active materials. The slide deck and presentation were a little difficult to follow, but show that many techniques (differential scanning calorimetry, time resolved in-situ X-ray diffraction, X-ray scattering, microscopy) were utilized to understand the phase/particle evolution of various cathode active materials (Co-free Ni/Mn oxides, cation disordered rocksalts, and $LiNiO_2$ specifically), including those with coatings. Overall, the project is reasonably well-designed, although it does feel like multiple individual projects tied together (multiple materials are studied using various techniques, without a clear scientific objective that ties everything together).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the team has successfully achieved the following accomplishments: First, process design strategies have been developed to address performance, safety and cost/scalability by tuning Li/TM-stoichiometry and controlling local stoichiometry through surface coating/doping. Second, important insights were obtained through correlated experimentation and theoretical modeling on a lithiation-induced kinetic pathway of phase propagation and crystallization; intrinsic roles of Li and TM stoichiometries in controlling the structure and morphology of CAM as well as roles of surface coating on precursor cathode active materials (pCAMs) in tuning the crystal growth of CAMs during calcination, which in turn determine their structure, morphology, and performance. Third, new in situ spectroscopies have been developed for processing CAMs including absorption/scattering spectroscopy for correlating phase progression to lithiation and multimodal X-ray, neutron and electron spectroscopy/microscopy for examining short- and long-range structural ordering and chemical heterogeneity.

The reviewer said these accomplishments are outstanding and have important impact in guiding the synthesis of pCAM and cathode materials for Li-ion batteries.

Reviewer 2

The reviewer said the kinetics and thermodynamics during battery calcination of high-Ni low Co were well studied and documented.

Reviewer 3

The reviewer said progress is reasonable as compared to the plan.

Reviewer 4

The reviewer commented the impact of transitional metals (Co and Mn) in determining the phase propagation and crystallization was elucidated. It might be better to manifest the role of ratio of lithium hydroxide (LiOH), or the ratio of LiOH to the precursor, in the phase propagation and crystallization.

Reviewer 5

The reviewer said good progress has been made. Specific conclusions gleaned included $LiNiO_2$ tends to degrade at lower temperatures when delithiated to some extent; Li_xNiO_2 and NMC811 calcination temperature controls the Li/Ni stoichiometry in the ultimate material, minor Co incorporation improves low temperature layering of nickel manganese oxides, and niobium (Nb) and Mn coatings can be applied by dry coating methods. These conclusions are all supported by the spectroscopic, imaging and modeling analysis provided.

Reviewer 6

The reviewer detailed the project's accomplishments.

Accomplishment 1. Argonne National Laboratory (ANL) shows through differential scanning calorimetry (DSC) that there appears to be a different mechanism from pCAMs to CAM of NiO_2 when LiOH is present that is supported by DSC measurements. Brookhaven National Laboratory (BNL) conducted their in situ spectroscopy analysis to show that lithiation and dehydration were occurring at the same time as the temperature was increasing to lead to the final preferred composite structure. This material had good capacity and excellent capacity retention.

Accomplishment 2: Researchers then turned their attention to Co/Mn substitution in Ni-oxides to understand their role and found that the Co and Mn result in early layering of the Ni-based oxides while limited the rate of crystal growth. By investigating the components separately, the team found that Co accelerates layering and crystal growth whereas Mn hinders layering and crystal growth but promotes stability over long calcination times.

Accomplishment 3: The team found that they can play with the Li fraction to change cyclable capacity and stability.

Accomplishment 4: The team helped identify synthesis conditions for deposition of a Nb surface coating on NMC 90 5 5.

Accomplishment 5: The team also helped identify conditions for Mn coating on Ni materials.

Reviewer 7

The reviewer remarked technical progress was very good in linking the cathode performance to changes in synthesis approach; for example, on the control of Li/TM stoichiometry control. Suggested processes could lead to making high-performance CAMs, but how scalable it could be was not demonstrated. The reviewer noted several chemistries were investigated: composite $LiNiO_2$ (LNO), NMC811, Mn/Co substitution, composite NM9505, etc., but there was no deep focus on either of these systems to provide a practical system for industrial applications.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said like most DOE research projects, all work is done by extensive collaboration among various national laboratories and universities.

Reviewer 2

The reviewer referenced prior comments. It does feel as though there may be some close collaboration, particularly between the modelling efforts and certain experimental analyses, but for the most part, this feels like many individual projects stitched together. Nevertheless, the team is very strong and are making good progress in understanding the synthesis of many materials.

Reviewer 3

The reviewer said collaboration of this project is excellent, involving many research groups funded by VTO, including modeling scientists at ANL, scientists at the Advanced Photon Source (APS) of ANL, National Synchrotron Light Source II at BNL, at LBNL and Oak Ridge National Laboratory (ORNL), as well as scientists at Binghamton University, University of Texas at Austin, and University of Buffalo.

Reviewer 4

The reviewer commented these researchers list a number of collaborators and a number of materials they have worked on. The reviewer cannot tell if this was over the past year or over the years the team has developed and applied this technique.

Reviewer 5

The reviewer noted there was strong team collaboration with participation from three other national laboratories and four universities. The reviewer noted no participation from industry. There was good coordination among the team members.

Reviewer 6

The reviewer noted excellent collaborations among national laboratories and universities. Collaborating with industries might be necessary, especially when the project move to the process design to address safety, cost and scalability.

Reviewer 7

The reviewer remarked collaboration is great among team members. However, it would be better to develop the low-cost/scalable processes together with an established materials company to speed up the process.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the project has clearly defined a purpose for future work as developing process design by in situ spectroscopy for scalable synthesis and processing of next generation industrially relevant CAMs. It includes developing process design strategies to address performance, safety and cost/scalability; investigating coating processes for improving cycling and thermal stability through correlated experimentation and modeling; investigating the calcination process of Li/Mn-rich, disordered rock salt and other Co/Ni-free CAMs; and designing scalable processes for pCAM fabrication, alternative to the traditional coprecipitation. The reviewer said these planned future works are likely to achieve the targets and objectives of this project.

Reviewer 2

The reviewer said the future work has been clearly defined for scalable synthesis to address disparities in materials, process and heat/mass transport. The reviewer suggested collaboration with industry in the future.

Reviewer 3

The reviewer said looks like the project plans to continue on many of the projects already listed above. The team is planning to develop a new capability with ORNL to combine information from neutron scattering with X-ray data to look at disparities in high volume production.

Reviewer 4

The reviewer remarked future work is to process design by in situ spectroscopy for scalable synthesis and processing of next generation industrially relevant CAMs. The reviewer said the team proposed several future research activities that are part of other projects and the reviewer was not clear what the role of this project is. If the syntheses process needs to be scalable, the presentation did not identify how the scaleup process would work. The reviewer was not clear what problems the new proposed technique/capability development would address and recommended that the project focus on 2-3 chemistries and go deeper to finalize and optimize the synthesis process rather than going from one research area to another.

Reviewer 5

The reviewer reiterated the majority of the future work is the low-cost/scalable process development. It is better to develop the processes together with an established materials company.

Reviewer 6

The reviewer remarked the future work all appears to be fairly generic, unfocused extensions of the current efforts. It will be interesting to see how correlated X-ray/neutron characterization will be implemented to study the synthesis of various materials.

Reviewer 7

The reviewer provided a general comment related to all Co-free projects in VTO. Co-free research ideas were proposed for a few reasons: 1) Cost: Co price jumped almost 300% in 2018. This pushed many original equipment manufacturers (OEMs) to move to high Ni, low Co NMC cathodes. 2) Geopolitical: majority of Co has been mined in Congo and processed in China. 3) Supply shortage: over-optimism about EV sales growth causes concern of Co shortage.

The reviewer noted the situation has changed over the past several years: 1) Supply: there is enough Co resources and reserves for EV demand and there is a market oversupply of Co in the near and medium term. The reviewer referenced https://www.ft.com/content/e6f131c8-4945-45f9-84ad-18eec58df0d9. 2) Cost: due to oversupply of Co, the price of Co is back to normal and only 30% of the highest price in 2018. Besides, Co prices are currently close to or even lower than Ni's price. The reviewer referenced https://www.reuters.com/default/surpluses-low-prices-remain-feature-cobalt-market-2023-08-14/. 3) Geopolitical: by 2030, close to 40% of global Co will come from Indonesia and the Democratic Republic of the Congo will have less dominance in this market. The reviewer referenced https://www.mining.com/indonesia-emerges-as-a-cobalt-powerhouse-amid-surge-in-demand/. Co is critical to maintain NMC structure stability. High-Ni low-Co makes more sense like NMC811 due to high capacity. But, according to the reviewer, the benefit of Co-free cathodes is in question.

Since the concerns on Co price, supply, and geopolitical have changed, the VTO Program Manager could shift the future research focus away from Co-free work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented the achievements obtained from this project will enable next-generation cathode materials for electric batteries, which support the overall VTO objectives.

Reviewer 2

The reviewer remarked yes, this work is relevant to Batteries, Mobility, etc., sub-programs.

Reviewer 3

The reviewer said yes, the project supports the overall VTO subprogram objectives. It focuses on the novel high energy cathode materials development and synthesis.

Reviewer 4

The reviewer noted there are many researchers seeking to make new materials for Li-ion batteries with high capacity and better cycle stability. This research allows one to better understand the material transformation during high temperature synthesis conditions in order to optimize the synthesis conditions and the resulting material. This is an extremely valuable resource.

Reviewer 5

The reviewer said this project focuses on CAM synthesis, which is entirely relevant to VTO subprogram objectives.

Reviewer 6

The reviewer said this project is relevant to current DOE objectives by providing guidance for pCAM and CAM synthesis to improve the performance of Li-ion batteries.

Reviewer 7

The reviewer said this project support the overall VTO Battery objectives by synthesizing better pCAMs and CAMs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked yes, there is sufficient research staff and lab facilities for this project.

Reviewer 2

The reviewer said resources are sufficient.

Reviewer 3

The reviewer said resources from ANL, ORNL, BNL, LBNL, Binghamton University, University of Texas at Austin, and University of Buffalo are sufficient to achieve the stated milestones.

Reviewer 4

The reviewer commented the researchers appear to be able to collaborate with several PIs using the present resources.

Reviewer 5

The reviewer said resources appear sufficient for the scope of the project.

Reviewer 6

The reviewer remarked resources are sufficient for the project to achieve the milestones and objectives.

Reviewer 7

The reviewer found that the $500,000 provided is sufficient for achieving the objectives of the project.

Presentation Number: BAT287
Presentation Title: Advanced In Situ Diagnostic Techniques for Battery Materials
Principal Investigator: Xiao-Qing Yang, Brookhaven National Laboratory

Presenter

Xiao-Qing Yang, Brookhaven National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

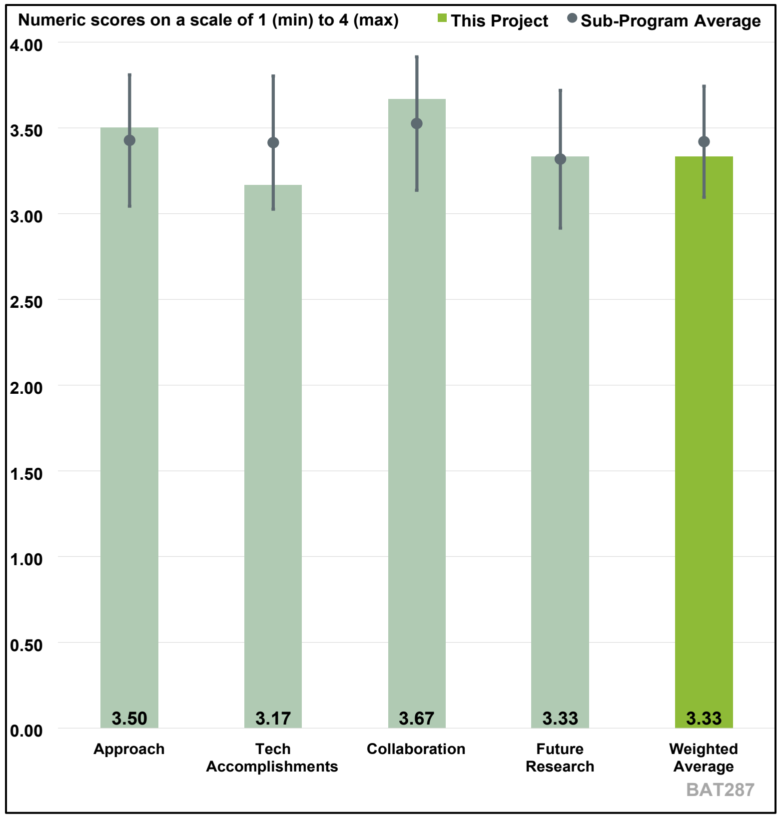

Figure 1-4. Presentation Number: BAT287 Presentation Title: Advanced In Situ Diagnostic Techniques for Battery Materials Principal Investigator: Xiao-Qing Yang, Brookhaven National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project developed synchrotron-based in situ and ex situ X-ray techniques and uses them to perform advanced diagnostic studies on battery materials and cells. The approach is excellent, and it has been demonstrated to be effective in numerous studies. The reviewer noted the team has a long history of productive research in this space.

Reviewer 2

The reviewer said the goal of the project is to couple a Li-metal anode with a high-Ni-NMC or sulfur (S) cathode to “achieve a specific energy of up to 500 Wh/kg through cell level design and optimization of materials and architectures.” The approach includes “integrating development and discoveries from materials to cell level” and leveraging “state-of-the-art DOE facilities to understand and prevent degradation.” The reviewer noted that in this project presentation, use of BNL’s synchrotron facilities is used to examine cathode and anode materials used in the B500 cells. The techniques included XRD, PDF, XAS and transmission X-ray microscopy (TXM). The project design and timelines appear to be reasonable and appropriate technical barriers are being addressed.

Reviewer 3

This project focuses on addressing the barriers of rechargeable batteries for plug-in hybrid electric vehicle (PHEV) applications, typically such as the calendar and cycle life of rechargeable batteries as well as their abuse tolerance. The team develops and integrates advanced in-situ X-ray techniques, such as synchrotron-based XRD and PDF, to probe into the fundamental cause of the fading of battery performance with the microstructural evolutions. The materials studied include cathode, solid electrolyte, and solid electrolyte interphase. The reviewer said the project is well designed and the timeline for carrying out the proposed research is reasonable. It would be expected that this team's research can be complementary at scale with other experimental techniques.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the presentation includes a summary of characterization of interphases in Li-metal cells using various fluorinated ether electrolytes developed at Stanford University. The presentation shows the S fluorescence mapping of the Li-metal anodes and S-edge XAS of the NMC811 cathode showing S in the cathode electrolyte interphase (CEI). For in situ TXM, beam damage was observed in coin cells but not in pouch cells with applied pressure. PDF studies were conducted on a sulfur-iodine (S-I) cathode material developed at the University of California San Diego (UCSD). The reviewer said results show that the S-S bonds are maintained while the iodine (I) exists as I_2 and in S-I bonds. The technical progress appears to be in line with the project plan.

Reviewer 2

The reviewer said the team made good progress toward reaching their milestones. Using fluorinated ether electrolytes, the team studied the interphases, such as CEI and SEI layer, in the Li-metal cell (Li||NMC811) by synchrotron-based imaging and spectroscopy techniques. These studies provide insights into the interphase formation mechanism and its dependence on the charging voltage. Even though the X-ray based technique is widely used, the beam damage to the sample has never been symmetrically evaluated. This team evaluated the X-ray beam damage effect, which will benefit the development of in-situ X-ray techniques for battery studies. The reviewer said for the novel S-I cathode material for lithium-sulfur (Li-S) solid-state batteries, the team shows that the S-S bond in S8 puckered ring structure is preserved in the new cathode while the iodine in the form of I_2 and S-I bonds are formed through sintering. The reviewer said the research progress is in accordance with what the team has proposed, which all align well with their milestones.

Reviewer 3

The reviewer found that overall, good progress has been made in a number of areas. The team investigated the interphases in the Li-metal cell (Li||NMC811) using various fluorinated ether electrolytes, evaluated cell configurations for in situ TXM studies, and analyzed S-I cathode materials for Li-S solid-state batteries developed at UCSD. The PIs have produced several publications and delivered invited presentations. The reviewer said that while these results are interesting, their significance is not clear to this reviewer as the background info on the studies were not provided. It would be good to indicate what specific challenges the team is trying to address in each study, why their techniques are unique in doing so, and how their work complements the overall goals. For example, why is the S-I cathode material chosen for investigation, and do they have particular advantages and challenges?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the BNL team has been collaborating with various teams in the Battery500 program.

Reviewer 2

The reviewer remarked the team is collaborating with universities and other national laboratories. The benefit of such a broad collaboration is that characterizing team can use the advanced technique to study the most advanced materials, which is apparently verified by the high impact publications of the project. Integration of other experimental techniques and results across the research board will be beneficial for the interpretation of the results captured in this work.

Reviewer 3

The reviewer commented there are several effective and productive collaborations with researchers from Stanford University and UCSD. The team uses their diagnostic tools to obtain a deeper understanding of materials provided by their collaborators. The reviewer said it would be helpful to provide more information on each collaboration, particularly as to what was the context for the study, and how the PI’s work helps to tackle the specific challenges etc.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer pointed out the proposed next steps include “the study of polysulfides using PDF techniques” and X-ray fluorescence mapping to study dissolution, deposition and distribution of polysulfides in Li-S batteries. The team also plans to use X-ray techniques to examine the interphases formed during cycling. The reviewer found that in general, the future plans appear to be reasonable and have a defined purpose.

Reviewer 2

The reviewer said the future work plan includes further diagnostic studies of Li-metal interphases and the behavior of polysulfides in Li-S batteries. Considering the expertise of the team and the wide array of diagnostic tools at their disposal, this is a reasonable and achievable list for the team.

Reviewer 3

The reviewer said the proposed future research aligns well with the overall milestone of the project. What has been accomplished and planned to be done are well conceived for gaining insights on the fading mechanism of rechargeable batteries. The insights gained from these studies can be used to guide the design of novel electrode and electrolyte system toward enhanced performance of the rechargeable batteries. The reviewer noted the team has a good track record of accomplishing what they proposed to do. It would be beneficial to consider integrating experimental observation of other techniques with the same materials system.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked yes, the project supports overall VTO subprogram objectives.

Reviewer 2

The reviewer commented microstructural features of the electrode and solid electrolyte as well as their evolution upon battery cycling are critical factors that control the stability of rechargeable battery. This project is primarily focused on investigating the microstructural feature of the active battery materials and their correlation with battery performance. The reviewer said the proposed research is highly correlated with the overall objectives of VTO subprogram.

Reviewer 3

The reviewer said research using state-of-the-art diagnostic techniques to obtain fundamental knowledge at both material level and cell level is critical to future development of advanced batteries, which is directly related to DOE goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the team members of the project possess expertise for using synchrotron-based X-ray techniques for rechargeable battery studies. It is apparent that the team has the privilege for accessing to the light source at BNL for carrying out the proposed research, which will warrant, timewise, what they proposed to be carried out in this project. The reviewer said integration of other experimental techniques across different teams will be complementary and therefore gain insights at different scales.

Reviewer 2

The reviewer said the PIs have adequate resources to conduct the proposed research activities.

Reviewer 3

The reviewer said the total resources available to the project are sufficient. It is not known whether the resources available for this particular project are sufficient, as no information is provided.

Presentation Number: BAT309
Presentation Title: Electrode Materials Design and Failure Prediction
Principal Investigator: Venkat Srinivasan, Argonne National Laboratory

Presenter

Venkat Srinivasan, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

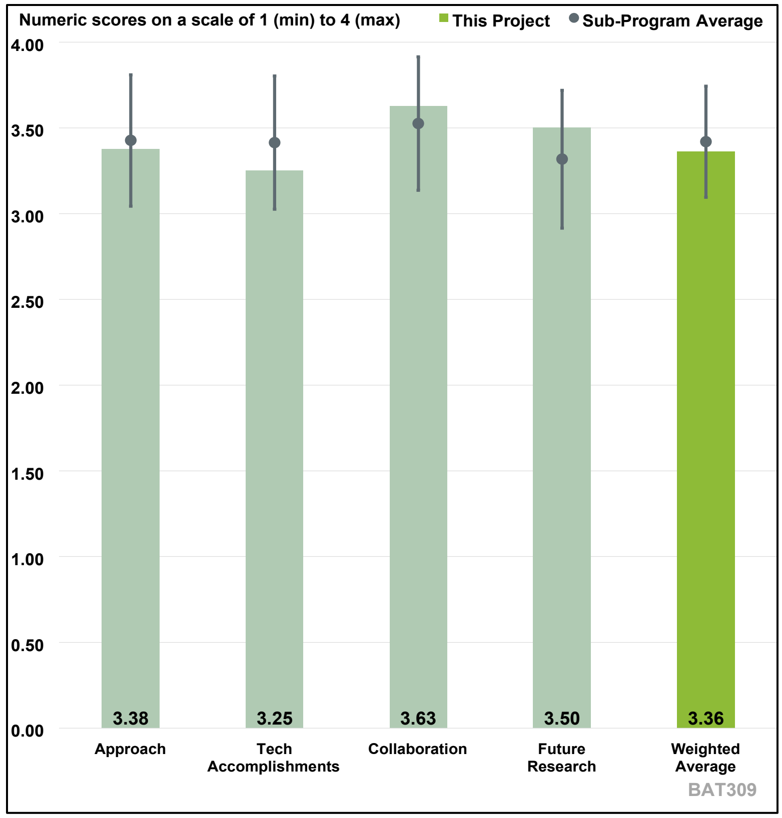

Figure 1-5. Presentation Number: BAT309 Presentation Title: Electrode Materials Design and Failure Prediction Principal Investigator: Venkat Srinivasan, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the team has correctly identified the key barriers in solid state Li-ion batteries.

Reviewer 2

The reviewer said the project is well designed and the listed technical barriers are systematically addressed, especially in the first part of the project as discussed below.

Reviewer 3

The reviewer remarked that to achieve a highly reversible Li-metal anode, the team has been addressing the following technical barriers in this fiscal year presentation report: Modeling ionic electronic conducting interphase layers; determining the location of Li deposition; and understanding the diffusion of ions between cathode and solid electrolyte. The project is well designed and the timing is well planned. The reviewer said it would be ideal if the Li deposition position can be in-situ experimentally visualized. It would also be ideal if the electronic and ionic conductivity in the interphase can be quantified through experimental methods.

Reviewer 4

The reviewer remarked this project aims to develop a multiscale and multiphysics model to simulate various failure mechanisms related to Li-metal solid electrolyte batteries. It provides fundamental insights for several key design challenges in solid-state Li-ion batteries, e.g., dendrite growth during plating and maintaining contacts during stripping.

The reviewer said it is often seen that the model varies material properties by five orders of magnitude, but without mentioning the matching materials. For example, high ionic and lower electronic conductivity are desired, but how to achieve it? Another example is the adhesion energy. It varied from 0.001 to 10 J/m^2. The reviewer said it is rare to see any measured adhesion energy below 0.1 J/m^2. The model can further guide the experiments if it can point out what type of materials to be used.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said technical progress is satisfactory. About 45% of the work is remaining, whereas only 30% time is remaining.

Reviewer 2

The reviewer said technical progress well aligned with the project plan.

Reviewer 3

The reviewer said the project seems to touch many different areas for Li-metal batteries, e.g., interphase design for Li-plating, plating and stripping, and solid electrolyte/cathode interface. The reviewer said it could be more focused on solving more specific technical barriers quickly.

Reviewer 4

The reviewer said overall, the results are interesting and well discussed. However, some aspects need work. The reviewer pointed out Section 1, modeling of interfacial reactions: This section is excellent. It is not clear how the model considers that Li reaches the back side of the interphase. The reviewer said that selection of silver (Ag) as an alloying material for the interphase is not clear and asked does it come only from literature reports, what would be the additional impacts of the presence of Ag in that layer, and how is the allowing proportion decided.

Regarding Section 2, Cathode surface degradation, the reviewer said this section appears not well-advanced; it was unclear what theory has been used in the graph displaying theory/experiments for interdiffusion. Analysis of stress evolution is also very unclear. Experimental results are shown but not commented on. Regarding plating/stripping modeling, the reviewer said the effect of the SSE modulus is included. However, the interphase effect which is discussed in the first section of the modeling is not included here. Same as the previous section, this modeling appears at its initial stage.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked collaboration is excellent. The teams consist of the needed expertise from LBNL, ANL, and the University of Giessen. The computational simulation of plating and stripping of Li is notably strong.

Reviewer 2

The reviewer said the project has outstanding collaborations with different experimental groups.

Reviewer 3

The reviewer said the team had collaborations with national laboratories (e.g., LBNL), universities (e.g., University of California, Berkely; University of Chicago), and a German institution (i.e., Justus-Liebig-Universität,), which broaden the impact of this work.

Reviewer 4

The reviewer said good collaboration, but these could be enhanced so sections 2 and 3 receive the benefits of the knowledge developed in section 1.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said proposed research is aligned with current results and expectations.

Reviewer 2

The reviewer remarked most future work is excellent. One point is unclear on the plan to simulate Li plating in the presence of alloying. The plan did not address the alloying effect.

Reviewer 3

The reviewer commented future work is well articulated.

Reviewer 4

The reviewer said it would be ideal if some detailed plan on combining research with experimental groups can be listed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said yes, the project is very relevant to developing further understanding of battery materials and interfaces.

Reviewer 2

The reviewer remarked this project builds simulation capabilities that can accelerate battery design, achieving the Batteries program objectives.

Reviewer 3

The reviewer remarked the project will support the VTO program objectives.

Reviewer 4

The reviewer commented the proposed work well supports the Batteries program in VTO. This team's work on theoretical modeling part will support experimental progress towards the development of Li-metal batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented the overall budget is well aligned with the tasks in the projects.

Reviewer 2

The reviewer said resources are sufficient.

Reviewer 3

The reviewer said sufficient resources are available for the team to achieve their proposed tasks.

Reviewer 4

The reviewer said resources are abundant.

Presentation Number: BAT360
Presentation Title: Cathodes Beyond Lithium Nickel Manganese Cobalt Oxide (NMC) 811
Principal Investigator: Arumugam Manthiram, University of Texas at Austin

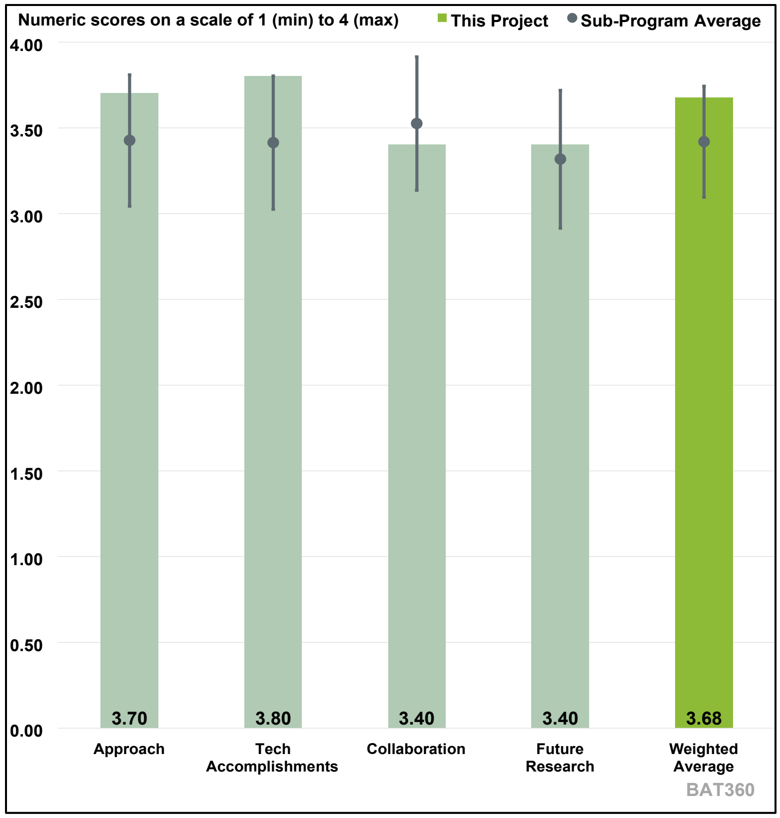

Figure 1-6. Presentation Number: BAT360 Presentation Title: Cathodes Beyond Lithium Nickel Manganese Cobalt Oxide (NMC) 811 Principal Investigator: Arumugam Manthiram, University of Texas at Austin

Presenter

Arumugam Manthiram, University of Texas at Austin

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented Dr. Manthiram’s approach to R&D is always insightful and uses well thought-out approaches to investigating fundamental issues with high energy cathodes. The reviewer was very impressed by all of the high Ni and S work, and encouraged the program to shift more and more of its focus to S as industry is heavily invested in improving high-Ni NMC.

Reviewer 2

The reviewer said Professor Manthiram’s approach to developing high-capacity, stable cathode materials is logical and well-structured. The research team is methodical in identifying the key factors responsible for the cycle, air, and thermal instabilities of high-Ni cathodes. The increased focus on S cathodes is a positive development as it addresses the cost barrier ($80/kWh).

Reviewer 3

The reviewer said the project is very well designed, with a clear experimental plan and realistic goals and timeline. The team has expertise in this topic and extensive experience in the techniques they are using. The team executed all proposed milestones and delivered an in-depth study on proposed objectives. The work is very systematic and of high quality.

Reviewer 4

The reviewer remarked high Ni content for cathode materials are pursued for maximum specific capacity and energy density at the material level. The project systematically investigated the impact of doping and electrolytes on the cycling performance, storage stability, as well as thermal stability. The reviewer said the safety characterization at cell level can be of value for cell development, module and pack design.

Reviewer 5

The reviewer remarked this project aims to develop high-energy-density, long cycle life high-Ni cathodes to support Battery500's cell development. The project is well designed and the timeline looks reasonable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the project is on track with the milestones and has a few world-class accomplishments to address the challenges of utilizing a high Ni cathode with a Li-metal anode, including air, thermal, and surface stabilities and transition metal cross over. The reviewer had two technical comments: first, most of the cathodes developed by University of Texas-Austin experience a capacity increase for the first 20 cycles. This capacity increase is not clearly observed in commercial NMC811 and may have important implication in interfacial stability, particularly cathode/electrolyte interface. A more detailed study is suggested to understand the differences. The reviewer also wondered whether coating development is planned for this project, since most commercial cathodes will have certain coatings. Second, to provide more insights to support Battery500's overall goal, this reviewer suggested studying the transition metal crossover on SEI chemistry using the Battery500's liquid electrolyte, rather than the typical $LiPF_6$ in an EC/ethylmethyl carbonate (EMC)-based liquid electrolyte.

Reviewer 2

The reviewer said milestones were well delivered.

Reviewer 3

The reviewer remarked the amount of data that Dr. Manthiram generates and presents is incredibly impressive. Outstanding data on a variety of critical subjects, including the impact of air exposure on high Ni gas generation and cycling, impact of dopants on thermal stability and gas generation, impact of Ni oxidation state on gas generation, and influence of electrolyte composition on cycling and gassing, among others.

Reviewer 4

The reviewer said the Manthiram Group is successfully meeting its milestone objectives and making significant progress on the high-nickel cobalt effort. They have synthesized several materials delivering over 200 mAh/g and determined the role of common dopants on air, thermal, and surface stabilities. The group has also authored numerous journal articles, significantly enhancing battery knowledge within the community.

Reviewer 5

The reviewer noted that high Ni cathodes suffer from cycle, air, and thermal instabilities; cation doping is beneficial, but there is no clear understanding of what dopants do and which dopant does what. This is very important goal and team did great job assessing the role of common dopants (Mn, Co, Al, and magnesium [Mg]) on cycle, air, and thermal stability. Confirm with different characterization techniques (time of flight secondary ion mass spectrometry [TOF SIMS]?) dopants sites and correlate with the electrochemical performance. The reviewer asked if $LiNi_{0.95}Al_{0.05}O_2$ nickel aluminum cathode chemistry is the most promising for overall performance metric investigated. The reviewer said the team did not recommend dopant of choice in regard to cycle, thermal stability, and gas evolution. If Al is the best performing dopant they the team should study if there is an additional effect of Al dissolution and crossover (at 10% dopants?) on Li deposition morphology. The reviewer asked does the spinel phase stabilize nickel manganese (NM) cathode chemistry for O-loss, is there a trade-off with aging degradation and suppression of gas generation?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said Professor Manthiram's work on high-Ni NMC and S cathodes is well coordinated with others in the Battery500 consortium and hopefully his best performing cathodes are used and validated by others in the program soon.

Reviewer 2

The reviewer remarked the Manthiram Group has demonstrated outstanding collaboration with the Battery500 Consortium's national laboratories and universities. High-Ni samples have been evaluated by Pacific Northwest National Laboratory (PNNL), BNL, ANL, and Stanford University. If testing by PNNL and the University of Washington proves promising, the General Motors (GM) group will proceed with cathode evaluation. It is clear that the Manthiram Group is actively seeking support from the community as needed.

Reviewer 3

The reviewer said the team clearly listed contributions from various collaborators, both from national laboratories and academia. This is really a very big team, so this reviewer's only comment is when different teams have some overlap in their investigations (like dopants in this case) they need to communicate results and help each other in interpretation using all available characterization and expertise resources.

Reviewer 4

The reviewer said the project greatly leverages the team members in Battery500, and other expertise outside of Battery500. The project is also engaged in collaboration with industrial partners like GM. The reviewer said more industrial engagement on battery/pack design can add more value to the project.

Reviewer 5

The reviewer said the project shows a strong record of collaborating with multiple national laboratories on materials characterizations. The reviewer recommended extending the collaboration beyond characterization to facilitate the integration of these cathodes with Li-metal anodes.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said proposed future efforts are appropriate and built on the current successful initiatives. The proposed future efforts are well-suited and build on the current successful initiatives.

Significant knowledge has been gained about the benefits of dopants, which should lead to the development of a cathode with enhanced thermal stability and cycle life.

Reviewer 2

The reviewer remarked Professor Manthiram's future work is well focused, particularly on the need to reduce cathode irreversible capacity loss to improve cell watt-hours per kilogram and the impact of anode to cathode and cathode to anode cross talk.

Reviewer 3

The reviewer said good future research was proposed to address the potential barriers at the materials level.

Reviewer 4

The reviewer commented future work is clearly defined and justified. The reviewer's suggestion to the team is to systematically look into the roles of bulk and surface dopants (such as Nb?). The team said at the Annual Merit Review (AMR) that they did not investigate Nb as dopant (even though it was displaying great performance) because some Nb stays in the lattice and some goes to the surface. The reviewer asked if bulk and surface dopants can be combined to take advantage of their different roles on electrochemical performance. Regarding the impact of transition-metal crossover on SEI chemistry: the reviewer asked if the team can think creatively about how to strategically design desirable crossover to achieve beneficial SEI, and if reactive/reducible surface dopants can passivate cathode surface and prevent gas release at lower SOC with low Ni-cathodes.

Reviewer 5

The reviewer said proposed future work looks reasonable to achieve the project target. The reviewer recommended the PI quantitively study the effects of the catalyst on the kinetics of the S cathode, to hopefully provide more insights to develop high-loading S cathode to achieve 500 Wh/kg cell energy density.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this very exciting and important work aims to systematically study and design Li cells with high-energy density, long cycle life, and safe operation at an affordable cost that can accelerate vehicle electrification. It fully supports VTO objectives, the team has a high number of high impact publications and invited presentations.

Reviewer 2

The reviewer remarked the project is highly relevant, aligning with VTO goals of achieving higher energy density, longer-lasting batteries, and reducing the cost of EV batteries (ultimate goal $80/kWh).

Reviewer 3

The reviewer said the effort greatly supports the ultimate goal of Battery500.

Reviewer 4

The reviewer said yes, the development of high-energy-density cathodes including Ni-rich oxides and S is critical to achieve 500 Wh/kg.

Reviewer 5

The reviewer said highly relevant. The reviewer referenced prior comments; although the high-Ni NMC work is world-class, it might be time for the program to shift more and more of its focus to S as industry is heavily invested in improving high-Ni NMC.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said excellent value for the R&D investment.

Reviewer 2

The reviewer commented the team possesses excellent resources and is well-equipped to successfully complete their milestones in a timely manner.

Reviewer 3

The reviewer said resources of the project look reasonable.

Reviewer 4

The reviewer remarked the resources were sufficient and effectively utilized (advanced in-situ and ex-situ characterization: XRD, scanning electron microscopy [SEM], transmission electron microscopy [TEM], XPS, TOF-SIMS, DSC, differential electrochemical mass spectrometry) to achieve the proposed milestones in a timely fashion.

Reviewer 5

The reviewer remarked this is a subtask of Battery500. No detailed resource on the subtask was disclosed.

Presentation Number: BAT361
Presentation Title: Understanding and Improving Lithium Anode Stability
Principal Investigator: Yi Cui, SLAC National Accelerator Laboratory

Presenter

Yi Cui, Stanford University / SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

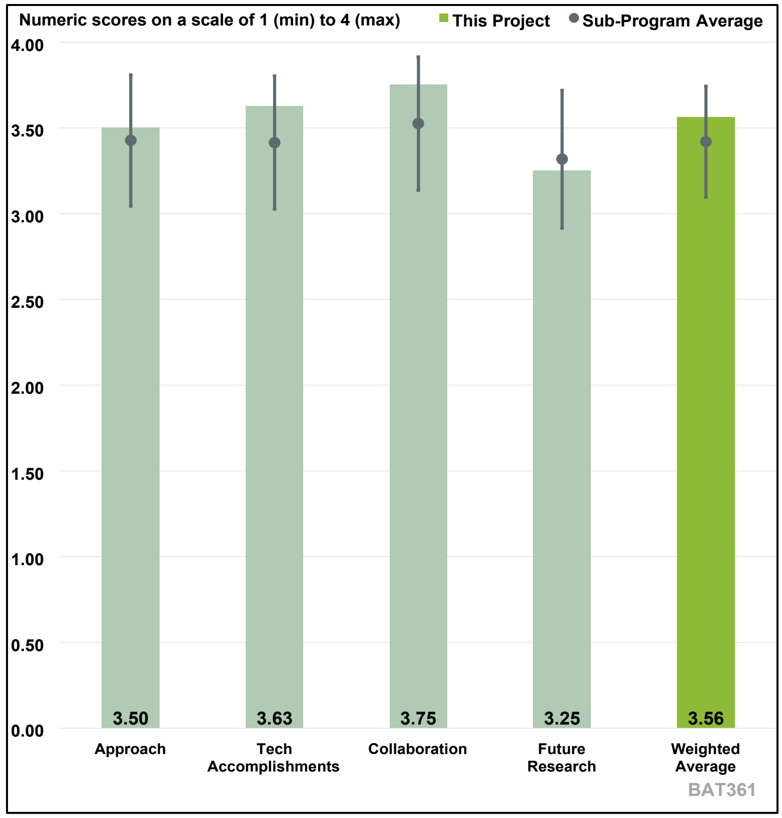

Figure 1-7. Presentation Number: BAT361 Presentation Title: Understanding and Improving Lithium Anode Stability Principal Investigator: Yi Cui, SLAC National Accelerator Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project approaches to addressing technical barriers in next-generation Li-metal battery technology are both innovative and commendable. By focusing on fundamental breakthroughs in controlling Li-metal electrochemical reactions, the discoveries set a solid foundation for substantial advancements. The integration of materials and cell-level discoveries is particularly noteworthy, as it ensures rapid incorporation and validation of the latest research findings, leading to more realistic and practical applications. Leveraging materials from other DOE programs and utilizing state-of-the-art DOE facilities at SLAC to understand and prevent degradation is a strategic and efficient use of resources. The reviewer said the emphasis on multi-disciplinary approaches and enhancing collaborations between national laboratories, universities, and industry highlights a holistic and synergistic strategy. This comprehensive and well-coordinated effort is likely to yield highly productive results, driving significant progress in the development of high-energy, low-cost Li-metal based batteries. Overall, the approach is excellently designed and executed, promising to overcome technical barriers effectively.

Reviewer 2

The reviewer pointed out that one of the major issues related to the metallic Li anode is the formation of the SEI. While SEI protects the Li anode, it also results in the creation of unrechargeable Li (dead Li). The PI utilized advanced analytical and electrochemical diagnostic techniques to investigate SEI formation, dissolution, and potential capacity recovery. These findings represent a significant step towards understanding the complex Li redox reactions and corrosion mechanisms. This research is valuable for future developments in Li anode and electrolyte technology. The project is well planned.

Reviewer 3

The reviewer said Dr. Cui's approach is excellent as always and encouraged this team to consider adopting quantitative milestones to demonstrate progress towards improving either Wh/kg, cycle, or calendar life. The existing milestones are good but are all qualitative. The use of Li hosts is a good one but has been under development for several years or more. The reviewer said there may be much more to do in this area but wondered if a go/no go decision is possible in the near future.

Reviewer 4

The reviewer said the Approach as outlined on the Approach slide is too generic to understand the specific approach used over the past year to address the problems of making cyclable Li foil. In the future, please complete the slides for this specific project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the technical accomplishments achieved by the team are outstanding, with a sharp focus on addressing the critical barriers associated with Li-metal and electrolyte reactions. Through comprehensive and innovatively designed electrochemical experiments, the team has successfully navigated complex challenges that have long hindered progress in battery technology. The productivity of the team is commendable, as they have demonstrated a high level of expertise and dedication in their approach. Their ability to integrate cutting-edge research with practical applications has resulted in significant advancements, paving the way for the development of next-generation high-energy, low-cost batteries.

Reviewer 2

The reviewer commented it is amazing, and somewhat disconcerting, that aging a cell for 24 hours decreases the next cycle coulombic efficiency as shown on Slide 13. Calendar aging is much more important than we first thought, excellent data. Data shown on Slide 15 is an excellent idea, measuring SEI dissolution could be immensely valuable in many other chemistries, specifically silicon-based anodes which are believed to have an unstable or non-passivating SEI. The reviewer said it is also excellent to see the correspondence between SEI dissolution and cycling stability as shown on Slide 17 The idea of letting the SEI dissolve to improve cyclability is fascinating but appears very impractical in any real cell due to the time frames involved.

Reviewer 3

The reviewer said the major technical advancements include the proposal of SEI dissolution and the elucidation of the SEI propagation mechanism. The concept of potential capacity recovery is novel. These discoveries can significantly contribute to the development of long-cycle Li anodes.

Reviewer 4

Regarding Technical Accomplishment 1, the reviewer believed the team plated Li and used cryo SEM to measure the cross section and then looked at the deposited Li a day later and the deposited Li was thinner and the SEI was thicker. Regarding Technical Accomplishment 2, the team used a quartz crystal microbalance and held a piece of copper foil on the balance at a potential low enough to deposit an SEI but not low enough to deposit Li-metal. The potential was then allowed to float, the SEI dissolved and there was a decrease in weight as measured by the electrochemical quartz crystal microbalance. The time constant for dissolution was around 15 minutes. Regarding Technical Accomplishment 3, the reviewer remarked if you use a LHCE, the majority of components in the SEI are inorganic and this SEI is more stable and does not dissolve as badly as the SEI's formed from other electrolytes. Regarding Technical Accomplishment 4, if you perform plating and stripping in a Li|copper (Cu) cell and go to open circuit when the Cu is bare instead of when the Cu has Li on it, you have a better coulombic efficiency (i.e., you lose less Li from the copper if the Li is not there to begin with.) Regarding Technical Accomplishment 5, if you let the residual SEI dissolve away from the Cu surface, you are better able to access the isolated Li that forms near the Cu during plating and stripping. Regarding Technical Accomplishment 6, the reviewer noted that during discharge, isolated Li will grow on the end that is closest to the anode. The speaker focused on the effect of electrolytes on Li cycling efficiency and the mechanism for formation of isolated Li and how one might reconnect it. It appears that some electrolytes dissolve and result in low coulombic efficiency and others dissolve less and result in higher coulombic efficiency. The reviewer was curious, which electrolyte is better for reconnecting isolated Li, an electrolyte that dissolves easily or the opposite?

The reviewer said these accomplishments point to a better understanding of Li deposition and SEI formation and dissolution, but the reviewer did not see a solution to these problems emerging. We have known about mossy Li for some time now and the co-deposition of Li and SEI during plating. No one has figured out how to stop that phenomena without using hosts.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked excellent collaboration with many other institutions and saw no issues.

Reviewer 2

The reviewer said Battery500 has demonstrated a highly creative and successful collaboration among a diverse group of PIs and institutions.

Reviewer 3

The reviewer said this project is a key component of the Battery500 team effort, showcasing major collaboration within Stanford/SLAC and extending to many top institutions within the Battery500 network. The collaborative nature of this initiative has facilitated the pooling of diverse expertise and resources, leading to groundbreaking advancements. The project's integration of innovative electrochemical experiments with a strong, productive team has significantly addressed critical barriers in Li-metal and electrolyte reactions, driving substantial progress in battery technology.

Reviewer 4

The reviewer said there is a lot of collaboration but that it appears that the team is out of ideas. The team is trying stuff and looking at it to see what happens, and the result is usually the same.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked excellent future research plans based on stabilizing the Li SEI.

Reviewer 2

The reviewer said the proposed future research is commendable, with a clear focus on understanding and designing host materials for Li-metal anodes, investigating SEI dynamics across different stages of charge/discharge, and developing innovative solvent molecules and polymer coatings. The commitment to collaboration with other groups will undoubtedly accelerate advancements and deepen understanding in these critical areas.

Reviewer 3

The reviewer remarked the proposed research aligns well with the overall goals, though the PI should provide details for the future work.

Reviewer 4

The reviewer said proposed future research is to continue to go back to looking at hosts for Li. The reviewer pointed out graphite and silicon are hosts for Li. If the team does this, they will essentially be making a Li-ion battery and lose the energy density benefit of going to pure Li deposition, which is the purpose of the program. The team wants to continue to study the dynamics of SEI formation and dissolution. The reviewer commented that the team will continue to try new solvent molecules and polymers and increase their collaboration; however, none of this really bodes well toward ultimate success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project is highly relevant. Li-metal is the core issue with Battery500 cells using NCM cathodes.

Reviewer 2

The reviewer said enabling Li-metal as an anode for rechargeable batteries is a critical focus for achieving high energy density. This advancement is essential for enhancing battery performance, offering significantly higher capacity and efficiency compared to traditional anodes.

Reviewer 3

The reviewer remarked the research toward the high-performing metallic Li anode is very relevant to the overall VTO objectives and Battery500 goals.

Reviewer 4

My comments are fairly pessimistic. This is not to reflect on the capabilities of the researchers, who are trying everything they can with liquid electrolytes and not much is working, but that has been true with all of the researchers that preceded them. This is still a very hard problem.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said good use of appropriate resources.

Reviewer 2

The reviewer remarked the PI's institution and his collaboration institutions have more than sufficient resource for the proposed research.

Reviewer 3

The reviewer said the overall resources for the Battery500 program appear sufficient, supporting its ambitious goals. However, it is noted that the actual budget allocation for the Stanford/SLAC team has not been reported in the presentation. The team should consider including this information for reviewers, ensuring that all sub-teams have adequate funding to meet their objectives.

Reviewer 4

The reviewer did not see a lot of new ideas that suggest the researchers need more resources to investigate those ideas.

Presentation Number: BAT362
Presentation Title: High Capacity S Cathode Materials
Principal Investigator: Prashant Kumta, University of Pittsburgh

Presenter

Prashant Kumta, University of Pittsburgh

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

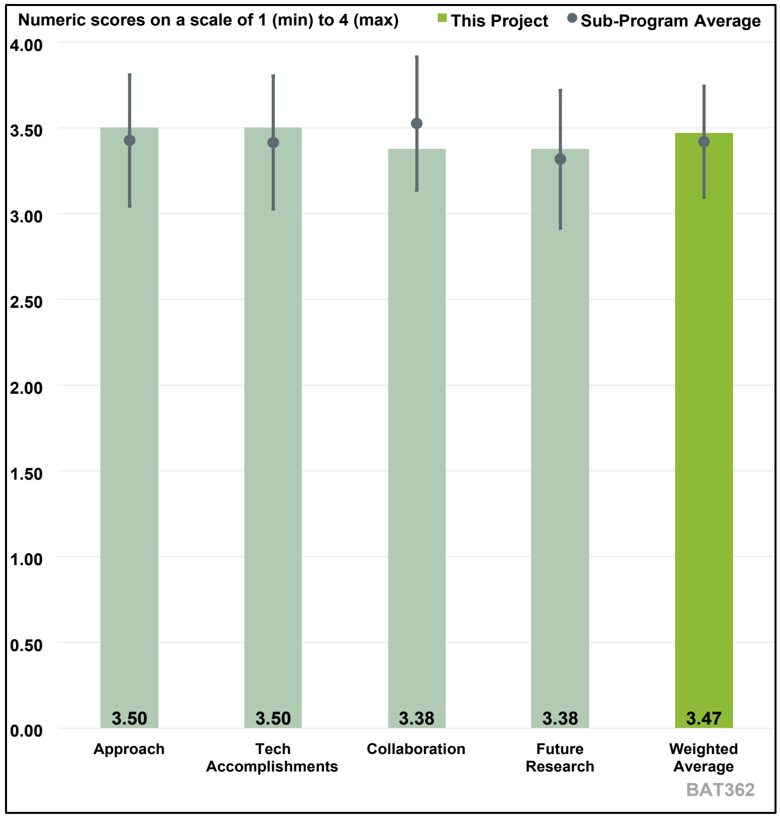

Figure 1-8. Presentation Number: BAT362
Presentation Title: High Capacity S Cathode Materials
Principal Investigator: Prashant Kumta, University of Pittsburgh

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project approaches to addressing technical barriers in next-generation Li-S battery technology are both innovative and commendable. By focusing on fundamental breakthroughs in controlling S electrochemical reactions, the development of the functional electrocatalysts as well as the spun polyacrylonitrile (PAN) fiber approach set a solid foundation for substantial advancements. The integration of materials and cell-level discoveries is particularly noteworthy, as it ensures rapid incorporation and validation of the latest research findings, leading to more realistic and practical applications. The reviewer said leveraging materials from other DOE programs and utilizing state-of-the-art DOE facilities, and industry collaborations to understand and prevent S electrode degradation is a strategic and efficient use of resources. The emphasis on multi-disciplinary approaches and enhancing collaborations between national laboratories, universities, and industry highlights a holistic and synergistic strategy. The reviewer said this comprehensive and well-coordinated effort is likely to yield highly productive results, driving significant progress in the development of high-energy, low-cost Li-metal based batteries. Overall, the approach is excellently designed and executed, promising to overcome technical barriers for S electrodes effectively.

Reviewer 2

The reviewer said excellent approach to addressing an extremely difficult problem, enabling high-energy S cathodes. Technical milestones are quantitative and excellent. The use of theory to guide experimental investigations into polysulfide trapping agents and catalysts to enable the conversion of Li_2S_2 to Li_2S is excellent.

Reviewer 3

The reviewer remarked the host design and incorporation of advanced catalysts have shown as good approaches to suppress shuttle effect and improve S utilization. This project focused on processing of integration of catalysts and host to achieve better S cathode performance. However, the demonstrated S utilization is less than 1,000 mAh/g (400-500 mAh/g in most cases) even with a higher electrolyte-to-sulfur (E/S) ratio of 8. The reviewer was not expecting a possibility of 500 Wh/kg (project goal) by using this cathode. The reviewer recommended the PI explore other catalysts or a combination of multiple catalysts.

Reviewer 4

The reviewer detailed that to realize long lifetime Li-S batteries, the team addressed two technical barriers: Identify functional electrocatalyst (FEC) using theoretical calculations, and synthesize FEC and integrate it into the S cathode. The project is well designed and the timing is well planned, but the reviewer expressed concerns. The content of FEC in the cathode is more than 5%, which could decrease the energy density a lot; the porosity of cathode is 50%, which could also decrease the volumetric energy density.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked the team developed a series of electrocatalysts to control S to Li_2S transformation. This is a crucial area, and the team made excellent progress this period. The spun PAN fiber approach to confine S and provide a two-dimensional effect are also innovative accomplishment, achieving high capacity and stable cycle life for S electrodes effectively.

Reviewer 2

The reviewer said making any progress in S cathodes is extraordinarily difficult. The down-select of several possibly electrocatalysts to one or two that perform best, for further testing, is promising. The improvements in cycling compared to the baseline carbon/sulfur composite (C/S) cathode shown in Slides 14 and 15 is impressive and promising. The reviewer noted it is impressive that Prof. Kumta shows both improvements and lack of improvements with the different functional electrocatalyst carbon framework materials. The reviewer believed industry has already demonstrated the ability to grow/incorporate carbon nanotubes in electrodes and on current collectors. This portion of the work is not bad, but hopefully is not a major effort.

Reviewer 3

The reviewer remarked the technical progress is well aligned with the project plan. The team demonstrated the use of FEC can improve the cell performance.

Reviewer 4

The reviewer commented the project should look for approaches to significantly improve S utilization at high S loading and lean electrolytes.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked this project is part of Battery500 team effort. The project team has made great efforts to collaborate within the Battery500 team and beyond, as demonstrated by their partnerships with Brookhaven National Laboratory, Malvern Panalytical, PNNL, and GM. These collaborations have significantly advanced the understanding and development of innovative battery technologies, showcasing the team's commitment to leveraging collective expertise and resources.

Reviewer 2

The reviewer said excellent collaboration with others on the Battery500 team.

Reviewer 3

The reviewer noted the team had collaborations with national laboratories (e.g., PNNL, BNL) and industries (e.g., GM), which further extended the impact of this work.

Reviewer 4

The reviewer noted the project is part of the Battery500 consortium, including multiple teams. However, the reviewer did not see the supporting characterization results to understand the reason for low S utilization. The reviewer recommended the PI work with other team members to understand and improve S utilization at the next AMR.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said very good list of future research, attempting to address a lot of issues though. Just want to make sure the team has enough resources to deal with optimizing carbon framework material (CFM) structures, generating polysulfide trapping agents, stabilizing agents on Li-metal, etc.

Reviewer 2

The reviewer said future work focuses on optimizing CFM structures with FEC and lithium-ion conductors, identifying stabilizing agents for the anode, developing low-temperature electrocatalysts, and enhancing cathode composites. Additionally, it aims to incorporate FECs in cathode architectures and optimize binder-free systems for higher capacity, cyclability, and stability in sulfur-based batteries. The reviewer said these are all critical areas need to be address.

Reviewer 3

The reviewer suggested focusing on understanding the effect of FEC on cell energy density and how to optimize the FEC content in the future work.

Reviewer 4

The reviewer said more understanding on the characterization of the cathode structure and their evolution during charge/discharge should be implemented.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said it is excellent that so many of the challenges are presented with quantitative metrics, this is an excellent way to ensure that the future research is relevant and impactful.

Reviewer 2

The reviewer remarked the project is developing an advanced high-capacity and Earth-abundant S cathode to enable Li-metal batteries beyond what can be achieved in today's Li-ion batteries.

Reviewer 3

The reviewer said mediating S material transformation and controlling S dissolution in the electrolyte are crucial research areas. This work effectively addresses these critical issues, providing significant advancements in enhancing battery performance. By tackling these challenges, the research paves the way for more stable and efficient S-based battery technologies.

Reviewer 4

The reviewer said the proposed work well supports the Batteries program in VTO by developing long lifetime Li-S batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said good use of resources.

Reviewer 2

The reviewer said overall resources for the Battery500 program appear sufficient, supporting its ambitious goals.

Reviewer 3

The reviewer commented sufficient resources are available for the team to achieve their proposed tasks.

Reviewer 4

The noted remarked weakness in the characterization of the proposed concept at the material and device level.

Presentation Number: BAT364
Presentation Title: Synergistic Effects of Electrode and Electrolyte Materials for High Energy Lithium Cells
Principal Investigator: Jihui Yang, University of Washington

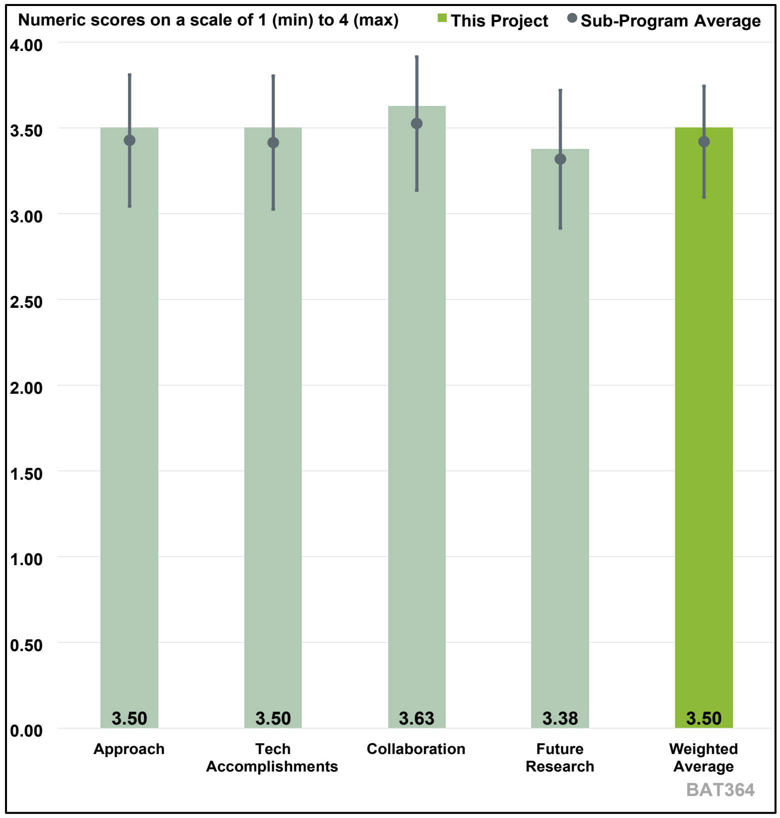

Figure 1-9. Presentation Number: BAT364
Presentation Title: Synergistic Effects of Electrode and Electrolyte Materials for High Energy Lithium Cells
Principal Investigator: Jihui Yang, University of Washington

Presenter

Jihui Yang, University of Washington

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said this project is considering failure modes involved in realistic cells, which have high cathode loading and lean electrolyte. Understanding the function under such conditions is essential to developing practical solutions, which will be relevant to making future high-energy, low-cost batteries. The reviewer said this is an approach less commonly used in the field and is important to the community. It is important to integrate capabilities across different disciplines, which take advantage of complementary strengths within the national laboratory system, universities, and industry. It is valuable that various materials science, chemistry and cell engineering approaches are being deployed within the study.

Reviewer 2

The reviewer remarked the team's evaluation of critical current density for thick cathode electrodes and the assessment of the ability of such cathodes to operate with reasonable current rates was well conceived and the approach is valid. The team approach to look at the literature for direction and behavior of thick electrodes is useful, and compare their calculations is an important aspect. The reviewer noted the LATP coating approach on the separator is novel.

Reviewer 3

The reviewer commented based on the team's report, they have addressed two technical barriers: determined the relationship between cathode thickness and rate; and used an LATP-coated separator to prevent dendrite formation by homogenizing the Li morphology. The project is well-designed, and the timing is well planned. The reviewer suggested understanding the effect of temperature and cathode chemistry (e.g., Co-free cathode) on the thickness rate dependency in the future work.

Reviewer 4

The reviewer said there are two sections to this work. The first is determination of cathode thickness rate dependence. The approach empirically determines the critical thickness to achieve C/3 rates for a series of porosities. The work was well designed for this purpose. The second section designed a functional coating on the separators. The reviewer said using LATP as the functional coating indicates improved Li-metal pulverization; however, the direct reaction with Li-ion (which is expected) was not discussed in depth. In particular, any changes to the Li-metal impedance are not presented.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that progress since last year is good. Direct electrochemical/electrical performance (i.e., impedance rise) of Li-metal anodes in contact with LATP to be completed to demonstrate long cycle life of up to 1,000 deep charge-discharge cycles.

Reviewer 2

The reviewer said technical accomplishment in understanding the critical cathode thickness rate dependence is notable. While this has been described previously theoretically as highlighted by the presenter, having a practical study which involves NMC electrodes calendared to different porosity is valuable. The reviewer said it is important to recognize that depending on the material and the electrode characteristics, transport can be limited at different length scales. It would be useful to link the information at the mesoscale electrode level to information at the atomic and particle level in future investigations, i.e., incorporating NMC type (single crystal, polycrystal) and associated particle morphology into the study to determine the effect on critical C-rate. The reviewer said it would be interesting to understand if greater than 250 μm thick without experiencing an electrolyte diffusion limit at C/3 is a universal or a specific limit.

The reviewer said the microscopy evidence of reduced Li pulverization and mitigation of pit formation is clear and impressive, as are the electrochemical cycling results. The plans not to pursue the three dimensional (3D) electrode architecture and to use impedance measurements to better understand the liquid electrolyte/LATP solid state electrolyte interfacial properties are appropriate.

Reviewer 3

The reviewer said technical progress well aligned with the project plan. The team completed the first phase study of thickness effects of cathode on charge transport by 03/31/2024.

Reviewer 4

The reviewer said the team measured the current rate at C/3 for various cathode thickness of NMC and showed that there is no electrolyte diffusion limitations that could hinder their operation at this rate. The authors did not specify what NMC chemistry was used; the electrical conductivity of the material could make a difference. The reviewer said Slide 7 is noted as Technical Accomplishments but in actuality, this is simply data taken from the literature. As for the LATP coated polypropylene, the team provided SEM of the Li-metal and it is clear that the Li deposits more evenly. The number of cycles is only one, and the reviewer said the team should have done more cycles to look at the Li morphology. Also, the impedance of the LATP coated separator was not measured. Certainly, this could make a big difference in the practicality of the approach. However, the team's full body of work is not sufficient and all-encompassing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said that as part of Battery500, this work is in close collaboration with PNNL researchers. The reviewer noted future work to scale to 5-10 Ah pouch cells will require additional collaborations.

Reviewer 2

The reviewer said impressive collaboration across the members of Battery500 is noted, and this work is no exception. Highly successful coordination was completed.

Reviewer 3

In this project, the University of Washington is collaborating with Stanford/SLAC and the University of Maryland to analyze the mechanisms of coated separator. The reviewer was not sure if any battery separator industry is involved in this project. If not, it might be helpful to involve one (e.g., Celgard).

Reviewer 4

The reviewer was well aware of the very interactive collaboration and exciting work happening across the Battery500 consortium. However, this specific presentation, while emphasizing important recent results at PNNL and the University of Wash, did not showcase the collaboration and coordination across the project. In future presentations it would be valuable for the coordination across the project team to be highlighted in more detail.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said future plans to implement the nano-coated separator in coin-cell and pouch cells applications aligns with the program targets. Future work should be considered to identify and characterize the impedance increase due to the expected reaction products between LATP and Li-ion metal. The reviewer said a comparison of LATP versus another coating material based on this analysis is important before scale up and cell builds.

Reviewer 2

The reviewer noted that further understanding the reaction-diffusion dynamics in thick cathodes is a useful goal. Additional specific suggestions relevant to future studies are noted above. The long-term stability of a PE separator with a nano coating in Li-metal batteries merits further investigation. Comparisons employing symmetric and full cells should yield useful information.

Reviewer 3

The reviewer said proposed future work is plausible and good. More work is needed, however, on the understanding of LATP functionality, just like what was presented in previous AMR reports.

Reviewer 4

The reviewer commented the team clearly defined the purpose for future work, which is to achieve Li-metal batteries with long lifetime and high energy density. In the near future, the team proposes to understand the separator coating mechanisms and integrate the functional separator in their battery demonstration. This will increase their successful rate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said yes, this work aligns and supports the goals of the Battery500 consortium.

Reviewer 2

The reviewer said this program is highly relevant to EERE VTO subprogram objectives, toward developing next-generation high-energy, low-cost batteries for EVs.

Reviewer 3

The reviewer remarked this project is very relevant and important to the Battery500 objectives of using Li-metal and thick high-Ni cathodes.

Reviewer 4

The reviewer commented the proposed work well supports the Batteries program in VTO. The proposed Li battery will have long lifetime, and high energy density, which fulfills the objectives of reducing volume, and weight of batteries, while simultaneously improving the vehicle batteries' performance (power, energy, and durability). It is worth considering the safety performance of Li-metal batteries because one of the VTO's objective is to increase the ability to tolerate abuse conditions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources for this project are sufficient.

Reviewer 2

The reviewer remarked the current project resources are sufficient and appropriate.

Reviewer 3

The reviewer said sufficient resources are available for the team to achieve their proposed tasks.

Reviewer 4

The reviewer said more impedance (for example analysis with electrochemical impedance spectroscopy [EIS]) is needed in this work. Perhaps the team needs additional electrochemical instrumentation to fully measure the LATP properties and the impedance associated with thicker cathodes.

Presentation Number: BAT365
Presentation Title: Stabilizing Lithium Metal Anodes by Interfacial Layer and New Electrolytes
Principal Investigator: Zhenan Bao, SLAC National Accelerator Laboratory

Presenter

Zhenan Bao, Stanford University / SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

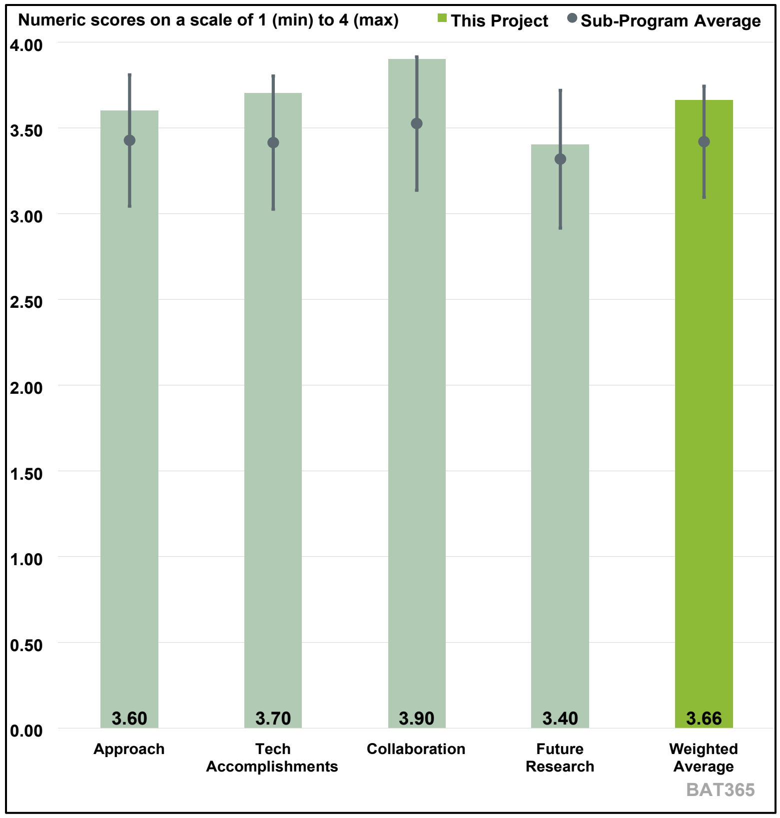

Figure 1-10. Presentation Number: BAT365 Presentation Title: Stabilizing Lithium Metal Anodes by Interfacial Layer and New Electrolytes Principal Investigator: Zhenan Bao, SLAC National Accelerator Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the proposal is geared toward discovering electrolytes and interfacial layers for stabilizing 500 Wh/kg rechargeable batteries. The team has settled on Li-S and Li-NMC (high Ni content). The team is expansive covering 14 institutions, and the PIs are world leaders. The reviewer said the project is well-designed, and the approach is rigorous and noteworthy.

Reviewer 2

The reviewer remarked the approach by Dr. Bao is excellent as always. Improved electrolytes and stable interlayers are critical to enabling Li-metal anodes. The reviewer encouraged this team to consider adopting quantitative milestones to demonstrate progress towards improving either Wh/kg, cycle or calendar life. The existing milestones are good but are all qualitative.

Reviewer 3

The reviewer said there is a clear approach to drive fundamental breakthroughs in controlling the electrochemical reactions in high-energy electrode materials and cells for next generation high-energy, low-cost batteries. Incorporating both high CE electrolytes and novel coatings into the study provides two complementary pathways from which to address the challenges.

Reviewer 4

The reviewer said Dr. Bao's overarching goal is to design electrolytes and Li-metal coatings for high coulombic efficiencies in Li-metal cycling. In so doing she systematically explored how fluorination of ethers affects the SEI composition on Li. This is a really well thought out study that involved changing the number of fluorine on various carbons within the ether as well as looking at the effect of solvent purification (impurities). She found that the use of such solvents will require proper purification in the scale up stage, which may add cost in the short term before economies at scale catches up. The reviewer said the shift to full pouch cells by working with University of Texas-Austin was good to see pushing the technology further.

Reviewer 5

The reviewer commented the presenter listed the general approaches to control the electrochemical reactions in high energy electrode, and to scale up the discovered materials with resources within the DOE programs and industry. They are all encouraging but too general. The critical issues such as the compatibility between the designed electrolyte and high-Ni NMC/S cathode, the problem of cell thickness variation during cycling, material utilization of high loading electrode and the fading mode under lean electrolyte in lithium metal batteries (LMB) were not specified and were not addressed in this annual review. The reviewer said maybe it is more appropriate to state that the project is to limit the dendritic growth of Li-metal anode and achieve high CE cycling with rationale electrolyte and anode coating design.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said technical progress is excellent. The reviewer appreciated the attention to the relationship between molecular structure, solvation, and electrochemical stability (Slides 8-10, 17). The reviewer thought the inclusion of acetals is interesting. The conductivity of F2DEM is very interesting. The collaboration between Stanford, where solvents are being designed, and ANL where, the solvents are being scaled up, is impressive.

The reviewer also appreciates the attention to purity. Very often, small levels of contaminants can dominate side reactions in electrochemical systems and ensuring that the data reflect the designed molecule is important. Stability of solvent F5DEE to NMC622 is noteworthy. The use of molecular simulations to elucidate degradation mechanisms is complementary to the experimental program. The reviewer also appreciates the honest reporting of instability against the target-NMC811 for high energy. However, it is only with this kind of discrimination that we can hope to achieve the high goal of 500 Wh/kg. Moving on to the design of layers, it is interesting to see that creep (not modulus) has been identified as the important metric for cycling stability (Slide 14). It seems to be consistent with emerging literature. The new material being patented (Slide 20) is innovative and interesting, and the cycling performance of FDMB is very impressive.

Reviewer 2

The reviewer pointed out that the importance of electrolyte purity is a critical item to be understood by the entire program. It seems likely that critical impurity levels will vary depending on the specific electrolyte being used, but a minimum purity level for all to adhere to might be a good idea. Cycle data in Slides 12&13 is impressive and encouraging. Would be nice to see cycling data with varying levels of impurity in the electrolytes, but perhaps that is down elsewhere. The reviewer said it is also very promising to see some of these materials tested in cells at PNNL, and noted a very impressive diagnosis of SEI evolution during cycling shown on Slide 15.

Reviewer 3

The reviewer said a rational design of weakly solvating electrolyte solvents has shown significant progress through the project. Understanding the steric and electronic effects and the role of solvation in the system is valuable for the community. For the most promising electrolytes, it would be useful to have more information about the conductivity impacts on use of the electrolytes under different use cases (i.e., different rate cycling). Often there is a tradeoff between stability and transport, and it would be useful to understand this in greater detail based on the findings of the team.

Reviewer 4

The reviewer remarked the publication record proves the technical progress of this project. The work has brought good understanding of how fluoro-ethers coordinate to Li ions and the team has looked at Li-metal cycling, Li plating, and explored the use of the electrolytes in various full cells with differing cathode materials. The reviewer appreciated the logic of keeping the system binary, one salt with one solvent. This will add in understanding more complex electrolyte formulations.

Reviewer 5

The reviewer commented the deliverables partly align with the project plan. The mechanistic properties and the evolution of the SEI was studied in SLAC and BNL, acetal-based solvent was designed to further stabilize the LMB, validation of the electrolyte was done by PNNL and other universities, new study on Li-metal coating was published on Nature Energy. However, it does not seem to have any deliverables related to “understand the good fluorinated electrolytes developed recently.”

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said there are clear handoffs between different team members. Electrolytes designed and synthesized on a small scale are being purified at ANL. Electrochemical stability of the same compounds is being studied in full cells at Binghamton and Idaho National Laboratory (INL), and examined theoretically at Texas A&M.

Reviewer 2

The reviewer noted very strong collaboration.

Reviewer 3

The reviewer said the project shows engagement across the program taking advantage of complementary expertise in theory, experiment, and characterization within the national laboratories and university partners. The presentation effectively highlighted roles of the teaming partners and their valuable contributions to the program.

Reviewer 4

The reviewer said that the PI’s group is very much integrated with the Battery500 team, as well as outside.

Reviewer 5

The reviewer remarked there are active collaborations within and outside of the project team, and it serves as a good example of how the synergy from the Battery500 team accelerates and deepens understanding of new electrolyte systems. It will be even better to develop capabilities to predict the physiochemical properties of the fluorinated ethers with potentially different structures in the future.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented proposed future work follows directly from the accomplishments described and is consistent with the milestones. It follows logically from prior work and is aimed at meeting overall programmatic needs.

Reviewer 2

The reviewer said excellent proposed future work is focused on further understanding the Li-metal SEI and its evolution during cycling with different electrolytes and current densities.

Reviewer 3

The reviewer said the proposed research is good, and takes the necessary next steps. However, the reviewer suggested that increased stress tests and advanced cycling protocols be incorporated to facilitate low Co cathode degradation (or to show electrolyte's ability to stabilize).

Reviewer 4

The reviewer remarked while the key targets of this project are to develop electrolyte and Li-metal coating to enable high CE cycling of Li-metal anode, it is necessary to consider the compatibility of the new solvent with other components in the cell, their physical properties (vapor pressure, boiling point, density) and the ion transport kinetics at industry relevant conditions to understand the limits of the design and truly enable high-energy Li-metal batteries.

Reviewer 5

The reviewer said results reported were very impressive for understanding fundamentals and moderate cycle life behavior (200-500 cycles). The proposed future research emphasizes continuing to elucidate fundamental SEI properties. However, the reviewer encouraged the team to provide more specific plans toward the objective of achieving long cycle life of up to 1,000 deep charge-discharge cycles. Understanding the onset of electrolyte breakdown in terms of cycling condition (depth of (dis)charge, and cycle life) would be valuable for the community. The reviewer asked is there an inherent advantage to the liquid electrolyte approach or the novel coatings approach, or are specific chemistries more beneficial in this regard?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer pointed out one of the objectives of the VTO program is to enable high specific energy rechargeable batteries and enabling Li-metal is the key to meeting this objective. The work of the team is clearly aimed at this goal.

Reviewer 2

The reviewer said understanding and improving Li-metal stability during cycling is critical to enabling Battery500's success.

Reviewer 3

The reviewer said this is a relevant project which supports VTO subprogram objectives.

Reviewer 4

The reviewer said this work supports the development of next-generation batteries for vehicular transportation. One of the benefits of this project is the understanding gained in how the SEI forms on Li-metal and evolves from the initial cycle to 100s of cycles. This is important to follow to understand and track the health of Li-metal batteries which is much more than just capacity retention. Li dendrites are still an issue and, for liquid electrolytes, the SEI is the only preventor of this.

Reviewer 5

The reviewer commented the project is highly related to the Battery500 target of achieving battery energy density of greater than 500 Wh/kg with the Li-metal battery.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said that all the institutions have sufficient resources to meet milestones in a timely fashion.

Reviewer 2

The reviewer said good use of resources.

Reviewer 3

The reviewer remarked project resources are sufficient.

Reviewer 4

The reviewer had no information on the funding of this subproject, but the PI clearly has the support she needs to contribute significant understanding to the Battery500 project.

Reviewer 5

The reviewer said resources are sufficient to achieve the stated goals.

Presentation Number: BAT366
Presentation Title: Manufacturing and Validation of Lithium Pouch Cells
Principal Investigator: Mei Cai, General Motors

Presenter

Mei Cai, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

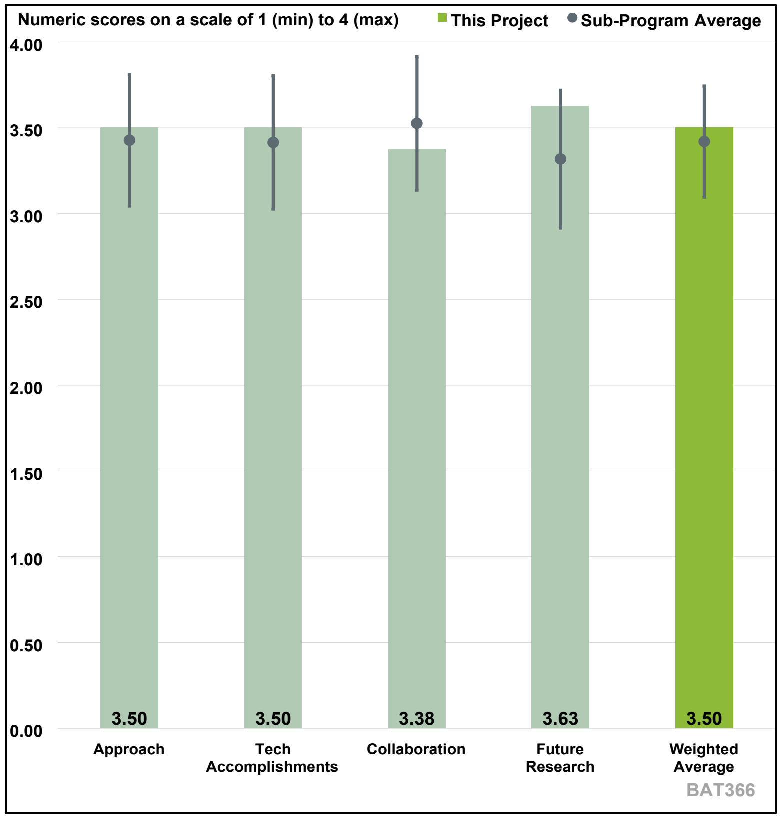

Figure 1-11. Presentation Number: BAT366 Presentation Title: Manufacturing and Validation of Lithium Pouch Cells Principal Investigator: Mei Cai, General Motors

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project's goal is to couple a Li-metal anode with a high-Ni-NMC or S cathode to "achieve a specific energy of up to 500 Wh/kg through cell level design and optimization of materials and architectures." The approach includes "integrating development and discoveries from materials to cell level" and leveraging "state-of-the-art DOE facilities to understand and prevent degradation." In this project presentation, GM has been assigned the task of C/S composite electrode fabrication and Li-S pouch cell development. Multiple C/S active materials, electron conduction additives, binders, and current collectors are being evaluated to optimize electrode fabrication. The reviewer said initial electrochemical tests were conducted with various electrode formulations and reasons for cell performance loss examined with techniques that include ultrasonic testing. In general, the project design and timelines appear to be reasonable, and the appropriate technical barriers are being addressed.

Reviewer 2

The reviewer said Dr. Cai's team conducted some optimization baseline measurements to evaluate Li-S and Li- Sulfurized polyacrylonitrile (SPAN) cells. They also developed ultrasonic imaging to correlate cell failure (capacity loss) with electrolyte depletion. The team used a material design sheet to predict the energy density. The team's characterization is focused on understanding why actual cells miss the energy density predictions in pouch cells.

Reviewer 3

The reviewer said the project is well designed and focused on resolving the issues currently present in Li-S technology.

Reviewer 4

The reviewer remarked the approach as presented in the approach section is fairly generic and does not really get at the unique capabilities that will be applied to this problem. The team indicated that their job is to confirm that the S cells will be manufacturable. This is great.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted the presentation includes a summary of electrode optimization tests. Some cathode binders are more suitable than others. For example, carboxymethyl cellulose (CMC)-only binder yields brittle coatings, whereas CMC-styrene butadiene rubber (SBR) improves initial mechanical properties, but the SBR oxidizes and degrades during cycling. Polyacrylic acid (PAA-) type binders have been selected for "fine formulation tuning." Pouch cells containing elemental S cathode (1Ah) and SPAN cathode (1.4 Ah) have been assembled and are being tested. The reviewer said cell parameters (including cathode capacity, electrolyte content, etc.) are first determined to achieve the target energy density. Initial tests conducted on the pouch cells appear promising and the technical progress appears to be in line with project plan.

Reviewer 2

The reviewer said the team has systematically down-selected cathode and binder components using coin cells and processability in roll-2-roll methods. The team correlated nonuniform Li plating with gas generation from electrolyte decomposition. The ultrasonic imaging effective in understanding gas distribution after cycling.

Reviewer 3

The reviewer said the project has made good technical progress and 1 Ah pouch cells have been designed and fabricated that meet goal of 300 Wh/kg.

Reviewer 4

The reviewer detailed technical accomplishments. Technical Accomplishment 1) The team performed a complete design of experiment of 3 carbon additives and 4 binders and found that a blend of MWCNT and PAA with or without Li performed the best. Technical Accomplishment 2) The team performed a root cause and tear down analysis of the pouch cell of the cell with CMC binder and found gassing, that the binder was brittle, non-uniform plating, and a change in color of the separator. This cell performed the worst of the four with a blend of MWCNTs. Technical Accomplishment 3) Gas analysis of CMC-SBR cell showed methane and other hydrocarbons. This cell lost half of its capacity in the first 5 cycles and then maintained capacity for the next 20. Technical Accomplishment 4) A cyclic voltammetry was performed on SBR. It appears it is not stable above 2.5V vs Li/Li+. The team believes vulcanization occurs in the presence of S and conclude they cannot use CMC or CMC/SBR. Technical Accomplishment 5) The team measured the rheological properties of the slurries with different binders and the adhesion and found that the Li-PAA has almost no adhesion. PAA-co polymer had the best adhesion. Technical Accomplishment 6)

Using a spreadsheet the team designed 4 batteries of energy densities of 500, 400, 350, and 300 Wh/kg by varying the electrolyte content, porosity and cathode loading. The specific capacity used in designing batteries of a given energy density is much higher that the practical capacity achieved in actual cells. Technical Accomplishment 7) Increased charge voltage results in improved capacity but significant gassing—pressure increased from 10 psi to 47 psi. Technical Accomplishment 8) Evaluated SPAN in coin cells and pouch cells. The coin cell performance is good. Delivers just under 700 mAh/g for 200 cycles. Pouch cells just started. Technical Accomplishment 9) Still developing a technique for using ultrasonic mapping to map concentration of electrolyte in a pouch cell.

In general, the team is trying to establish a reasonable baseline pouch cell by screening binders and additives. One concern the reviewer expressed is that the cells' CE appears to worsen with cycles and finishes near 80% after around 100 cycles. Seems like the team needs to address the crossover problem. The team is using 2x Li in their cells, so it is mostly an evaluation of the cyclability of the cathodes with different in actives. There have been reports that the excess Li needs to be about 50% to meet energy density goals. The reviewer would like to see more about manufacturing and if the PIs have a plan for removing the non-uniform utilization of the battery.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the GM team appears to be well connected to the rest of the Batt500 team.

Reviewer 2

The reviewer said the GM team appears to be collaborating with the PNNL team and INL team for the cell engineering development. It is not clear from the presentation where the characterization work (SEM, infrared, XPS) was conducted; it appears to have been conducted at GM. Collaborating with the other team partners for electrode and cell characterization may help accelerate cell development.

Reviewer 3

The reviewer noted GM is working with INL testing cells and thinks more correspondence with PNNL and other Battery500 partners on the material design landscape would be benefitable. A lot of work is happening in Battery500 and the imaging tool and pouch cell processing developed here should be used throughout.

Reviewer 4

The reviewer said it appears that GM is out on their own testing binders and carbons in their pouch cells as they work on electrode and cell optimization. The reviewer noted the team received SPAN from INL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted proposed next steps include "further optimization of electrode formulation," "processing and integration of optimized components from [Battery500] teams" and testing cell designs which yield more than 300 Wh/kg energy density. In addition, it would be good to understand the effect of other temperatures (both lower and higher than room temperature) on cell cycle and calendar aging.

Reviewer 2

The reviewer commented future plans are to continue optimization and to integrate with Battery500 teams' optimized components. The reviewer would like to see the expansion of the ultrasonic mapping to other Battery500 systems.

Reviewer 3

The reviewer said the proposed future research focused on further improving energy density and using non-destructive ultrasound to monitor electrolyte consumption/gassing seem like a good plan.

Reviewer 4

The reviewer noted the team's next step is they plan to keep doing what they have been doing which is trying different materials until they come across something that works better than previously tried materials. The big problem this reviewer has is the summary does not really relay that the team fully understands why what they have been trying is not working. The reviewer would like to see more work on understanding the nonuniformity that grows in the cells and maybe achieve some basic understanding of this problem.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project is very relevant to VTO's goal of improving energy density and removing dependency on critical materials.

Reviewer 2

The reviewer said the PI's team is focused on Li-S system for the high energy density applications for VTO. The development of non-destructive pouch cell level characterization methods is important for quality control and assurance. The reviewer noted work like this is sometimes neglected in favor of route optimization and new materials, which are important, but consumer safety and commercial reliability/predictability are key in economic advancement.

Reviewer 3

The reviewer guessed that the end game here is a full, pouch cell that meets a specific energy target and achieves 1000 cycles. Since GM has large cell build capability, the reviewer assumed they will play a large role in meeting this target, so their effort is very relevant.

Reviewer 4

The reviewer affirmed yes, the project supports overall VTO subprogram objectives. That said, for commercial viability, cell performance at various temperatures needs to be determined. Furthermore, safety tests (overcharge, overdischarge, etc.) needs to be conducted on these Li anode cells.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said funding support seems reasonable for this work, the team is hitting their milestones.

Reviewer 2

The reviewer said total resources available for the overall project are sufficient. It is not known whether the resources available for this particular project are sufficient, as no information is provided.

Reviewer 3

The reviewer noted the Battery500 team goals are very ambitious, and the high budget is in line with what is needed to meet those goals.

Reviewer 4

The reviewer said it is hard to give a good answer to this question because, like all of the other Battery500 projects, the PIs report funds spent for the entire program instead of specific to the individual project under review. That said, there was not significant work proposed that was much different than the level of work presented so the reviewer believed the present funds are sufficient.

Presentation Number: BAT367
Presentation Title: Multiscale Characterization Studies of Lithium Metal Batteries
Principal Investigator: Peter Khalifah, Brookhaven National Laboratory

Presenter

Peter Khalifah, Brookhaven National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

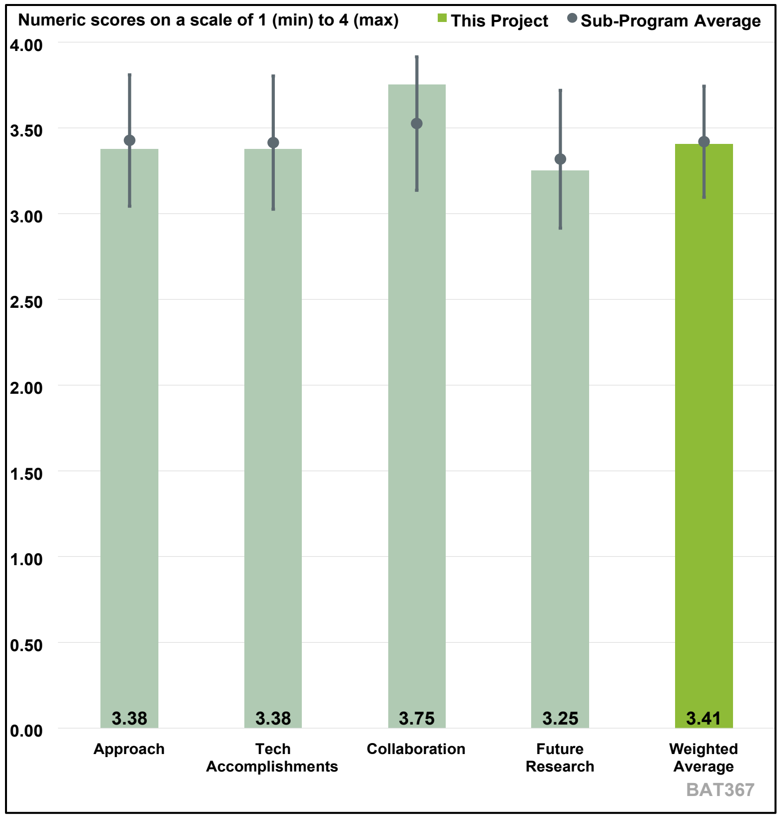

Figure 1-12. Presentation Number: BAT367 Presentation Title: Multiscale Characterization Studies of Lithium Metal Batteries Principal Investigator: Peter Khalifah, Brookhaven National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project team investigates cell aging in NMC cathodes, heterogeneity in Li-S cells, and the SEI using advanced synchrotron X-ray techniques. These techniques include operando X-ray diffraction (XRD) and PDF analysis, spatially resolved 2D XRD mapping, and soft XAS of Li and S. The results deepen our understanding of the electrochemical properties of these systems and provide guidance for new materials synthesis. The reviewer said that with years of experience in applying synchrotron techniques to battery studies, the team is at the forefront of cutting-edge research to advance energy storage technology.

Reviewer 2

The reviewer said that most of the first 3 to 4 slides are generic to the program so one does not get a good understanding of how the researchers listed on the first slide approached the problem defined in the title of the first slide. The Milestones let us know that several different advanced characterization techniques will be used on all parts of the system.

Reviewer 3

The reviewer remarked as a cross-cutting activity, this effort effectively contributes to addressing technical barriers in many areas within the Battery500 program. The first two examples given—the PDF study helping to explain the extra capacity of the new UCSD SPAN material and the ultrasound/synchrotron mapping to help partner GM explain the heterogeneity in thick S cathodes—support the conclusion that the cross-cutting team is effective in helping other team members surmount challenges. In fact, perhaps due to the nature of the cross-cut effort, this research effort seems much more integrated and less isolated than some of the other Battery500 efforts that were presented throughout the day, where it often appears that a small team was tackling a challenge by themselves. The reviewer said this would argue for more resources being devoted to the cross-cut efforts when appropriate opportunities appear.

In general, an area for improvement in the overall approach might be to not stop when an explanation that is consistent with the data is generated, but to continue on to rule out other explanations that might also be consistent with the data. The reviewer cited as an example, in the new SPAN material study, it was not clear that the offered explanation was the only possible mechanism or that the PDF and modeling uniquely pinpointed the reason for the higher capacity. It would be nice to see a project designed to pursue experimental and computational data that definitely rule out competing explanations. Also, data is often not shown with error bars, so the uncertainty in the conclusions is not evident. The reviewer said it is hard to believe claims of super sensitivity of 1% SOC and 1% loading uniformity without seeing some error bars and uncertainty analysis now and again. Similarly, for the SEI work on F5DEE, it would have been nice to see error bars and how repeatable the non-linear speciation really is. The reviewer said that despite this, the cross-cutting effort is generally designed well and is overall making important and substantial contributions to Battery500 by providing key data to unravel mechanisms, performance changes, etc., throughout the larger program.

Reviewer 4

The reviewer said the approach using state-of-the-art characterization techniques for investigating the different systems being studied by the Battery500 consortium is very good. However, it seems to be a collection of results, without a clear statement of how they are helping Battery500 to meet its goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer detailed accomplishments. Accomplishment 1) Position-dependent speciation in Li-S ouch cells. The team conducted two-dimensional mappings of Li_2S distribution in a Li-S pouch cell using XRD measurements. The team observed that the spatial heterogeneity in speciation changes with the state of charge and is not fully irreversible—the Li_2S distribution differs significantly between the 1st and 2nd charge cycles. The team infers that this heterogeneity depends on the electrolyte distribution. Investigating the cause of this irreversibility could provide valuable insights for improving cycle stability.

Accomplishment 2) Synchrotron diffraction mapping of aged NMC: The team conducted Li cell SOC mapping using XRD on four Li/NMC cells aged 11 months under different pressures, SOCs, and temperature operating modes, with a cell aged under open circuit voltage (OCV) at 10 psi, 25°C, and 100% SOC as the reference. The spatially resolved SOC provides new insights into the effects of aging. The mapping was performed at the discharged state. The reviewer noted that although technically challenging, in situ mapping during a full discharge process would yield more informative results.

Accomplishment 3) SEI evolution when using new F5DEE electrolyte: Using synchrotron XRD, the team measured the detectable crystalline amounts of Li_2O and LiF in the SEI of a Li-metal cell with F5DEE electrolyte. Both Li_2O and LiF increase with cycle numbers, but their ratio exhibits a non-monotonic trend.

The reviewer said it would be helpful to combine the in situ and operando characterization with thermodynamic modeling to predict long term performance of battery systems. The reviewer found that in general, the project is making steadfast progresses, as evidenced by the high-quality research outcomes.

Reviewer 2

The reviewer said that the technical progress in the various areas is very good. The SEI studies are providing insight into mechanisms for formation. The reviewer was not clear how crystalline Li_2O contributes to SEI effectiveness since it is not a good Li ion conductor. The reviewer said that overall, it would be good to show better how the characterization and understanding is contributing to the overall goal of the Battery500 program.

Reviewer 3

The reviewer said this research effort is continually meeting its objectives and timelines, and the results are translating in a timely fashion to many efforts across Battery500, contributing to the overall success of the larger program. The reviewer said it is notable that the cross-cut milestones are being met with regularity because many of the experiments and computations are difficult to do or otherwise require some level of invention to apply a particular characterization or modeling technique to the present problem. The reviewer said that having to unravel coupled processes across length scales (1 Å –10 cm) and time scales (1 s –1 yr) is not easy. Given that national laboratory user facilities—both experimental and computational—are necessary for much of this work, it is impressive that the progress has been steady and that milestones are being met.

Reviewer 4

Regarding Technical Accomplishment 1, the reviewer noted the team completed a PDF study of a new span from UCSD and discovered that mechanism for the 25% enhancement capacity. Regarding Technical Accomplishment 2, the team used modeling to support understanding of SPAN lithiation mechanism and developed a method for casting a thin layer of SPAN that did not require an additive. Regarding Technical Accomplishment 3, the team used ultrasound to follow uneven electrolyte consumption during cycling and correlated that with synchrotron data that tracked Li_2S non-uniform generation and consumption. Regarding Technical Accomplishment 4, using XRD data, the team was able to chart the ratio of Li_2O/LiF with cycle life and show that this ratio first increases and then decreases. Regarding Technical Accomplishment 5, the team used AFM to show that CE correlated well with the creep of the SEI, which was dependent on electrolyte components. Regarding Technical Accomplishment 6, the team used TOF-mass spectrometry to map the CEI on the surface of cathode material at full charge and full discharge.

The reviewer noted the emphasis of the presentation was work at BNL, and asked why is the electrolyte not uniformly distributed, and why so much non-uniformity in the cell? The Li is reacting non-uniformly which is leading to non-uniform use of the cathode. The reviewer found that overall, this was a presentation of many efforts at characterizing different aspects of Li/NMC cell performance. The team is starting to understand the system a little better with each experiment. It is not yet clear how this is translating to solutions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the team has established extensive and productive collaborations within the Battery500 Consortium. The collaboration model of the Battery500 Consortium, which combines the strengths of national laboratories, universities, and the R&D sections of industrial companies, is exemplary and highly effective.

Reviewer 2

The reviewer said the team has excellent collaborations across the different institutions. An example of this is the studies of the F5DEE electrolyte by different institutions to understand its SEI formation mechanism.

Reviewer 3

The reviewer said as implied in response to a prior question, the collaboration and coordination in this effort is very impressive. There obviously has to be coordination between cross-cut team members (e.g., experimental and computational efforts have to be aligned), but the coordination with most of the rest of the Battery500 team is outstanding based on the results presented at the review. Most of the work presented had many moving parts, and the coordination of the efforts was the key to making progress.

Reviewer 4

The reviewer noted there are several different institutions using their specific techniques to study the myriad of problems of trying to a get a Li-based battery to cycle a thousand times. The teams are doing good research but as mentioned above, it is not clear how this information is being used to design better electrolytes that allow for high CE and uniform plating characteristics.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed that the “Remaining Challenges and Barriers” section should outline the problems to be resolved in the next stage of research. Therefore, ‘N/A’ is not a proper answer. Nevertheless, the team has proposed future research with concrete plans. These plans remain centered on synchrotron and neutron techniques and focus on Li-S and Li-metal battery systems. The primary objective of the research is to develop an atomic-scale understanding of the electrochemical processes in these battery systems to improve their performance.

Reviewer 2

The reviewer said the PIs talk about continuing to study the NMC surface but is not sure why when there are several cathode programs already doing this. The proposed future work also includes a mapping study of Li-S when varying the cell formulation, pressure and with aging. To better understand the mechanisms of SPAN lithiation to develop new materials, and to study the SEI formed from alternative electrolytes. It would be nice if the team had some hypotheses on some of these problems that they were testing but it looks like a lot of the work is still mapping.

Reviewer 3

The reviewer commented future plans are okay, but they are a bit generic and were only very briefly presented. Objectives such as “continue to understand and enhance capacity of SPAN systems” translate to a vague promise to do more good work in the future. It would have been nice to see a little more prioritization and specificity in the future plan. The reviewer asked what is the biggest challenge for the cross-cut team, and where can they have the most effect and contribute the most?

Reviewer 4

The reviewer remarked the proposed work is clearly defined, but its contribution to meeting the consortium goals is not so well defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the cross-cut effort clearly supports the overall VTO objectives by making substantial contributions to the progress of the Battery500 effort, which itself is a flagship effort within the VTO portfolio of energy storage research. It is fairly easy to look at the overall progress of Battery500 towards its objectives each year and be able to attribute some of that progress to the key efforts coming from the cross-cut team. These contributions are most obvious in two Battery500 objectives: demonstrate long cycle life of up to 1,000 deep charge-discharge cycles; and achieve total control of battery chemistries for robust, scalable and commercially viable technologies. It is really hard to reach those kinds of performance objectives when designing, building, testing, and optimizing battery systems with blinders. The cross-cut team continually provides the relevant information to Battery500 colleagues so that they can see what is actually happening and then control it to achieve long life and safe performance.

Reviewer 2

The reviewer noted the project is a part of the Battery500 consortium, which aims on developing next generation high-energy low-cost batteries for EVs.

Reviewer 3

The reviewer said the program supports the VTO objectives in achieving a higher energy density battery through use if Li anodes and NMC as well as Li-S batteries. It contributes to the crosscutting effort of the consortium.

Reviewer 4

The reviewer said the work is relevant to VTO’s mission as a Li-metal based system is considered one of the best approaches to getting to 500 Wh/kg. All of this work goes to understanding the present limitations in such a system.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented resources are clearly sufficient. However, new opportunities may arise as experimental and computational capabilities increase and researchers “learn by doing.” So, if appropriate, funding could be increased if the proper opportunity appeared.

Reviewer 2

The reviewer said funding is sufficient for the project to successfully achieve its adjectives.

Reviewer 3

The reviewer remarked resources for the characterization is excellent and contribute to the objectives of the program.

Reviewer 4

The reviewer said there is no indication of the resources dedicated to this effort in the presentation. That said, there does not appear to be a lot of work proposed that would require more resources than the work performed this year.

Presentation Number: BAT368
Presentation Title: Full Cell Diagnostics and Validation to Achieving High Cycle Life
Principal Investigator: Eric Dufek, Idaho National Laboratory

Presenter

Eric Dufek, Idaho National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

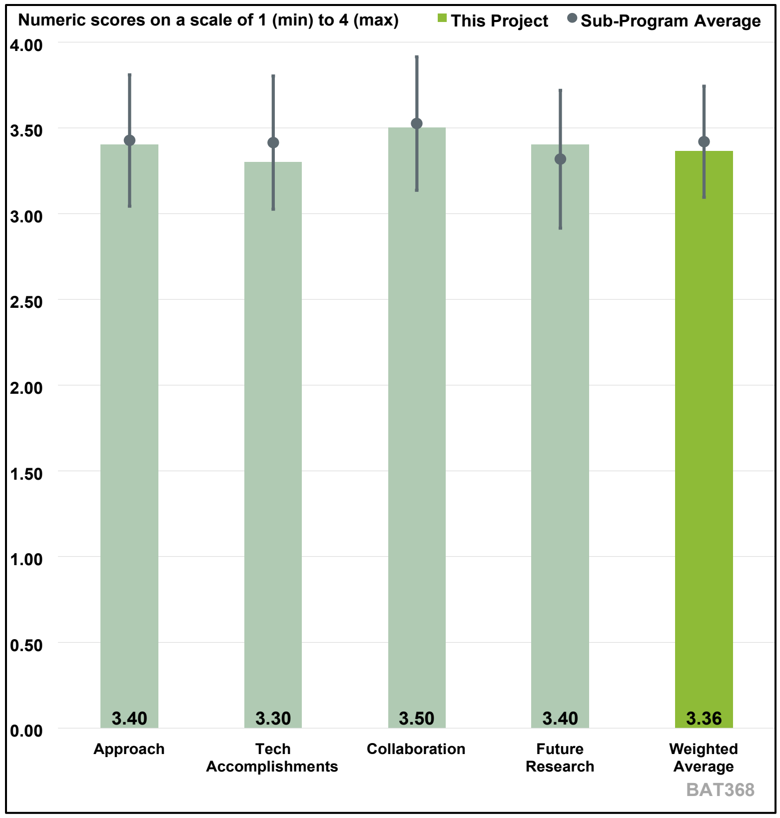

Figure 1-13. Presentation Number: BAT368 Presentation Title: Full Cell Diagnostics and Validation to Achieving High Cycle Life Principal Investigator: Eric Dufek, Idaho National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked this project's focus is to explore failure modes in real cells involving SPAN cathodes. It seems like calendar life and aging was the focus of this year. Timeline is appropriate and shows steady process in understanding cycle and calendar life with the development of accelerated aging.

Reviewer 2

The reviewer said standard testing protocols were developed and applied to evaluate the electrochemical performance of Li/MNC cells.

Reviewer 3

The reviewer remarked the project focuses on the needed full cell testing for long term, which help reveal technical barriers faced at more practical conditions.

Reviewer 4

The reviewer said the goal of the project is to couple a Li-metal anode with a high-Ni-NMC or S cathode to "achieve a specific energy of up to 500 Wh/kg through cell level design and optimization of materials and architectures." The approach includes "integrating development and discoveries from materials to cell level' and leveraging "state-of-the-art DOE facilities to understand and prevent degradation." In this project resources at INL and BNL are used to examine calendar life of NMC/Li cells. The reviewer said the approach is reasonable, though it is unclear why 4.4V was chosen as 100% SOC for the tests, as NMC811 electrodes yield little capacity when cycled past 4.3V versus Li. The calendar aging tests at 25 and 45° Celsius (C) are reasonable—though tests at higher temperatures (such as 55°C) and lower temperatures (such as -10°C) would be needed for the cells to be considered in vehicular applications.

Reviewer 5

The reviewer remarked in this FY, the team has been mainly working on the two technical barriers: Understanding the calendar lifetime decay; and extending cell lifetime under lean electrolyte condition. While some progress has been made, some details could be further explored. For example, how did the team understand the cathode capacity decay and anode capacity decay during OCV storage? If this is studied by ex-situ method, is this real for storage process? It is not clear about the temperature condition during the calendar lifetime testing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the NMC/Li calendar aging studies reported in this project are for up to a 18-month period. The data show that cells held at the higher SOC (100% or 4.4V) fail faster than cells held at the lower SOC (70%). Cells held at the higher temperature (45°C) degrade faster than cells held at the lower temperature (25°C). And cells tested at lower pressure (10 psi) degrade faster than cells tested at the higher pressure (50 psi). The reviewer said the effect of lean and "non-lean" electrolytes are also studied with the latter performing better than the former. In addition to electrochemistry tests, microscopy on the Li anode and X-ray diffraction of the NMC811 cathode were also performed to determine reasons for the performance loss. All in all, the electrochemical and physicochemical tests conducted are reasonable and important to support the overall project plan.

Reviewer 2

The reviewer remarked a good effort was utilized to characterize the long term electrochemical behavior of cells under different operation/storage conditions.

Reviewer 3

The reviewer said the project is making good progress towards technical accomplishment.

Reviewer 4

The reviewer said technical progress is aligned with the project plan.

Reviewer 5

For the Calendar life work, it was difficult for this reviewer to have a feel for the confidence of the data, as in, having multiple cells or at least a small discussion to the effect of "2 out of 3 these cells fail by 5 months." This is important as nonlinear processes (such as reactions, corrosions, etc.) are stochastic prior to the runaway/takeoff event. The differential analysis was important to understand how cycling may be contributing to gas evolution (electrolyte degradation). The reviewer was interested in the accelerated stress tests. More work should be done here.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked work is well supported by the partners.

Reviewer 2

The reviewer said the project presented work conducted at INL, BNL, and SUNY Stony Brook. The NMC811 electrolyte was obtained from PNNL and the LHCE electrolyte was also likely designed at PNNL. That is, the project shows good collaboration across the multiple national laboratories and universities.

Reviewer 3

The reviewer remarked collaboration was limited to Battery500 team.

Reviewer 4

This reviewer wanted to see these accelerated stress tests on other systems to understand exactly what is being stressed and how different chemistries and formulations response to them.

Reviewer 5

The reviewer remarked in addition to Battery500 consortium partners, Brown University and University of Connecticut were involved for Li-S work. The reviewer was not sure if any industry partners are involved in the project or not.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked good future research was proposed to support Battery500.

Reviewer 2

The reviewer noted a good focus on cycling impact and Li electrode performance, SPAN/Li-S cells, and wetting.

Reviewer 3

The reviewer said the team proposed to understand “how variation in initial Li state impacts life and performance.” It is not clear where the difference of initial Li state is from. Is this from air-exposure or somewhere else? It could be further elaborated.

Reviewer 4

The reviewer commented that future plans include studying “how variations in cycling impact life and Li electrode performance” and “understanding how variation in initial Li state impacts life and performance.” In addition, it would be good to understand the effect of lower temperatures (0°C and below) on cell cycle and calendar aging. In addition, the effect of other promising electrolytes should be examined.

Reviewer 5

The reviewer said there were a lot of confounds in this report. The future plans actually focus on deconvoluting these confounds (such as electrolyte formulation versus using excessive electrolyte) to aid in moving from correlative understanding to causal. This is important for others to make reasonable predictions for optimizing these Li-S/SPAN systems.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the team goal is to develop high-energy (500 Wh/kg), low-cost batteries for EVs. This project examines electrochemical performance of 100 mAh cells, with various chemistries, designed to meet the project goal. Hence, the project is relevant to overall VTO subprogram objectives.

Reviewer 2

The reviewer remarked good alignment with Battery500.

Reviewer 3

The reviewer said calendar life tests and accelerated tests are invaluable to the development and commercialization of next generation energy storage devices.

Reviewer 4

The reviewer affirmed yes, the project supports overall VTO subprogram objectives.

Reviewer 5

The reviewer said the proposed work well supports the Batteries program in VTO by developing high energy density Li-metal batteries. It is worth considering the safety performance of Li-metal batteries because one of the VTO’s objective is to increase the ability to tolerate abuse conditions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the total resources available to the project are sufficient. It is not known whether the resources available for this particular project are sufficient, as no subproject financial information is provided.

Reviewer 2

The reviewer said this project is slightly ahead of schedule and is making great progress. Funding seems appropriate.

Reviewer 3

The reviewer said there are sufficient resources.

Reviewer 4

The reviewer said sufficient resources are available to achieve the proposed tasks.

Presentation Number: BAT369
Presentation Title: High Energy Rechargeable Lithium-Metal Cells Design Fabrication and Testing
Principal Investigator: Jie Xiao, Pacific Northwest National Laboratory

Presenter

Jie Xiao, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

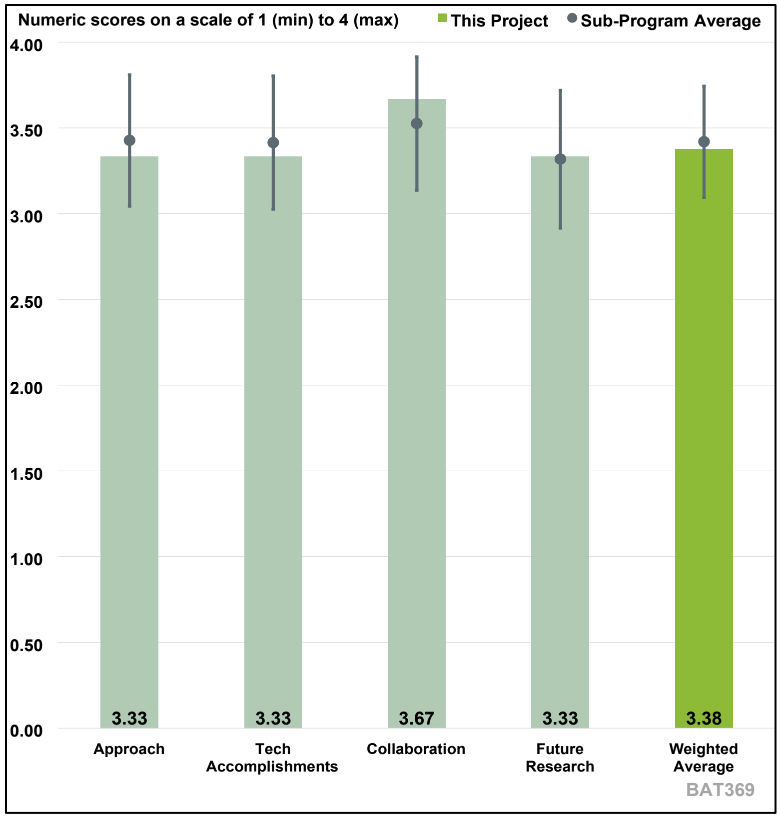

Figure 1-14. Presentation Number: BAT369 Presentation Title: High Energy Rechargeable Lithium-Metal Cells Design Fabrication and Testing Principal Investigator: Jie Xiao, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said BAT369 is one of the three keystone projects in the Battery500 Consortium, aiming for pouch cell fabrication, testing, and diagnosis. The team's approach involves developing scientific insights and a research roadmap to enable high-energy, long-lasting Li-metal batteries by testing Li-metal pouch cells under different designs and conditions, using new cell components (electrodes and electrolytes) developed by other Battery500 teams. The approach has been effective so far, and the milestones are well defined with a reasonably planned timeline.

Reviewer 2

The reviewer remarked very good progress is being made in addressing technical barriers including demonstration of a 500Wh/kg pouch cell and understanding of pressure effects. The Li anode work is well defined and systematic. The charge rate is still low and has to be overcome. It is not clear how this will be overcome.

Reviewer 3

The reviewer remarked the team says in the Approach slide that part of their approach is to develop a research roadmap to enable rechargeable high energy Li-metal pouch cells. Which essentially means they will start from a 350 Wh/kg battery and work their way up to a 500 Wh/kg battery and try to understand the engineering and cycling limits along the way. The team also plans to benchmark new material in coin cells and advance pouch cell development, which means trying to get good cycling in pouch cells. It is an Edisonian approach where they will try things and take note of the results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked the team has made good progress on the overall goals of getting to 500 Wh/kg battery according to the project plan. The team exceeded this year's goal for 450 Wh/kg cycling. Much remains to be accomplished including longer cycle life and charge rates. Very good progress has been made on the pressure effects.

Reviewer 2

The reviewer said the team conducted a systematic investigation on Li-metal coin cells and found that high areal capacity increases cell capacity but shortens cycle life, while higher electrolyte loading effectively prolongs cycle life (though it obviously lowers energy density) for thicker Li anodes. For thin Li-metal, the effect is much weaker. The conclusion is that these parameters can be used to tune the Li-metal coin cell as a model system.

For the 350 Wh/kg pouch cell, the team found that the electrolyte amount is still a deciding factor for cycle life, and thinner Li anodes work better than thicker ones. The 600-cycle capacity retention for the 350 Wh/kg cell is impressive. The reviewer noted the team also demonstrated 80% capacity retention at 215 cycles for a 450 Wh/kg pouch cell. The reviewer noted the Pressure Study: The team reported their research efforts on the interplay between uneven pressure distribution and Li deposition, concluding that the origin of the uneven distribution is the "'Li+ detour phenomenon." The team suggested that utilizing external pressure (using a hybrid device) to facilitate preferred deposition in specific anode regions can solve the problem of uneven Li plating during charging. The reviewer was not fully convinced that the electric field (EF) distribution calculated in Figure 5 of the team's Nature Energy paper can explain the origin of the uneven Li plating and does not believe that using the hybrid pressure device will solve the problem. In general, the reviewer believed that the team is making solid progress following the project plan.

Reviewer 3

The reviewer detailed accomplishments. Technical Accomplishment 1: The team first evaluated coin cell performance of Li/NMC cells varying the amount of electrolyte with thick Li foil (250 micron) and thin Li foil (50 micron), varied the loading of the cathode with thin Li foil, and used a low loading cathode, lots of electrolyte, and a thick Li foil to optimize cycle life. From this the researchers learned that for thick Li foil, the more the electrolyte the better, but the effect goes away for thin Li foil. The team also found that the cycle life goes down proportionately to the loading of the cathode going up. So the best cycle performance they could get is thick Li foil, at low loading and high electrolyte concentration.

Regarding Technical Accomplishment 2: The team then switched to pouch cell cycling, tried two different electrolyte levels, and found a 15% increase in electrolyte lead to a 66% increase in cycle life. The team also found that the cycle life improved with reduced Li thickness. The researchers say thicker Li may lead to more dry layers of SEI—this reviewer did not understand what this means.

Regarding Technical Accomplishment 3: The team now applied pressure to a cell with a loading around 3.5 mAh/cm^2 and found that the pressure in the cell cycles with cycling and that the peak in pressure is inversely related to the external applied pressure, i.e., low applied pressures result in very high internal pressures at top of charge (high level of plating). The researchers claim the pressure results in less fluffiness of Li from cycling, less exposed surface area. This also slightly extends cycle life. Eventually the cells dry out.

Regarding Technical Accomplishment 4: The team shows that the cells cycling under pressure only swell 6% to 8 %, which the reviewer assumed that is all the room there is for swelling. Not sure what the accomplishment is here. The team also took some SEMs of the edges of the cells and found Li to be very non-uniform with large columns everywhere. Regarding Technical Accomplishment 5: The team cycled multi-layered pouch cells (16 layers of Li) and found after 335 cycles that the Li in the center of the electrode is still shiny and that around the edges is dark.

Regarding Technical Accomplishment 6: The team found that for a cycled discharge anode where the Li is now in the cathode, that the Li in the center of the cell seems less used that that on the edges. Regarding Technical Accomplishment 7: The team cycled pouch cells under pressure and opened them up after discharge and claimed that the Li from the cathode seems to like to cycle in the middle of the cell. The researchers believe the pressure in the cell is uneven. The researchers gave no explanation for either hypothesis.

Regarding Technical Accomplishment 8: The team open cycled cells after charge and again claim that the Li that is originally from the NMC is cycling in the center. The reviewer did not know how the researchers deduced this. Regarding Technical Accomplishment 9: The team provided a schematic of what they think is happening and say that Li from the NMC in the early cycles preferentially plates on the Li in the center of the electrode. So, after long-term cycling, there is more pressure in the center and Li cycling at the edges goes deeper and deeper, which may be driven by lack of pressure on the edges where side reactions are greater, while the Li foil in the center is under higher pressure and plates more uniformly. The reviewer noted it helps to understand why the Li from the cathode wants to go to the center of the Li anode.

Regarding Technical Accomplishment 10: Cells were made at PNNL in 2023 at 450Wh/kg and cycled about 130 times. Similar cells were sent to GM for testing and achieved about 180 cycles. More cells built at PNNL in 2024 and they now achieve more than 200 cycles, with no explanation as to why the improvement–was this due to experience?

Regarding Technical Accomplishment 11: The last achievement reported was that the team made a cell of 500 Wh/kg specific energy and just started cycling it. The researchers basically have mapped out the space for cell construction and are learning about the effects of thin Li, high loadings, pressure, and electrolyte volumes, and are fine tuning their formulation. Not sure we are learning anything very fundamental that will lead to a specific change in one of the components that will result in a step change in cyclability.

The researchers say they say need 3.5 to 4 mAh/cm^2 to meet Battery500 energy goals. 20 micron thick Li-metal films work better because there is less Li for the electrolyte to react with. If the applied pressure is higher, the rise in pressure in the cell is less. The cycle life only partly improves because of electrolyte dry out. The researchers show pressure increase and decrease in cell from gas generation and then show a distribution of gas pressure in the cell with cycling—the reviewer asked how can a gas not be at uniform pressure in the cell. The reviewer asked why the non-uniformly plated Li does not reverse, and asked for any explanation of why the cell cyclability is improving by 40 cycles a year.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the team has established extensive and productive collaborations within the Battery500 Consortium. The collaboration model of the Battery500 Consortium, which combines the strengths of national laboratories, universities, and the R&D sections of industrial companies, is exemplary and highly effective.

Reviewer 2

The reviewer observed excellent collaboration among many industrial partners, university, and national laboratories that make use of expertise on materials, design, and characterization. For example, the new results on the 450 Wh/kg cell cycling over 200 cycles.

Reviewer 3

The reviewer said the team lists tons of collaborators on the collaboration page and on the second slide but really do not point to much collaboration on the Technical Accomplishments slides other than trading cells with GM.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked the research plan addresses the targets of the Battery500 program including redesigning cells for pressure effects, new electrolyte development, and other challenges.

Reviewer 2

The reviewer said the team has a very clear awareness of the remaining challenges. The reviewer agreed that more innovations are needed in electrolyte design and SEI control and also suggests keeping abreast of the latest developments in high-Ni or Co-free cathodes, especially those with better compatibility with high-pressure electrolytes. The proposed future research is clearly defined and heading in the right direction.

Reviewer 3

The reviewer said for future research the researchers said they have found that pressure has an effect on cyclability so the team will redesign the pouch cell structure to enhance homogenous Li plating. The reviewer was not sure how exactly what the researchers are going to do here. The PI said the team will develop a new electrolyte compatible with Li-metal and NMC—not sure how any of the work presented will lead to a better electrolyte formulation. And the researchers will continue to make cells and try to figure out what leads to better cyclability. It would be nice if there was a list of things the team learned that will guide the cell changes.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted the project is a part of the Battery500 consortium which aims to develop next generation high-energy low-cost batteries for EVs.

Reviewer 2

The reviewer affirmed this project is relevant to the VTO goals of achieving a high energy density battery based on use of Li in combination with NMC.

Reviewer 3

The reviewer said the goal of the program is to make batteries with 500 Wh/kg specific energy that cycle 1000 times without a lot of chemistry development. The researchers are making some progress.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient for the project to achieve the goals as planned.

Reviewer 2

The reviewer commented the project has sufficient resources.

Reviewer 3

The reviewer said the team did not provide an amount on the second slide as to how much was spent on the effort presented and the proposed work is not outside the limits of the conducted work, thus the reviewer would have to say that funds are sufficient.

Presentation Number: BAT402
Presentation Title: Improving Battery Performance through Structure-Morphology Optimization
Principal Investigator: Venkat Srinivasan, Argonne National Laboratory

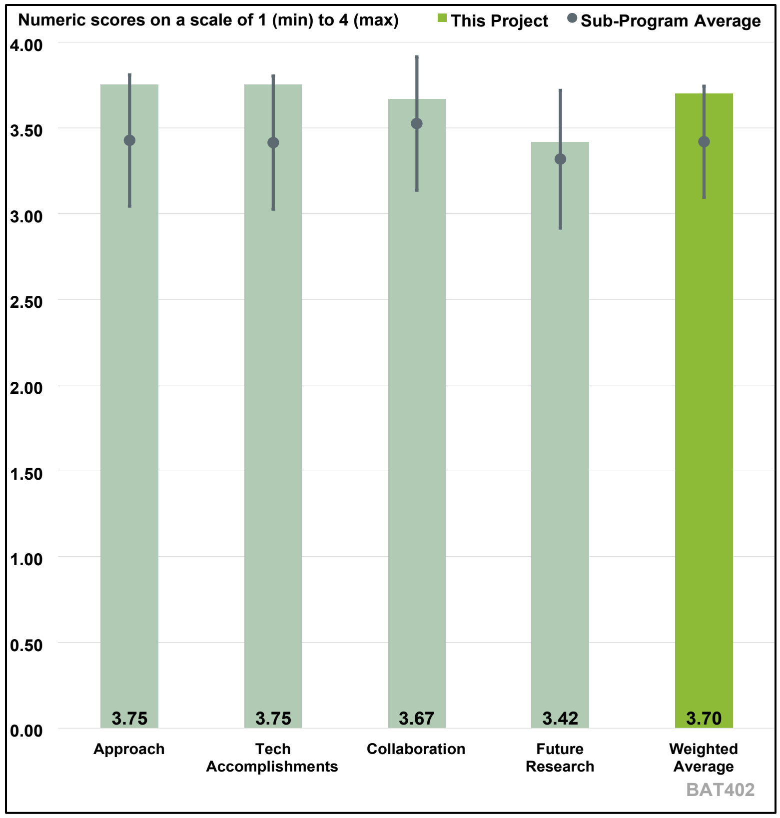

Figure 1-15. Presentation Number: BAT402 Presentation Title: Improving Battery Performance through Structure-Morphology Optimization Principal Investigator: Venkat Srinivasan, Argonne National Laboratory

Presenter

Venkat Srinivasan, Argonne National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that understanding the intricate relationship of cathode materials among synthesis, morphology/structure, and electrochemical performance is critical for developing new lithium-ion battery (LIB) chemistry, e.g., Li-rich NMC and single crystal NMC. The reviewer believed this project is aiming to achieve that by studying the key control factors during the pCAM and calcination process that can affect the morphology/structure/chemistry and thus the performance of the final products. The project is well-designed to focus on lithium manganese-rich (LMR)-NMC and single-crystal NMC cathodes.

Reviewer 2

The reviewer stated the project represents an excellent combination of the use of experiments and modeling to predict particle morphology and material performance.

Reviewer 3

The reviewer stated that the objective of this project is to understand how synthesis conditions and precursors impact LMR and nickel-rich NMC morphology and performance. The approach uses a feedback loop between experiments and DFT/continuum scale modeling to fully understand the synthesis condition/morphology relationship. Coprecipitation and hydrothermal methods have been studied, as have been various precursors and final sintering temperatures and protocols. The approach leads to an impressive understanding of how to control NMC morphology.

Reviewer 4

The reviewer stated that the approach for this project is excellent. It forms a combination of expertise in synthesis, in situ characterization and multiscale modeling to decipher the relationship between the synthesis process and the morphology of pCAM and the CAM of Li-rich NMC, as well as high nickel NMC811. This relationship is also extended to performance of the CAM materials. The reviewer stated this is an innovative approach.

Reviewer 5

The reviewer stated that the objective of this effort is to understand the relation between synthesis condition, morphology, and performance. The reviewer believed the researchers used a novel combination of in-situ analysis and fundamental density functional theory molecular dynamics (DFT-MD) modeling. The researchers studied the synthesis process of making cathodes from precursors at various conditions and built cells to evaluate performance. The reviewer stated this approach was appropriate and novel to address technical barriers in a scientific way. The reviewer believed the project was well-designed, and the timeline was well-planned.

Reviewer 6

The reviewer stated that the project combines experimental results with computational modeling and it has made significant progress in the understanding of pCAM particle formation and growth. Several research topic areas were explored, including single crystal NCM synthesis, LMR-NMC and calcination processes. It is appropriate to look into diverse areas of development in the early stage of the project, but in future, resources might get spread too thin if the project team dives deeper into all these topics. The reviewer would recommend some prioritization for the next phase of work to focus on the most valuable research topics and on addressing them.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated the project has made great achievements: it completed LMR-NMC cathode calcination process study and modeling, it studied pCAM synthesis with co-precipitation and hydrothermal methods, it looked into the composition gradients in pCAM particles with both co-precipitation and hydrothermal methods, and it studied the NMC811 calcination process and the effect of temperature on product morphology.

Reviewer 2

The reviewer stated the project team has applied its modeling approach to the synthesis of several materials and material types and is able to predict critical lengths for transport. The reviewer believed that since this is such a model-heavy project, the researcher should probably be able to provide more dimensionless parameters of properties that are easily measured and that will allow anyone starting a synthesis optimization some guidelines on what measurements should be made in order to fine tune synthesis.

Reviewer 3

The reviewer stated that the project progress has been excellent, leading to many insights. New established observations include the relationship between precursor and particle growth, the role of supersaturation on transition metal ™ gradients within a single particle, and the role that sintering plays on particle agglomeration and porosity. Five publications have resulted from this work, the reviewer believed that is a very solid number at the given funding rate.

Reviewer 4

The reviewer believed the project team has successfully connected synthesis conditions to composition and morphology and their impact on performance by developing: 1) models for pCAM synthesis using coprecipitation and hydrothermal synthesis; 2) models providing insights into single crystal formation as well as formation of compositional gradients; 3) models for calcination capture of the chemical reactions along with particle sintering effects, and 4) performance models showing the balance between transport in electrolyte pores, primary particle, agglomerates, and grain boundaries. The reviewer believed these are outstanding accomplishments with important impact in guiding the synthesis of pCAM and cathode materials for Li-ion batteries.

Reviewer 5

The reviewer stated that the technical progress was in line with the proposed project plan. The reviewer believed the researchers examined different pCAM synthesis processes such as co-precipitation and hydrothermal to provide an interesting hypothesis that surface energy minimization dictates growth morphology, and they support it by showing the evolution of surface energy with time due to increasing particle size. The time scale of the synthesis process the researchers studied for various cathodes was of the order of hours, in industrial processes they are of the order of seconds; so the reviewer suggested that future studies focus on finding a correlation between laboratory- and industry-scale processes.

Reviewer 6

The reviewer believed that great progress has been made in this project in multiple fronts of CAM synthesis.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the project accomplished a collaborative effort among ANL, BNL, University of Chicago, and a few DOE facilities. This observation is supported by the fact that most journal publications and presentations resulting from this project were done by authors from multiple organizations.

Reviewer 2

The reviewer observed that the project involved working with several principal investigators (PIs) across the VTO-supported program. The reviewer found that very impressive.

Reviewer 3

The reviewer observed that the project represents a collaboration between ANL PIs primarily, all of whom appear to contribute different expertise. The reviewer stated that the project appears well-coordinated.

Reviewer 4

The reviewer observed that the project is highly collaborative across multiple research groups funded by VTO, including the synthesis groups at the Materials Engineering Research Facility

(MERF) at ANL, the APS at ANL, the national synchrotron light source II (NSLSII) at BNL, and the University of Chicago.

Reviewer 5

The reviewer considered the collaboration between the team members, including that between the national laboratories and university partners, as excellent. The reviewer observed that it could be even more improved by including an industry partner to provide insight on usability of the results from laboratory scale to industrial scale.

Reviewer 6

The reviewer stated that more collaboration with industry will be helpful. The reviewer has the understanding that since there are currently no US-based NCM CAM producers, obtaining commercial single crystal NCM and testing it as a benchmark material will be helpful in comparing the materials under this project with what is in the market. The reviewer also believes that more collaboration on the calcination process of pCAM (to better understand it) will be helpful.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed this project helps gain a better understanding of the synthesis-performance relationship of LMR-NMC and single crystal NMC. It is desirable that with all these new findings, at the end of this project, the project team can recommend optimal synthesis conditions, to help solve the LMR-NMC, single crystal NMC performance issues. Commercial single crystal NMC cathodes have been available in the Chinese market for at least 5 years. So far, they do not seem of much interest to EV OEMs, possibly because of low rate performance and higher cost. The reviewer suggested that future work could focus more on lithium iron phosphate (LFP) chemistry for battery energy storage system (BESS) applications that require a longer cycle life and have lower rate requirements.

Reviewer 2

The reviewer believed the project team is planning to move to other materials and other processes. The reviewer commended the expansion of work.

Reviewer 3

The reviewer stated that future work will focus on further answering open questions related to unexplained experimental observations, including particle morphology differences between various precursors. Also, phosphate morphologies and the formation of coatings via solution/hydrothermal methods are being proposed. The reviewer believed these are reasonable directions to pursue.

Reviewer 4

The reviewer believed the PI and the project team has clearly identified a set of questions to be answered in future research, including: why do NMC-hydroxide pCAMs form a plate-like morphology while NMC-carbonates form spherical primary particles; what are the underlying processes driving supercritical hydrothermal reactions and can they be modeled; can the understanding gained on NMC be utilized towards phosphate cathodes; can the synthesis of coatings and their impact on particle morphology be understood; and can a mathematical model be used to optimize the synthesis conditions of LMR-NMC to obtain particles that can maximize energy density and rate capability? The reviewer believed answering these questions could help develop a good research plan in future.

Reviewer 5

The reviewer drew attention to the proposed future work plan which lists the ‘questions’ for the remaining challenges and barriers. The reviewer emphasized that it is to be assumed that the future plan would propose an approach and specific plan on addressing those questions; but those are missing.

Reviewer 6

The reviewer stated that many commercial high nickel NCMs contain either alumina coating or doping to enhance cycling stability. Also, those coatings are typically applied on pCAM before calcination. The reviewer recommended a study of how such a coating will impact the calcination process and CAM structure/performance – both experimentally and through computational simulation in future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believed a good understanding of fundamentals of the cathode synthesis process is critical to improve the performance of Li-ion battery with new chemistry. Therefore, the reviewer considered this work relevant to VTO subprograms like Batteries and Electrification.

Reviewer 2

The reviewer believed this work is very relevant to the battery industry as new materials are critical to reducing the nickel and cobalt contents of the cathode, or even the replacement of Li altogether. This work helps the synthesis researchers on how to tune reactors to achieve material properties needed for high rate, high density, and good stability.

Reviewer 3

The reviewer believed this project is highly relevant to the overall VTO subprogram objectives.

Reviewer 4

The reviewer believed this project is relevant to current DOE objectives because it provides guidance for pCAM and CAM synthesis to help improve the performance of Li-ion batteries.

Reviewer 5

The reviewer believed this project is very relevant to VTO Battery R&D activity because finding the relationship between synthesis impacts, composition, and morphology (and in turn, the performance) is crucial.

Reviewer 6

The reviewer believed this project is highly relevant to the battery R&D objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed the resources (including research staff and laboratory facilities) are enough for this project.

Reviewer 2

The reviewer believed this research group has been very productive with current resources and has not proposed a significant increase.

Reviewer 3

The reviewer believed the funding level appears reasonable for the effort involved.

Reviewer 4

The reviewer believed the resources are sufficient for the project to achieve the milestones and objectives.

Reviewer 5

The reviewer believed the current resources ($500,000 per year) are sufficient for this project. The reviewer also believes it could utilize information available from several other related projects.

Reviewer 6

The reviewer believed the resources are sufficient.

Presentation Number: BAT496
Presentation Title: Silicon Consortium Project Advanced Characterization of Silicon Electrodes
Principal Investigator: Robert Kostecki, Lawrence Berkeley National Laboratory

Presenter

Robert Kostecki, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

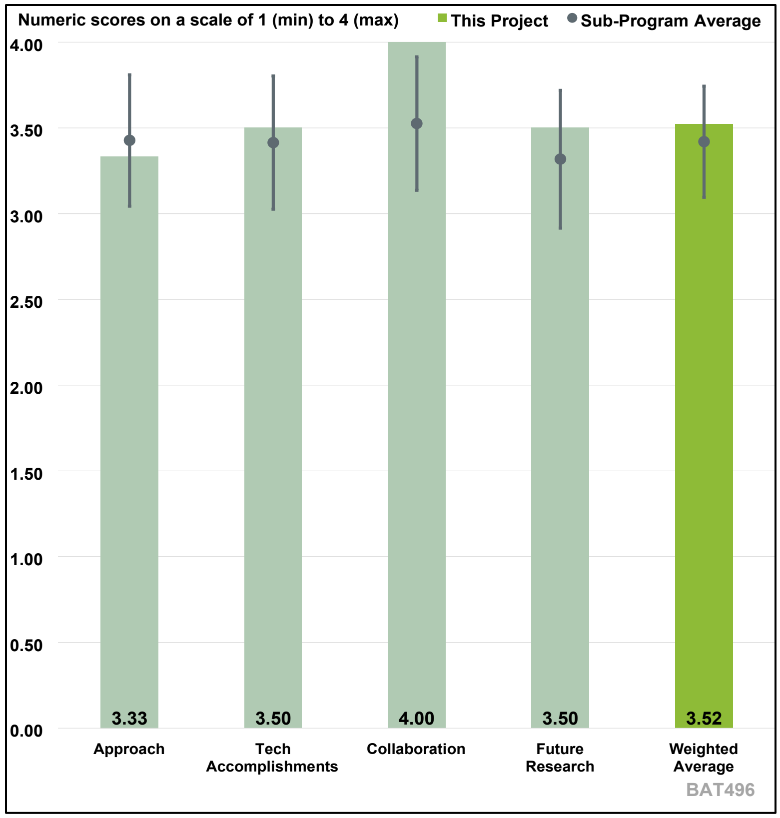

Figure 1-16. Presentation Number: BAT496 Presentation Title: Silicon Consortium Project Advanced Characterization of Silicon Electrodes Principal Investigator: Robert Kostecki, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer believed the program is broad and comprehensive in scope and fundamental progress and understanding is taking place. The reviewer also believes that the Si-PEO system is arguably not representative of the best-in-class silicon materials. The reviewer suggested that if possible, some incorporation of commercial Si-C composites should be added to the program. The reviewer stated that even inclusion of some commercial Si manufacturers or cell manufacturers would add insight and make the project more relevant to industry.

Reviewer 2

The reviewer stated that the project's approach is to study the fundamental reason for Li loss in Si based cells. The reviewer believed the study focuses on studying this problem using ideal samples and better-focused characterization techniques to deep-dive Si solid-electrolyte interphase (SEI).

Reviewer 3

The reviewer believed that the approach has been well thought-out and the project team has shown great depth in developing analytical tools necessary to study the SEI phenomenon within silicon-containing anodes. However, the reviewer also stated that the third design approach of ‘rational Si electrode design principles to address performance challenges’ was not sufficiently addressed in the presentation – it was somewhat talked about with the role of electrolyte and carbon in the anode system, but further explanation/discussion in future presentations would be appreciated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer believed that understanding the SEI layer formation, structure and stability is key to improving Si anodes. The reviewer stated that this project is making important strides toward obtaining that understanding.

Reviewer 2

The reviewer believed the project is very systematically studying the dissolving of SEI. The project has developed new focused characterizations to study this phenomenon. The project observed SEI to be inhomogeneous which can create more failure paths.

Reviewer 3

The reviewer believed that the project has made significant technical progress, and its results have been of assistance to other groups/projects within the consortium.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer believed that the overall Si program is well-connected across many organizations.

Reviewer 2

The reviewer believed that the project facilitates collaboration with seven national laboratories and multiple universities. The reviewer emphasized that silicon is very surface-sensitive, and it would be ambitious for the teams to be studying and understanding its mechanism.

Reviewer 3

The reviewer stated that it is evident from this presentation and from other silicon-anode consortium presentations, that the project team is highly integrated and is collaborating well. The reviewer would like more participation/transition from/to industry partners as the consortium winds down.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that future work is well laid out and relevant.

Reviewer 2

The reviewer remarked that exploring NMR to study dissolving SEI should give more details on its mechanism and on how to mitigate it.

Reviewer 3

The reviewer stated that proposed future research is clearly defined and appropriate for the outlined project. The reviewer did have concerns concerning the large scope of the proposed future research (‘develop new, expand existing and combine in situ and ex situ diagnostic approaches’ can involve five distinct techniques). As such, the reviewer believed it may be necessary for the PI to scrutinize the project to reduce the scope of future research if the work timeline increases.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer referenced earlier comments (for question 1).

Reviewer 2

The reviewer believed that the Si anode has a lot of potential in electrification and studying its failure modes is necessary for its commercialization.

Reviewer 3

The reviewer believed that the project actively addresses analysis and battery subprogram objectives, as set by VTO. The reviewer also believes that numerous analytical techniques were developed and utilized to address the long withstanding issues concerning silicon-containing anodes for battery applications. The reviewer stated that over the long term, manufactured cells/batteries are not just for EV markets but for all high-energy-density applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the research teams appear well-staffed, and their resources seem adequate.

Reviewer 2

The reviewer stated that the resources provided are sufficient for the program.

Reviewer 3

The reviewer believed that the resources for this project and the rest of the silicon anode consortium, are sufficient to achieve its stated milestones in a timely fashion.

Presentation Number: BAT497
Presentation Title: Silicon Consortium Project Electrochemistry of Silicon Electrodes
Principal Investigator: Christopher Johnson, Argonne National Laboratory

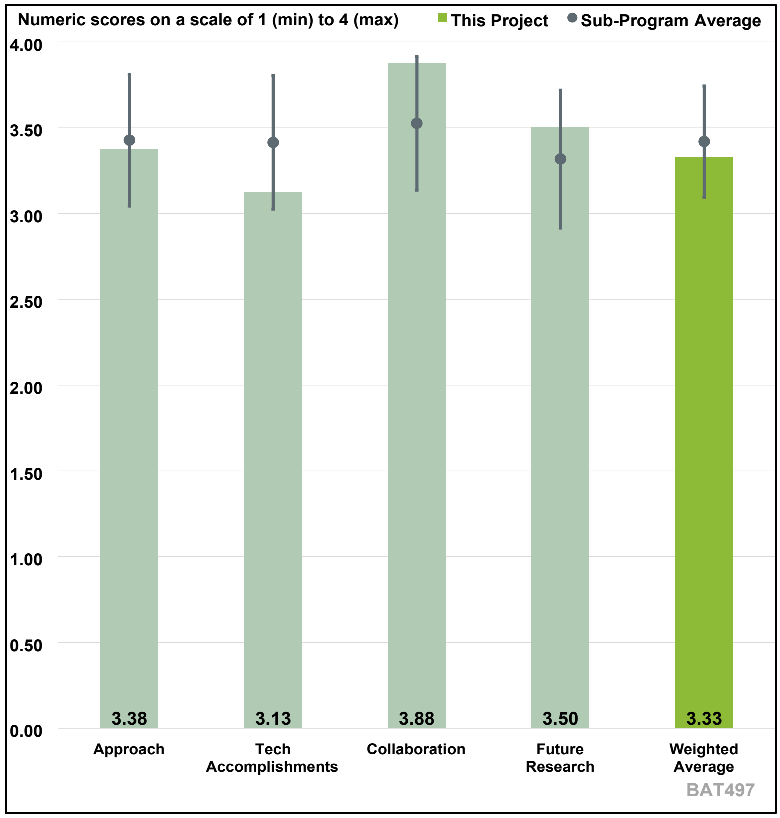

Figure 1-17. Presentation Number: BAT497 Presentation Title: Silicon Consortium Project Electrochemistry of Silicon Electrodes Principal Investigator: Christopher Johnson, Argonne National Laboratory

Presenter

Christopher Johnson, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project is more academic oriented and focusing on fundamental studies.

Reviewer 2

The reviewer stated that silicon anodes remain an important focus for EV development. The reviewer believed this project is doing a good job of expanding analysis tools to better understand the degradation mechanisms of Si anodes. The reviewer thinks the robustness of the voltage hold method is unverified, which was pointed out in the prior year. The reviewer would like verification of the variables Qhold, Qrev, and Qirrev by recharging the cell and directly measuring Qirrev and Qrev. The reviewer would like to know if that has was done. The reviewer also would like to know how accurate the studies of electrolyte additives are in this setup, whether the cell flooded such that there is always massive excess electrolyte and additives, and ow this corresponds to larger, more EV-relevant cells.

Reviewer 3

The reviewer believed the calendar life is a complex parameter to study. The reviewer also believes that using three electrode cells opens up a new level of evaluating Vhold and developing the protocols to screen material is a useful process.

Reviewer 4

The reviewer commended the use of a three-tier approach for addressing the objective of identifying calendar life within a 15-month window. However, the reviewer felt that most of the discussion focused on the Tier 1 approach of a voltage hold and it was unclear how much evaluation was done using Tier 2 and Tier 3 methodologies. The reviewer understood that Tier 3 methodologies, which involve a 12-month test, may not have been available at the time, but the reviewer would appreciate knowing how the Tier 2 approach fared or whether it provided additional information over the Tier 1 approach. At minimum, it would be nice to know which tier was used in each test (i.e., machine learning used Tier X approach).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that many tests are being conducted in coin cells. Such cells are good for early-stage materials screening, but their performance is very different from large format cells, including in the area of gas generation and calendar life. The reviewer believed that with only 1 year left in the program, it is time to study those parameters in large format cells (i.e., 2-5Ah cells).

Reviewer 2

The reviewer believed that the project utilizes a wide range of electrochemical methods to characterize the cells. This work helps the research community in both developing the methods as well as in understanding them better.

Reviewer 3

The reviewer believed that screening protocols need to be continuously evaluated for robustness. They represent a useful tool but the tool should be consciously checked periodically to ensure it continues to apply. The evaluated materials continuously change with program evolution. Identifying that the SEI dissolves and reforms based on voltage, the reviewer would like to know if there have been any changes to the screen protocols based on that finding.

Reviewer 4

The reviewer believed the project team has developed some good insights into silicon-containing anodes by using mechanistic and electrochemical techniques. However, the true technical ‘achievements’ are unclear for the project and it is also unclear how those are tied to determining the final calendar cell life.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer believed the collaboration among team members is excellent.

Reviewer 2

The reviewer believed the work is well coordinated across the teams.

Reviewer 3

The reviewer believed that the collaboration with other national laboratories has been outstanding (including in having regular meetings and data sharing).

Reviewer 4

The reviewer believed that as for all of the silicon-anode consortium, the project maintains extensive collaboration between all the group members.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer was pleased to see pouch cells proposed for Si SEI study. The reviewer recommended ensuring that its capacity remains at Ampere-hour (Ah) level in order to represent real applications.

Reviewer 2

The reviewer stated that the planned future work appears interesting and useful.

Reviewer 3

The reviewer stated that predicting and validating SEI represents an excellent approach. The reviewer also stated that continued material evolution from different methods is technically sound.

Reviewer 4

This reviewer agrees with prior suggestions that future work needs to focus on the relationship between short-term and long-term testing needs. The reviewer believed that those tests are ongoing at this time, but it is unclear if the long-term tests will ultimately achieve the program targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believed the project supports the overall VTO subprogram objectives. The reviewer stated that Si anode is a very promising candidate for high-energy EV batteries.

Reviewer 2

The reviewer stated that the work in the project strongly contributes to the development of Si anodes for EVs.

Reviewer 3

The reviewer stated that the program is very relevant to Batteries, Electrification and Energy Efficient Mobility Systems. The reviewer stated that this research is highly needed for progress in automotive industry.

Reviewer 4

The reviewer believed the project is highly relevant to the overall VTO subprogram objectives for analysis and battery areas.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed the resources are sufficient.

Reviewer 2

The reviewer believed the project seems appropriately resourced.

Reviewer 3

The reviewer believed that the funding for the project is sufficient.

Reviewer 4

The reviewer believed that the resources for this project appear sufficient to achieve the stated milestones.

Presentation Number: BAT498
Presentation Title: Silicon Consortium Project Next-Gen Materials for Silicon Anodes
Principal Investigator: Nathan Neale, National Renewable Energy Laboratory

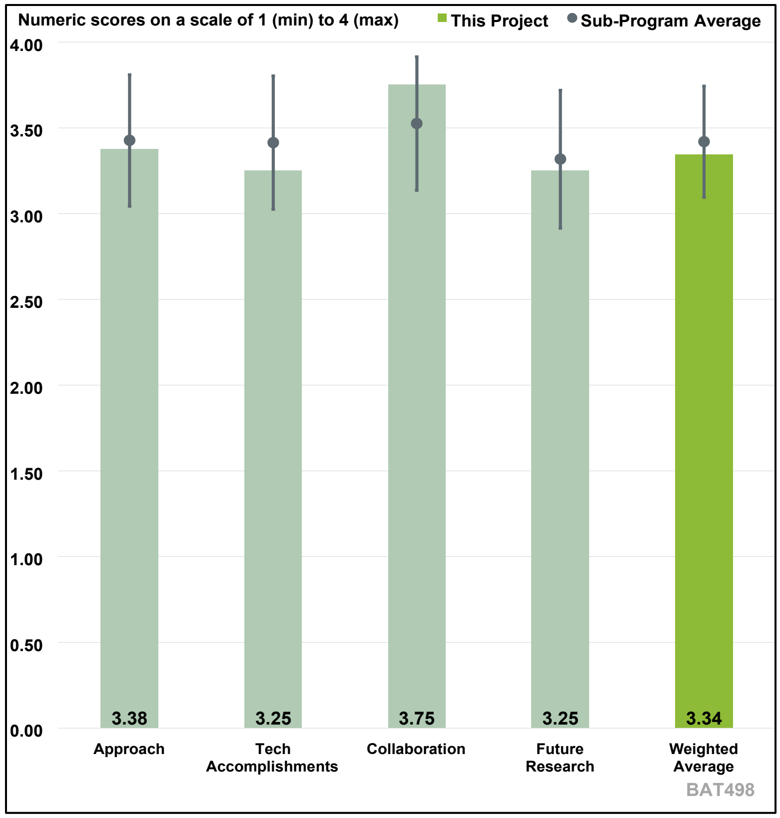

Figure 1-18. Presentation Number: BAT498 Presentation Title: Silicon Consortium Project Next-Gen Materials for Silicon Anodes Principal Investigator: Nathan Neale, National Renewable Energy Laboratory

Presenter

Nathan Neale, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project is more academic oriented and is focusing on fundamental studies at small scales.

Reviewer 2

The reviewer believed that the structure of the silicon particles and the electrode design is crucial to create silicon anodes that will impact the next generation of EV. The reviewer also praised the project for investigating those areas.

Reviewer 3

The reviewer stated that the approach to systematically study the various combinations of Si particle structure, coatings, conductive materials while keeping the scalability of these methods is excellent.

Reviewer 4

The reviewer stated that this project addressed some key parameters that could affect battery performance of composite electrode. The reviewer believed the current work clearly demonstrated how different type of conductive carbon affects electrical and ionic conductivity of the resulting electrode as well as the Si utilization. However, no full cell testing results are provided at this time. Unlike the effect on conductive carbon effect, the effect on Si particle size was demonstrated with full cell testing results. The reviewer considered this work as well-designed. Lithium iron phosphate (LFP) was selected as the counter electrode to understand the Si particle size effect on cycle life and calendar life. The reviewer was optimistic that the optimal particle size in LFP//Si full cell can be translated to NMC//Si.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that many tests are being conducted in coin cells. The reviewer opined that coin cells are good for early-stage materials screening, but their performance is very different from large format cells. Therefore, coin cells are not good tools to evaluate the effects of particle size, conductive additive (CA) and binders. For example, industrial CA is about 1%, and variations is at 0.1% level. The difference is hard to see based on laboratory-scale experiment.

Reviewer 2

The reviewer believed the project has provided useful and interesting results on carbon additives, binders, and Si particle size. All of this is essential to further improve the performance of Si anodes. The reviewer questioned the relevancy of conclusions due to the specific Si anode material used. If possible, the reviewer recommended that this should be benchmarked against commercial materials which have improved dramatically in the last few years.

Reviewer 3

The reviewer opined that deep dives into the mechanism by which improvements are observed is very insightful. The reviewer found it interesting that the project identified that smaller particles and RT14 works best.

Reviewer 4

The reviewer believed that there has been good progress in scaling up the composite electrode and enough amount of electrode film has been prepared and shared with collaborators. The reviewer would like to see more work around binder optimization in the future. The reviewer mentioned that PI’s binder has some negative effect on cell performance compared to either polyacrylic acid (PAA) or polyvinylidene fluoride (PVDF). However, future plans on how to integrate different types of binder into this composite electrode are not clear.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer believed that the collaboration among team members is excellent.

Reviewer 2

The reviewer believed that the project teams are well connected and coordinated.

Reviewer 3

The reviewer believed that Si consortium maintains outstanding collaboration within the national laboratories.

Reviewer 4

The reviewer believed that this work greatly benefitted from collaboration within the project team across seven different national laboratories as well as the University of Maryland. It would be nice to have some collaboration with industry to gain some knowledge on what is needed to commercialize this material.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer was pleased at proposals of larger scale experiments critical to real applications. First-cycle efficiency needed to be greatly increased from 80% to 90% for real applications.

Reviewer 2

The reviewer believed that the future work is well detailed and relevant.

Reviewer 3

The reviewer believed that the observation of SEI dissolution and reformation based on voltage is an interesting finding in the Si consortium. How this finding impacts this program is unclear.

Reviewer 4

The reviewer believed that the project clearly defined the purpose for future work, such as, the continuous improvement on scaling up plasma enhanced chemical vapor deposition (PECVD) Si nano particle production and optimization of electrode composition to enable high loading and enhance Si utilization. However, it is unclear if the proposed solution will likely achieve the targets. The high surface area of conductive carbon indeed showed improved electrical and ionic conductivity, but also increased parasitic reaction which likely will have negative impact on cycle life and calendar life. The reviewer was not sure if the calendar life target can be achieved by optimizing the wt% of single-wall carbon nanotubes (SWNT). The reviewer stated that the binder plays an important role in Si anode due to its high-volume expansion during charging and discharging, more binder optimization seems to be needed to further work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believed the project supports the overall VTO subprogram objectives. The Si anode is a very promising approach for high-energy EV batteries.

Reviewer 2

The reviewer believed the project contributes toward better understanding of Si anode designs.

Reviewer 3

The reviewer believed the program is very interesting and relevant for electrification.

Reviewer 4

The reviewer agreed that this program clearly supports the overall VTO objectives, especially for batteries and materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed the resources are sufficient.

Reviewer 2

The reviewer believed the resources are in balance.

Reviewer 3

The reviewer believed the funding is sufficient for the program.

Reviewer 4

The reviewer believed that the resources are sufficient for the project to achieve the state milestone on time so far.

Presentation Number: BAT499
Presentation Title: Silicon Consortium Project: Mechanical Properties of Silicon Anodes
Principal Investigator: Katherine Harrison, National Renewable Energy Laboratory

Presenter

Katharine Harrison, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

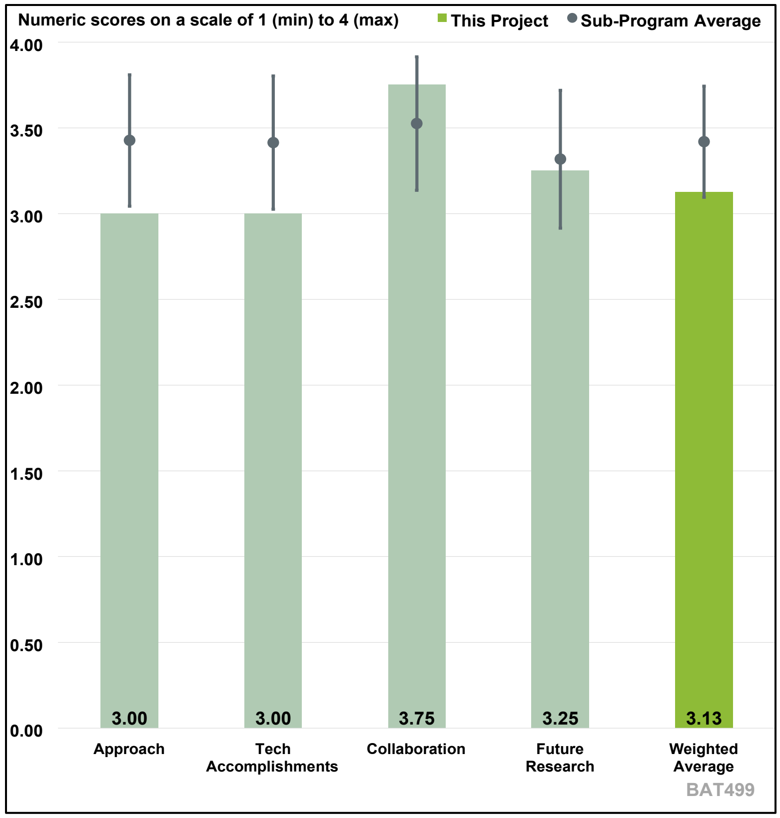

Figure 1-19. Presentation Number: BAT499 Presentation Title: Silicon Consortium Project: Mechanical Properties of Silicon Anodes Principal Investigator: Katherine Harrison, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the structure of the Si is key to improving its performance. This project made and characterized unique Si structures to help guide future development. It is not clear to the reviewer how applicable that is to commercial EVs because the methods are not easily scaled. The reviewer stated that the work on wrinkling and processing is useful for cell manufacturers.

Reviewer 2

The reviewer stated that the overall approach of the silicon consortium project (SCP) is quite specific and appears well-focused on the issue of calendar life for cells that achieve high specific energy and cycle life. The approach of the architectures thrust sub-project appears to be good, addressing most barriers. The approach is to identify different architecture routes to achieve the goals, and to try to evaluate whether architecture affects calendar life. However, it seems to the reviewer that the work is mostly focused on low-loading electrodes that will not lead to 375 Wh/kg cells. Also, there are several companies (Sila, Enovix, etc.) specializing in high-loading Si anodes, and the present work could be informed by their efforts. The reviewer was not convinced that the 'architecture' needs to be addressed on a priority basis, compared to alternate approaches like having a stronger current collector, changing stack pressure, etc.

Reviewer 3

The reviewer observed that this project took various approaches to resolve challenges presented by Si anode, including micro-patterning, deposition techniques, electrolyte formulation, and binder materials.

Reviewer 4

The reviewer stated that in this thrust, the project goal is to develop electrode architectures to enable high loading Si electrode and to understand how electrode architecture impacts calendar life. Several approaches had been proposed and tested, including: 1) increasing electrode porosity; 2) introduction of micropattern into the electrode to help electrolyte wettability and transport as well as stress relief of electrode; 3) using alternative anode current collector to reduce the stress etc. The reviewer noted that although many of those approaches showed impact on reducing the mechanical stress (e.g., less wrinkle of the electrode or less pulverization of electrode), none of them seems to be able to improve cycle life so far. The reviewer stated that other approaches focused on understanding at the material level should be also considered in the future study.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the project is testing some interesting architectures which would be leading to a better understanding of Si structures that can be commercially viable.

Reviewer 2

The reviewer stated that the results of the architecture thrust appear to be good. There are specific ideas that are being explored to deal with the volume change, such as porosity engineering at different length scales. It seems to the reviewer that most results are on low-loading electrodes, and the performance even at low loading is not that good. Hence, while some lessons are being learned, it’s unclear to the reviewer how well they will apply to the best high-loading electrodes. Also, on the key point of how architecture affects calendar life, some work has been reported, but it does not appear definitive. The reviewer observed that most battery experts would consider architecture alone as less important to calendar life than numerous other factors (e.g., active material design, electrode formulation, etc.) so it is important to have a well-defined case to assess whether architecture affects calendar life.

Reviewer 3

The reviewer noted that the project achieved some advances in understanding about Si electrode fabrication. But when compared with the commercialized Si-based LIBs, this project is not at the forefront of the technology. The reviewer noted that the performances are still below the DOE goal. The reviewer suggested rethinking approaches, especially the electrolyte design philosophy.

Reviewer 4

The reviewer stated that the current project figured out how to manipulate electrode porosity by either from Si particle size control and composition of the resulting slurry or from controlling electrode architecture via laser ablation. Those approaches are pretty novel. It is valuable to accumulate the knowledge and understand their impact on battery performance from an electrode engineering perspective. However, the reviewer has not seen any calendar life data generated by those electrodes from this work although those approaches do not seem to improve the cycle life. The reviewer would recommend starting calendar aging test as soon as possible.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the project is well-coordinated.

Reviewer 2

The reviewer observed that it appears the team is well-integrated within the large SCP.

Reviewer 3

The reviewer stated that the collaborations are outstanding.

Reviewer 4

The reviewer observed that this project involves multiple national laboratories with different cross functional teams. All teams work on the same coherent goal from different perspectives, which the reviewer praised. However, it seems to the reviewer that the project lacks input from industry. The reviewer recommended evaluating this novel approach from operation cost perspective.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed research is relevant. The reviewer would like to understand how commercially scalable the structures are.

Reviewer 2

The reviewer observed that overall, the future research on the project is to continue along the current directions. The reviewer considered it important to move as quickly as possible to a high-loading electrode to evaluate concepts in that format. Evaluating concepts with low-loading electrodes may have little relevance to solving problems with higher loadings. The reviewer also considers it important to receive more specifics on future architecture work and on how it will help address the calendar life.

Reviewer 3

The reviewer stated that the proposed future direction seems reasonable.

Reviewer 4

The reviewer understood that the next step is to integrate the successful mitigation into pouch cells. Hopefully, the combination of those mitigations could result in a better outcome. The reviewer remarked that is a certainly good approach and the reviewer thinks that it will definitely mitigate the mechanical stress of the cell when using high Si percentage with high electrode loadings. However, the reviewer would like to see new approaches to be proposed as well. For example, porosity, micropatterning and current collector architecture could mitigate the wrinkling effect, those solutions often reduce cell energy density. The reviewer asked if there is any other way to mitigate the adverse effect from volume expansion of Si anode without sacrificing the overall energy density.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the work is contributing toward fundamental understanding of Si anodes.

Reviewer 2

The reviewer stated that the present work is relevant to the Batteries program.

Reviewer 3

The reviewer stated that the project is highly relevant.

Reviewer 4

The reviewer stated that this project directly supports the overall VTO subprogram objectives, especially for Materials, Batteries and Energy Efficient Mobility Systems.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are appropriate.

Reviewer 2

The reviewer stated that the resources appear sufficient.

Reviewer 3

The reviewer stated that the resources allocated are sufficient.

Reviewer 4

The reviewer remarked that this project seems to have enough resources. The project received enough materials for evaluation not only at material level but also at pouch cell level. The team possesses adequate analytical tools to understand the mechanical aspect of the electrode. The researchers also have access to the modeling team to provide explanation on the high stress phenomena observed for high-loading Si anode electrodes.

Presentation Number: BAT501
Presentation Title: Integrated Modeling and Machine Learning of Solid-Electrolyte Interface Reactions of the Si Anode
Principal Investigator: Kristin Persson, Lawrence Berkeley National Laboratory

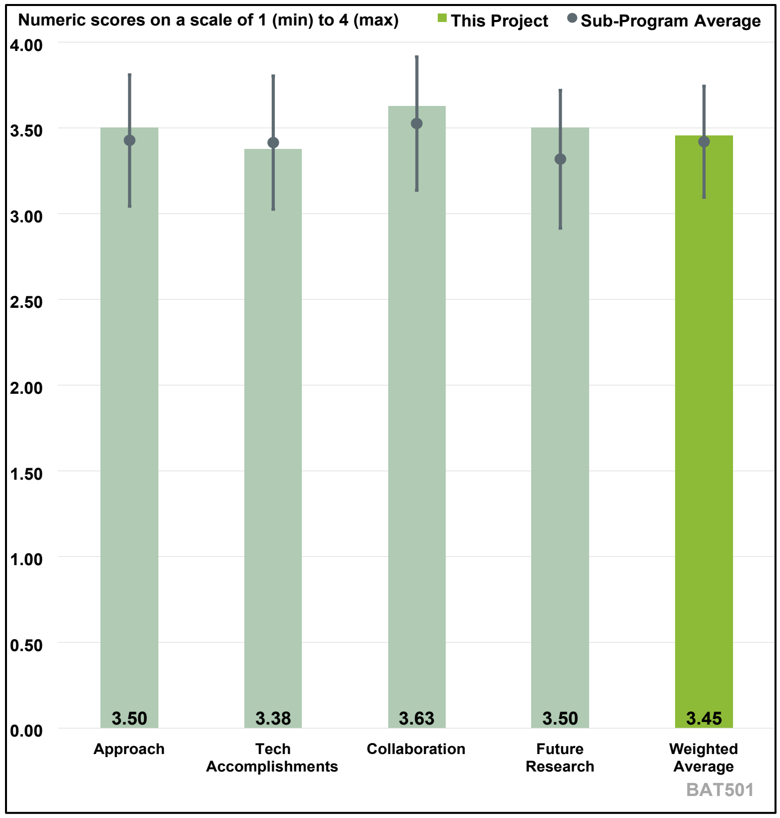

Figure 1-20. Presentation Number: BAT501 Presentation Title: Integrated Modeling and Machine Learning of Solid-Electrolyte Interface Reactions of the Si Anode Principal Investigator: Kristin Persson, Lawrence Berkeley National Laboratory

Presenter

Kristin Persson, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the interaction between electrolyte and Si anodes is key to making them commercially viable. The reviewer added that this project explores such interaction with well-designed experiments. The reviewer inquired if the cells are flooded and if so, if the study of additives in commercial, non-flooded cells can still be considered accurate.

Reviewer 2

The reviewer stated that the project uses an ambitious and impressive approach to improve understanding of the fundamental mechanisms of SEI formation on anode materials. The reviewer found the chemical complexity and number of pathways as truly impressive. The reviewer also sees a connection to experiments through the voltage hold experiments.

Reviewer 3

The reviewer stated that the overall approach to 'characterize the paths and mechanisms that form key SEI species' using atomistic simulations/machine learning, continuum modeling, and experimental modeling is comprehensive and addresses the project goal of assisting team members with understanding on SEI evolution affects silicon-anode calendar life.

Reviewer 4

The reviewer stated that it is extremely challenging to develop atomistic simulations to monitor/modeling SEI growth. The reviewer considered the approach took in this project as quite novel.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the salt/solvent/Si interactions are fundamentally important to make Si anodes a success. The reviewer added that this program is contributing valuable information toward understanding them.

Reviewer 2

The reviewer considered the technical accomplishments to be impressive. To the reviewer, it appears to be first-of-a-kind work that heavily invests in new methods development, which is a valuable part of the Batteries program, and highly relevant to the chemical complexity of SEI formation. The reviewer stated that the work provides fundamental insights on how SEI formation on Si can differ from that on graphite (i.e., differences in inner vs. outer SEI properties as a result of the voltage at which the electrode operates), which in turn can help with insight on calendar life. The reviewer saw some limitations due to the complexity of the chemical mechanisms and time scales for the atomistic reaction network which puts a limit on the number of electrolyte formulations that can be studied. There also could be limits on how much detailed chemistry of the Si surface can be included in the reaction network.

Reviewer 3

The reviewer praised the team on its great technical work in identifying an elementary mechanism for PF_5 decomposition and prediction tools for SEI growth and trends in its continuum modeling.

Reviewer 4

The reviewer stated that so far, the model developed in this project is able to reproduce the Peled model without any fitted parameters. More importantly, it can also predict SEI evolution at both large time and length scale which could be really valuable. Currently, SEI evolution was done at an electrochemical potential similar to a constant current discharging. The reviewer would find it interesting if it were investigated how SEI evolution could be altered at a certain constant potential. It could be really valuable to understand how to design and optimize formation protocol when electrolyte formulation contains several SEI forming additives.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project is well coordinated.

Reviewer 2

The reviewer stated that the work with NREL in particular is impressive. The reviewer stated that it must have been a major effort to bring the atomistic reaction network results into a continuum model.

Reviewer 3

The reviewer stated that the collaboration for the project is outstanding—the team is taking research results from all consortium members and integrating into the machine learning algorithms.

Reviewer 4

The reviewer stated that the model developed in this project has been used to understand promising electrolyte candidates developed by other projects, this received praise from the reviewer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future work is well documented and relevant.

Reviewer 2

The reviewer stated that the future work looks excellent. The reviewer remarked that some additional focus on calendar life prediction and improvement could be added.

Reviewer 3

The reviewer stated that the team's proposed future research is extensive and addresses the consortium's needs. The reviewer advised the PI to ensure the project team focus on necessary and relevant tasks, especially referencing the proposed task entitled 'create chemically complex SEI model framework bridging length-/time-scales'.

Reviewer 4

The reviewer stated that all of the proposed future directions seem to be very relevant. In particular, the reviewer was very interested in the future work to predict degradation mechanism in novel chemistries where there is not much reported literature available.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer restated that the project is highly relevant.

Reviewer 2

The reviewer stated that the work is relevant to Batteries.

Reviewer 3

The reviewer stated that the project supports VTO subprogram objectives of Analysis and Batteries.

Reviewer 4

The reviewer stated that this work is relevant in support of the overall VTO subprogram. The reviewer remarked that if the model can be successfully developed, it can significantly accelerate the battery material development process, and directly benefit Batteries, Electrification, and Materials subprograms.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient.

Reviewer 2

The reviewer commented that the project budget was cut for the past year. The context on this decision was not clear. The reviewer stated that the funds are probably insufficient to support a heavy workload from LBNL and NREL but may be sufficient in case of a reduced scope of work.

Reviewer 3

The reviewer commented that the resources of the project are sufficient for achieving the stated milestones in a timely fashion.

Reviewer 4

The reviewer stated that the project seems to have access to the high-performance computing power as well as the electrolyte expert with deep mechanistic understanding of electrolyte degradation and it appears to have sufficient resources to achieve the milestone on time.

Presentation Number: BAT523
Presentation Title: Development of Long Life Lithium and sulfurized polyacrylonitrile (SPAN) Cells
Principal Investigator: Ping Liu, University of California-San Diego

Presenter

Ping Liu, University of California-San Diego

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

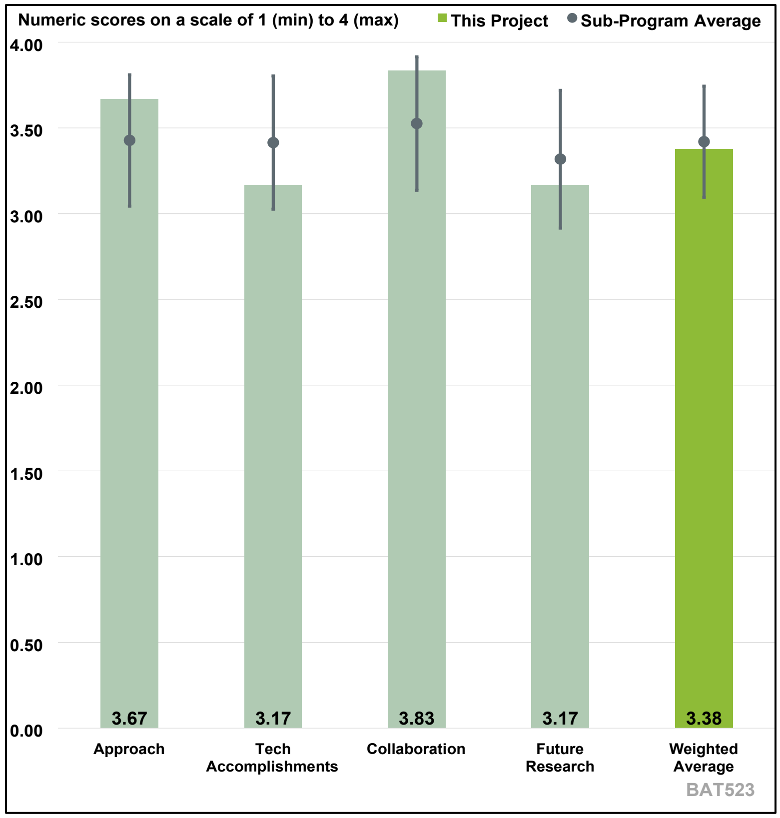

Figure 1-21. Presentation Number: BAT523 Presentation Title: Development of Long Life Lithium and sulfurized polyacrylonitrile (SPAN) Cells Principal Investigator: Ping Liu, University of California-San Diego

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the PI has concentrated on addressing the primary technical barrier of the sulfur—sulfurized polyacrylonitrile (S-SPAN) cathode material—its capacity limitation to around 600 mAh/g. The reviewer observed that they aimed to understand the reaction mechanism of S-SPAN and proposed a material structure and potential approach to enhance its specific capacity. The resulting CS-SPAN, based on a saturated short-chain sulfur environment, demonstrated promising performance, marking significant progress. The reviewer remarked that further detailed investigation into the reaction mechanism is needed.

Reviewer 2

The reviewer stated that the project utilized multiscale characterization tools to understand the structure of SPAN and to further develop high-capacity SPAN cathode to increase the capacity and stability. The developed new cathode shows the promise to achieve 300-350 Wh/kg Li-S batteries. The reviewer remarked that the role of electrolyte needs more understanding.

Reviewer 3

The reviewer stated that the project's approach for addressing technical barriers in next-generation LiS battery technology is both innovative and commendable. By focusing on fundamental breakthroughs in controlling sulfur electrochemical reactions, the discoveries set a solid foundation for substantial advancements. The integration of materials and cell-level discoveries is particularly noteworthy, as it ensures rapid incorporation and validation of the latest research findings, leading to more realistic and practical applications. The reviewer remarked that leveraging materials from other DOE programs and utilizing state-of-the-art DOE facilities and industry to understand and prevent degradation is a strategic and efficient use of resources. The emphasis on multi-disciplinary approaches and enhancing collaborations between national laboratories, universities, and industry highlights a holistic and synergistic strategy. This comprehensive and well-coordinated effort is likely to yield highly productive results, driving significant progress in the development of high-energy, low-cost LiS based batteries. The reviewer stated that the project particularly focuses on understanding the fundamentals of SPAN chemical transformation. SPAN is one of the few sulfur composites demonstrating excellent cycling performance in Li-S batteries. This approach and understanding can significantly contribute to designing better sulfur composites, enhancing battery performance and stability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the PI demonstrated an increase in the specific capacity of S-SPAN, a successful accomplishment for the budget year. In addition to enhancing the material’s performance, the PI conducted thorough analyses using Mass Spectroscopy and XPS to identify the reaction products and the chemical environment in the active material. A hypothesis was proposed regarding the formation of N-S bonds. The reviewer recommended further electrochemical analysis.

Reviewer 2

The reviewer commented that multiscale characterization tools and modeling were used to clearly understand the structure of the SPAN and the extra capacity beyond the theoretical value. The reviewer observed that loading needs improvement, as may the E/S ratio, which is not provided.

Reviewer 3

The reviewer commented that during this period, two major accomplishments stand out. First, the team has provided a detailed characterization of SPAN materials’ performance as a Li-S cell cathode. This involved extensive testing and analysis, demonstrating SPAN’s exceptional cycling stability, capacity retention, and overall efficiency in Li-S batteries. Second, the team has gained a fundamental understanding of SPAN chemistry transformation. Through advanced electrochemical and spectroscopic techniques, the team has elucidated the underlying mechanisms of SPAN’s chemical changes during battery operation. The reviewer stated that this insight is crucial for optimizing SPAN’s structure and composition, paving the way for the development of superior sulfur composites for high-performance batteries.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the collaboration among Battery500 team members has been proven very productive and effective.

Reviewer 2

The reviewer commented that the collaboration with other teams at the Battery500 Consortium on modeling and characterization as well as cell integration are well demonstrated to resolve the technical barriers.

Reviewer 3

The reviewer commented that the project team demonstrates excellent collaboration within the Battery500 team, addressing critical issues in battery technology through a diverse network of partners. Idaho National Laboratory is scaling up SPAN synthesis, while multiple universities, including the University of Maryland, Pennsylvania State University, and the University of Pittsburgh, supply standard SPAN electrodes. Pacific Northwest National Laboratory focuses on electrolyte studies, and Stanford University evaluates these electrolytes. Brookhaven National Laboratory provides insights into mechanisms using in-situ X-ray diffraction (XRD) and atomic PDF, Texas A&M University conducts computational studies, and GM contributes to pouch cell fabrication, showcasing a well-coordinated, multidisciplinary effort.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future works were good. But the reviewer suggested that the PI spend effort to better understand the mechanism, particularly the S-S- bond formation during the charging process.

Reviewer 2

The reviewer stated that the increase of sulfur loading, the reduction in electrolyte/sulfur ratio and a demonstration of pouch cell are planned for the next year.

Reviewer 3

The reviewer stated that the proposed future work effectively addresses the immediate challenges facing SPAN materials. By focusing on optimizing electrode compositions, enhancing binder interactions, and developing suitable electrolytes, the research aims to improve SPAN stability and performance. Additionally, fabricating SPAN pouch cells will translate laboratory-scale findings into practical applications.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the research on S-SPAN was very relevant to the VTO goal of developing high-energy-density battery systems.

Reviewer 2

The reviewer stated that the project is developing a high-capacity SPAN cathode alternative to element sulfur cathode to demonstrate 300-350 Wh/kg Li-S batteries, offering improved energy density, lower cost and better sustainability than today’s Li-ion batteries.

Reviewer 3

The reviewer stated that the SPAN is one of the few sulfur composites that offer excellent cycling stability in batteries. Understanding the fundamental properties and chemical transformations of SPAN is crucial to advancing Li-S battery technology, as it provides insights necessary for optimizing performance, enhancing durability, and achieving higher capacity in practical applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the PI and collaborators can access more than sufficient resources to conduct the proposed research.

Reviewer 2

The reviewer stated that the project has sufficient resources on the synthesis of SPAN cathode, characterization and modeling from Battery500 Consortium team.

Reviewer 3

The reviewer stated that the overall resources for the Battery500 program appear sufficient, supporting its ambitious goals.

Presentation Number: BAT524
Presentation Title: Advanced Electrolytes for Lithium Metal Batteries
Principal Investigator: Chunsheng Wang, University of Maryland

Presenter

Chunsheng Wang, University of Maryland

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

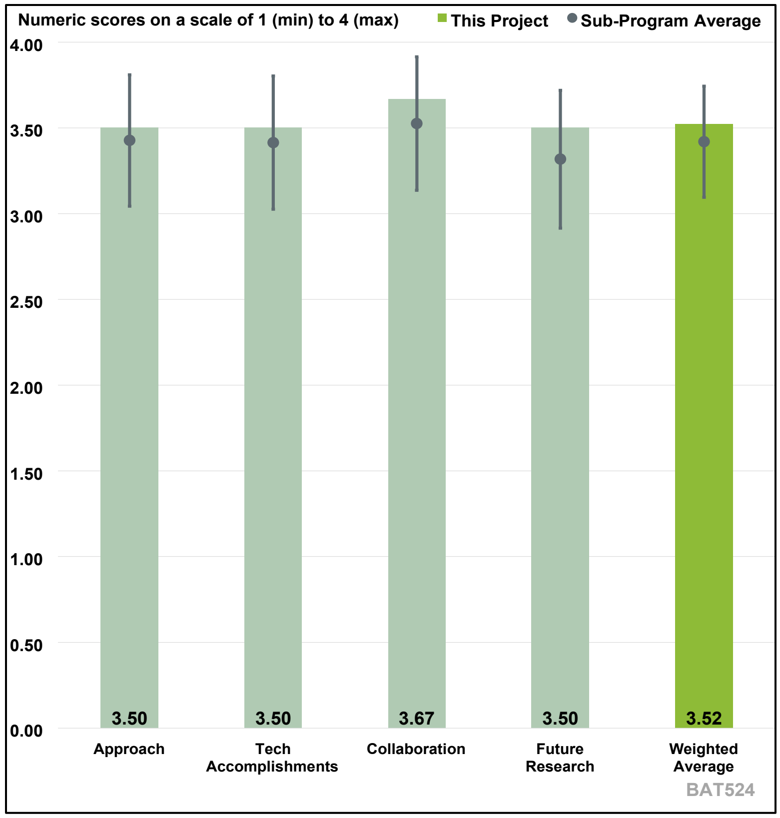

Figure 1-22. Presentation Number: BAT524 Presentation Title: Advanced Electrolytes for Lithium Metal Batteries Principal Investigator: Chunsheng Wang, University of Maryland

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that this project on all-anion electrolyte and weak solvation electrolyte has provided preliminary evidence demonstrating that LiF-rich SEI and CEI, through promoting anion/additives decomposition and suppressing solvent degradation, could stabilize Li anodes and NMC811/SPAN cathodes. Studies on two types of all-anion electrolytes for Li||SPAN cells were conducted, using 0.5C and 1C rates respectively for the two cells with different loading (Slides 16 & 17). The reviewer remarked that it might be helpful to provide data with the same current rate for the cells with the different loading and/or different current rates for the cells with the same loading.

Reviewer 2

The reviewer commented that this project was difficult to review because of insufficient information on developments. It appears that the goal is to improve cell life and coulombic efficiency with electrolyte additives and design. The reviewer was unable to ascertain the systematic development and its understanding. The ionic liquid was not specified, and because (except for some Li carboborates) there are no ionic liquids so this must be Li+ ionic liquid mixture. There was no discussion on costs with Li. Since the research direction and the reason for the choices are unclear, the reviewer believed that cost is a fair question.

Reviewer 3

The reviewer stated that the research team addresses the challenge of developing high-energy-density Li-metal batteries through innovative electrolyte design. The testing conditions are highly relevant to practical applications, including high cathode loading, low N/P ratio, and lean electrolyte. The reviewer commented that the team tackles the challenge from a fundamental perspective, incorporating molecular design, leveraging experience from other DOE-supported programs, and closely collaborating with other U.S. institutions using multidisciplinary approaches. In its electrolyte design, the team employs two primary technical approaches: using a TFSI-derived solvent and a weak solvating solvent, dibutyl ether. Both strategies facilitate the decomposition of anions or anion-like molecular motifs at the interface, forming robust and stable interphases on the Li-metal anode. The reviewer remarked that based on the set milestones and current achievements, the project is well designed, and the timeline is reasonably planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the coulombic efficiency appears higher for higher capacity, but there seems to be no discussion on the reasons for this (Slide 11).

Reviewer 2

The reviewer remarked that there were a lot of good results shown. Coulombic efficiencies were improved through electrolyte design. However, the reviewer was unable to develop an understanding of what actually happened and what was learnt from it. The reviewer observed that the total pouch cell capacitance is good, and the 5C cycle rate result was astounding. The improvement of the Li transference number correlates to high cycle rate performance improvement. However, the reviewer was unable to see what was learned – only how well the best cell performed.

Reviewer 3

The reviewer remarked that the research team's novel electrolyte systems have enabled significant technical progress. Various coin cells and pouch cells, including those at the hundreds of mAh level, using different high-energy battery chemistries such as NMC||Li and SPAN||Li, have been tested and show performance at or above the state-of-the-art. The testing conditions consistently feature high cathode loading and a low N/P ratio, with some tests even utilizing zero N/P (anode-less) configurations. Lean electrolyte is implemented in some pouch cell tests, though it is likely not used for coin cell tests due to reproducibility issues. The reviewer stated that overall, technical progress is in line with, or even ahead of, the project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the research group is gaining a lot of understanding of the electrolyte physics and chemistry from Brookhaven and ARL, and clearly utilizes SAFT for high quality electrode and pouch cells.

Reviewer 2

The reviewer remarked that the research team collaborates with national laboratories (BNL and Army Research Laboratory), universities (UC San Diego), and industry (SAFT). The reviewer stated that the collaboration is comprehensive and synergistic.

Reviewer 3

There were no collaborations noted.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that one of the targets for the proposed future research is to achieve Li CE: greater than 99.7% and high-loading NMC811 CE: greater than 99.9%. The reviewer suggested analyzing which of the two CE's is more important for cell life to address key challenges, although improving both the CE's is beneficial.

Reviewer 2

The reviewer was favorably impressed to see the electrolyte formulations on high NMC loaded pouch cells and Li-SPAN batteries for high-energy-density cells. The reviewer considered this a logical progression.

Reviewer 3

The reviewer stated that the research team has proposed to further address the challenges in Li||NMC811 and Li||SPAN cell chemistries with a target of more harsh testing conditions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that while cost may be an issue in the future, the knowledge gained here will be valuable in developing high charge and discharge rate batteries for high power applications.

Reviewer 2

The reviewer commented that the project addresses the high-energy-density objective of VTO. It also pays some attention to the low-cost aspect.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that current level of funding seems to support this work well.

Reviewer 2

The reviewer commented that the resources are sufficient to achieve the stated milestones in a timely fashion.

Presentation Number: BAT536
Presentation Title: Polyester-Based Block Copolymer Electrolytes for Lithium Metal Batteries
Principal Investigator: Nitash Balsara, Lawrence Berkeley National Laboratory

Presenter

Nitash Balsara, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

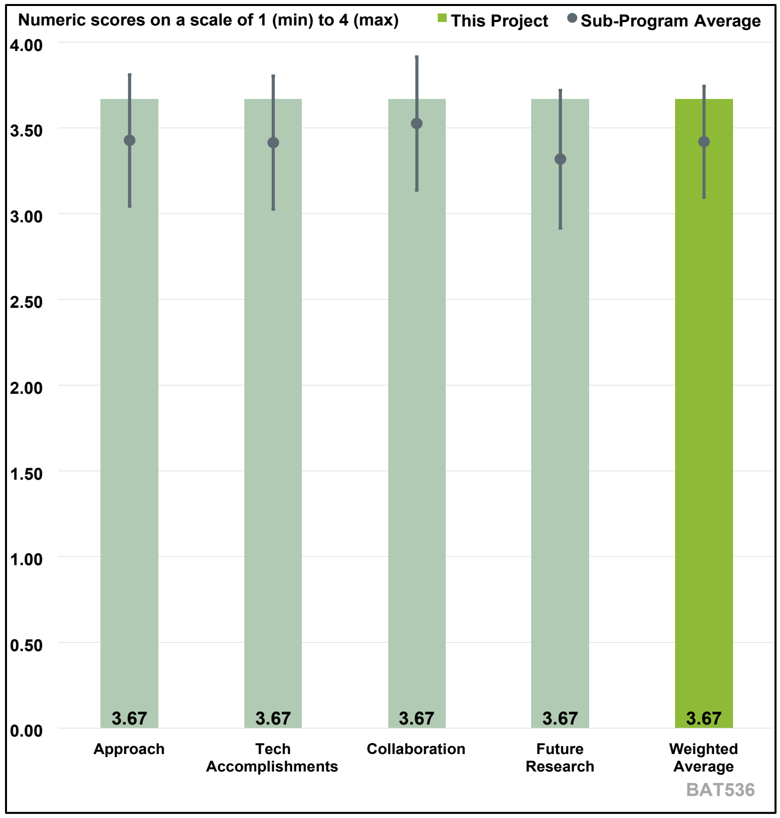

Figure 1-23. Presentation Number: BAT536 Presentation Title: Polyester-Based Block Copolymer Electrolytes for Lithium Metal Batteries Principal Investigator: Nitash Balsara, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer agreed with the argument that polymers may be advantageous due to their deformability, which seems critical given the huge volume change of Li during cycling and the need to deform when non-uniform plating occurs. The reviewer remarked that the approach by Dr. Balsara is excellent as always. The reviewer would encourage this team to consider adopting quantitative milestones to demonstrate progress towards developing an optimal block copolymer electrolyte. The reviewer stated that the existing milestones are good but are all qualitative.

Reviewer 2

The reviewer stated that the project uses an excellent fundamental approach to understanding transport in polymer electrolytes. A new polymer poly(pentyl malonate) (PPM) electrolyte is also identified, but the most important part of the approach is that it is well-grounded in fundamental understanding and connected with several methods (modeling, tomography). The reviewer remarked that this type of foundational knowledge can help eventually overcome barriers and is an important part of the Batteries program.

Reviewer 3

The reviewer stated that this project employs fundamental electrochemical techniques and X-ray characterizations to address performance bottlenecks in solid-state cells. The research team has designed experiments to identify the factors limiting the current of polymer electrolytes and have improved these experiments by transitioning from Li||Li symmetric cells to LiIn||LiIn cells. The mechanism is analyzed by fitting experimental data to the Newman model. X-ray tomography has been used to characterize the solid-state cells, revealing void formation at the interface between Li and polymer. This information has been utilized to analyze impedance data, leading to the conclusion that the increase in interfacial impedance is due to the polymer moving away from the Li metal. To enhance the stability between the polymer electrolyte and Li-metal anode, a new polymer, poly(pentyl malonate) (PPM), has been synthesized and characterized. Based on the milestones and achievements, the project is well-designed with a reasonably planned timeline.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer agreed with the argument that polymers may be advantageous due to their deformability, which seems critical given the huge volume change of Li during cycling and the need to deform when non-uniform plating occurs. However, as expected and demonstrated here, the polymer must be designed to maintain contact with the highly mobile Li-metal surface or external pressure (sometimes significant external pressure) must be applied. The rapid growth in impedance in solid-state cells is a long-standing problem, since the earliest years of solid-state cell research. The reviewer wondered if a radically novel approach will be needed to address it.

Reviewer 2

The reviewer stated that the technical accomplishments are outstanding. The measurements of the limiting current are very valuable and capture much more of what is important about an electrolyte than simpler measures often used (e.g., ionic conductivity at an equilibrium concentration). A wider use of limiting current measurements, and methods for getting reliable results, is a major accomplishment for the project. Connecting these measurements with both transport theory / modeling and tomography enhances the fundamental understanding of limits in these systems. The reviewer suggested that information about the temperature at which each test was conducted could be added. The reviewer would also like to know if PPM have a higher limiting current than PEO polymer electrolyte at the same temperature. The reviewer noted that some information on temperature dependence of the transport properties would help understand whether the materials would only work in heated cells.

Reviewer 3

The reviewer stated that several technical accomplishments have been made: the team has identified the LiIn||LiIn symmetric cell as a reliable platform to measure the limiting current for polymer electrolytes. The excellent fitting results between the measured data and the predictions by the Newman model confirm the reliability of this method. The synthesized PPM polymer electrolyte has shown a higher limiting current than the conventional PEO polymer electrolyte, indicating better ion transport properties and/or better stability with Li. X-ray tomography characterization has revealed that the rise in impedance is mainly due to the polymer moving away from the Li metal, a new and inspirational finding. These accomplishments are crucial to understanding the bottlenecks in solid-state batteries and may provide opportunities to solve the problem, such as with the synthesized PPM polymer electrolyte. Overall, the technical progress is following or even surpassing the project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated there was good collaboration with modelers at ANL and diagnosticians at SSRL.

Reviewer 2

The reviewer stated that results from collaborators are mentioned and considered valuable.

Reviewer 3

The reviewer stated that the PI collaborates with scientists from SSRL and ANL on both experiments and theories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the research team has a very reasonable approach to future work, without any major issues.

Reviewer 2

The reviewer stated that the proposed future work builds on previous accomplishments and will extend it in important ways.

Reviewer 3

The reviewer stated that detailed future research plan is provided, both from experimental and theoretical aspects.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is highly relevant. Polymer electrolytes, however, need to be engineered to work at room temperature for automotive applications, which entails a very high degree of difficulty.

Reviewer 2

The reviewer stated that the work is relevant to the Batteries program.

Reviewer 3

The reviewer stated that the project is highly relevant to the VTO solid-state batteries subprogram. Solid-state batteries provide possible solutions to the high-energy safe batteries goals of DOE.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project has made good use of resources.

Reviewer 2

The reviewer stated that the resources appear sufficient for the work.

Reviewer 3

The resources are sufficient for the project to achieve the stated milestones in a timely fashion.

Presentation Number: BAT538
Presentation Title: Ion conductive high Li+ transference number polymer composites for solid-state batteries
Principal Investigator: Bryan McCloskey, Lawrence Berkeley National Laboratory

Presenter

Bryan McCloskey, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

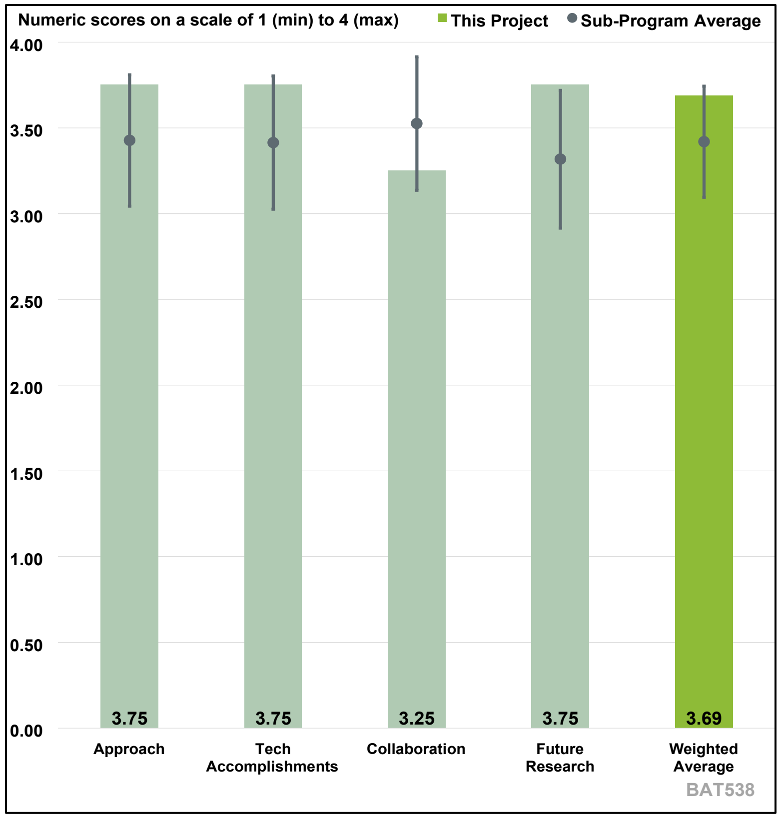

Figure 1-24. Presentation Number: BAT538 Presentation Title: Ion conductive high Li+ transference number polymer composites for solid-state batteries Principal Investigator: Bryan McCloskey, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the approach is novel, in that the initial work uses a viscous liquid electrolyte instead of a polymer. This simplifies processing, and it allows the investigators to focus on varying the type and size of the conductive particles. Extending this to polymer electrolytes in the second half of the project is critical. The reviewer remarked that it would be useful to include more modeling work. In light of the complexity of these systems, it might be difficult to define relevant atomic scale modeling at this point. However, some initial continuum modeling could allow the investigators to better interpret their experimental results.

Reviewer 2

The reviewer attended the talk, analyzed the talk slides in detail, asked questions, and then viewed a few of the quarterly reports on this project. Based on these review activities, the PI appears to understand the technical barriers very well and has designed the project and timeline well. The design of the polymer-inorganic composite systems is careful and grounded in sound fundamental principles, and the characterization techniques and choice of system materials and the specific range of compositions excellent. Based on the approach stated in the presentation and reports, it appears that the timeline makes sense and the PI's team is learning new aspects of polymer-inorganic composite design. The PI presented specific barriers to the approach such as the high interfacial impedance arising from the slow transport of Li+ from polymer to inorganic particle and back. The team wisely proceeded to vary the particle diameter and type and is starting to explore surface treatments to understand and then control this interface issue.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the milestones have been met, and future work appears to be on track.

Reviewer 2

The reviewer stated that the PI's group wisely chose to start with suspensions of liquid electrolytes (with chemical similarity to polymer electrolytes) and a wide range of inorganic particle chemistries and sizes. This, as stated, helps eliminate polymer processing variations in order to focus on the soft-hard electrolyte interfacial aspects. The PI's group has subsequently built an experimentally validated model that shows the importance of the soft-hard interface, and quantitatively shows the effects of particle size on overall composite electrolyte performance. The reviewer remarked that this has not been achieved before, and the quality of this work should help the entire community more predictively design and understand the composite electrolytes. This satisfies many of the key project goals and plan. The reviewer commented that the next step is to use this model and knowledge to build polymer-inorganic particle composites, and to investigate and employ surface treatments to improve soft-hard interfacial transport.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that primary collaborations are relevant during the second half of this project (which was just starting at the time of this review). This makes sense, based on the proposed work. However, it is not possible to evaluate these efforts at this time.

Reviewer 2

The reviewer stated that the PI's team appears to be handling nearly all aspects of this project in-house, and calling on collaborators at LBNL to assist with specific knowledge and handling of inorganic conductor particles. The PI's group has deep experience in appropriate electrochemical methods and other transport characterization methods and is employing these across the group to great effect. The reviewer wondered if collaboration with surface science experts outside the group, in order to go to the next stage of the project, might be prudent to best improve the interfacial chemistry and effective contact between particles and polymeric electrolyte.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the overall success of the project hinges on extending this work to polymer matrices. This is ongoing, and it is likely that the results will be interesting and relevant. The results to date indicate that modeled circuit resistor 2 (R2) must be reduced to improve the conductivity of organic-inorganic composite electrolytes. A better mechanistic understanding of R2 is needed here. The reviewer hoped that the second half of this project will begin to explore some approaches for reducing R2.

Reviewer 2

The reviewer commented that the PI has chosen and described relevant goals and objectives to the VTO Battery subprogram. The goals of developing and understanding polymer-ceramic composite electrolytes and studying them by systematic electrochemical and other transport/property measurements are very relevant to advancing solid-state batteries, Li-metal batteries, and other subprogram goals. It is very likely that the results to date and the proposed future work (creating reproducible polymer-inorganic composites and understanding/improving interfacial properties and transport) will achieve the stated targets and help advance composite electrolytes on a sound and reliable foundation. This reviewer asked several questions of the PI during and after the AMR presentation, including: 1) what are the plans for the PI to do controlled surface treatment of ceramic particles and characterize these effects? (The PI answered that it is being done now following different chemical and physical procedures; 2) you are using large cells with low voltage, which is wise for avoiding nonlinear effects. However, 0.05V over 0.02 electrode distance means that the movement of ions are undergoing average oscillatory motions over angstrom distances (assuming mobility of 10^-7 m^2/V-s and 1kHz frequencies). How does this effect the quantitative values of impedances and what structures are averaged in the electrolytes? (The PI answered that this needs to be looked into); and 3) can you make particles intentionally with negative surface charge to ty to help Li+ interfacial transport? (The PI answered this is not known yet but will be tried.)

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that organic-inorganic composite electrolytes have several practical advantages, and the successful development of these types of materials has the potential to be transformational. This project addresses high interfacial impedance between the two phases, which is one of the key problems that has been identified with these types of materials.

Reviewer 2

The reviewer remarked that the PIs have chosen and described relevant goals and objectives to the Battery subprogram of VTO. The goals of developing and understanding new polymer-ceramic composite electrolytes are highly relevant to advancing solid-state batteries, Li-metal batteries, and other subprogram goals. The reviewer referenced prior comments.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources needed for this project are well-defined. For the work date, this project focuses on electrochemical characterization. Processing capabilities are important for the future work, and the collaborators bring important expertise in that area.

Reviewer 2

The reviewer stated that the PI has sufficient resources (both in terms of funding and laboratory manpower infrastructure) to conduct this work and achieve the stated milestones. The synthetic and materials formulation abilities/expertise/experience and the materials analysis capabilities/expertise are very well-matched to this project and sufficient to achieve the project objectives.

Presentation Number: BAT539
Presentation Title: 3D Printing of All-Solid-State Lithium Batteries
Principal Investigator: Jianchao Ye, Lawrence Livermore National Laboratory

Presenter

Jianchao Ye, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

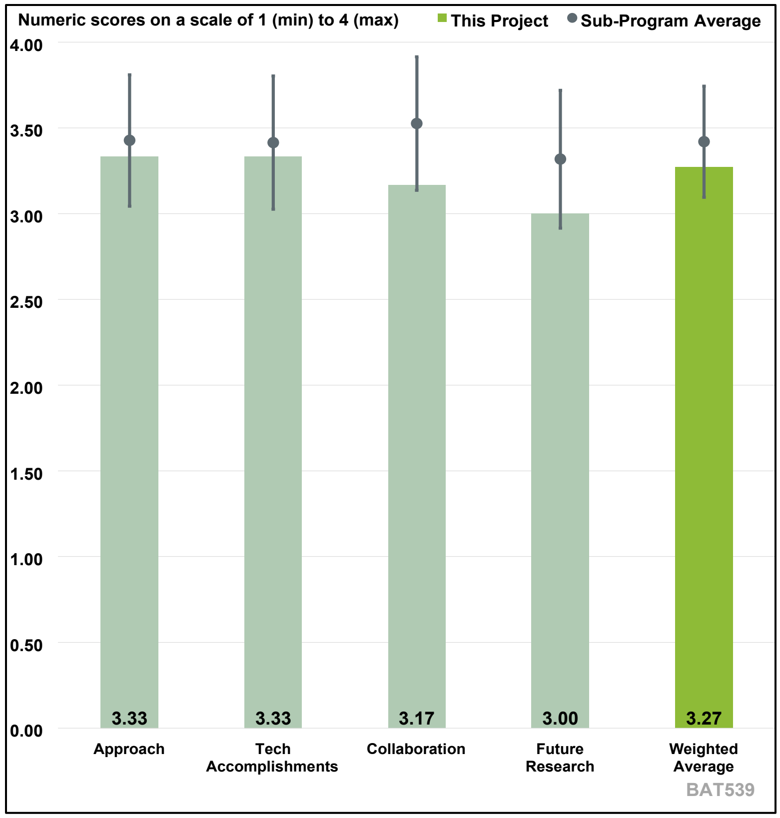

Figure 1-25. Presentation Number: BAT539 Presentation Title: 3D Printing of All-Solid-State Lithium Batteries Principal Investigator: Jianchao Ye, Lawrence Livermore National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that after a two-year study, the team thinks that composite polymer electrolyte (CPE) approach is suitable for 3D printing solid-state batteries (SSBs) due to issues of co-sintering between the solid electrolyte and the cathode. Therefore, the team demonstrated the cell performances via CPE approach. The reviewer was pleased to see the variation and the optimization of 3D printing geometries can help improve the battery performances especially for high-mass loading cells. However, in Slide 14, the labeling is not clear to the reviewer (e.g., it is unclear what the label 200N1L1X stands for). In addition, in Slide 16 and 17, the same labeling exists in the right figures. The reviewer remarked that the presenter should highlight the direction or principles of designing geometries.

Reviewer 2

The reviewer stated that 3D printing can enhance the reaction kinetics, but cannot solve the intrinsic challenges of solid-state batteries, such as Li dendrite growth, $LiCoO_2$/LLZO (lithium lanthanum zirconium oxide) reaction during sintering.

Reviewer 3

The reviewer remarked that the PI and team have made substantial progress addressing and mitigating several technical challenges associated with 3D printing method to develop solid-state polymer composite batteries. The main highlights and comments are: 1) Co-sintering of lithium lanthanum tantalum zirconate (LLZTO) with $LiCoO_2$ cathodes was clearly a no-go. The reviewer thinks this approach should never have been followed given so many earlier reports that cobalt diffusion is one of the issues. Sintering free approach for CPE seemed the right one. 2) The polymer composite electrolyte design, although complex, seems to be working with 3D printing approach. (The reviewer will highlight the complexities in the next section.) 3) 3D printing approach allows higher mass loading. The reviewer commended the PI and team for 3D printed device results with planar 2D for the same CPE and cathode [LFP]).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the team completed the work as planned although the results are not as good as expected. 3D printing SSBs are still at early stage and needs more efforts in the future.

Reviewer 2

The reviewer inquired why cobalt-doped LLZTO has a low electronic conductivity than pristine LLZTO. (The reviewer expected it should have a high electronic conductivity.) The reviewer also inquired about the particle size of LLZTO filled into SPE and whether LLZTO particles are uniformed distributed into the SPE matrix. The reviewer also inquired why the mechanical property of SPE increased with content of FEC in SPE and what the stability window of SPE is. The reviewer asked if SPE can support NMC811 cathode.

Reviewer 3

The reviewer remarked that the CPE design includes three different kinds of polymers based on the functionality and properties necessary for a solid electrolyte. In addition, as for Li-ion salt the CPE has LiTFSI and 7 wt% LLZTO plus 1-5 wt% FEC added for enhancing interfacial stability and to facilitate polymerization (Slide 11) 1). The two added salts have different ion-transport properties. LiTFSI is solvated in the polymer matrix and LLZTO is a single ion conductor. It would be worth investigating their contribution to the total conductivity and the mechanism of ion transport behavior in such a complex matrix. 2). Long term stability of FEC: In-depth studies need to be done to further quantify the role of FEC towards performance improvements.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team needs more collaboration with other teams/organizations (e.g., in the selection of composite polymer electrolytes).

Reviewer 2

The reviewer stated that no simulation work from collaborators was presented.

Reviewer 3

The reviewer remarked that there was good internal collaboration. The reviewer would encourage collaboration with external institutions. This can be done at the unfunded level, since many groups would like to leverage the capabilities developed at the PI laboratory. Collaboration with partners having advanced characterization capability, X-ray synchrotron for operando studies among other things would be valuable.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the team needs to collaborate with other laboratories. The battery materials optimization should not be the focus in this project, which can be collected from other laboratories. More efforts should be put on the materials development for 3D printing, such as the ink recipes as the presenter proposed and the patterns/structure design. In particular, the structure design should be guided by modeling.

Reviewer 2

The reviewer remarked that the PI has identified the future work.

Reviewer 3

The reviewer would like to know if the PI and team have plans to integrate other cathode chemistries beyond LFP in their 3D printing approach.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project supports VTO Batteries subprogram.

Reviewer 2

The reviewer remarked that the project supports the VTO objective.

Reviewer 3

The reviewer remarked that the project supports the VTO battery development goal of attaining 500 Wh/Kg and 750 Wh/L. This project advances scalable approach for fabricating solid-state batteries by demonstrating 3D printing method.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are enough to perform the work in this project well and in a timely manner.

Reviewer 2

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 3

The reviewer stated that the resources are adequate. The PI and team are successfully leveraging the outstanding modeling capabilities in the sister group.

Presentation Number: BAT540
Presentation Title: Synthesis of Composite Electrolytes with Integrated Interface Design
Principal Investigator: Sanja Tepavcevic, Argonne National Laboratory

Presenter

Sanja Tepavcevic, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

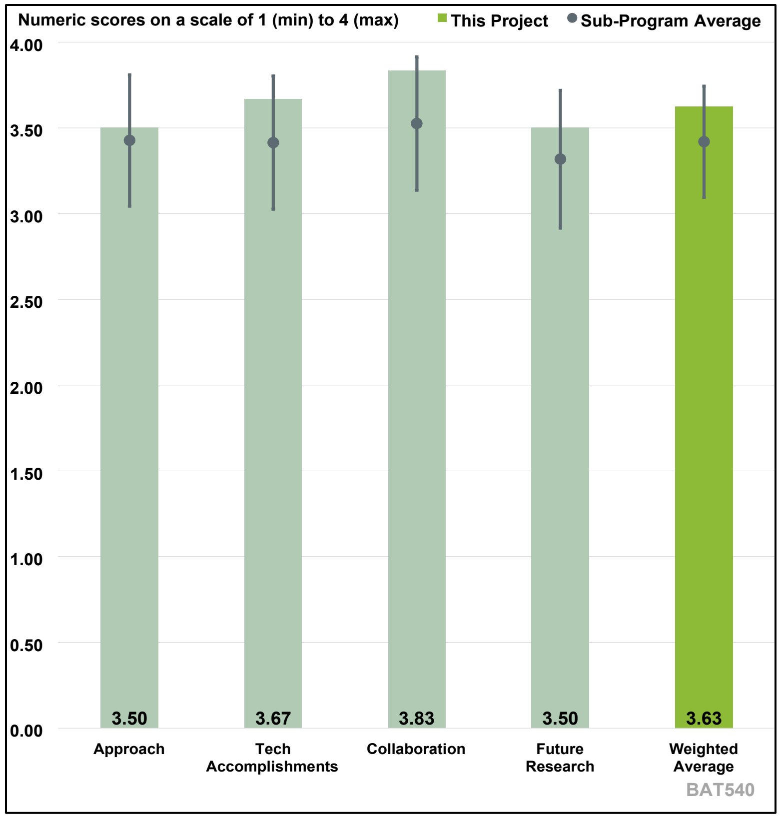

Figure 1-26. Presentation Number: BAT540 Presentation Title: Synthesis of Composite Electrolytes with Integrated Interface Design Principal Investigator: Sanja Tepavcevic, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that recent progress in this project is focused on understanding and improving interfacial properties. This is a critical issue that must be solved to implement these types of materials. The nanofiber architectures being explored in this project are a promising direction. These are complex structures, with a variety of technical barriers. Since a number of problems need to be solved, the reviewer recommended making sure that significant attention is focused on specific issues related to the nanofiber architectures.

Reviewer 2

The reviewer stated that the project approach is a viable method to achieve processable electrolytes that show promise in achieving the ion transport kinetics necessary for practical applications. An outstanding challenge is how these composites will interface with desirable cathode chemistries and Li-metal anodes.

Reviewer 3

The reviewer stated that there are fundamental barriers to Li+ exchange between LLZO and PEO that produce high interphase resistances. The goal of this project is to develop well-controlled, scalable LLZO nanofiber and CPE synthesis processes and demonstrate the fabrication of large-area, thin CPE membranes with outstanding electro-chemo-mechanical properties. The reviewer remarked that the team correctly identified the technical barriers in CPE and designed three approaches to address the challenges. The timeline is reasonably planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the milestones have been met, and future work appears to be on track.

Reviewer 2

The reviewer stated that the team has made strides in materials engineering and processing of LLZO-PEO and lithium lanthanum titanate oxide (LLTO)-PEO composite electrolytes to meet their listed milestones. In particular, the team has achieved ionic conductivities of 0.1 mS/cm for these composites. The team also demonstrates that these composites can be fabricated into free-standing films. The project is on track according to the presented milestones. There are outstanding questions regarding the electrochemical stability of these composites with Li-metal anodes.

Reviewer 3

The reviewer stated that the project team demonstrated improved ionic conductivity of CPE to 5 * 10^-4 S/cm by improving percolation of LLZO nanofibers, which is the highest value ever reported for CPE. The team also explored the other approaches such as surface modification of LLZO particles, in situ polymerization and crosslinking PEO.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaborations outside of Argonne are well integrated into the project and are providing relevant and important information. Clearer explanations of the contributions of the individual team members at Argonne would be helpful.

Reviewer 2

The reviewer stated that the work appears to be highly collaborative among the participating team members. The team is collaborating externally with experts in solid-state nuclear magnetic resonance spectroscopy, TOF-SIMs, ionic conductivity measurements, and interfacial transport. These collaborations have been successful in understanding how PEO-LLZO and PEO-LLTO composites can be engineered to improve ion transport and scalability of processing.

Reviewer 3

The reviewer stated that the PI collaborated with Prof. Chibueze Amanchukwu, University of Chicago in solid-state NMR to identify Li+ transport pathway. The team also collaborated with Luke Hanley at the University of Illinois, Chicago to image 6Li transport in cycled composite electrolytes with ToF-SIMS; conductivity measurements of cold and hot-pressed pellets of LLZO nanofibers with LBNL, and measuring interface resistances in planar trilayer cells, dense LLZO pellets (Chih-Long Tsai, IEK-9, FZ Jülich).

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the current work (Fiscal Year 2024) is moving towards additional improvements in interfacial properties, and towards optimizing the microstructure, which are good directions. A significant focus for the Fiscal Year 2025 work is the demonstration of full cells. This may be premature, since a number of improvements are needed to make these complex materials practically viable.

Reviewer 2

The reviewer stated that the future research is well-aligned with the project goals and will address additional barriers that are still outstanding challenges (e.g., Li-metal anode stability).

Reviewer 3

The reviewer stated that the project has clearly defined the future work in two areas: improving ion transport and fabricating full cells. Plans are proposed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the organic-inorganic composite electrolytes have several practical advantages, and the successful development of these types of materials has the potential to be transformational.

Reviewer 2

The reviewer stated that the work is focused on new composite solid-state electrolytes for all-solid-state batteries and is well-aligned with the VTO Batteries subprogram.

Reviewer 3

The reviewer stated that developing polymer-based composite electrolyte with improved ionic conductivity is directly related to VTO program to enable batteries with higher energy density.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project makes good use of a variety of important resources, both within the core team and via outside collaborators.

Reviewer 2

The reviewer stated that the resources are sufficient to complete the project objectives.

Reviewer 3

The reviewer stated that the project team has suitable and sufficient resources to carry out the proposed work.

Presentation Number: BAT541
Presentation Title: Substituted Argyrodite Solid Electrolytes and High Capacity Conversion Cathodes for All-Solid-State Batteries
Principal Investigator: Jagjit Nanda, SLAC National Accelerator Laboratory

Presenter

Jagjit Nanda, SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

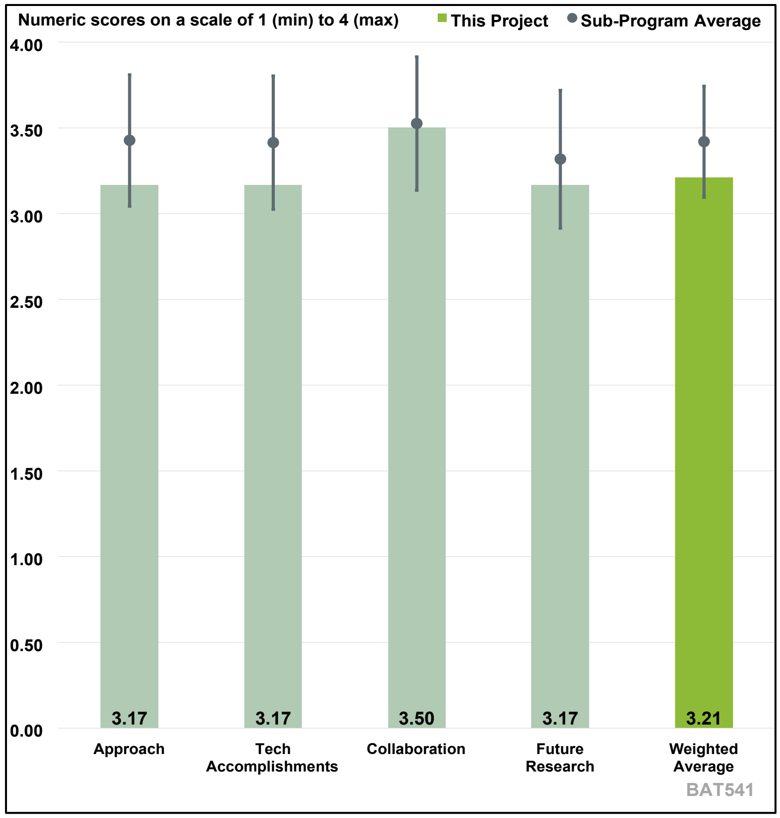

Figure 1-27. Presentation Number: BAT541 Presentation Title: Substituted Argyrodite Solid Electrolytes and High Capacity Conversion Cathodes for All-Solid-State Batteries Principal Investigator: Jagjit Nanda, SLAC National Accelerator Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the major barriers that need to be addressed include performance, interfacial stability, areal specific resistance, and current density, all of which are related to the conductivity and thickness of the SSE. The PIs attempted to fabricate thin SSE films using slurry casting methods, successfully producing thin, free-standing SSE films with decent conductivity. The researchers also investigated the impacts of binders. The project was well-designed to address these technical barriers, particularly in creating thin SSE films. The PIs reported that the thickness of the SSE can be as low as 30 µm. The reviewer stated that they should also mention the durability of the cells and the success rate during cell production.

Reviewer 2

The reviewer stated that thin and free-standing SSE is required for practical SSBs. The team is developing LPSC-based SSE films by screening different binders. It is found that the binder with high molecular weight benefits the formation of crack-free films but significantly lowers the conductivity of the films. Although the mechanisms on the selection of binders are unclear and needs to be further investigated for pursuing more appropriate binders, the results look promising. In addition, the pressure effect on the free-standing SSE films needs to be studied. New discoveries are expected through advanced characterizations from SLAC, which would be helpful to speed up the study on the failure mechanisms of SSBs.

Reviewer 3

The reviewer stated that the project focuses on development of thin sulfide solid electrolyte for all-solid-state batteries, which is one of the keys to achieve 500 Wh/kg at the cell level. The group investigated the effect of binder on the mechanical properties, thickness and electrochemical properties of the fabricated thin film separator. Improvement has been achieved. The project also utilized advanced characterization tools including Raman imaging and synchrotron TXM to probe the degradation mechanism of NMC cathode for further improvement. However, the project title is high-capacity conversion cathodes. The reviewer stated that the group should specify their plan on the conversion cathodes in their system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the PIs successfully demonstrated the fabrication of a thin SSE with a thickness of less than 30 μm. In addition to this achievement, the research team also investigated the use of binders for making thin SSE films, as well as the performance of high-nickel cathode electrodes in combination with these thin films. The PIs made significant progress in accordance with the project plan, and their results were comprehensively reported, providing strong support for their conclusions. The reviewer suggested that the PIs conduct more extensive full cell testing on the thin SSE to further demonstrate the durability and long-term reliability of their design. This additional testing would provide valuable data to ensure that the thin SSE can maintain its performance under practical operating conditions.

Reviewer 2

The reviewer stated that the team has achieved the goals set in the project plan.

Reviewer 3

The reviewer stated that the project has demonstrated the capability to fabricate 30-80 um thick LPSCl thin film separator and indicated possibility for further improvement. Advanced characterization to reveal the failure mechanism of NMC cathode is on-going.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the PI and co-PI demonstrated extensive and highly successful collaboration within the project team. Their coordinated efforts and effective communication significantly contributed to the project’s overall success. The level of collaboration among the team members was sufficient to achieve the project’s goals and milestones. However, to further enhance the project’s impact and ensure its practical application, it would be beneficial for the PI to consult with industry experts regarding the feasibility of the thin SSE. Specifically, discussions with industry professionals could provide valuable insights into the processability and scalability of the thin SSE, addressing any potential challenges that may arise during mass production. Engaging with industry stakeholders could also facilitate the transition from laboratory research to commercial application, ensuring that the thin SSE can be effectively manufactured and implemented on a larger scale.

Reviewer 2

The reviewer stated that the team is well coordinated and performs the proposed work well and in a timely manner.

Reviewer 3

The reviewer stated that the Collaboration within SLAC, ORNL, University of Houston, Virginia Commonwealth University, UT-Austin, FSU on thin film fabrication, advanced synchrotron X-ray characterization, cell integration, modeling and interface characterization have been well demonstrated. Suggest collaboration with conversion cathode.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the PIs have proposed further investigation into binder loading to minimize the thickness of the SSE and optimize the properties of the cathode. Additionally, they plan to explore the potential of other Li alloy anodes. These future research directions are aligned with the overall project plan and objectives, aiming to increase the energy density of the Li-S solid electrolyte full cell. Success in these areas will provide the PIs with a deeper understanding of the existing barriers and opportunities for improvement. To enhance the impact of their research, it is recommended that the PIs allocate more time to studying metallic Li rather than Li alloys.

Reviewer 2

The reviewer stated that the proposed future work makes sense. The reviewer suggested that more efforts should be focused on the binder study.

Reviewer 3

The reviewer stated that the project will further optimize binder to reduce the thickness of solid electrolyte membrane, enabling better performance with NMC cathodes. The project will also develop new substituted argyrodite solid electrolyte to achieve higher conductivity and better electrochemical properties.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is related to the solid-state Li batteries. It is very relevant to the VTO objectives for 500 Wh/kg and 1000 cycles batteries for EV applications.

Reviewer 2

The reviewer stated that the project supports the VTO Battery programs.

Reviewer 3

The reviewer stated that the development of thin solid electrolyte membrane is one of the keys to enable high-energy all-solid-state batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the team has sufficient characterization and cell fabrication tools to accomplish the proposed task.

Reviewer 2

The reviewer stated that the resources are sufficient for the team to timely support the proposed work in this project.

Presentation Number: BAT542
Presentation Title: Polymer Electrolytes for Stable Low Impedance Solid State Battery Interfaces
Principal Investigator: Chelsea Chen, Oak Ridge National Laboratory

Presenter

Chelsea Chen, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

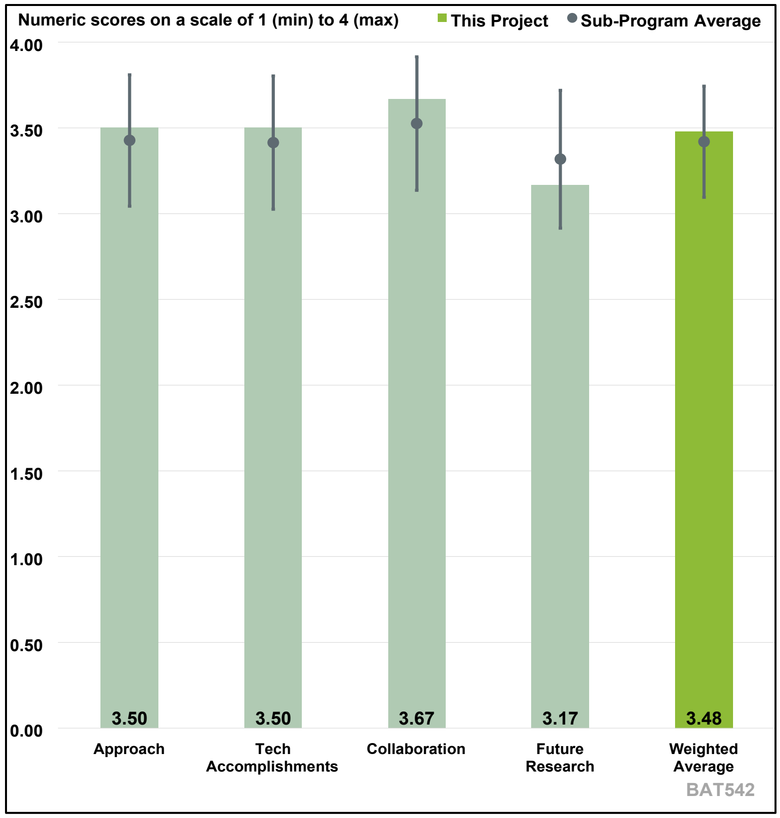

Figure 1-28. Presentation Number: BAT542 Presentation Title: Polymer Electrolytes for Stable Low Impedance Solid State Battery Interfaces Principal Investigator: Chelsea Chen, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the integrated efforts in this project address a range of important challenges in a logical fashion. However, the low conductivity of the polymer being studied is a significant impediment.

Reviewer 2

The reviewer stated that the project is well-designed and has a reasonable timeline planned. The reviewer commented that this project would benefit greatly by demonstrating the performance of the 3D composite structure in industry-relevant pouch cells.

Reviewer 3

This reviewer affirmed attending the talk, analyzing the talk slides in detail, asking questions, and then viewing a few of the quarterly reports on this project. The reviewer commented that based on these review activities, the PI and the team appear to understand very well the technical barriers and have designed the project and timeline sensibly. The reviewer praised how the team has designed this project, from the choice of ceramic electrolyte to the choice of in-situ polymerized single-ion-conducting polymer electrolyte. The overall approach is to vary the ceramic interpenetrating network porosity and void/particle size and vary the polymer parameters, including comparison to benchmark salt-in-PEO polymer systems, and then systematically study the interfacial aspects, and overall battery performance including limiting current. The reviewer said that given the complexity of this project, the timeline is reasonable, although a bit ambitious. The technical barriers are many and significant and include the brittle nature and low interfacial contact of ceramics and the inherently low conductivity of single-ion-conducting polymers. The team is operating near the cutting edge of what is possible and is wisely choosing to carefully understand the limiting factors in a polymer-ceramic composite system. The team is building key knowledge to understand and improve these systems both experimentally and computationally/theoretically.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the milestones have been met, and future work appears to be on track.

Reviewer 2

The reviewer stated that the team has made excellent technical progress in a short time frame.

Reviewer 3

The reviewer stated that the PI's group wisely chose to start with LLZO ceramic networks with known and controllable porosity and pore size. The single-ion-conducting (SIC) polymer can then be filled into this network as a monomer and then in-situ polymerized to go for uniform and conformal interfaces within the composite and with anode and cathode. The team has shown that LLZO ceramic + polymer has higher conductivity than the component parts and that this composite exceeds PEO-salt-ceramic systems in terms of the limiting current and ASR. The team has found an optimum porosity of 35%. It appears also that the polymer part of the composite reduces/eliminates the need for high stack pressure. These results all address technical goals of the project and demonstrate clear progress. One criticism from the reviewer was that the performance parameters are still somewhat modest and further improvement should be expected. Also, some of the polymer parameters are not measured or well defined. The reviewer addressed this in more detail later.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the current collaborations are integrated and well defined. Additional work characterizing the porous structure of the ceramic scaffolds would be a valuable addition.

Reviewer 2

The reviewer stated that the project has an excellent research team comprising ORNL as the lead with collaborators at LBNL and MERF. However, the project would benefit greatly with an industry partner to evaluate the technology in industry relevant pouch cells.

Reviewer 3

The reviewer stated that the project has experimental and theoretical participants and collaborators across many national laboratories (ORNL, ANL, SLAC, LBNL, PNNL, and NREL). This represents a very impressive integration of researchers with diverse skillsets, and it appears to the reviewer that all of these members are collaborating very effectively to achieve the project goals. It also appears to the reviewer that these members can address any future issues of fabrication, characterization, or conceptual/theoretical understanding.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future work is directed at goals that make sense. However, it is not clear what the team is doing to pursue improved resistance to dendrites. Also, it looks like the performance target of 1 mA/cm^2 requires operation at elevated temperatures (due primarily to the relatively low conductivity of the polymer).

Reviewer 2

The reviewer stated that the proposed future research plan is sufficiently defined. It is great to see that the project team is continuing to search for new materials to form composites in order to reach the DOE goal of 10^{-3} S/cm. But there does not appear to be a proposed plan on demonstrating the performance of the 3D composite structure in a real pouch cell.

Reviewer 3

The reviewer stated that the future research goals and plans are well-described in the presentation and in reports. It is very likely that the future targets will be achieved, at least in terms of basic understanding and development of a working and well characterized composite systems. It is possible that battery performance goals will be achieved but is not certain in any study like this. The reviewer asked several questions of the PI during and after the AMR presentation:1) What is the molecular weight of the SIC polymer and is it possible there are oligomers left in the material giving a liquid-like internal environment? The PI answered that they need to check into that. 2) Assuming you can determine what is the actual polymer composition inside the composite, what are its mechanical properties (e.g., moduli) and fragility (e.g., compressive/tensile strength)? The PI is planning to study this. 3) The reviewer asked if the PIs checked for or removed residual salt (e.g., charged monomers + Li+)? The Bruce-Vincent method says $t^+ = 0.86$-0.9. PI: We did pulsed field gradient NMR on the polymer only (not in composite) and get 100x slower D for the anion species. Thus, the transference is 0.99 by nuclear magnetic resonance (NMR) in the neat polymer. This reviewer recommended trying pulse Fourier transformation (PFT) NMR in the 6um pores in the composite, which may be possible. The reviewer also recommended checking for diffusion of residual monomers or mobile oligomers. 4) How will you improve the interface between polymer and ceramic? PI: (Preliminary Answer) The team needs better polymer with better transport and mechanical properties.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the organic-inorganic composite electrolytes have several practical advantages. However, to make this project more relevant, more effort should be directed towards a polymer with improved conductivity.

Reviewer 2

The reviewer stated that the project does support the overall VTO subprogram objectives.

Reviewer 3

The reviewer stated that the PIs have chosen and described relevant goals and objectives to the VTO Battery subprogram. The goals of developing and understanding new polymer-ceramic composite electrolytes and integrating them into practical battery cells are highly relevant to advancing solid-state batteries, Li-metal batteries, and other subprogram goals. This project is doing that well. The reviewer also referred to earlier comments.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that this project makes good use of a variety of important resources, both within the core team and via outside collaborators.

Reviewer 2

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones in a timely fashion. However, the resources may not be sufficient to achieve performance in pouch cells, as suggested.

Reviewer 3

The reviewer stated that the PI and the team members and institutions have impressive and sufficient resources (both funding and laboratory and human infrastructure) to conduct this work and achieve the stated goals and milestones. The synthetic and materials formulation abilities/expertise/experience, the materials analysis capabilities/expertise, the battery cell development skills, and the computational/theoretical experience are very well-matched to this project.

Presentation Number: BAT543
Presentation Title: Integrated Multiscale Model for Design of Robust 3D Solid-state Lithium Batteries
Principal Investigator: Brandon Wood, Lawrence Livermore National Laboratory

Presenter

Brandon Wood, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

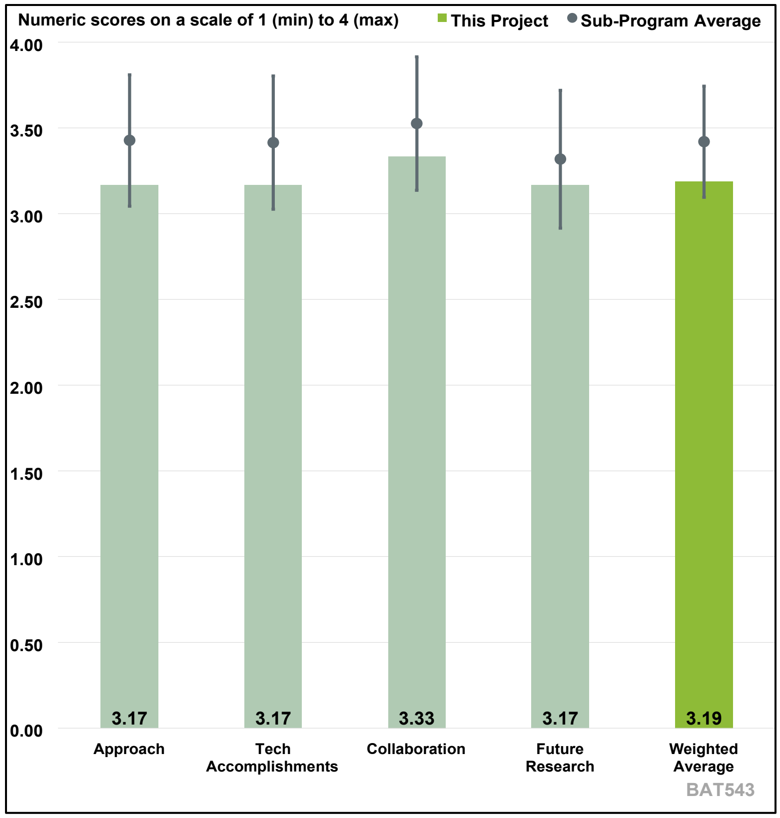

Figure 1-29. Presentation Number: BAT543 Presentation Title: Integrated Multiscale Model for Design of Robust 3D Solid-state Lithium Batteries Principal Investigator: Brandon Wood, Lawrence Livermore National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project is focusing on the poor battery cyclability due to interfacial chemical reactions, which is critical for solid-state batteries. The project is well-designed and reasonably planned. However, the work is based on the materials made by the chemomechanics method, with limited applications in industry.

Reviewer 2

The reviewer stated that this project aims to develop and apply multiscale, multiphysics models to connect composition, microstructure, and architecture to chemomechanical integrity and transport performance of 3D solid-state battery materials. The project is well-designed and has a reasonably planned timeline.

Reviewer 3

The reviewer stated that the project is well-designed, and the timeline is reasonably planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the progress is reasonable compared to the plan.

Reviewer 2

The reviewer stated that significant technical progress has been made in the project.

Reviewer 3

The reviewer stated that the project does not include any experimental validation, which needs to be addressed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaboration and coordination across the project team is excellent. It would be better to obtain industrial inputs and to work on more representative materials in industry, such as sulfide-based electrolytes.

Reviewer 2

The reviewer stated that this project is well-rounded in collaboration with an excellent lead and partners from the national laboratories, academia, and “industry”. Note that while there is no specific industry entity listed, certain researchers do bring that to the table.

Reviewer 3

The reviewer stated that the project really needs to collaborate with experimentalists.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed work is limited to evaluating the materials made by the chemomechanics method. It may be more effective if investigating widely used materials and its combinations, such as NMC/sulfide/Li-metal. It is critical to include the effect of time in the modeling since the interfacial reactions do not stop. And the ratio of electrolyte/electrode active materials is also critical for high energy.

Reviewer 2

The reviewer stated that the project has clearly defined a purpose for future work is likely to achieve its targets.

Reviewer 3

The reviewer stated that the project clearly defined a purpose for future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the overall VTO subprogram objectives since solid-state batteries represent a promising approach for potential high energy and long-life EV batteries.

Reviewer 2

The reviewer stated that the project does support the overall VTO subprogram objectives.

Reviewer 3

The reviewer stated that the project supports the overall VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient.

Reviewer 2

The reviewer stated that the resources are sufficient to achieve the stated milestones in a timely fashion.

Reviewer 3

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones.

Presentation Number: BAT553
Presentation Title: Understanding solid electrolyte interphase (SEI) reactions in Lithium metal and Lithium-Sulfur batteries
Principal Investigator: Perla Balbuena, Texas A&M University

Presenter

Perla Balbuena, Texas A&M University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

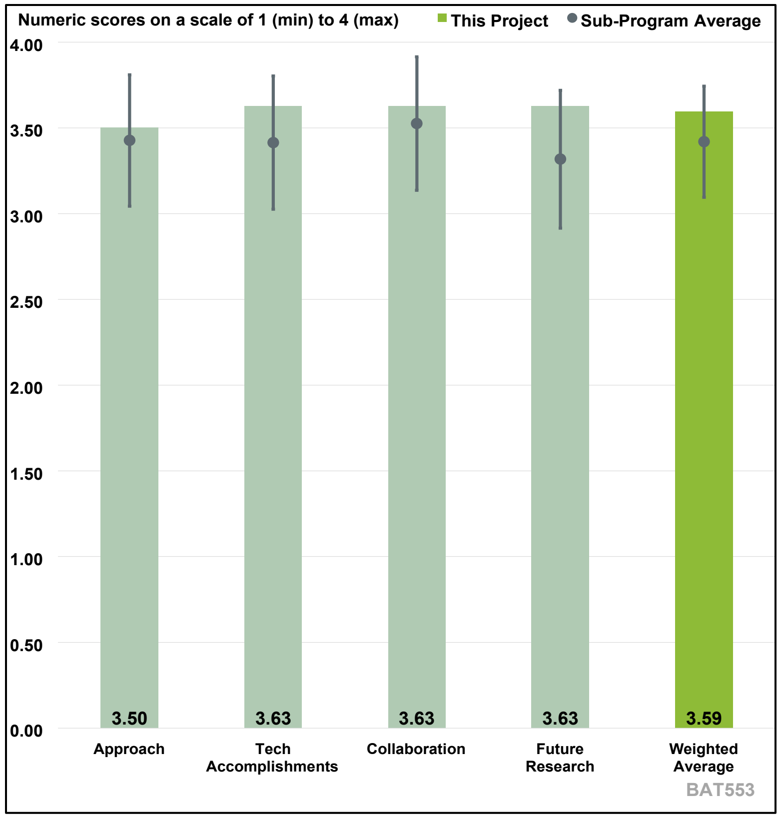

Figure 1-30. Presentation Number: BAT553 Presentation Title: Understanding solid electrolyte interphase (SEI) reactions in Lithium metal and Lithium-Sulfur batteries Principal Investigator: Perla Balbuena, Texas A&M University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project aims to address the challenges in developing safe, high-energy-density Li-metal rechargeable batteries. This modeling effort is meticulously designed to integrate seamlessly with other ongoing Battery500 material synthesis and diagnostic experimental endeavors. The Balbuena group provides a fundamental understanding of the charge-transfer and electrochemical/chemical reactions, enabling laboratory scientists to better select the materials that are to be explored. Several promising areas of exploration are being pursued, including SPAN reactions, electrical conductance properties of Li, transition metal dissolution mechanisms, and pressure effects. The reviewer stated that the proposed timeline is both realistic and appropriate for the scope of the work.

Reviewer 2

The reviewer stated that the Ab initio calculations and kinetic Monte Carlo method were utilized to investigate the interactions between electrolytes and electrode materials. This provides important chemical information on solid electrolyte interphase/cathode electrolyte interphase (SEI/CEI) that is difficult to get from experimental approaches alone.

Reviewer 3

The reviewer stated that this project aims to provide theoretical understanding of the Battery500 cell chemistry using multi-scale computation and simulation approaches. The approach is well-designed and is critical for the success of the Battery500 project. Since pressure control has an important effect on the cycle life of the high energy density battery, the reviewer was not clear how the pressure effect, proposed in the project, will be studied computationally.

Reviewer 4

The reviewer stated that to achieve a highly reversible Li-metal anode, the team addressed three technical barriers in this fiscal year (FY) presentation report: 1) Characterize the relationship between SEI and Li anode reversibility using first principle calculations; 2) Understand the degradation reactions of transition metal oxide cathode; 3) Understand the role of electrolyte in S cathode conversion reactions. The project is well designed, and the timing is well planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the team was highly productive and has made significant contributions useful to the battery research community. The team helped develop a deep understanding of the effect of Li SEI structure/morphology and electrical conductance properties. New insights were also obtained on the pressure effects of NMC cells and alternative SPAN chemistries. Several journal articles were published.

Reviewer 2

The reviewer stated that chemical/electrochemical events were used as an indicator of interfacial reactivities. This indicator works well for guiding the design of stable interface. However, the importance of the events is not functionally equivalent to the SEI/CEI. For instance, the formation of ‘good’ or ‘bad’ can be equally counted as ‘event’ at the interface. Statistical analysis of these events can play a more important role in guiding interfacial design.

Reviewer 3

The reviewer stated that the project has provided fundamental understanding on multiple topics of Battery500 cell components, including NMC, Li-metal and sulfur cathodes. The proposed pathway for the SEI formation is particularly impressive and will be important in designing better electrolytes. The PI shows sharply different solubilities of NMC in liquid electrolyte for the pristine and protonated surfaces, the results are inspiring and the reviewer wonders if there is a plan to collaborate with experimentalist to validate this results.

Reviewer 4

The reviewer stated that the technical progress is well aligned with the project plan. The team’s calculation capability well supports the experimental teams.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the PI has demonstrated outstanding collaboration within the Battery500 Team. That group’s efforts dovetail the research of several material scientists and battery engineers (PNNL, BNL, Stanford, UCSD) in the Battery500 Consortium. The team provides fundamental chemical and electrochemical insights to address challenges associated with the Li anode and SPAN cathode/electrolytes. These efforts have resulted in several significant publications.

Reviewer 2

The reviewer commended good collaboration within Battery500. The reviewer observed that stronger benchmarking with experimental data will add more value to the effort.

Reviewer 3

The reviewer stated that the PI has established strong collaborations with multiple PIs within the Battery500 team.

Reviewer 4

The reviewer stated that the research team had collaborations with national laboratories (e.g. PNNL, BNL) and universities (e.g., UCSD, Stanford), which shows the considerable impact of this work. The reviewer remarked that it has been reported that Germany is also involved in the collaboration. The reviewer was uncertain regarding specific contributions from Germany.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future research is well-conceived. Building on this year's achievements, the project is poised to continue delivering excellent results.

Reviewer 2

The reviewer stated that the proposed future research is reasonable. The SPAN chemistry is really complex, and the reviewer recommended more computational focus on that particular chemistry.

Reviewer 3

The reviewer stated that thermal runaway reaction studies are proposed in the future work. This will be important for addressing Li-metal battery safety issues.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that this is a valuable project in the VTO portfolio. The solid–electrolyte interphase critically governs the performance of rechargeable batteries. Developing a fundamental understanding of the SEI will enable investigators find methods to better control electrode-electrolyte reactions resulting in prolonging the battery cycle life and improving performance.

Reviewer 2

The reviewer stated that the project supports the ultimate goal of Battery500.

Reviewer 3

The reviewer stated that theoretical studies using multi-scale computations and modeling are important and the project supports the Battery500's goal of developing high-energy-density batteries.

Reviewer 4

The reviewer stated that the proposed work well supports the Batteries program in VTO. This team's contribution from the theoretical modeling part will support experimental results and accelerate the development of Li-metal batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project has the necessary resources to complete the tasks on time.

Reviewer 2

The reviewer stated that the resources of for proposed research are reasonable.

Reviewer 3

The reviewer stated that sufficient resources are available for the team to achieve their proposed tasks.

Presentation Number: BAT587
Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries Theory and Modeling
Principal Investigator: Hakim Iddir, Argonne National Laboratory

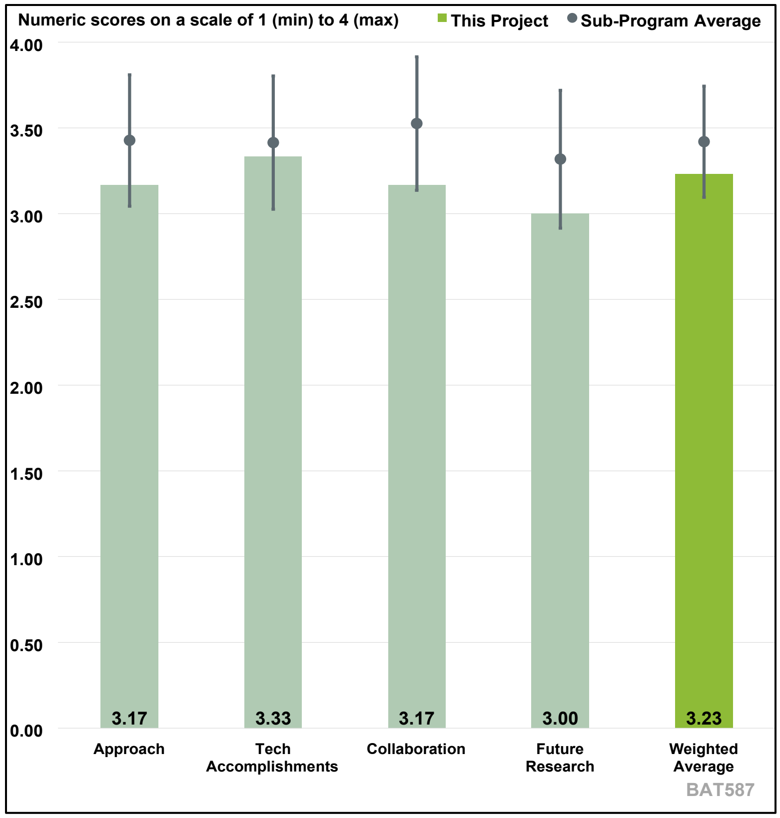

Figure 1-31. Presentation Number: BAT587 Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries Theory and Modeling Principal Investigator: Hakim Iddir, Argonne National Laboratory

Presenter

Hakim Iddir, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that this project is part of the consortium led by Argonne National Laboratory, which addresses the major barriers of cost, performance, safety, and supply chain for rechargeable batteries. The overall strategy is to develop electrode materials to eliminate expensive and limited availability elements, typically cobalt and nickel in the cathode. Toward this end, the objective of the proposed research focuses on developing cathodes based on earth-abundant materials, such as manganese-based materials. Specifically, this project is oriented toward theoretical understanding of such cathode materials. The team uses a combined theoretical approach and model system to gain fundamental insights for correlating design, synthesis, and structure-property relations of the cathode based on earth-abundant materials. Overall, the project is well-designed and streamlined in time scale for carrying out the proposed research. The reviewer stated that the theoretical result appears to be standalone, it would be beneficial if the theoretical result can be directly integrated with the experimental observations.

Reviewer 2

The reviewer stated that density function theory was applied to investigate the transport properties of Li ions in cathode materials containing earth-abundant elements like manganese. Particularly, lithium-manganese-rich cathodes were the primary focus. It was claimed that the extremely low Li-ion diffusivity at low state of charge (SOC) can be problematic for adopting this class of materials. However, it is not clear that transport properties are taking priority over the structural stability.

Reviewer 3

The reviewer stated that project focuses on key barriers in non-cobalt, lithium-nickel-manganese batteries.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that to accomplish the proposed research and meet the technical milestones, the team has carried out Ab-Initio Molecular Dynamics (AIMD) at 900K for $0.4Li_2MnO_3•0.6LiMn_{0.5}0Ni_{0.5}0O_2$, revealing the domain distribution in the Li-rich and manganese-rich cathode (LMR). Further, the team calculated the Li diffusivity in each of the domains of the LMR cathode, revealing that diffusivity in the half-lithiated $Mn_{0.50}Ni_{0.50}$ domains is almost 3 times the diffusivity in staggered domains at an equivalent SOC during activation. The team also revealed the anionic redox process in the LMR cathode, demonstrating the oxygen formation. All these insights represent great progress in developing the LMR-based cathode for the next generation high-capacity battery. The reviewer stated that the modeling results should be compared with experimental observations in the same materials system.

Reviewer 2

The reviewer stated that effort was made to calculate the Li ion diffusivity and technical difficulty at low SOC was identified.

Reviewer 3

The reviewer stated that excellent progress was made in all three components of the project: lithium- and manganese-rich (LMR) cathodes: structure-property-performance; first principles phase diagram of the $LiMnO_2$-Li_2MnO_3 space; and single-crystal models: particle size effects.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team is outreaching well and collaborating with other institutions, in particles including universities and national laboratories. It would be expected that the team's expertise in theoretical modeling will be integrated with experimental tools, in order to warrant the success of the proposed research.

Reviewer 2

The reviewer stated that there is good collaboration within and across the consortium teams.

Reviewer 3

The reviewer stated that the collaboration among the team members consisting of ANL, NREL, ORNL, LBNL, PNNL, SLAC is satisfactory.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that for future research, the team proposed to evaluate the effect of dopant concentrations on manganese stability and irreversible oxygen redox, which is critical to the performance of the LMR cathode. Further, the team will assess the impact of spinel-layered, integrated domains on stability of LMR cathode, which is another emerging domain with a lot yet unknown for LMR cathode. The team also plans to develop techniques for improving and increasing the use of machine-learning potentials in molecular dynamics simulations to extend the time scale and system sizes. All the proposed future research steps are well-conceived and carrying out the proposed tasks will lead to insights for the optimization of LMR cathode. A close integration with experimental observation will be complementary to the proposed theoretical modeling results.

Reviewer 2

The reviewer stated that the effort can be better utilized to tackle more important barrier—structural stability.

Reviewer 3

The reviewer stated that the extension of the current approach is well-proposed. However, a comparison with some experimental data is important to ensure that the modeling is accurate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that developing cathode with earth-abundant elements is a critical step for energy sustainability. This project focuses on gaining insight on the fading mechanism of LMR cathode, which is very important and relevant to the objective of VTO subprogram on developing high-capacity battery with sustainable element and affordability.

Reviewer 2

The reviewer stated that developing cathode materials using earth-abundant element supports DOE’s mission to maximize the sustainability of low-carbon transportation.

Reviewer 3

The reviewer affirmed that the project supports overall VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the PI and team of this sub-project of the consortium possess the theoretical expertise for carrying out the proposed research. The computational power and resources are adequate for the proposed research to reach the laid-out milestones in a timely fashion. The reviewer articulated the desirability of the team closely integrating theoretical results with experimental observations.

Reviewer 2

The reviewer stated that there are sufficient resources available.

Presentation Number: BAT590
Presentation Title: Lithium Halide-Based Superionic Solid Electrolyte and High-Voltage Cathode Interfaces
Principal Investigator: Robert Sacci, Oak Ridge National Laboratory

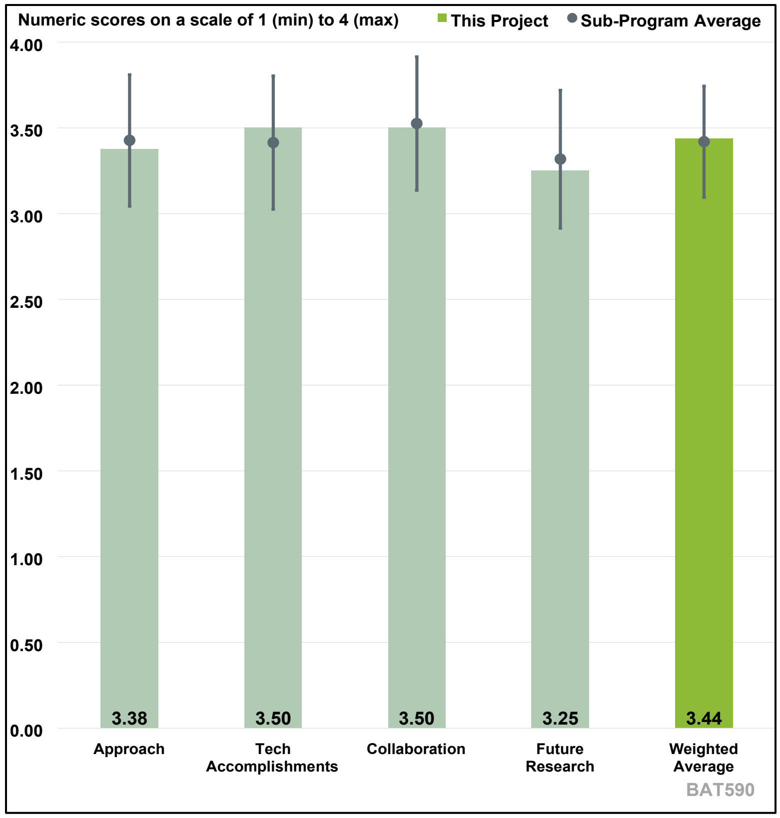

Figure 1-32. Presentation Number: BAT590 Presentation Title: Lithium Halide-Based Superionic Solid Electrolyte and High-Voltage Cathode Interfaces Principal Investigator: Robert Sacci, Oak Ridge National Laboratory

Presenter

Robert Sacci, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the need for a solid catholyte, which can be integrated throughout the cathode porous structure, is often neglected in solid-state battery R&D. The reviewer commended the focus on that issue. The reviewer commended the excellence of the milestones to measure progress towards a functional solid catholyte. As with much solid-state research, there are non-ideal material choices made that may impact the interpretation of results. For example, 1 mm thick SSE as mentioned on Slide 6. Slide 7 mentions the recent manufacture of thin (possibly about 20 microns) LIC layers which represents a huge improvement.

Reviewer 2

The reviewer stated that the basic concept of the project and the approach are good. Methods to make a cathode with a solid electrolyte are important, and solution processing is a reasonable approach for doing so. The methods used, including evaluation in full cells, are reasonable. The reviewer pointed out that the limitation that several of the elements may apparently be too expensive for any commercial cell—for example, Indium. Another limitation is the full cells have multiple layers.

Reviewer 3

The reviewer stated that the primary approach in this project is the solution-based synthesis of halide SSEs. This method has several advantages over the mechano-synthesis method. Solution-based synthesis allows for better control over the parameters of the final products, making it easier to achieve the desired specifications. It is also more cost-effective and scalable, therefore suitable for larger production runs. The reviewer recommended that the PI explore a wider range of options for full cell fabrication beyond the bi-electrolyte approach. By investigating and experimenting with various methodologies, the PI can potentially identify more efficient or effective techniques for constructing full cells, thereby improving the overall outcome.

Reviewer 4

The reviewer stated that the project sets very specific objectives: developing inexpensive, solution-based methods that allow for growing halide-based solid electrolyte within the porous high-voltage cathode matrix, leading to a drastic increase in the mechanical robustness and high-rate performance. However, the approach being taken is not very clear to the reviewer. On the other hand, research presented by the team deals with the practical issues in developing halide SSEs, including scalable synthesis using solution-based methods, making thin membranes, and lowering applied pressure during cycling. These are valuable contributions towards accomplishing better processing and engineering of solid-state batteries, and they are important to achieving overall VTO goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer praised the researchers on their practical (cycling) and diagnostics accomplishments. The reviewer encouraged this project team, and others, to report mAh/g quantity of the electrode, not of the active material. For example, the results shown on Slide 10 must be active material as 200mAh/g is not possible at the electrode level with just 50% NMC in the cathode. This is critical to understand the likely attainable cell energy. The reviewer praised the researchers on their pressure study. The reviewer remarked that external pressure requirements are a large concern for automotive OEMs, so the reviewer was pleased to see it explicitly addressed here. The reviewer also remarked that the high voltage stability of the halide SSEs is critical and impressive.

Reviewer 2

The reviewer stated that overall, the technical accomplishments are strong and clearly presented. The demonstration of the solid electrolytes in the full cells is really the best way to evaluate their performance, and this was done in a systematic and reasonable way. The work on solid electrolyte films and consideration of the mechanical properties and applied pressure are also valuable accomplishments. The reviewer was quite impressed with the cycling with single crystal NMC.

Reviewer 3

The reviewer stated that the most significant accomplishment and contribution from this project is the successful synthesis of halide SSEs using a solution-based method. This achievement is particularly noteworthy because it includes the development of an effective technique for drying and removing the attached solvent molecules, specifically water. This aspect of the synthesis process has posed a considerable challenge to researchers for many years, making this breakthrough especially impactful. By overcoming this long-standing obstacle, the project has made a substantial contribution to the field. The ability to efficiently dry and purify the synthesized halides is a crucial step towards the scale-up of halide production. This advancement not only improves the quality and consistency of the final products but also makes the production process more viable for larger-scale applications.

Reviewer 4

The reviewer stated that overall, good progress has been made on this project. The team evaluated solution synthesis of Li_3InCl_6 (LIC) and LYC, fabricated thin membranes of LIC, and evaluated pressure effect on cell cycling performance. Particle size appears to play an important role. The reviewer asked one question relating to particle size and morphology control in solution synthesis. What are the parameters for optimization and how can they be controlled during the synthesis?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised the collaboration as excellent.

Reviewer 2

The reviewer stated that the collaboration across team members appears to be strong.

Reviewer 3

The reviewer stated that the PI collaborated with another national laboratory and two universities for testing and diagnostic purposes. This collaboration proved to be generally effective, with clearly defined roles for each partner. However, the reviewer commented that as part of a larger program, efforts should be made to minimize redundancy. For example, the same bi-layer SSE has been reported by multiple groups, highlighting the need for better coordination to avoid duplicate work.

Reviewer 4

The reviewer stated that the collaborations across the teams of ORNL, SLAC and the University of Houston are excellent. There appears to be clear integration of expertise in different areas.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commended the excellence of the future research described. The reviewer posed the question whether it is reasonable to target a significant reduction in the non-active weight percent in the cathode. The reviewer expressed that a value of 50% active material will make any solid-state cell significantly less competitive in comparison to a graphite/NMC Li-ion liquid cell.

Reviewer 2

The reviewer stated that the future research is clear and specific, and well prioritized based on work to date.

Reviewer 3

The reviewer stated that the PI proposes to further investigate the stability of halide SSEs, modify the SSE through transition metal doping, enhance the cathode, and develop thin SSE separators. The reviewer remarked that the proposed research activities are well-aligned with the overall project objectives. The reviewer encouraged the PI to consult with industry experts regarding the scale-up processes for halide production. This collaboration could provide valuable insights and help ensure that the project's advancements are practical and scalable for commercial applications.

Reviewer 4

The reviewer stated that the list of future work items seems to cover various directions and a bit scattered. The reviewer suggested narrowing down the scope and focusing on developing a more in-depth understanding, maybe in just one or two areas. For example, it would be helpful to have more knowledge on halide processing and membrane fabrication, and outline where the potential barriers might be in this area.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that as mentioned earlier, the project is highly relevant. The reviewer clarified that a major issue with consideration of different solid anolyte and catholyte usage is the need to keep the total thickness of those layers (combined) to 30 microns, which is exceedingly difficult to accomplish with a solid electrolyte.

Reviewer 2

The reviewer stated that the work is relevant to the Batteries program.

Reviewer 3

The reviewer stated that solid-state batteries and scale-up material manufacture are relevant to VTO's goal of making 500Wh/Kg, 1000 cycle batteries for EV applications.

Reviewer 4

The reviewer stated that addressing the practical issues in solid electrolyte synthesis, processing, manufacturing, and cell integration is critical to the future development of solid-state batteries. The project is relevant to the overall DOE objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commended the excellent value received for the $250,000/year investment in the project. The reviewer would also consider slightly more resources to accelerate this work.

Reviewer 2

The reviewer commended the budget was only $250,000/year—yet a significant amount of results were achieved. The reviewer would consider increasing the budget.

Reviewer 3

The reviewer commended the PI, and the team can access adequate resources to conduct the proposed research.

Reviewer 4

The reviewer commended the project has sufficient resources.

Presentation Number: BAT591
Presentation Title: High-Conductivity and Electrochemically Stable Thioborate Solid-State Electrolytes for Practical All-Solid-State Batteries
Principal Investigator: Yi Cui, SLAC National Accelerator Laboratory

Presenter

Yi Cui, SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

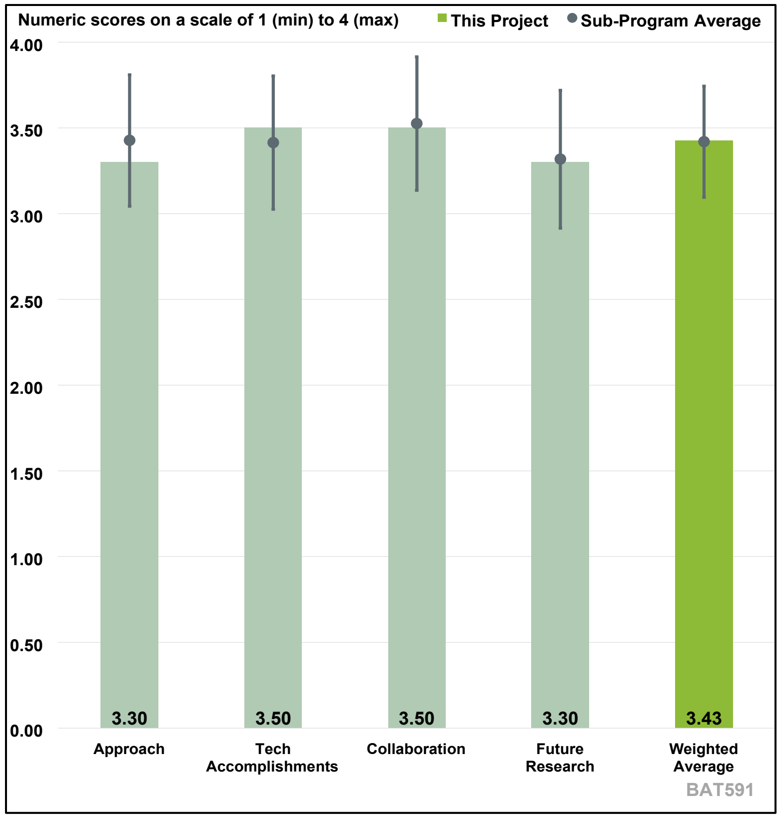

Figure 1-33. Presentation Number: BAT591 Presentation Title: High-Conductivity and Electrochemically Stable Thioborate Solid-State Electrolytes for Practical All-Solid-State Batteries Principal Investigator: Yi Cui, SLAC National Accelerator Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project focuses on the development of a new electrolyte Li-B-S. But it seems having a compatibility issue with Li-metal and cathode materials, and buffer layers have to be used to make it cycle.

Reviewer 2

The reviewer stated that the materials closely related to thioborates which have been studied as solid-state electrolytes for over 30 years. Perhaps this specific class of material is new, but materials like B_2S_3-Li_2S were known to provide 10-100x the conductivity of their oxide counterparts long ago. These are attractive low-cost materials and there may be a path forward with them. It’s interesting that the ratio of B/S/Li of the highest conductivity material here, $Li_{10}B_{10}S_{20}$ is the same as that of Li_2S-B_2S_3. The relatively low voltage stability of any sulfide electrolyte will require either a catholyte or a low voltage cathode, and of course the latter will limit cell energy.

Reviewer 3

The reviewer stated that the project has a unique approach using machine learning to identify high ionically conductive thioborate-based solid electrolytes—theoretically $Li_5B_7S_{13}$ has the highest ionic conductivity at 74 mS/cm. However, experimentally $Li_{10}B_{10}S_{20}$ had the highest ionic conductivity at 0.1 mS/cm (experimentally, $Li_5B_7S_{13}$ was several orders of magnitude lower). Ionic conductivity increases to over 1 mS/cm with the addition of LiI. The reviewer remarked that the advantages of Li thioborate electrolytes over other solid electrolytes are unclear. Moreover, the unique annealing process needs to be better understood—its unusual that the formulation requires a 12 hour anneal at 550°C work after a 2 hour anneal at 750°C.

Reviewer 4

The reviewer stated that the researcher plans to understand the structure and transport mechanism of thioborate solid electrolytes. The researcher also plans to figure out its integration into a full cell design.

Reviewer 5

The reviewer stated that exploring new and high-performance solid-state electrolyte is critical to the development and improvement of solid-state battery technology. The reviewer remarked that the project is well designed, planned and executed at the given budget level and timeframe.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that reasonable progress has been made towards the project plan.

Reviewer 2

The reviewer stated that as with many solid-state research projects, it's difficult to understand how some of these measurements, like EIS as 350MPa and 500 microns thick, will relate to materials used in actual cells. The addition of LiI to increase the conductivity is interesting and valuable. Similar additives were used to increase the conductivity of B2S3, The reviewer also found it very interesting that ball milling decreases the conductivity, and that the crystallinity is helpful.

Reviewer 3

The reviewer stated that there has been significant technical progress made in the project thus far. The addition of LiI demonstrated enhanced performance which increases the ionic conductivity by an order of magnitude.

Reviewer 4

The reviewer identified the technical accomplishment for the project. The first technical accomplishment the research team found is that Li-S battery 10-10-20 had the best ionic conductivity of the materials synthesized. The researchers wanted to improve it even more and also improve the electrochemical stability by doping with different halides. The addition of 24% LiI further improved the conductivity to approximately 1 mS/cm. Using SEM EDS and TEM with EELS, the researchers demonstrated that the LiI was not integrated into the electrolyte. Using EIS the research team determined that there are no grain boundaries in the mixture of Li and thioborate. Ball milling reduced the crystallinity of the mixture and decreased the conductivity. The team showed through EIS and cycling that the addition of LiI also improved the interface stability. XPS of the interface revealed LiI, Li_2S, and Li metal. Little LBS remained. The team then investigated different solid electrolytes that should be compatible with the cathode and found the Li_2ZrCl_6 was the most stable and it resulted in the highest capacity when mixed with NMC in a composite cathode. Lastly, the team put together a full cell of In-LBS-LiZCl-NMC. The reviewer would like to see how this cell performed without the use of Indium. Apparently, the electrolyte does not cycle large amounts of Li very well. The reviewer remarked that it appears additional work on stabilizing the interface through dopants is needed. The project team made a lot of progress in creating a cell with high initial capacity that could cycle fairly well and also in optimizing the thioborate and understanding the mechanism of how it works.

Reviewer 5

The reviewer stated that the synthesized materials demonstrate decent ionic conductivity at room temperature. The research team studied and decoupled conductivity contributions of grain and grain boundaries of the materials, which is helpful in understanding and designing other solid electrolyte materials.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaboration within the project team is excellent, but the reviewer did not see contributions from industry. It is better to have industrial inputs regarding the buffer layers in real applications.

Reviewer 2

The reviewer stated that the collaboration was good.

Reviewer 3

The reviewer stated that the project has a strong leading team at Stanford University that is well experienced in next-generation Li batteries. The work is also supported by SLAC and ORNL via beamtime. The project would benefit greatly by having an industry partner that can demonstrate the scale up manufacturing capability of the Li thioborate solid electrolyte and the performance in industry relevant pouch cells.

Reviewer 4

The reviewer stated that it seems like a small amount of money, and they accomplished quite a bit which would require a team.

Reviewer 5

The reviewer stated that there was good collaboration with domestic and international partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future research plan is clearly defined. It is better to work with industrial partners to figure out if the buffer layers acceptable/applicable or should be removed by improving chemical compatibility between LBS and other active electrode materials.

Reviewer 2

The reviewer was uncertain if a 50% capacity retention over 50 cycles is competitive with what industry can currently achieve. Making thin and conformal electrolytes is critical. If they are to be used on the cathode side as well, they must be used in relatively small weight percentages.

Reviewer 3

The reviewer stated that the proposed future work is clearly defined and is likely to achieve project targets. However, the proposed future work plan should also include collaboration with an industry partner to demonstrate relevance, manufacturing and performance capabilities. There are already quite a few solid-state electrolyte materials that are much further along development wise in industry (sulfides, oxides, halides). In fact, solid-state batteries comprising sulfides, in particular argyrodites, are near commercialization. Any new class/group of solid electrolytes needs to quickly get into the hands of an industry partner to accelerate development.

Reviewer 4

The reviewer stated that for future work, the team hopes to investigate bromine and chlorine substitution in LBS and investigate Yttrium (Y), Indium (In), and Erbium (Er) substitution in LiZCl and investigate the possibility of using doped LBS as the catholyte. The reviewer commended the researcher on working through the development of LBS as an anolyte and the reviewer is looking forward to his work on the catholyte.

Reviewer 5

The reviewer praised the plan for future work. Given the target and scale of the project, more efforts would be focused to advance the solid electrolyte development and improvement. Particularly, further enhancement of ionic conductivity and electrochemical window would be interesting direction.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the overall VTO subprogram objectives since solid-state batteries are a promising approach for potential high energy and long-life EV batteries.

Reviewer 2

The reviewer stated that the project has very high relevance. These are high conductivity and earth-abundant materials. The reviewer would encourage this team to differentiate between this work and that on the B_2S_3 class of electrolytes described in the early 1980s.

Reviewer 3

The reviewer stated that the project supports the overall VTO subprogram objectives.

Reviewer 4

The reviewer remarked that DOE VTO would like see progress in solid-state batteries as the possibility of improved energy density and low flammability is very appealing. This research moves the world closer to that reality.

Reviewer 5

The project is relevant to DOE/VTO's mission of vehicle electrification and supports the VTO's solid battery programs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient.

Reviewer 2

The reviewer stated that the project showed very good progress for only an investment of $200,000/year.

Reviewer 3

The reviewer stated that the project resources are sufficient to achieve the ‘stated’ milestones in a timely fashion. However, the resources may need to be increased in the future to include an industry partner.

Reviewer 4

The reviewer stated that the group is making good progress with the present funding. It could probably make faster progress with an increase in funding.

Reviewer 5

The reviewer stated that the resources are sufficient to achieve the proposed research goals.

Presentation Number: BAT599
Presentation Title: Fluorinated Glyme Solvents to Extend Lithium-Sulfur Battery Life
Principal Investigator: Taylor Xu, Navitas Systems

Presenter

Taylor Xu, Navitas Systems

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

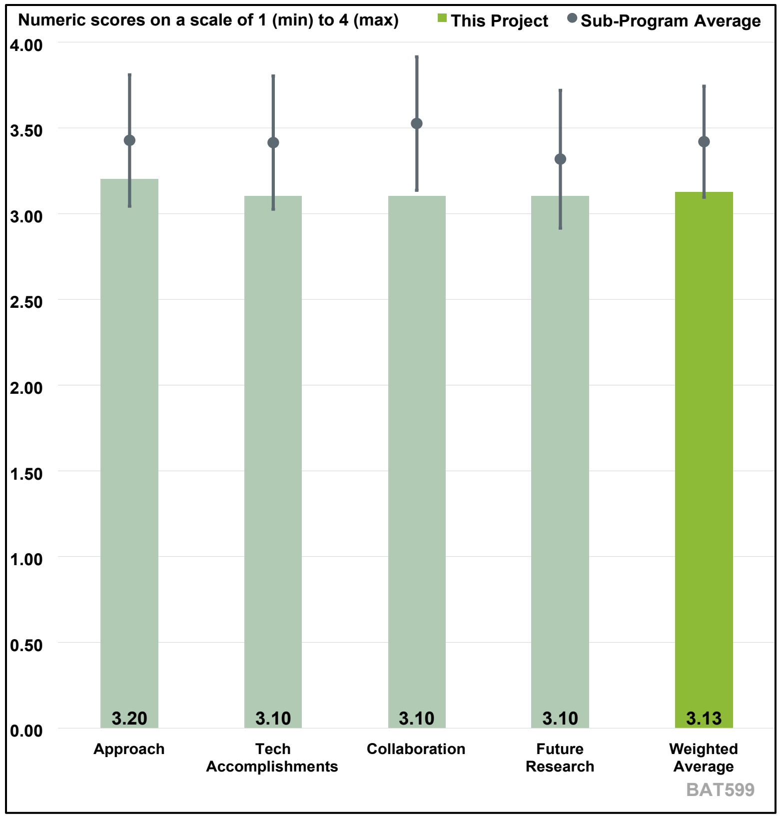

Figure 1-34. Presentation Number: BAT599 Presentation Title: Fluorinated Glyme Solvents to Extend Lithium-Sulfur Battery Life Principal Investigator: Taylor Xu, Navitas Systems

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that even though the project is titled ‘Fluorinated Glyme Solvents to Extend Lithium-Sulfur Battery Life’, it explores a multifaceted approach to enhance the performance and longevity of Li-S batteries. In addition to developing electrolytes based on partially-fluorinated glymes (PFGs), the project incorporates Navitas’ ceramic host cathode and a coated separator. These measures collectively aim to suppress polysulfide shuttling, a critical factor in improving the cycle stability of L-S batteries.

Reviewer 2

The reviewer stated that in this project, the team developed ceramic host materials for sulfur with strong polysulfide absorption capability and scaled up the high-mass-loading (more than 3.6 mgS/cm^2) sulfur electrode based on the ceramic host. In addition, new solvents (e.g., PFGs) were explored to address the shuttling issues in Li-S batteries. The project is reasonably designed. However, the reviewer stated there is some room to be further improved. For example, the team prefer to choose DOL/PFG solvent in Li-S batteries for shuttling. The reviewer asked why the anode stability testing uses DME/PFG rather DOL/PFG. In addition, >200 mAh pouch cells with 400 cycles need to be set up and tested according to milestones. So far, 70 cycles have been run with obvious capacity decay. The reviewer remarked that the team needs better solutions to achieve the milestone.

Reviewer 3

The reviewer stated that a C/ceramic host is used as an host for S, taking advantage of high absorption capability to Li polysulfides and good electronic conductivity. At the same time, fluorinated glyme solvents are used to further suppress the dissolution of Li polysulfide.

Reviewer 4

The reviewer praised the approach to performing the work of this project. Three approaches were used: 1) Use ceramic host with high conductivity, strong polysulfide absorption, and catalytic conversion effects on high/low order polysulfides. 2) Use PFGs as multifunctional solvents with high ionic conductivity to increase coulombic efficiency, to improve safety, to suppress polysulfide dissolution in electrolyte, and to promote SEI formation on Li anode surface. 3) Use innovative separators to block polysulfide shuttling and to reduce resistance of assembled cells. The reviewer remarked that these approaches are well designed to address technical barriers, and the timeline is reasonably planned.

Reviewer 5

The reviewer stated that the milestones should be better identified with measurable targets. Given the budget level, the research effort and planning need improvement.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer suggested including specific dates in the milestone list, as it is hard to follow the timeline without them. The Navitas team designs and selects PFGs based on their chemical properties (polarity, oxygen number) and their effects in the L-S cell, rather than merely searching among commercial products. The team has demonstrated that the PFG1 (understandably, the molecular formula is not revealed) improves the interfacial stability of the Li anode, reduces lithium polysulfide dissolution, and is non-flammable, thereby enhancing electrolyte safety. The team understands the tradeoff between initial capacity, coulombic efficiency, and capacity retention, which is controlled by the amount of PFG1 added to the electrolyte. Although their double-layer pouch cell has not yet achieved the targeted performance, they have demonstrated the advantages of PFG1 over the baseline electrolyte, indicating that the project is moving in the right direction.

Reviewer 2

The reviewer stated that the team is on the right track to improve the cycling performances of Li-S batteries through improvement of electrolytes. Just the experimental design should be further optimized, for example, by improving anode stability with DOL/PFG electrolyte.

Reviewer 3

The reviewer stated that good progress was made to improve the cycling performance and coulombic efficiency. Safety study is currently limited to flammability test. With the help of C/ceramic host and FGS, the highest coulombic efficiency achieved was about 90%, which is below expectation for the strong absorption capability of C/ceramic host.

Reviewer 4

The reviewer stated that a set of accomplishments took place: 1) Ceramic sulfur host with strong polysulfide absorption capability was used to make sulfur composite cathodes successfully containing 76wt.% sulfur with uniform sulfur distribution. 2) Rolls of high sulfur loading electrode (≥ 3.6 mg of S/cm^2) have been made in pilot scale. 3) Low polarity solvents (aliphatic and aromatic group) using PFGs have been designed and synthesized to prevent Li_2S_x dissolution and shuttling, to improve electrode and separator wetting. The cell using DME/PFG1 electrolyte shows less overpotential growth and stable Li stripping and plating indicating improved interphase stability on Li anode. These accomplishments are very good compared to the project plan. The reviewer suggested the project PI may want to present results on why aliphatic PFGs work better than the aromatic ones and discuss the effects of chain length and sites of fluorinations.

Reviewer 5

The reviewer stated that although electrode coating quality is visually good, the performance improvement of the C/ceramic cathode is not clear in terms of sulfur utilization, rate capability and polysulfide trapping. The reviewer was unable to see clear improvement of electrolyte or insightful understanding; the research is more like routine test of electrolytes with their electrodes. For practical use, the cell test should be under practical conditions of both high sulfur loading and lean electrolyte conditions. Given the scalable electrode coating by the company, the reviewer suggested to the team to use realistic pouch cells for all the materials/electrolyte test, better identifying real challenges of the technology.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project is a good example of synergic collaboration between industry company and national laboratory.

Reviewer 2

The reviewer stated that ANL is developing PFG solvents in this project. More characterizations after cell decay from ANL is expected to study the failure mechanisms, which would help further improve cell performance.

Reviewer 3

The reviewer stated that there is good collaboration with ANL.

Reviewer 4

The reviewer stated that this project includes collaborative research carried out with a VTO-funded project at ANL. Collaborative research with more VTO-funded projects is encouraged for Fiscal Year 2025.

Reviewer 5

The reviewer stated that one can see cross-side materials exchange and test, but it would be better to see more on how to further improve the materials or electrolytes based on the collaborations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the team has clearly listed the remaining challenges in further developing the Li-S battery. The milestones for the third year are well-defined. Overcoming the barriers in Li-S battery development requires more than just improving a single component. Navitas plans to address these challenges through three main approaches: optimizing the cathode formulation, developing a multi-coating separator, and evaluating new PFGs. The reviewer stated that emphasis should be placed on the compatibility and synergy between components with different features.

Reviewer 2

The reviewer has some concerns on achieve BP 3 milestone regarding 2Ah pouch cells with more than 600 cycles. More efforts need to be put on developing electrolytes.

Reviewer 3

The reviewer stated that a good plan was proposed to further improve safety, coulombic efficiency and cycle life.

Reviewer 4

The reviewer stated that the following future research works are planned: 1) Design and synthesis of new PFG electrolytes to further improve cycle life. 2) New electrolyte additives to stabilize Li anode. 3) Reduce E/S ratio to demonstrate cell level 400 Wh/kg specific energy density. 4) Pass safety and abuse testing with large format 2 Ah pouch cells. 5) Validate and evaluate 2 Ah prototype pouch cells with new electrolytes (more than 600 cycles). These future works are well planned to achieve the targets of this project.

Reviewer 5

The reviewer stated that future research and cell test should be under practical conditions such as high mass loading, lean electrolyte and pouch cells. This would be required for industry-lead projects.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the Li-S batteries are a potential solution to address the shortage of high energy density batteries that meet the DOE-VTO targets, thereby advancing vehicle electrification.

Reviewer 2

The reviewer stated that the project supported the VTO Batteries programs.

Reviewer 3

The reviewer stated that the project supports DOE’s goal to develop high energy density safe battery for transportation applications.

Reviewer 4

The reviewer stated that the project is relevant to current DOE objectives by providing approaches to improve Li-S battery cycle life and performance using innovative electrolytes based on PFGs.

Reviewer 5

The reviewer stated that the Li-S battery has great potential as a low-cost and high-energy battery, which is relevant to DOE’s mission of vehicle electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that $748,000 for the 3rd year operation of the project is adequate and sufficient.

Reviewer 2

The reviewer stated that the resources in the project are sufficient to perform the proposed work timely.

Reviewer 3

The reviewer stated that the resource is reasonable to execute the plan. Given the major challenges to be addressed, the duration of the project is relatively short.

Reviewer 4

The reviewer stated that the resources are sufficient for the project to achieve the milestones and objectives.

Reviewer 5

The reviewer stated that the resources are sufficient for the project to achieve the goals/milestones.

Presentation Number: BAT600
Presentation Title: Liquid Electrolytes for Lithium-Sulfur Batteries with Enhanced Cycle Life and Energy Density Performance
Principal Investigator: Gaind Pandey, Giner Inc

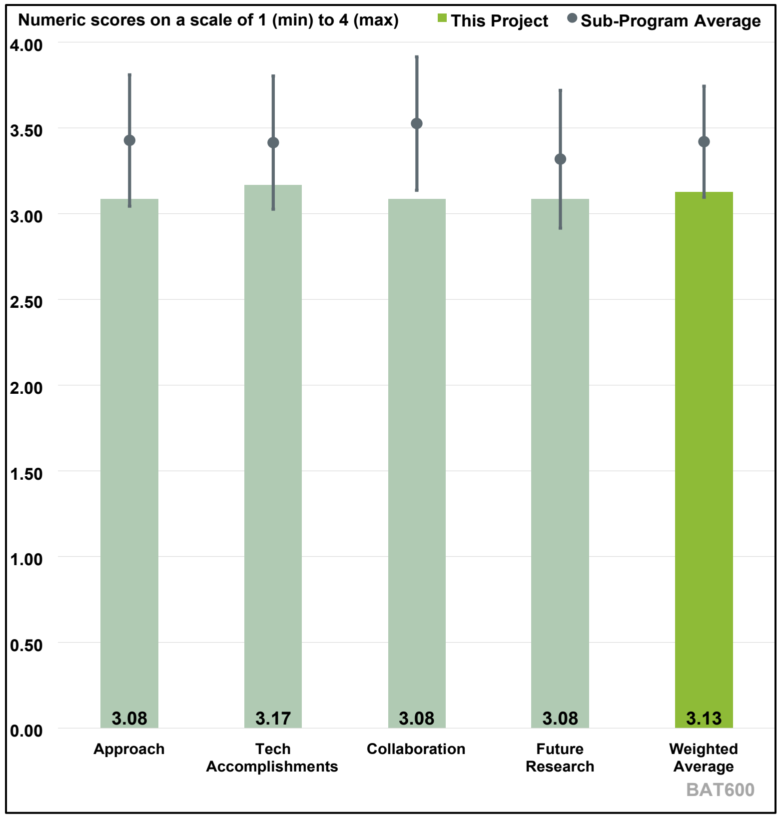

Figure 1-35. Presentation Number: BAT600 Presentation Title: Liquid Electrolytes for Lithium-Sulfur Batteries with Enhanced Cycle Life and Energy Density Performance Principal Investigator: Gaind Pandey, Giner Inc

Presenter

Gaind P. Pandey, Giner Inc

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the project was designed well to screen nine fluorinated ether cosolvents resulting in a down-selection to two. Spectroscopy was effectively used to identify a reduction in shuttle effects and formation of long-chain polysulfides.

Reviewer 2

The reviewer stated the objective of this project is to demonstrate 80% capacity retention with over 500 cycles at an energy density of more than 400 Wh/kg by developing novel electrolytes. The approach involves developing innovative electrolytes with fluorinated co-solvents and strongly bound Li salts to suppress polysulfide dissolution and prevent Li dendrite formation. The effects of fluorinated electrolytes on suppressing Li polysulfide dissolution and Li dendrite formation have been reported as early as 2015 (Journal of The Electrochemical Society, 162 (1) A64-A68). Therefore, the novelty and efficacy of the proposed approach are questionable. Regarding the timeline, the project began in 2021 and is scheduled to finish in 2025, but to date, only 35% of the work has been completed. The primary method to ‘develop’ novel electrolytes involves screening nine fluorinated co-solvents with four Li salts using coin cell tests. These tests employ relatively low sulfur loading (3.6 to 3.8 mg/cm^2) and a high electrolyte-to-sulfur (E/S) ratio (8 µL/mg-S). Many of the co-solvents and Li salts tested, such as TTE, ETFE, TFTFE, LiTFSI, and LiFSI, have been extensively studied in the literature. To achieve the target energy density of 400 Wh/kg in pouch cells, the E/S ratio should be less than 3 µL/mg-S. Potential co-solvents and Li salts for high-energy-density pouch cells should be screened under lean electrolyte conditions.

Reviewer 3

The reviewer stated that the PI seems to have a good grasp of the challenges in this very difficult problem for both the Li and the sulfur electrodes. In general, it is hard to believe that all the issues can be addressed with a change of electrolyte, but clearly it is a critical component and the focus of this effort. The reviewer praised the PI’s approach of a mixture of electrochemical and analytical analysis. The reviewer remarked the PI also seems to have a good plan for electrolyte development. The reviewer was not sure how the discussed electrode modifications work into the approach. The reviewer stated that the use of pre-dissolved polysulfides was a surprise but seemed to improve performance.

Reviewer 4

The reviewer stated that the goal of this project is to develop an electrolyte system for high energy density Li-S batteries under high sulfur loading, low N/P ratio, and lean electrolyte conditions. The PI has proposed using fluorinated co-solvents, strongly-bound Li salts, and additives to suppress polysulfide dissolution and prevent Li dendrite formation. Current review only presents results for fluorinated co-solvents. The reviewer stated the PI also collaborates with others to characterize the new electrolyte system using Raman, NMR, and XAS techniques to gain a mechanistic understanding of the developed system. Using fluorinated co-solvents (ethers) is expected to decrease the overall solvating power of the electrolyte solvents and suppress polysulfide dissolution. However, it is essential to maintain polysulfide dissolution at an optimal level to benefit from the fast kinetics of polysulfide conversion while avoiding reactions with Li metal and the resulting shuttling effect. The reviewer stated that the chosen characterization tools are appropriate for this analysis.

Reviewer 5

The reviewer stated that the approach focuses on developing new electrolytes and sulfur composites to significantly enhance Li-S battery performance. By formulating electrolytes with fluorinated co-solvents, strongly-bound salts, and innovative additives, the research aims to suppress polysulfide dissolution and prevent Li dendrite formation. Utilizing advanced characterization techniques and scaling up to high-energy pouch cells, this comprehensive strategy addresses key challenges and promises to deliver batteries with superior stability, capacity, and cycle life. The approach to address both electrolyte and sulfur composite is poised to make meaningful advancements in Li-S battery technology.

Reviewer 6

The reviewer stated that from the project objectives, key focus of the project is development of optimal electrolytes. However, too much research efforts rely on co-PIs’ fundamental understanding and characterization. Efforts on electrolyte development should be enhanced.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated there has been significant progress to meet goals of this project. Namely, screening and evaluating a subset of fluorinated ethers. Empirical investigation of shuttling effects are established for two of the cosolvents. The reviewer inquired that to fully meet the goals if there were other (beyond the original nine) cosolvents considered. The reviewer inquired what knowledge can be gained in the role of the cosolvent to identify alternative (i.e., improved) cosolvents for suppressing S shuttling? The MXenes are shown to be good at adsorbing polysulfides. The reviewer also inquired what the S capacity for MXene is to remove polysulfides. The reviewer inquired what effect extracting generated polysulfides will have on cell capacity fade, if any.

Reviewer 2

The reviewer stated that the milestones for March and June 2024 are essentially the same. Achieving 1000 mAh/g is a conservative goal, especially with no E/S ratio specified, as there are already numerous reports in the literature with capacities greater than 1000 mAh/g. Additionally, stating a ‘ >50% improvement’ without context is unclear. The reviewer inquired what the baseline for this improvement is. One of the technical accomplishments mentioned is ‘demonstrated improved cycling stability using fluorinated ether co-solvent-based electrolytes’ in coin cells. However, the figures show no improvements with the 1,1,1,3,3,3-hexafluoro-2-methoxypropane (HFMP)-added electrolytes over the baseline (0% HFMP) in either capacity or coulombic efficiency. No data has been presented for the down-selected TFEM co-solvent and LiTFA salt. The pouch cell development, which is a milestone for June 2024, is far from complete. Not only is the discharge capacity of the 10% TFEM battery lower than 1000 mAh/g, but the cycling test also only runs to 40 cycles with low retention. The high E/S ratio (8 µL/mg) makes the full cell energy density much lower than the targeted 400 Wh/kg.

Reviewer 3

The reviewer stated that the PI showed excellent progress with both electrochemical and analytical studies. The reviewer stated had always wanted to see more electrolyte options, but quality over quantity. The reviewer remarked that a better understanding of the pre-dissolved polysulfide additive would be useful.

Reviewer 4

The reviewer stated that two fluorinated co-solvents are evaluated in this year’s project review: HFMP and TFEM (bis(2,2,2-trifluoroethoxy)methane). HFMP shows some improvements over the baseline electrolyte, but there is concern that the specific capacity is only around 600 mAh/g during cycling. The state-of-the-art Li-S cell typically achieves capacities above 800 mAh/g during cycling, even under high sulfur loading and low N/P ratio conditions. Similar performance is observed for TFEM, which slightly outperforms the baseline but still exhibits limited capacity. The reviewer remarked that this low-capacity behavior may be related to the PI’s approach. As noted previously, excessive fluorination in the electrolyte can significantly weaken the solvating power and overly suppress polysulfide solubility. This can compromise polysulfide conversion kinetics, leading to limited capacity. Overall, the project has made some technical progress that aligns with the project plan.

Reviewer 5

The reviewer stated that the team has made very good progress during this period, particularly in evaluating the effects of various factors on Li-S battery performance. The team has thoroughly investigated the impact of fluoro solvent content and salt concentration on the electrolyte’s stability and effectiveness. Additionally, the incorporation of sulfur composite with MXene materials has been explored, showing promising results. Detailed materials characterization, including structural and compositional analyses, has been performed to understand the interactions and transformations occurring within the battery. Comprehensive electrochemical characterization has also been conducted, assessing parameters such as capacity, cycle life, and efficiency. These efforts have provided valuable insights and advanced the development of high-performance Li-S batteries.

Reviewer 6

The reviewer stated that it is not clear which electrolyte (cosolvents and/or salts) comprehensively performs better compared to baseline electrolyte. So far, no electrolyte can really deliver high specific capacity of more than 1000 mAh/g at flooded conditions, not mentioning lean electrolyte conditions. It seems LiFSI shows better cycling when combined with 3% HFMP, but this electrolyte was not used for the following cell test or characterization. The reviewer found that confusing and it seems the research was not well organized across teams with a clear path or focus. The reviewer suggested to be cautious when using Raman or XAS to interpret reactions of Li polysulfides, especially correlating these spectra results to polysulfide conversion kinetics and shuttling suppression.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that clear roles and responsibilities are defined for this project.

Reviewer 2

The reviewer stated that the project currently has collaborators only from two universities. The project team needs to broaden its collaborations, particularly with the national laboratories, to access advanced user facilities for in situ/operando studies on Li-S batteries.

Reviewer 3

The reviewer stated that the PI's collaborations were clearly helpful to the project.

Reviewer 4

The reviewer stated that the PI has established extensive collaboration with Northeastern University and Drexel University on Raman, NMR, XAS measurements. The reviewer suggested the PI may consider working with the national laboratories in the future.

Reviewer 5

The reviewer stated that the national laboratories collaboration with Dr. Sanjeev Mukerjee and Dr. Yury Gogotsi has been highly productive, leveraging their expertise in operando studies and MXene synthesis. Their contributions in advanced characterization techniques have provided critical insights and significantly advanced the understanding and development of the Li-S batteries.

Reviewer 6

The reviewer stated there was good team structure although inter-team collaboration needs improvement. It appeared to the reviewer that each team worked independently and put the slides together for a report.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the need to reduce the E/S ratio is identified, however, the strategy to achieve less than 5 μL/mg is not articulated. Also, the role to be played by MXenes future work is not identified.

Reviewer 2

The reviewer stated that the team has correctly pointed out the major remaining challenges. The team needs to lower the E/S ratio (less than 3) and increase the areal sulfur loading (more than 5 mg/cm^2) to achieve the goal of creating a high energy density Li-S battery (more than 400 Wh/kg). For the proposed future research, there is no clear road map to reach the 400 Wh/kg /500 cycle goal, which is the objective of the project. One of the reported technical progresses is that the MXene composition shows good polysulfide adsorption capability, as evidenced by multi-modal characterizations. The reviewer suggested the team conduct more coin-cell and pouch cell tests to see the effects of the MXene-engineered cathode and separators on improving the Li-S battery performance.

Reviewer 3

The reviewer stated that the PI's is plan is good. The reviewer's only criticism is that the latter part of the program is heavy with scale-up and reducing electrolyte amounts.

Reviewer 4

The reviewer stated that the PI has proposed future research in many aspects which are needed to make progress in this project.

Reviewer 5

The reviewer stated that the proposed future work aims to address key issues and enhance the understanding and development of Li-S cells. By demonstrating high-performance SLP cells, optimizing electrolytes for extreme temperatures, improving cycle performance, and fabricating advanced prototype pouch cells, the research will lead to better stability, capacity, and overall reliability of Li-S batteries.

Reviewer 6

The reviewer stated that based on the current progress, the proposed future research would need a big push to achieve the proposed goals. For example, at E/S 8-10 uL/mg, the cells hardly reach 1000 mAh/g, it may not be practical to reach both 1000 mAh/g and 50% improvement in cycling at E/S 5 uL/mg. It is hard to see a clear technology route to reach 50% capacity retention at -40°C, and whether this would come from improved electrolyte, electrode or coating.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that this project supports the overall VTO objectives for beyond Li-ion energy storage.

Reviewer 2

The reviewer stated that the L-S battery, with its potential high energy density, if successfully developed will provide reliable portable power for electric vehicles.

Reviewer 3

The reviewer stated that the PI is tackling critical problems in battery technology.

Reviewer 4

The reviewer stated that this project is highly relevant to VTO's goal of high energy density, beyond Li-ion batteries. Li-S battery is also in line with the supply chain and resource strategy.

Reviewer 5

The reviewer stated that the development of Li-S batteries is highly relevant to DOE's battery research goals. By addressing critical issues and advancing the understanding of Li-S cell performance, this research aligns with the DOE's objectives to create high-energy, low-cost, and long-lasting battery technologies. This work contributes significantly to the broader goals of enhancing energy storage solutions and promoting sustainable energy innovations.

Reviewer 6

The reviewer stated that the Li-S battery is a promising next-generation battery technology for electric vehicles, so the project is closely relevant to VTO's mission.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources for this project are sufficient.

Reviewer 2

The reviewer stated that the project was delayed, perhaps due to the pandemic, with no activity in 2022. It is unclear what the funding level was in Fiscal Year 2022, making it difficult for the reviewer to judge the funding level for the project in 2025. In the past, the funding level has been sufficient.

Reviewer 3

The reviewer stated that there seems to be a good amount of work being done on a very difficult problem.

Reviewer 4

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 5

The reviewer stated that the funding provided is sufficient to support the team's ongoing and proposed research efforts.

Reviewer 6

The reviewer stated that the resources would be sufficient, and the lead team need focus more on electrolyte development and evaluation, particularly for new solvents, salts, additives and their compatibility with cathode and Li anode.

Presentation Number: BAT601
Presentation Title: Development of Functional Electrolytes for Lithium Sulfur Battery Cells
Principal Investigator: Donghai Wang, Penn State University

Presenter

Donghai Wang, Pennsylvania State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

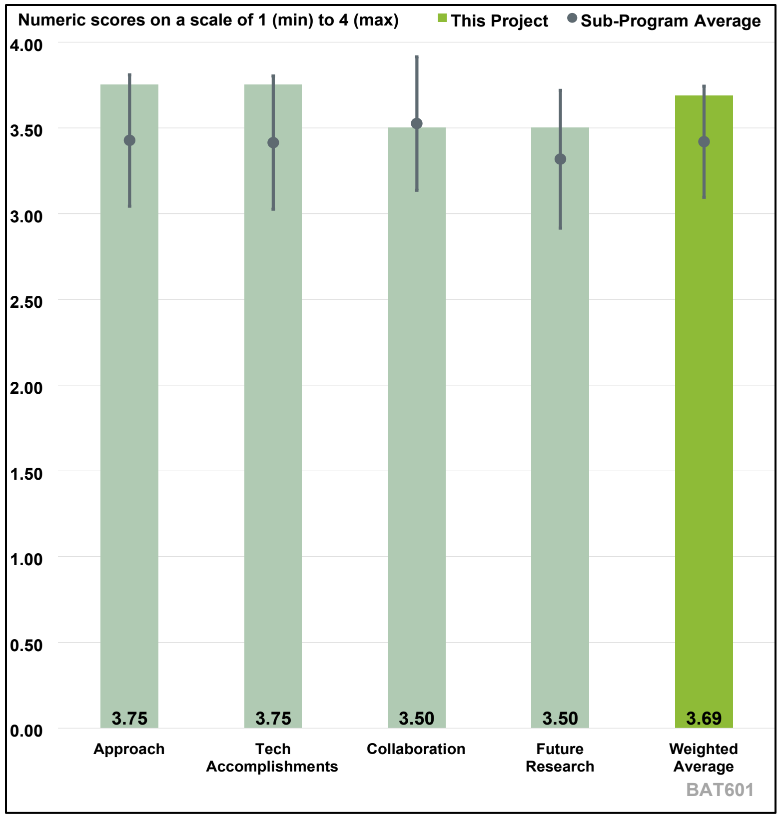

Figure 1-36. Presentation Number: BAT601 Presentation Title: Development of Functional Electrolytes for Li-S Battery Cells Principal Investigator: Donghai Wang, Pennsylvania State University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that this project aims to address the challenges of polysulfide shuttling and Li-metal instability in Li-S batteries. The approaches include introducing dual additives to the electrolyte system to form stable interphases, coating the Li-metal anode and sulfur cathode with a gel polymer to stabilize the interfaces on both sides, and using an additive that enhances Li2S solubility while suppressing Li polysulfide solubility to improve kinetics. The PI’s team combines experimental and theoretical studies to gain a fundamental understanding of the working mechanisms. Overall, the approaches effectively address the technical barriers, and the project is well designed with a reasonably planned timeline.

Reviewer 2

The reviewer stated that the team adopts a novel approach to overcome Li-S battery challenges by focusing on several key strategies. The team is developing innovative electrolyte systems with new solvents, diluents, and additives to suppress polysulfide dissolution and enhance polysulfide conversion kinetics. Additionally, it is optimizing dual-phase gel electrolyte coatings for both Li anodes and S cathodes to stabilize the Li-metal anode and prevent S cathode loss. Advanced characterization techniques, such as Raman spectroscopy and XAS, alongside simulations, are being utilized to gain fundamental insights and optimize Li-S electrolytes. This comprehensive strategy aims to significantly improve battery performance and longevity.

Reviewer 3

The reviewer stated that this project targets real challenges of the liquid Li-S battery technology with clear technology solutions. The reviewer stated that the project was well designed, planned, and executed through close collaborations across teams.

Reviewer 4

The reviewer stated that the authors focus on one of the most critical challenges in Li-S batteries, i.e., polysulfide shuttling problem. They designed several approaches to overcome this problem, including use of alternative co-solvent DEE to replace conventional DME, use of new additives (AD, MA, as well as ANL-1) to replace typical $LiNO_3$ additive, use of stabilizing gel-electrolyte on both anode and cathode, etc. Most works have been completed on time. The reviewer inquired what the performance of the single additive AD or MA is.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the dual additive electrolyte maintains the sulfur inventory better than the baseline electrolyte with $LiNO_3$, which consumes sulfur and leads to irreversible sulfur loss. The gel polymer coating strategy enables stable cycling of Li-S cells, achieving over 800 mAh/g specific capacity. The ANL-1 additive significantly improves polysulfide conversion kinetics and enhances the cyclability of high-loading Li-S pouch cells (60 mAh). In all testing conditions, sulfur loading is greater than 4 mg/cm², which is relevant to practical applications. Lean electrolyte is used when possible, and a low N/P ratio is consistently maintained. Based on these results, the reviewer stated the project has made significant technical progress, which is in line with or ahead of the project plan.

Reviewer 2

The reviewer stated that the team has developed superb electrolyte additives for Li-S batteries, optimizing a dual-additive electrolyte that significantly improves cycling stability and delivers a high specific capacity of 800 mAh g^{-1} at a 0.1C discharge rate. This innovation greatly reduces SEI waste accumulation and dead Li formation on the Li-metal anode surface. Comprehensive analysis of the dual-additive electrolyte reveals its positive impact on both sulfur and Li electrodes. Additionally, the team has created a dual-phase interface-stabilizing gel electrolyte for Li-S batteries and invented a novel additive to enhance polysulfide kinetics and mitigate the polysulfide shuttling effect. This additive also improves Li deposition morphologies, coulombic efficiency, and cycle life, showcasing a significant advancement in battery technology.

Reviewer 3

The reviewer stated that the dual-additive electrolyte fully eliminated the use of $LiNO_3$, which is a very effective approach to solve the cycle life and safety issues. The Li and S cathode coating approaches are also good ways to enhance capacity retention and Li cycling stability. The combined approaches significantly improved cell performance at practical high mass loading and lean electrolyte conditions. The kinetics-enhancing electrolyte also looks promising.

Reviewer 4

The reviewer stated that the new additive AD and MA can significantly improve the CE of the Li-S batteries when DEE solvent is used. Cycling stability of the cell has been improved even at lean electrolyte condition for 100 cycles. The effectiveness of additives and long term stability of Li-S cells with these additives still needs to be further investigated. Anode coating is 500 nm thick. The reviewer inquired what the thickness of cathode coating is.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that extensive collaborations have been established with national laboratories (ANL and PNNL) and the University of Illinois Chicago. The expertise from these different institutions is complementary and makes unique contributions to the project.

Reviewer 2

The reviewer stated that the project described mostly independent work, with collaboration with ANL for high loading Sulfur electrode.

Reviewer 3

The reviewer stated that the project demonstrated clear and close collaborations of multi-teams, which leads to improved cell performance and understanding.

Reviewer 4

The reviewer stated that the team used different approaches to address the key challenges in Li-S batteries. The reviewer stated it will be beneficial in future research to combine all these approaches together to test their combined effect.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the team has proposed to further optimize the electrolyte composition and have more in-depth mechanistic studies.

Reviewer 2

The reviewer stated that the proposed future research is crucial for Li-S battery advancements, focusing on optimizing electrolyte additives and gel electrolytes, investigating their protective mechanisms, and demonstrating advanced Li-S pouch cells. These efforts aim to achieve high specific capacity, low E/S ratio, and superior cycle life, addressing key performance challenges.

Reviewer 3

The reviewer stated that the team should seek collaboration with Battery500 Consortium to validate their materials/approaches in practical pouch cells under realistic conditions.

Reviewer 4

The reviewer stated that the proposed future research is excellent. To have a better understanding of the mechanism behind improved performance will lead to a more clear direction in future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is high relevant to the VTO’s goal of high energy density, beyond Li-ion battery systems. Use of sulfur as cathode is also in line with the strategy on supply chain and resources.

Reviewer 2

The reviewer stated that the development of Li-S batteries is highly relevant to the DOE's goals of achieving high energy density and low-cost energy storage solutions. By focusing on advanced materials and innovative electrolytes, Li-S technology promises to significantly enhance battery performance, align with DOE's objectives, and contribute to sustainable and efficient energy storage advancements.

Reviewer 3

The reviewer stated that the focused Li-S battery is a very promising next generation low-cost but high-energy battery technology for electric vehicles. The project is very relevant to DOE's mission of vehicle electrification and supports VTO's subprograms.

Reviewer 4

The reviewer stated that the project is highly relevant to overall VTO subprogram objectives on long term cycle life of Li-S batteries. It addressed one of the most critical challenges in this field.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 2

The reviewer stated that the funding provided is sufficient to support the comprehensive R&D efforts. It ensures the team can effectively optimize electrolyte additives, refine gel electrolytes, investigate protective mechanisms, and demonstrate advanced Li-S pouch cells, all aimed at achieving high energy density and low-cost battery solutions in line with DOE goals.

Reviewer 3

The reviewer stated that the resources are sufficient for project; and collaborations with Battery500 would be helpful to access more resources or support.

Reviewer 4

The reviewer stated that the resources for the project are sufficient.

Presentation Number: BAT602
Presentation Title: Extending the Operating Range and Safety of Li-Ion Batteries with New Fluorinated Electrolytes
Principal Investigator: Suresh Sriramulu, Koura Global

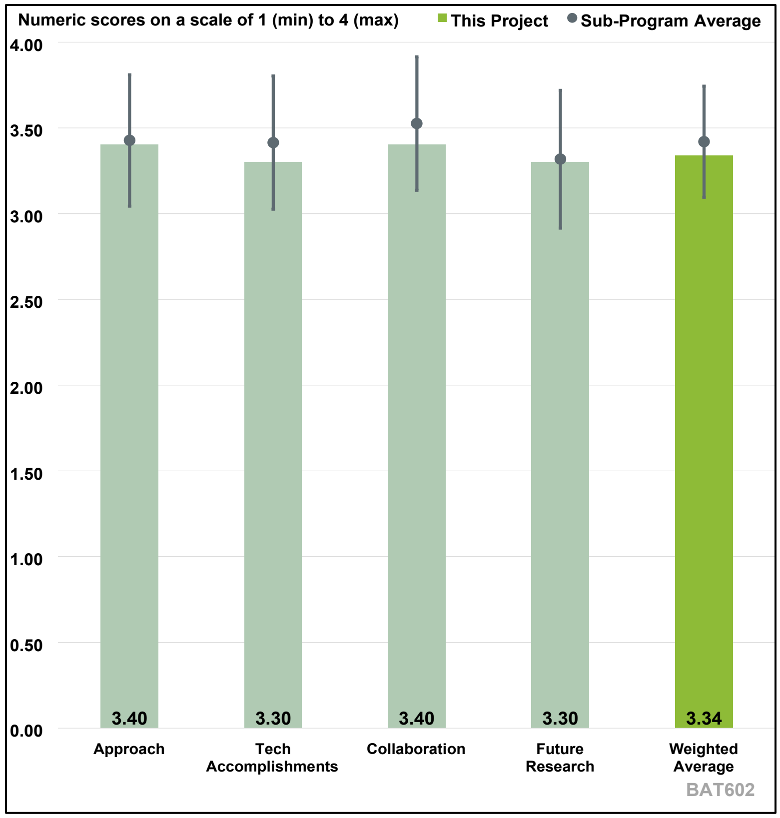

Figure 1-37. Presentation Number: BAT602 Presentation Title: Extending the Operating Range and Safety of Li-Ion Batteries with New Fluorinated Electrolytes Principal Investigator: Suresh Sriramulu, Koura Global

Presenter

Sarah Guillot, Orbia

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the investigators used a platinum working electrode to screen the electrochemical window stability for the various electrolyte solutions. This unfortunately can lead to an overestimation of oxidative stability. Differences in surface properties such as area and porosity of the working electrode are important factors. Electrolyte conductivity measurements at low and room temperature were not reported.

Reviewer 2

The reviewer stated that this work screened more than 10 solvents as major electrolyte components to solve the high-rate/low-T performance of LIBs. The identified solvent 403 demonstrated varying improvements in these performance matrices. The timeline is well kept. The progress has been made when compared with the commercial electrolytes, but not with the best electrolytes reported in the literature. The reviewer stated a suggestion: the PIs used Pt electrode as WE and LSV to assess the oxidation stability window. While this is a popular technique, it is also terribly inaccurate. The reviewer recommended the use of real cathode or anode materials as WE for more meaningful results.

Reviewer 3

The reviewer stated that fluorinated solvents encounter environmental issues. The reduction of fluorinated solvents to form both LiF SEI and organic SEI. Enhancing F-anion reduction but suppressing non-F solvent reduction is highly recommended.

Reviewer 4

The reviewer stated that the objective of this project is to identify fluorinated electrolyte components (additives or solvents) to improve the stability and fast charging/low temperature performance of graphite/NMC811 cells. To do so, multiple fluorinated compounds synthesized by the lead company (Koura) were screened for various properties (high voltage stability, viscosity, conductivity, impedance, etc.), then the best few candidates were further evaluated using a suite of (electro)analytical techniques. Overall, the approach is primarily empirical, but very exhaustive, resulting in a solid understanding of the best performing candidates on battery performance.

Reviewer 5

The reviewer stated that the process of down-selecting materials was well described but light on details in the presentation. However, it did achieve the proper results of down-selecting fluorinating materials. The screening of materials using linear sweep voltammetry is a decent first step to determine voltage stability but, as brought up during the presentation, may not convey voltage stability when in contact with different electrode materials. It is not described how electrolyte flammability and how it relates to safety will be addressed in either this phase or the next. In the talk, it was mentioned the work was performed using single crystalline materials. The reviewer inquired if the surface area or if the cathode was poly crystalline could play a role in how well the selected electrolyte performs.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the investigators have made good progress, keeping the project on schedule. Ten chemicals have undergone a comprehensive electrochemical evaluation for fast charging and wide temperature extremes. Performance feasibility tests using pouch cells were conducted at 0°C, and the initial results are promising.

Reviewer 2

The reviewer stated that the improvement achieved in high rate and low T performances appears to be valid, but verification in larger format pouch cells is recommended. The degree of these improvements need to be compared with the best results reported in the literature. The reviewer suggested that in future reports, all PIs should adopt this standard of contrasting their best results against the most updated literature results for the audience to better estimate the progress.

Reviewer 3

The reviewer stated that the linear potential scan is useful method to measure the anodic stability of electrolytes. However, the passivation capability of the electrolyte should also be considered by evaluating the currents in the second and third scans. The reviewer inquired what SEI is required to achieved targeted performance.

Reviewer 4

The reviewer stated that the progress has been excellent. The project has identified the ‘403’ dioxolane as a top candidate given its various performance-enhancing capabilities. ‘403’ has been extensively characterized in pouch cells, and interfacial and bulk analysis also being performed. Overall, ‘403’ improves the fast charging/low temp rate capability, as well as high temp stability.

Reviewer 5

The reviewer stated that the team is meeting their defined technical milestones for their down-select, post analysis testing, and feasibility of pouch cell performance. The biggest factor still remaining that will be the most challenging to predict will be to show the improvement of safety. It is not within the planned work listed in the presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that there has been good collaboration with a national laboratory to fabricate electrodes and test 2Ah pouch cells, and with the University of Wisconsin-Madison for XPS and NMR analysis.

Reviewer 2

The reviewer stated that the project has been in good collaboration and coordination with ANL. The electrolytes were provided and tested in the standard pouch made at ANL.

Reviewer 3

The reviewer stated that the contribution from ANL were reported.

Reviewer 4

The reviewer stated that the team is led by Koura, who also collaborate with ANL. University of Wisconsin-Madison analytical facilities were also utilized in this project. ANL has helped with pouch cell production. The collaborations appear to have been productive, although most of the work appears to occur at Koura.

Reviewer 5

The reviewer stated that for the work performed, electrolyte screening and pouch cell cycling, the collaboration is as expected. Argonne validated electrodes for large scale pouch cells in the next phase. Being able to replicate the performance on larger batches of materials will be crucial over the next phase for scale up into the 2 Amp-hour cells.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project is expected to end this year. The proposed plans for the remaining few months look reasonable.

Reviewer 2

The reviewer stated that the proposed research direction appears to be reasonable.

Reviewer 3

The reviewer stated that the future work project is clearly defined.

Reviewer 4

The reviewer stated that the project is ending in 2024, so modest future work/milestones are reasonable and primarily focus on further optimization and the construction of larger format pouch cells (2Ah).

Reviewer 5

The reviewer stated that the proposed future work with tuning the electrolyte for fast charge and wide operating temperature range will assist in designing the 2 Amp Hour cell. Additionally, investigating manganese dissolution will assist in reaching the required cycling needed in the project goals. However, in the remaining challenges, safety is not listed. There was no flammability test and no safety test listed in the proposed future research. Also, the challenges listed optimizing electrolyte composition for different cell chemistries. The reviewer inquired if this was planned. There is a lot of work to be performed by the end of Fiscal Year 2024. The reviewer recommended not focusing on different cell chemistries but rather on demonstrating the performance in pouch cells.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the goals for this project are based on the U.S. DRIVE Electrochemical Energy Storage Technical Team Roadmap (2017). It supports VTO objectives.

Reviewer 2

The reviewer stated that the project goal is directly relevant to VTO objectives of improving LIB performances in fast charge and low T applications.

Reviewer 3

The reviewer stated that the project supports the overall VTO subprogram objectives.

Reviewer 4

The reviewer stated that the project is directly relevant to VTO subprogram objectives (better high energy battery performance).

Reviewer 5

The reviewer stated that the work looks to research new electrolyte formulations to ease the transition to electric vehicles which would reduce oil consumption and harmful emissions. The work supports a robust US supply chain if the materials cannot be manufactured with.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the goals for this project are based on the U.S. DRIVE Electrochemical Energy Storage Technical Team Roadmap (2017). It supports VTO objectives.

Reviewer 2

The reviewer stated that the resources are sufficient for the project.

Reviewer 3

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones.

Reviewer 4

The reviewer stated that the project resources/funding appear sufficient.

Reviewer 5

The reviewer stated that the resources are sufficient for the work performed. Screening electrolytes, DPA, and making cells takes time and resources. Over the next phase, scaling up to 2 Ahr cells is within line for the requested resources.

Presentation Number: BAT603
Presentation Title: Fluorinated Ester Local High Concentration Electrolytes for Operation of Li-Ion Batteries under Extreme Conditions
Principal Investigator: Esther Takeuchi, Stony Brook University

Presenter

Esther Takeuchi, Stony Brook University

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

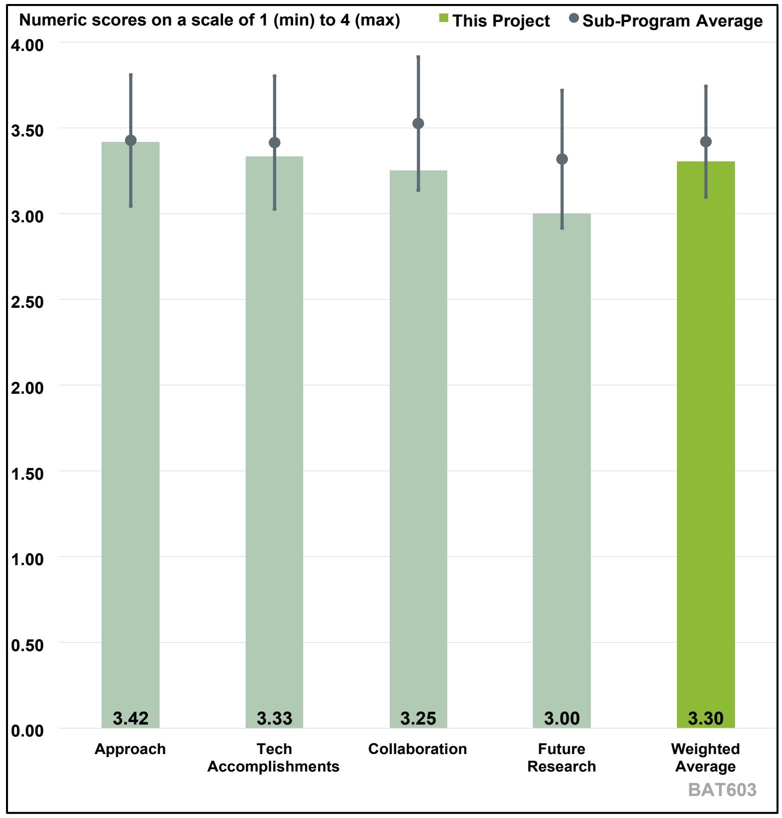

Figure 1-38. Presentation Number: BAT603 Presentation Title: Fluorinated Ester Local High Concentration Electrolytes for Operation of Li-Ion Batteries under Extreme Conditions Principal Investigator: Esther Takeuchi, Stony Brook University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the technical barriers are being effectively addressed, and the approach is very good. Incorporating fluorinated ester solvents into a localized high-concentration electrolyte offers an opportunity to fine-tune the electrolyte's functional properties, enhancing cell performance at low temperatures, fast-charge capability, and safety. However, concerns about the higher cost of these solvents remain.

Reviewer 2

The reviewer stated that the LHCE electrolytes are being proposed to solve a range of problems for Li-ion and other advanced batteries. The PI's approach is excellent. Although the reviewer would have liked to see more electrolytes studied, the initial screening was good and produced viable electrolytes. Ultimately, quality takes precedence over quantity. The reviewer remarked that characterization studies should identify the best electrolytes. It will be important to do the larger pouch cell tests with electrodes made on a roll-to-roll coater.

Reviewer 3

The reviewer stated that this project screened around 10 electrolytes and tested their fast charge, low temperature and flammability. The localized high concentration electrolytes were adopted from the most recent literature results and modified with proprietary solvents undisclosed. The performance improvements are apparent. For 200 cycles the performances at 4.5V, -20°C or 15 min charge all demonstrated superiority over conventional electrolytes. The simulation of SEI chemistry is of high value, because it is so far the most important missing link in predicting SEI chemistry. With it the entire chain of in silico chemistry will be complete.

Reviewer 4

The reviewer stated that the ether LHCE is suitable for Li-metal batteries, but faced challenges of limited anodic stability. Replacing ether solvent and diluent can enhance anodic stability of the LHCE, and also suitable for graphite anode (although it may reduce the Li-metal CE).

Reviewer 5

The reviewer stated that the localized high concentration electrolyte (LHCE) concept employed for this project h is not new. The conventional carbonate-based electrolyte (1.2 M $LipF_6$ EC/DEC) is a typical LHCE—EC is the solvating solvent, and linear carbonate DEC was added to EC/$LiPF_6$ solvation structure as diluent to reduce viscosity and conductivity. Solvation could improve the property of electrolyte, however the key technology still lies in the solvent, salt and additive used.

Reviewer 6

The reviewer stated that the technical goal of fast charge and low temperature performance was achieved, which is a very aggressive rate at a very low temperature. The data showed progress towards two goals set forth in the project. The electrolyte was studied using flammability tests showing some progress towards improving safety. All cell cycling work was performed at 4.5V as the charging voltage.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the project has made excellent progress, successfully meeting all milestones. Two electrolytes, MOF and MTF, demonstrated improved capacity retention compared to conventional electrolytes after 200 cycles under extreme test conditions, including high voltage, fast charging, and low temperatures. Additionally, these electrolytes exhibited reduced flammability. The research efforts were documented in two open literature papers and presented during a detailed presentation.

Reviewer 2

The reviewer stated that the PI's mix of electrochemical, analytical, and modeling studies are extremely good with a lot of interesting results. Most importantly, improved electrolytes were identified. The reviewer would see value in this project adding to the fundamental understanding of the SEI layer.

Reviewer 3

The reviewer stated two suggestions: 1) the PI used Pt electrode as WE and LSV to assess the oxidation stability window. While this is a popular technique, it is also terribly inaccurate. The reviewer recommended the use of real cathode or anode materials as WE for more meaningful results. 2) The safety of the electrolytes cannot be accurately evaluated by ignition only. The reviewer suggested testing electrolyte/electrode combination in DSC or ARC setups.

Reviewer 4

The reviewer stated that the coulombic efficiencies of graphite anode and NMC811 cathode in the MTF should be measured.

Reviewer 5

The reviewer stated that the electrolyte using fluorinated esters did show some improved performance over the baseline electrolyte (carbonate based), however the research and the discussion are pretty much focused on the additive effect (FEC, LiDFOB) on the LHCE. There is no data to support why fluorinated LHCE is better than the non-fluorinated counterpart. Furthermore, it is fair to compare with non-fluorinated counterpart instead of carbonate baseline electrolyte. Only improved cycling data were shown without any discussions of the mechanism.

Reviewer 6

The reviewer stated that the technical accomplishments related to the science of the electrochemistry, finding solvents that work at high rates and wide temperatures, and finding the correct mix of electrodes and electrolytes to meet fast charge is well on its way. However, there was not enough information given on scaling up to meeting the 2 Ah deliverable at end of the year. While that is at the end of the year and not planned yet, scaling up is no trivial task.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project is well-coordinated. While the presenter’s slides do not explicitly highlight this, a review of the PI’s journal articles and discussions with team members reveal the collaborative efforts of the team. Adding a small footnote to the relevant tables and plots could be beneficial to avoid confusion in future presentations.

Reviewer 2

The reviewer stated that the PI is collaborating with researchers on several of the studies.

Reviewer 3

The reviewer stated that the collaboration between the PIs and co-PIs are well managed.

Reviewer 4

The reviewer stated that the contributions from collaborators are presented and supported the proposed mechanism.

Reviewer 5

The reviewer stated that the collaboration with other organizations looks good.

Reviewer 6

The reviewer stated that it is not clear who did what in the presentation but all the work is being accomplished.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project is expected to wrap up by the end of the year. The future efforts of full-cell evaluations with optimized electrolyte is appropriate.

Reviewer 2

The reviewer stated that there is not a lot of detail on the proposed future work, but continuing the current studies should lead to important insights and advances. The rate of project advancement is good, but puts a lot of challenges on the final year.

Reviewer 3

The reviewer stated that the proposed future direction is great.

Reviewer 4

The reviewer stated that the future work was clearly defined.

Reviewer 5

The reviewer stated that the future study should focus on understanding why LHCE is better than non-fluorinated counterpart and the baseline electrolyte. Also, the correlation of fluorinated ester with cell performance needs to be studied.

Reviewer 6

The reviewer stated that the barrier remaining are critical to once in pouch cell. For instance, gas generation at extreme conditions on the electrodes may severely hinder the cycle life. Exploring through SEI measurements in modeling and simulation will provide insight into this as well. The reviewer inquired what the size of the pouch cells used was. The reviewer also asked if there is a concern with LHCEs not forming the proper interface when injected into a multi-layer pouch cell rather than a single layer. Assuming they are not large pouch cells, the reviewer wondered the safety implications once in a pouch cell.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is relevant to the VTO program as it is aimed at fast charge.

Reviewer 2

The reviewer stated that the new electrolytes are key to improving the Li-ion battery technology.

Reviewer 3

The reviewer stated that the project is highly relevant to VTO objectives in advancing battery chemistries.

Reviewer 4

The reviewer stated that the project supports the overall VTO subprogram objectives.

Reviewer 5

The project supports the overall VTO subprogram objectives.

Reviewer 6

The reviewer stated that the project is exploring using LHCE for fast charge applications, looking to expand the operational temperature range, and be a safe electrolyte.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project has the necessary resources to complete the tasks on time.

Reviewer 2

The reviewer stated that while not a lot of electrolytes, the depth of studies is impressive.

Reviewer 3

The reviewer stated that the project has sufficient resources.

Reviewer 4

The reviewer stated that the resources are sufficient for the project to achieve the stated milestones.

Reviewer 5

The reviewer stated that the interface analysis and deep understanding of the performance improvement needs to be studied.

Reviewer 6

The reviewer stated that the resources are sufficient. 75% of the budget has been spent with less than one year left on the effort.

Presentation Number: BAT604
Presentation Title: Novel Organosulfur-Based Electrolytes for Safe Operation of High Voltage Li-Ion Batteries Over a Wide Operating Temperature
Principal Investigator: Meinan He, General Motors

Presenter

Meinan He, General Motors

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

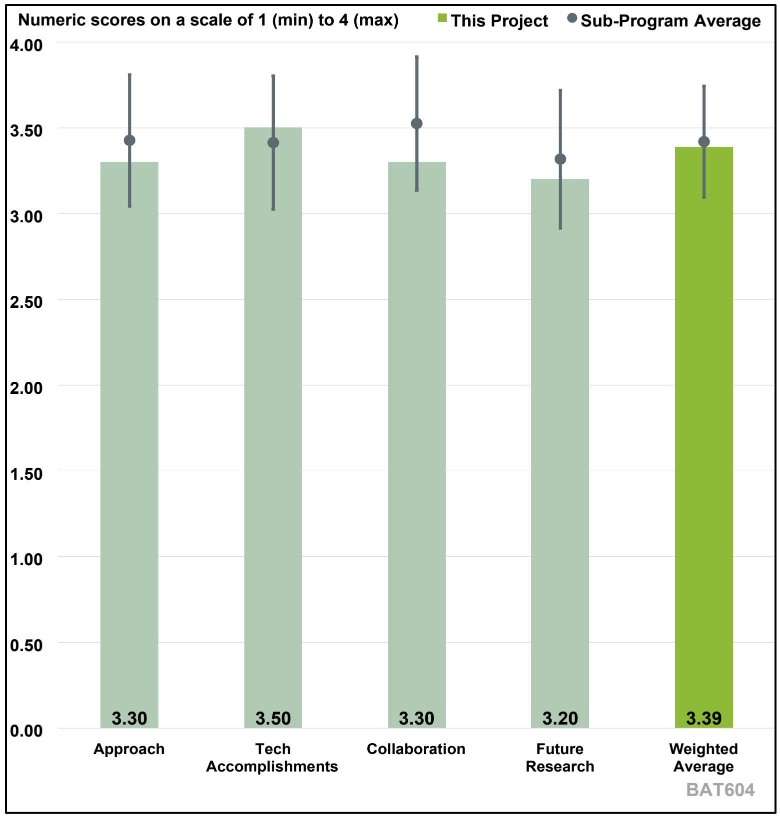

Figure 1-39. Presentation Number: BAT604 Presentation Title: Novel Organosulfur-Based Electrolytes for Safe Operation of High Voltage Li-Ion Batteries Over a Wide Operating Temperature Principal Investigator: Meinan He, General Motors

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the objective of the project was not clearly identified in the presentation. The only statement was a vague desire to develop a new electrolyte based on organosulfur compounds, with no mention of the desired voltage limits, temperature range, or rate capability. The reviewer suggested that future presentations include specific goals on the slides. Despite this, the reviewer remarked that the approach to developing a high-performance electrolyte is based on sound principles, and the tasks are logical.

Reviewer 2

The reviewer stated that this project explores sulfone-based electrolytes, and develops a series of new solvent structures. Considering that the battery community has been playing in the tiny chemical classes of ether and ester for the last 30 years, such highly risky and highly exploratory effort should be encouraged.

Reviewer 3

The reviewer stated that the barriers of high voltage stability appear to have been addressed with the organosulfur electrolytes with additives, although optimizations and new improvements to formulations are ongoing. Temperature studies on cell performance have not yet been presented. A lot of the presentation focused on baseline cells. This does help to demonstrate when new formulations/additives do make an improvement. The project has centered on an organosulfur containing electrolyte with better performance than Gen 2 electrolyte baseline. The time remaining in the project is 1 year- there appears enough time remaining to meet the remaining goals of pouch cell abuse testing. Fully completing the remaining studies on SEI formation, thermal stability, and an expanded solvent study may be challenging. The project is well thought out- the strategy of picking a single set of anode/cathode and modifying the electrolyte is a good approach. More projects should focus on electrolyte optimization such as this- each anode/cathode combination potentially benefits from a matched electrolyte. Based on the title, more work on organosulfur materials was expected. The reviewer inquired if there are any additional organosulfur targets competitive with the EMS data shown? The reviewer inquired if there are plans for designer materials.

Reviewer 4

The reviewer stated that work studying different cosolvents is very thorough but it is unclear what technical barriers are being addressed as the reviewer could not find them in the presentation. Assuming it is studying 4.5V operation and studying the effect in a pouch cell, the work from coin cells to 2 Ahr cells covers mixtures, most notably FEC, EMS, and additions of non-solvating fluoroaromatic co-solvents to improve cycling performance.

Reviewer 5

The reviewer remarked that the objective of this project is to develop a new electrolyte system based onorganosulfur compounds for high voltage LIBs, which is an important topic. The approach was very good to fabricate coin and pouch cells to establish a baseline with standard electrolyte and then test new electrolyte to compare with for any improvement.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that good progress has been made, with the team synthesizing new solvents and demonstrating a prototype organosulfur-based electrolyte with enhanced performance. However, not all accomplishments were clearly conveyed during the presentation. To fully appreciate the body of work, one had to consult the published journal articles. Perhaps more detail can be provided in any future presentations.

Reviewer 2

The reviewer stated that a series of sulfone solvents were thoroughly investigated in rigorous manner. The performances showed varying degree of improvements. The few top picks delivered impressive results in pouch cells. More complete verification especially on the gassing issue will further confirm the usefulness of these electrolytes.

Reviewer 3

The reviewer stated that the project has identified an organosulfur containing electrolyte that successfully cycles in 2 Ah pouch cells at high voltage for 100 cycles, much better than Gen2 baseline. Most of the work presented showed baseline data and comparisons of a single organosulfur containing electrolyte. It appeared that the remaining organosulfur targets shown were eliminated on the basis of calculations or modeling? The current pouch cells with the Gen A electrolyte appear to meet the target goals but show a modest improvement over standard Gen2 electrolyte (without additives). The reviewer inquired if this formulation can be cost-competitive with

Gen 2. Identification of fluorobenzene as a new co-solvent to replace fluoroethers showed better ionic conductivity and reduced viscosity. The fluorobenzene co-solvent seems to be a discontinuity in the program- it was not clear if this new formulation with fluorobenzene will be incorporated into the final pouch cell testing. The reviewer inquired if the team plans to explore other fluoroaromatics as co-solvents. The reviewer also inquired if fluorobenzene act similarly to local high concentration electrolytes (LHCE's). It seems counterintuitive that fluorobenzene shows the best conductivity but doesn't affect the solvation of the electrolyte. The review inquired if did the modelling studies on activation energies of the co-solvents towards singlet oxygen reactivity examine the para-hydrogen position of fluorobenzene as well as the ortho-position?

Reviewer 4

The reviewer stated that it was difficult to judge based on the presentation. They are using a feedback loop of coin cell results to feed into 2 Ah cell results and back again, while designing different electrochemical mass spectrometry to study off gassing of the 2 Ah cells.

Reviewer 5

The reviewer stated that good progress was made by identifying EMS as a good potential organosulfur compound. The results of showed improvement of EMS over the baseline. replacing $LiPF_6$ with LiFSI presents a promising and innovative approach to stabilize the organosulfur electrolyte. However, considering the potential corrosion of LiFSI with the Al current collector needs to be addressed. Impact of Co-solvent was investigated and showed that performance could be improved. The project was about safe operation over a wide range of temperatures. The presentation results seem to be at room temperature and did not provide any information on how the cells perform at higher or lower temperatures. No safety testing was presented.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team is highly qualified; however, it is difficult to discern the specific efforts of each collaborator. Providing footnotes for individual contributions in future reporting would be helpful.

Reviewer 2

The reviewer stated that the collaboration and coordination are excellent.

Reviewer 3

The reviewer stated that each team partner contributed to the presentation, and each section showed interesting data. However, the initial impression was that each team focused on their own area, and it was not merged until recently, with the more collaborative work with the fluorobenzene cosolvent. The presentation would have benefited from a more clear assignment of work activities from each group.

Reviewer 4

The reviewer stated that a mention in the presentation on who was participating in which aspects of the project but the group appears to be making progress towards their goals.

Reviewer 5

The reviewer stated that the team collaboration with participation from Industry (GM), a national laboratory, and two universities is good. Coordination between team member were acceptable.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future plans are satisfactory, but no specific details were provided.

Reviewer 2

The reviewer stated that the proposed future research is promising and worth looking into. The new solvents as well as new formulations will be interesting not only for LIBs but also for other battery chemistries.

Reviewer 3

The reviewer stated that the remaining project objectives (wide temperature studies, different organosulfur solvents) do not fully agree with the final slide next steps to study SEI formation and other SEI formers. It is not clear what new solvents are targets- commercial materials or newly designed and synthesized organosulfur solvents- that should be clarified. Several times the PI presented sulfates as a potential class of materials- has the toxicity and reactivity been examined? Has any data on flammability been established for the fully formulated electrolyte?

Reviewer 4

The reviewer stated that the part of what the issue was mentioned during the presentation was SEI formation during 4.5V operation, which is not surprising, and the team has proposed exploring other SEI forming co-solvents to combat this issue.

Reviewer 5

The reviewer stated that the future work was only three bullets and did not address how to prevent gas generation at higher temperature. The plan to looks at thermal stability of the electrolyte, but they also need to do some abuse/safety testing to show the cell with this electrolyte is safe.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the VTO battery objectives; however, these objectives were not clearly identified in the presentation due to the vagueness of the stated goals.

Reviewer 2

The reviewer stated that the project is highly relevant to VTO objectives of advancing battery technologies.

Reviewer 3

The reviewer stated that the organosulfur electrolytes have a potential to operate at higher voltages, thereby avoiding some of the voltage instability issues with current electrolyte formulations. The PI presented interesting additive- fluorobenzene- which may prove useful for other projects as well. The development of high voltage electrolytes clearly is of interest to the overall subprogram goals to improve LIB technology through stable high voltage cells. Although clearly the best cells, it was not entirely clear if this was a purely physical effect on viscosity, conductivity, etc., or there was also an effect on the SEI. PI's have demonstrated better high voltage cycling than baseline by using organosulfur electrolytes with additives. The reviewer inquired how the baseline electrolyte plus additives compare to the organosulfur cells, and how do these cells perform at high/low temperature?

Reviewer 4

The reviewer stated that the goal of the project is to explore high voltage electrolytes that are safe, while performing more in-depth characterization at the pouch cell level. The team is performing all of those but more safety data would be interesting, especially at the pouch cell level.

Reviewer 5

The reviewer stated that the projects support the overall VTO Battery objective of producing high voltage and safe electrolytes for Li-ion batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the available resources seem adequate to achieve the stated milestones, indicating that there are no concerns about resource sufficiency.

Reviewer 2

The reviewer stated that the resources are sufficient.

Reviewer 3

The reviewer stated that the resources appear sufficient for the project.

Reviewer 4

The reviewer stated that it is unclear if it is sufficient. The original budget was sufficient for the work being performed during the time line proposed.

Reviewer 5

The total budget of $3.2 million is sufficient for achieving the objectives of the project.

Presentation Number: BAT605
Presentation Title: Silicon Consortium Project Next Generation Electrolytes for Silicon Anodes
Principal Investigator: Gabriel Veith, Oak Ridge National Laboratory

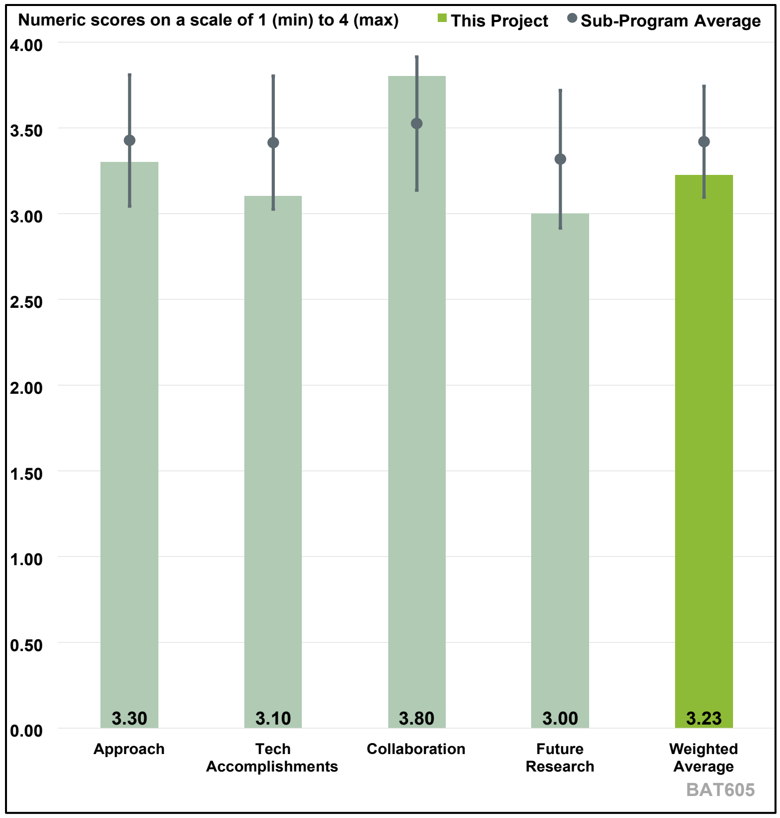

Figure 1-40. Presentation Number: BAT605 Presentation Title: Silicon Consortium Project Next Generation Electrolytes for Silicon Anodes Principal Investigator: Gabriel Veith, Oak Ridge National Laboratory

Presenter

Gabriel Veith, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that understanding and stabilizing the SEI is key to commercial success of Si anodes. This work is fundamental in nature and is contributing significantly to this goal.

Reviewer 2

The reviewer stated that the approach is very focused on the key challenge for the SCP, with a clear hypothesis and a work plan that pursues that hypothesis. Significant progress on evaluating this hypothesis is being made using the current approach.

Reviewer 3

The reviewer stated that the PIs proposed mechanism how Si-based batteries lose performance and believed that forming long chain SEI components is the key. The researchers adjusted electrolyte composition to execute such a strategy. The performance of the new electrolyte seems to provide certain improvements. But the performance are still under the targets.

Reviewer 4

The reviewer stated that the approach is satisfactory as a hypothesis is stated that can lead to an unstable SEI in silicon-containing anodes. However, while the team details how changing the solvation structure will decrease the SEI dissolution and promote larger polymerization products, there is no discussion how this change will address the consortium's overall goal of a 10 year calendar life silicon-anode containing cell.

Reviewer 5

The reviewer stated that the project focused on one leading hypothesis on might be the difference between Graphite SEI and Silicon SEI. The work focused on developing understanding of solvation structure/solvation energy effect on the resulting SEI on Si anode surface, which is believed to be the key to achieve superior cycle life and calendar life. Several different tests have been conducted with different electrolyte formulations with various solvent ratios and Li salts. This work clearly demonstrates that solvent ratio and Li salt type and combinations of them will significantly affect solvent structure/solvation energy. However, the reviewer commented that it would be beneficial if the correlation between the solvation energy and SEI stability (cycle life or calendar life) can be established in a clearer fashion. (For example, there is no cell test results for the electrolyte formulations showed different solvation energy on Slide 11. There is no solvation energy data of the different new electrolyte formulations on Slide 13 where the electrolyte formulations showed different calendar life.)

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the work is innovative and broad in scope. The results are interesting and relevant to further silicon anode electrolyte design and SEI understanding.

Reviewer 2

The reviewer praised the technical accomplishments to date. An electrolyte with improved performance has been identified. Methods to assess solvation—the key part of the idea—are being used to quantify the properties of candidate electrolytes. Full cell work is underway. One limitation is that in the focus on calendar life, other required electrolyte properties may be getting overlooked, in particular transport properties (e.g., ionic conductivity) and rate capability. If the new electrolyte improves calendar life but significantly impacts rate capability or other key properties, that is an issue. The impact of the electrolyte on the cathode is being pursued, which the reviewer approved, but other impacts should also be considered.

Reviewer 3

The reviewer stated that the electrolyte strategy may not be working as the PI suggested. According to the structures of the proposed SEI components, the solubility of these SEI ingredient should not be as pronounced as the PI expects. The reviewer commented that maybe an inorganic-rich, polymer-free SEI should be considered instead.

Reviewer 4

The reviewer praised the project's accomplishment of achieving 500+ cycles with its new electrolyte combinations, however this result is still far below the 1000 cycle threshold dictated by the consortium milestones (which was already achieved in previous programs). Also, while the project presentation details a four-times improvement in calendar life, the results are still significantly behind the ten-year goal of the consortium.

Reviewer 5

The reviewer stated that the EC-free electrolyte formulation was proposed and tested using NMC811//SiO_x/Gr composite anode. It is interesting to see that EC-free formulation showed superior cycle life than EC containing electrolytes. A systematic study on EC/EMC/$LiPF_6$ molar ratio suggests that PF_6- : EC concentration is strongly correlated with poorer cycle life and stability. However, those EC-free electrolyte formulations have not been demonstrated in PECVD Si/C composite anode yet, the reviewer was wondering if the positive impact can be translated to a different Si anode. FEC has been reported in several literatures as a beneficial additive for Si containing anode. However, in this work, the addition of FEC as an additive showed poorer cyclability in the NMC811/SiO_x/Gr pouch cell. The reviewer wondered if an explanation can be provided. The reviewer suggested this could possibly be due to the difference on the Si anode. If that is the case, the reviewer inquired if the optimal electrolyte formulations identified in SiO_x/Gr composite be able to show positive impact on PECVD Si/C anode.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the coordination is excellent across the different groups.

Reviewer 2

The reviewer stated that the it appears there are valuable contributions from many team members.

Reviewer 3

The reviewer stated that the collaboration is tight and well managed.

Reviewer 4

The reviewer stated that as with the other consortium projects, the team has outstanding and extensive collaboration with the partner national laboratories.

Reviewer 5

The reviewer stated that this work has involved multiple national laboratories. The team is composed of modeling experts, organic chemists, characterization experts and electrochemists, all of which are critical to developing a new electrolyte formulation for such a challenging system. However, the reviewer believed it would be beneficial to have more interaction with silicon anode development team, which will help understand the surface reactivity between electrolyte and silicon anode better.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that further experimental verification of the model results are planned and should be the focus of work.

Reviewer 2

The reviewer stated that future research is specific and looks excellent. The reviewer reiterated the suggestion on looking at key transport properties as a function of temperature and salt concentration to make sure the rate capability remains high enough.

Reviewer 3

The reviewer stated that the proposed future activity of looking into electrolyte composition is reasonable.

Reviewer 4

The reviewer stated that the future proposed research, while analytically sound, does little to exude confidence that an electrolyte solution can or will be developed to help create a silicon-containing anode that will have a calendar life of 10 years.

Reviewer 5

The reviewer stated that at this stage of project, several promising candidates have been identified, such as EC-free solvent system, Li salt with low solvation energy with certain solvents and promising additives that extended cycle life. However, no clear plan has been revealed on how to incorporate those promising findings into electrolyte formulation development. Additionally, it is not clear to the reviewer if those promising candidates will be validated in PECVD silicon based anode prior to combining them together to seek further improvement. More importantly, calendar life tests should be used as the primary test protocol in the future along with cycle life test. So far, the reviewer has seen more cycle life tests even though the project goal is to solve the calendar life issue of this chemistry.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is highly relevant for fundamental understanding of SEI, solvent and salt interactions.

Reviewer 2

The reviewer stated that the project is relevant to batteries.

Reviewer 3

The reviewer stated that the project is highly relevant.

Reviewer 4

The reviewer stated that the project supports the overall VTO subprogram objective of analysis, batteries, and materials.

Reviewer 5

The reviewer stated that this project is critical to address the calendar life issue of high energy density batteries. It supports the overall VTO subprogram objectives, especially for Batteries, Materials and Electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient.

Reviewer 2

The reviewer stated that the resources appear sufficient.

Reviewer 3

The reviewer stated that there are sufficient resources available.

Reviewer 4

The reviewer stated that the resources are sufficient for this program to achieve the stated milestones in a timely fashion.

Reviewer 5

The reviewer stated that this project is composed by a team of experts from different areas including modeling, organic synthesis, characterization and pouch cell testing, which seems to be sufficient for its needs. The reviewer made the recommendation, that it would be beneficial to plan enough resources to supply PECVD Si anode for initial electrolyte study to validate the positive impact observed in SiO_x based anodes.

Acronyms and Abbreviations – BAT

Abbreviation	Definition
μL/mg-S	Microliter per milligrams sulfide
0D	Zero-dimensional
1 Å –10 cm	Angstroms to centimeters scale
1 s – 1 yr	Seconds to year scale
1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
AD	Additives type
AFM	Atomic force microscopy
Ag	Silver
Ah	Ampere-hour
AIMD	Ab initio molecular dynamics
Al	Aluminum
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APS	Advanced Photon Source
ARC	Accelerating rate calorimetry
ARL	Army Research Laboratory
ASR	Double-loop DC drive system, speed loop (ASR)
B_2S_3	Boron Sulfide
B_2S_3-Li_2S	Boron Sulfide and Lithium Sulfide
B500	Battery 500 Consortium
BESS	Battery energy storage system
BNL	Brookhaven National Laboratory
BP	Budget Period
C/S	Carbon/sulfur
CA	Conductive additive
CAM	Cathode active materials

Abbreviation	Definition
CE	Coulombic efficiency
CEI	Cathode electrolyte interphase
CFM	Carbon framework material
CMC-SBR	Sodium carboxymethyl cellulose (CMC) and Styrene butadiene rubber (SBR)
Co	Cobalt
CPE	Composite polymer electrolyte
CS-SPAN	Carbon Supported Sulfurized polyacrylonitrile
Cu	Copper
CV	Cyclic voltammetry
DEC	Diethyl carbonate
DEE	1,2-diethoxyethane
DEMS	Differential electrochemical mass spectrometry
DFT	Density functional theory
DFT-MD	Density functional theory molecular dynamics
DME	1,2-Dimethoxyethane
DOE	U.S. Department of Energy
DOL	Electrolyte solvent 1,3-dioxolane
DPA	Diphenylamine
DRX	Disordered rock salt
DSC	Differential scanning calorimetry
E/S ratio	Electrolyte/Sulfur ratio
EC	Ethylene Carbonate
EDS	Energy-dispersive X-ray spectroscopy
EELS	In situ Electron Energy Loss Spectroscopy
EERE	Office of Energy Efficiency and Renewable Energy
EF	Electric field
EIS	Electrochemical impedance spectroscopy
EMC	Ethyl methyl carbonate
EMS	Ethyl methyl sulfone-based electrolytes

Abbreviation	Definition
EQCM	Electrochemical quartz crystal microbalance
Er	Erbium
ETFE	Ethylene tetrafluoroethylene
EV	Electric vehicle
F2DEM	bis(2-fluoroethoxy)methane
F5DEE	2-[2-(2,2-Difluoroethoxy)ethoxy]-1,1,1-Trifluoroethane
FDMB	Fluoro-dimethoxylbutane
FEC	Fluoroethylene carbonate
FGS	Functionally graded scaffold
FSU	Florida State University
FTIR	Fourier transform infrared spectroscopy
FY	Fiscal year
FZ	FZ Jülich-Company Name
Gen	Generation
GHG	Greenhouse gas
GM	General Motors
HFMP	1,1,1,3,3,3-hexafluoro-2-methoxypropane
I_2	Iodine
ID	Identification
IEK	IEK-9 - Company Name
In	Indium
INL	Idaho National Laboratory
J/m2	Joules per meters squared
Koura	Koura - Company name
kWh	Kilowatt-hour
LATP	$Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$, a potential solid-state electrolyte
LBNL	Lawrence Berkeley National Laboratory
LBS	Lithium thioborates
LFP	Lithium iron phosphate

Abbreviation	Definition
LHCE	localized high-concentration electrolyte
Li	Lithium
Li CE	Lithium coulombic efficiency
Li nm	Lithium and nanometers
Li NMC	Lithium nickel manganese cobalt oxides
Li SPAN	Lithium sulfurized polyacrylonitrile
Li/Ni	Lithium/nickel
Li_2O	Lithium oxide
Li_2O/LiF	Lithium oxide per lithium fluoride
Li_2S	Lithium Sulfide
Li_2S_2	Lithium disulfide
Li_2S-B_2S_3	Lithium Sulfide and Boron Sulfide
Li_2S_x	Lithium Sulfide type
Li_2ZrCl_6	Lithium zirconium chloride
$Li_5B_7S_{13}$	Lithium boron sulfide
LIBs	Lithium-ion battery(ies)
LIC	Li_3InCl_6
LiCoO2	Lithium cobalt oxide
LiF	Lithium fluoride
LiFSI	Lithium bis(fluorosulfonyl)imide
Li-ion	Lithium-ion
$LiNiO_2$	Li−Ni−O compound
$LiNO_3$	Lithium nitrate
LiOH	Lithium Hydroxide
$LiPF_6$	Lithium hexafluorophosphate
LiPS	Lithium polysulfide
Li-S	Lithium-sulfur
LiTFSI	Lithium bis(trifluoromethanesulfonyl)imide
Li_xNiO_2	Lithium nickel oxide cathode with variable lithium content

Abbreviation	Definition
LLTO	Lithium lanthanum titanate
LLZO	Lithium lanthanum zirconate
LLZTO	Garnet-type fast lithium-ion conductor $Li_{6.75}La_3Zr_{1.75}Ta_{0.25}O_{12}$
LMB	Lithium metal batteries
LMR	Lithium manganese-rich
LNO	$LiNiO_2$
LPSC	Li_6PS_5Cl
LPSCl	Lithium phosphorus sulfide chloride
LSV	Linear sweep voltammetry
LYC	Li3YCl6 (LYC)
m2/V-s	meters squared per volt seconds
MA	An (undefined) electrolyte additive
mAh	Milliampere-hour
mAh/g or mAh g^{-1}	Specific capacity [mAh/g] refers to the amount of electric charge [mAh] a material can deliver per gram of that material.
mAh/g	milliampere-hours per gram
MERF	Materials Engineering Research Facility
mg/cm²	milligrams per square centimeter
MLPs	Machine learning interatomic potentials
Mn	Manganese
MNC	$Li_{1.2}Mn_{0.54}Ni_{0.13}Co_{0.13}O_2$ a lithium manganese compound
MOF	Type of electrolyte
MPa	Megapascal
mS/cm	Millisiemens per centimeter
MTF	Type of electrolyte
MWCNT	Multi-walled carbon nanotubes
N/P ratio	Negative-to-positive electrode capacity ratio
Nb	Niobium
NCM	Lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC)
Ni	Nickel

Abbreviation	Definition
NiO_2	Nickel (II) oxide
NM	Nickel manganese oxides
nm	Nanometers
NM9505	$LiNi_{0.95}Mn_{0.05}O_2$
NMC	Nickel manganese cobalt oxide
NMC/Li	Battery system with a nickel manganese cobalt oxide cathode and a lithium metal anode
NMC622	cathode type with 60% nickel, 20% manganese, and 20% cobalt
NMC811	cathode type with 80% nickel, 10% manganese, and 10% cobalt
NMR	Nuclear magnetic resonance spectroscopy
NREL	National Renewable Energy Laboratory
NSLSII	National Synchrotron Light Source II
OCV	Open circuit voltage
ORNL	Oak Ridge National Laboratory
PAA	Polyacrylic acid
PAN	Polyacrylonitrile
pCAM	Precursor cathode active material
PDF	Pair distribution function
PE	Polyethylene separator
PECVD	Plasma-enhanced chemical vapor deposition
PEO	Poly(ethylene) oxide
PEV	Plug-in electric vehicle
PF5	Phosphorus pentafluoride anion
PF6	Hexafluorophosphate anion
PFG1	Partially-fluorinated glymes type
PFGs	Partially-fluorinated glymes
PFT	Pulse Fourier transformation
PHEV	Plug-in hybrid electric vehicle
PI	Principal investigator
PNNL	Pacific Northwest National Laboratory

Abbreviation	Definition
PP	Polypropylene
PPM	Polymer poly(pentyl malonate)
PS	Polysulfide
psi	Pound per square inch
PVDF	Polyvinylidene fluoride
Q1	Quarter 1/Quarter 2
R2	Modeled circuit resistor 2
ratio of B/S/Li	ratio of Boron per Sulfur per Lithium
RDD&D	Research, development, demonstration, and deployment
RT14	Particle Type
S	Sulfur
S/cm	Siemens per centimeter
S8	Octasulfur
SBR	Styrene–butadiene rubber
SCP	Silicon consortium project
SE	Solid electrolyte
SEI	Solid-electrolyte interphase
SEM	Scanning electron microscopy
SEMs	Scanning electron microscopies
SIC	Single-ion-conducting
SiO_x	Silicon Oxide Type
SLAC	SLAC National Accelerator Laboratory
SLP	Single-layer pouch
SOC	State of charge
SPAN	Sulfurized polyacrylonitrile
SPE	Solid polymer electrolyte
SSE	Solid-state electrolyte
S-SPAN	Sulfur – sulfurized polyacrylonitrile
SSRL	Stanford Synchrotron Radiation Light Source (SSRL) is a general user facility supported by the DOE Office of Science

Abbreviation	Definition
SUNY	State University of New York
SWNT	Single-wall carbon nanotubes
TEM	Transmission electron microscopy
TFEM	Time-frequency electromagnetic method
TFSI	Bis(trifluoromethanesulfonyl)imide (TFSI), [(CF3SO2)2N]−
TFTFE	1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl ether
TM	Transition metal
TOF	SIMS Time-of-flight secondary ion mass spectrometry
TofF SIMS	Time-of flight secondary ion mass spectrometry
TTE	1,1,2,2-tetrafluoroethyl-2,2,3,3-tetrafluoropropyl ether
TXM	Transmission X-ray microscopy
UC	University of California
UCB	University of California, Berkeley
UCSD	University of California-San Diego
uL/mg	micro liters per milligram
US	United States
UT	University of Texas
UW	University of Washington
V	Volts
VTO	Vehicle Technologies Office
WE	Working Electrode
Wh/kg	Watt hours per kilogram
Wh/L	Watt hours per liter
XANES	X-ray absorption near edge structure spectroscopy
XAS	X-ray absorption spectroscopy
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRF	X-ray fluorescence

2. Electrification R&D

The Vehicle Technologies Office (VTO) supports research, development, deployment, and demonstration (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement); combustion engines to reduce greenhouse gas (GHG) emissions; and technology deployment and integration at the local and state level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), the Vehicle Technologies Office advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The VTO Electrification Technologies subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, national laboratories, and industry covered under the Energy Storage Grand Challenge key priority and distinct crosscuts. The Energy Storage Grand Challenge encompasses research and development (R&D) across electrification including electric vehicle charging infrastructure. The Critical Minerals crosscut aims to realize electric drive motor innovations through high energy product magnet R&D to reduce or eliminate heavy rare earth (HRE) magnet materials. Grid Modernization continues to develop Smart Charge Management technologies for fleets, including medium and heavy vehicles to provide more advanced grid services such as resilience of the charging network and continuity of grid and emergency services operations during disruptive events.

The Electric Drive R&D activity supports early-stage R&D for extreme high-power density motors that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. Reduce the cost of electric traction drive through core research of motors, high-density integration technologies, leveraging high performance computing for modeling and optimization, and utilizing new materials for high-density electric motors. Approaches will include novel circuit topologies and new materials for high-density electric motors. Electric traction drive system integration based on electric motor innovations will also be a priority.

The Electrification R&D activity supports early-stage R&D to understand the potential impacts on, and benefits of, plug-in electric vehicle (PEV) charging to the Nation's electric grid. This research will inform the development of communication and cybersecurity protocols; enable industry to enhance the interoperability between charging equipment, the on-board vehicle charger, and charging networks; and foster technology innovations to improve PEV refueling through extreme fast charging. Core research focuses on developing smart charging, extreme fast charging, and wireless charging technologies for reliable and cost-effective charging of light-, medium-, and heavy-duty electric vehicles. This includes the research of technologies related to cybersecurity of electric vehicle charging/supply equipment, and integration with the electric grid.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 2-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT179	Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit	David Crecelius (American Axle & Manufacturing)	2-7	3.33	3.50	3.17	3.25	3.41
ELT209	High-Voltage High-Power Density Traction-Drive Inverter	Gui-Jia Su (Oak Ridge National Laboratory)	2-10	3.67	3.67	3.67	3.17	3.60
ELT210	Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain	Andrew Binder (Sandia National Laboratories)	2-13	3.33	3.33	3.67	3.33	3.38
ELT212	Non-Heavy Rare-Earth High-Speed Motors	Vandana P Rallabandi (Oak Ridge National Laboratory)	2-16	3.00	3.00	3.25	3.25	3.06
ELT215	Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form	Iver Anderson (Ames Laboratory)	2-18	3.50	3.50	3.17	3.50	3.46

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT216	Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines	Todd Monson (Sandia National Laboratories)	2-21	3.33	3.33	3.50	3.33	3.35
ELT217	Integrated/ Traction Drive Thermal Management	Bidzina Kekelia (National Renewable Energy Laboratory)	2-24	3.33	3.17	3.17	3.00	3.19
ELT218	Advanced Power Electronics Packages	Douglas DeVoto (National Renewable Energy Laboratory)	2-27	3.83	3.83	3.67	3.50	3.77
ELT221	Integrated Electric Drive System	Shajjad Chowdhury (Oak Ridge National Laboratory)	2-30	3.67	3.67	3.50	3.83	3.67
ELT236	Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture	Watson Collins (EPRI)	2-33	3.33	3.50	3.17	3.67	3.44
ELT238	Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection	Srdjan Lukic (North Carolina State University)	2-36	3.00	3.00	3.38	2.00	3.02

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT262	Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging	Ryan Reed (Kenworth)	2-40	3.33	3.33	3.50	3.50	3.38
ELT264	Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams	Stephanie Leach (Exelon/Pepco Holdings Inc.)	2-43	3.25	3.00	3.25	3.00	3.09
ELT265	A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale	Duncan Woodbury (Liberas)	2-46	3.75	3.75	3.75	3.25	3.69
ELT274	eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management	James Stoupis (ABB)	2-49	3.25	3.25	3.25	2.75	3.19
ELT275	Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management	Ayman El-Refaie (Marquette University)	2-52	3.38	2.75	3.50	3.00	3.03
ELT282	Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)	Robert Keefover (BorgWarner)	2-55	3.00	3.17	3.00	2.83	3.06

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT283	A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint	Bogdan Borowy (Eaton)	2-58	3.25	3.00	3.13	2.88	3.06
ELT285	Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (SuperTruck 3)	Maarten Meijer (PACCAR)	2-62	3.38	3.63	3.63	3.38	3.53
ELT286	A Zero Emission Freight Future (SuperTruck 3)	Eric Bond (Volvo)	2-67	3.92	3.42	3.42	3.42	3.54
ELT287	Cummins High Power Density Inverter	Santhosh Krishnamoorthi (Cummins)	2-73	3.40	3.20	3.30	3.30	3.28
ELT288	Scalable Ultra Power-Dense Extended Range (SUPER) Inverter	Harsha Nanjundaswamy (BorgWarner)	2-78	3.58	3.33	3.33	3.42	3.41
ELT290	Behind-the-Meter-Storage	Anthony Burrell (National Renewable Energy Laboratory)	2-83	3.00	3.50	2.50	2.75	3.16
ELT293	Ruggedized Mobile Fast Charger for Off-Road Vehicles	Brij Singh (John Deere)	2-86	2.50	2.83	3.17	3.00	2.81
ELT294	Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments	Leandro Della Flora (Beta Technologies)	2-89	2.67	2.67	2.83	2.83	2.71
ELT295	EVs@Scale VGI & SCM	Jesse Bennett (National Renewable Energy Laboratory)	2-92	3.13	3.13	3.38	3.13	3.16

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT296	Charging Infrastructure Interconnection Simplification Resource CIISR	Watson Collins (EPRI)	2-96	2.83	3.00	3.33	3.17	3.02
ELT297	Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility	Ed Gilliland (IREC)	2-99	3.50	3.33	3.33	3.00	3.33
ELT298	Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity	Steven Sokolsky (CALSTART)	2-101	3.75	4.00	3.50	3.75	3.84
ELT299	EVs@Scale High Power Charging Pillar	John Kisacikoglu (National Renewable Energy Laboratory)	2-104	3.33	3.33	3.17	3.17	3.29
ELT300	EVs@Scale Codes and Standards Pillar	Ted Bohn (Argonne National Laboratory)	2-108	3.50	3.50	3.33	3.33	3.46
ELT301	EVs@Scale Cyber-Physical Security Pillar	Richard Carlson (Idaho National Laboratory)	2-112	3.50	3.75	3.75	3.00	3.59
ELT302	EVs@Scale EV Modeling Toolkit	Andrew Satchwell (Lawrence Berkeley National Laboratory)	2-115	3.33	3.33	3.17	3.17	3.29
Overall Average				3.33	3.32	3.33	3.18	3.31

Presentation Number: ELT179
Presentation Title: Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit
Principal Investigator: David Crecelius, American Axle & Manufacturing

Presenter

David Crecelius, American Axle & Manufacturing

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

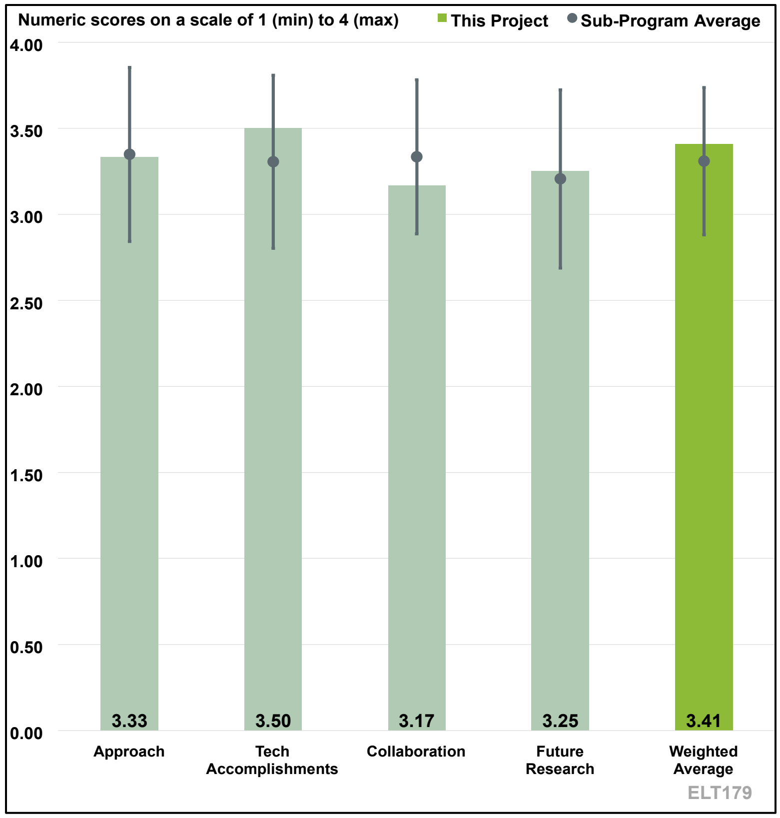

Figure 2-1. Presentation Number: ELT179 Presentation Title: Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit Principal Investigator: David Crecelius, American Axle & Manufacturing

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted American Axle & Manufacturing (AAM) used Arnon7 thin laminate to reduce the loss and achieved low core at high speed, solving the materials problem. The reviewer further noted AAM used the new insulated copper bar to reduce rotor losses and the high-speed approach to improve the motor power density. AAM used winding encapsulation to improve motor thermal management and designed a new inverter to run at 650V to improve system cost and power density. The reviewer concluded the combination of these five approaches resulted in highly efficient non-rare earth (RE) permanent magnet (PM) motor.

Reviewer 2

The reviewer observed the choice of very high-speed induction machine is challenging and noted it will be interesting to see the full test results all the way up to 30,000 rpm.

Reviewer 3

The reviewer said this is an exciting project in which all the technical barriers are addressed, and the timelines are reasonably planned. One doubt this reviewer had is in terms of the targets that the project is addressing. At a traction drive system level, these targets appear to not be either the 2020 or 2025 targets from the roadmap nor from the VTO solicitation out of which this project award came about. The reviewer requested the principal investigator (PI) and project team to look closely at some of the targets they listed in the table in their presentation and clarify what and why they were targeting certain numbers for cost and power density.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked it was impressive to see the team completed the majority of the milestones and demonstrated a motor at 30,000 rpm and met or exceeded all three objectives ($7/kW, greater than 12 kW/L, and greater than 600VDC).

Reviewer 2

The reviewer concluded the project seems to meet all the milestones so far and is on track to conclude by end of 2024.

Reviewer 3

The reviewer affirmed there was great technical progress made in the project. The reviewer also cautioned that more information about the flow configurations in the heat exchangers, as well as the specifics of the reliability characterization of the bonded interfaces would have been helpful.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted there was good collaboration across multiple organizations.

Reviewer 2

The reviewer observed most of the work is being done in-house within AAM, which is okay.

Reviewer 3

The reviewer observed the team worked with Electricore as a partner and with Encap Tech, MacDermid Alpha, and Munro as suppliers, but there is no national laboratory involvement. It is 100% industry.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer affirmed that a good future research and demonstration plan is laid out. The person added that the project is moving closer towards the end.

Reviewer 2

The reviewer observed the project is 90% complete at the time of review, is scheduled to end on Oct. 31, 2024, and the team did not request any no-cost extension.

Reviewer 3

The reviewer commented that testing of the full system will be the ultimate verification step.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer expressed that by pushing an induction motor to 92% efficient at 16,000 rpm, AAM provided an alternative solution and a backup plan for the EV industry in case of any RE crisis. It directly supports the overall VTO objectives in the Electrification Technologies (ELT) subprogram.

Reviewer 2

The reviewer emphasized the project is very relevant for vehicle electrification—specifically, on power electronics, electric machines, and the electric traction drive system for vehicles.

Reviewer 3

The reviewer mentioned the project addresses DOE power density and cost targets as well as the elimination of rare-earth materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted, with $7.8 million, the company has received sufficient funds to develop this impressive motor.

Reviewer 2

The reviewer observed the resources appear adequate.

Reviewer 3

The reviewer said the project is nearing its end and seems to be on track to meet its milestones within the allocated resources.

Presentation Number: ELT209
Presentation Title: High-Voltage High-Power Density Traction-Drive Inverter
Principal Investigator: Gui-Jia Su, Oak Ridge National Laboratory

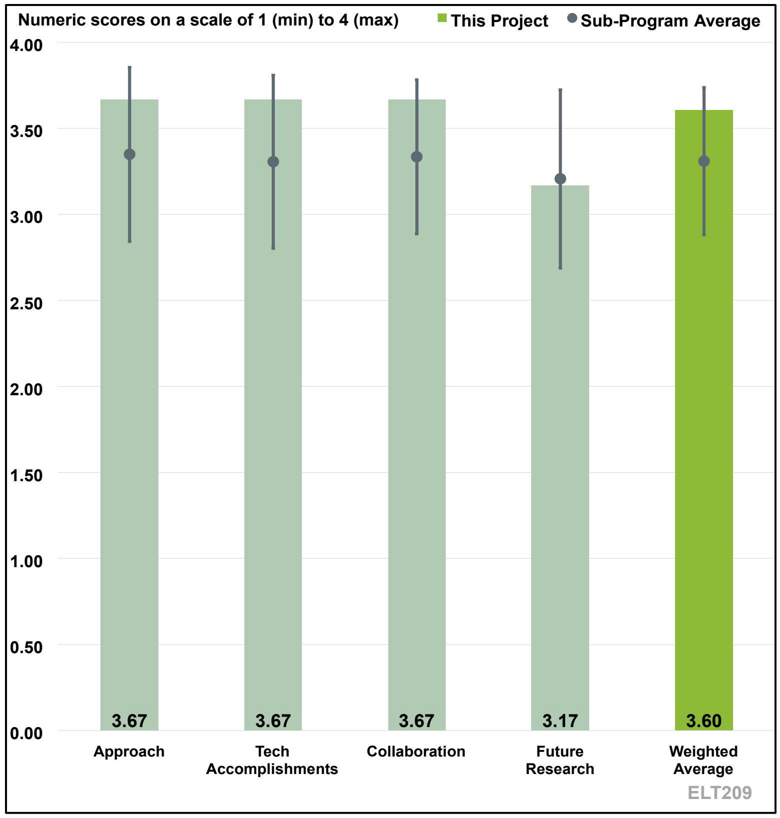

Figure 2-2. Presentation Number: ELT209 Presentation Title: High-Voltage High-Power Density Traction-Drive Inverter Principal Investigator: Gui-Jia Su, Oak Ridge National Laboratory

Presenter

Gui-Jia Su, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that this project focuses on high energy density traction inverter design for 100 kW and 200 kW size inverters. A new design was implemented to achieve high energy density in a 200 kW inverter by switching the design to a segmented inverter type. The project timeline was designed to achieve this in sequence where understanding from 100 kW is applied to optimized for the 200 kW design. The reviewer concluded the timeline is reasonably planned.

Reviewer 2

The reviewer noted this is one of the keystone projects with aggressive targets on power density (100 kW/L), cost ($2.70/kW), peak efficiency (greater than 97%) and reliability (300,000 miles or 15 years). Performance of this project and approaches taken in packaging and thermal management have met power density and efficiency targets. It is not obvious from the report and presentation if cost and reliability targets are met. The heat sink is optimized using genetic algorithm method. Phase-shifted control of dual winding electric motor driven by the six-phase inverter has resulted in a more than 50% reduction in capacitor size, which has helped to meet the power-density target; however, the reviewer sought clarity in how to meet the target costs of the capacitor and SiC devices, bus bar, heat sink, etc. The reviewer concluded the PI is executing this project quite well and doing a commendable job.

Reviewer 3

The reviewer asserted that the segmented inverter concept is an innovative approach for increasing the power density of the inverter. Simulation results support the approach, and experimental results are proving the feasibility.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the design phase and evaluation part has been successfully completed and the testing is on track for the project.

Reviewer 2

The reviewer observed the power module with integrated cooling has been fabricated, which is an enabling component in this project. This module is characterized and integrated in the power-dense inverter. Flow rate versus pressure drop evaluation has been carried out. A photo of the 200 kW Gen-1 SiC is included in the report. A mini-channel-based heat sink is also included in the project report. Efficiency characterization has been only carried out at 640 watts power and is quite high, greater than 97.5% when Gen-1 to Gen-2 power modules are compared. Tunnel magnetoresistance (TMR) based current sensor has been tried; however, the TMR sensor did not track the current signature measured by a current probe. There are additional efforts needed before the TMR-based sensor could be used in the power-dense SiC inverter. The reviewer concluded the project has adequately progressed in all aspects as needed to overcome barriers outlined in the overview slide of the project report.

Reviewer 3

The reviewer expressed there was great work on simulation and experimental validation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the project is a collaboration between Virginia Tech, University of Arkansas, Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory (NREL) and Stony Brook University and has been carried out in an effective manner by leveraging design and evaluation capabilities of various laboratories.

Reviewer 2

The reviewer observed the project team includes the following entities and members with their key and impactful contributions: Virginia Tech, with a power module for a 100 kW inverter; the University of Arkansas, with requirements for the inverter power modules including development of power modules for the 200 kW inverter; Stony Brook University, with support for the inverter power module; and NREL, with thermal management and expert feedback on thermal management.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that testing of the 100 kW inverter using a power module from Virginia Tech is outlined as a task for future research, along with research activities related to a 200 kW inverter.

Reviewer 2

The reviewer noted the project has a few months left, and the proposed future plan is sound.

Reviewer 3

The reviewer stated future research is outlined in terms of some of the remaining challenges of supporting component development, such as a bus bar for high voltage and thermal design. It is not clear whether these can be achieved in the remaining timeline of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted the project is fully aligned with the ELT subprogram objectives of achieving a lightweight and high powder density traction inverter.

Reviewer 2

The reviewer concluded the project activities do address VTO targets for inverter power-density, reliability, efficiency and cost.

Reviewer 3

The reviewer expressed that the project supports the overall ELT objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer asserted the resources are sufficient and include expertise from national laboratories.

Reviewer 2

The reviewer observed the project is well staffed and supported by its collaborators, and has necessary funding, concluding ORNL has excellent facilities to execute a project like ELT209.

Reviewer 3

The reviewer cautioned that more resources would be helpful.

Presentation Number: ELT210
Presentation Title: Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain
Principal Investigator: Andrew Binder, Sandia National Laboratories

Presenter

Andrew Binder, Sandia National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

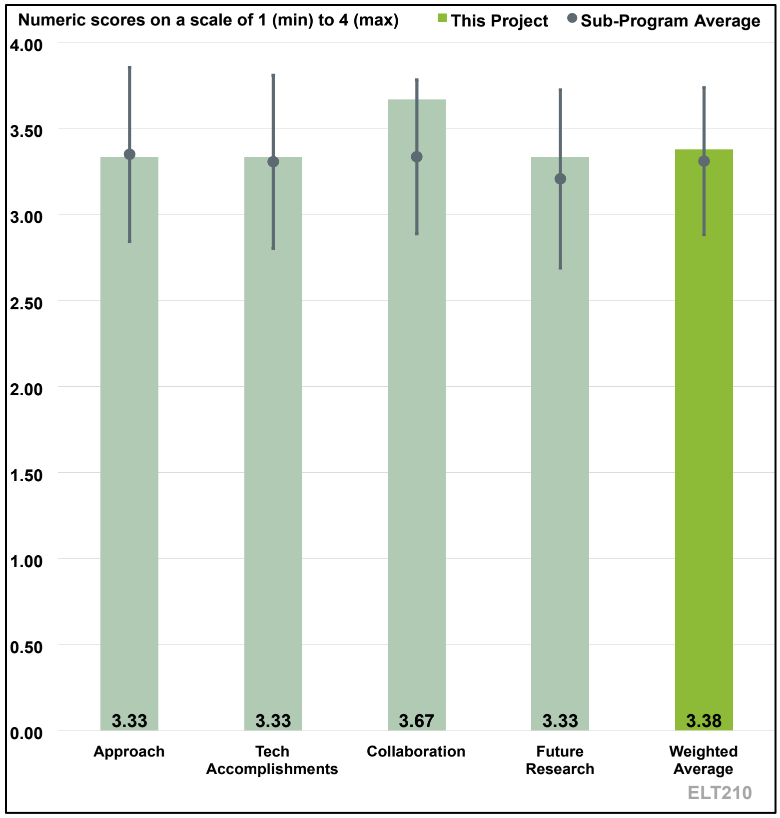

Figure 2-3. Presentation Number: ELT210 Presentation Title: Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain Principal Investigator: Andrew Binder, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted this project focuses on developing GaN based devices for high power density applications and uses vertical GaN design to achieve higher power density. The project is focused on the biggest technical challenges of power chip design.

Reviewer 2

The reviewer observed the project team is using stage approach from SiC metal-oxide-semiconductor field-effect transistor (MOSFET) plus SiC diode (stage 1) to SiC MOSFET plus GaN diode (stage 2) to GaN MOSFET plus GaN diode (stage 3). Each stage includes characterization and evaluation of device technology in the test bed. This approach will allow the project team to develop/evolve deep insight on various wide bandgap (WBG) devices, including their performance.

Reviewer 3

The reviewer cautioned that the goal of this project is high risk and ambitious. It focuses on addressing multiple challenging problems with fabricating vertical GaN devices with kilovolt blocking voltage.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer found the project had achieved a significant breakthrough in technology; however, there still remains many challenges before the technology can be practically employed to achieve targets of power density for the program.

Reviewer 2

The reviewer commented that the various processes needed to fabricate the devices are covered in the report, including passivation, edge termination, metal contact, etc. The project team has used a cycle of learning method until the appropriate device is achieved. Vertical GaN was compared with SiC MOSFET, and if the switching performance and dynamic Ron is accounted, the advantage of better FoM (figure of merit) offered by GaN is not as pronounced as claimed in the literature. Vertical GaN shows a marginal advantage. This is really great insight provided by the project team.

Reviewer 3

The reviewer praised the reported achievements of a kilovolt vertical GaN diode, adding that this is a big deal.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed the project is a collaboration among Ohio State University (OSU), ORNL, NREL, State University of New York Polytechnic Institute (SUNY Poly) and Sonrisa Research, Inc. These institutes together cover all aspects of development.

Reviewer 2

The reviewer noted ORNL, NREL, SUNY Poly and the OSU are collaborating with the team at Sandia National Laboratories (SNL).

Reviewer 3

The reviewer concluded there is great collaboration with university partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted future research efforts proposed are logical next steps in the development of GaN devices. The project develops new technology that is still in an immature stage and requires further development before commercialization.

Reviewer 2

The reviewer noted documentation on the project findings (including a research paper and patent disclosures) is one of the future works proposed. This is extremely valuable to researchers involved in the WBG device discovery and their applications to power electronic systems. High current devices will be realized, and the application of high voltage and lifetime analysis may be covered in future research.

Reviewer 3

The reviewer answered yes.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed the project is in alignment with ELT subprogram objectives.

Reviewer 2

The reviewer acknowledged the project activities are tied to 2025 VTO targets for power-density (100kW/L inverter) and concluded industry will greatly benefit from knowledge evolved through this project.

Reviewer 3

The reviewer stated the project supports the overall VTO ELT objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer affirmed the project has sufficient resources.

Reviewer 2

The reviewer expressed the project has the necessary resources; SNL has a world class research facility, and collaborators (ORNL, NREL, SUNY Poly and the OSU) seem to be providing support in execution of project activities.

Reviewer 3

The reviewer pointed out that more support would help speed up the progress.

Presentation Number: ELT212
Presentation Title: Non-Heavy Rare-Earth High-Speed Motors
Principal Investigator: Vandana Rallabandi, Oak Ridge National Laboratory

Presenter

Vandana P Rallabandi, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

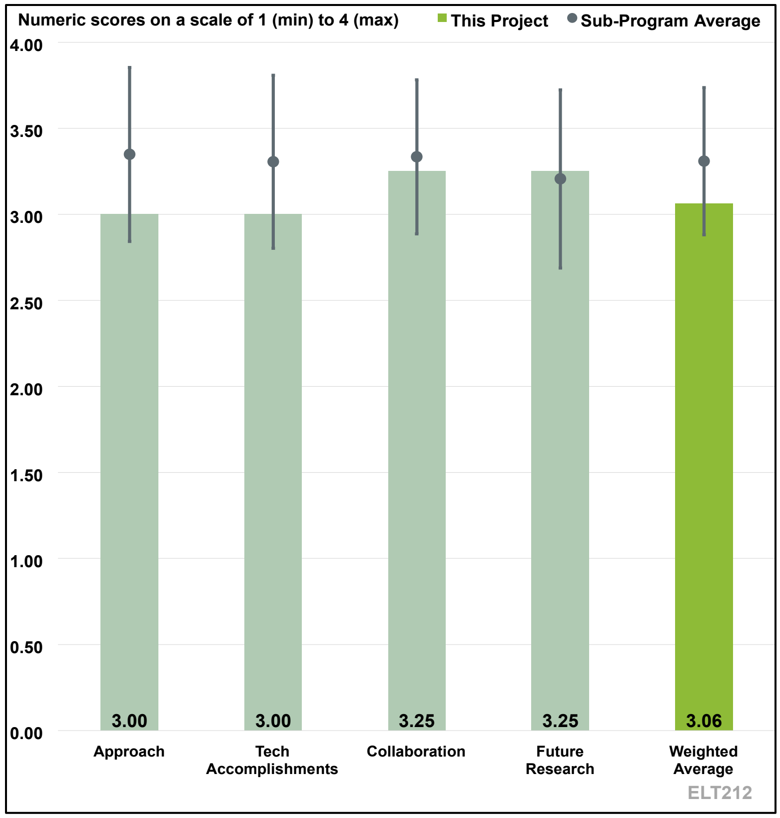

Figure 2-4. Presentation Number: ELT212 Presentation Title: Non-Heavy Rare-Earth High-Speed Motors Principal Investigator: Vandana Rallabandi, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer asserted the approach for replacing rare heavy earth metals is rightly designed.

Reviewer 2

The reviewer noted the proposed design is very high risk and fairly complicated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted communication of the results was very effective.

Reviewer 2

The reviewer cautioned rotor dynamics is a big risk that needs to be addressed. In addition, the very high fundamental frequency adds a lot of complications in terms of using Litz wire and very high level of magnet segmentation. The choice of a Halbach array also adds complications. Even though the focus is on improving the power density, the proposed design seems to be fairly complicated and expensive for traction applications, even though the integration concept of the motor and inverter has merit.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked there was excellent collaboration.

Reviewer 2

The reviewer noted there seems to be a good collaboration among multiple organizations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed the future work is clearly defined.

Reviewer 2

The reviewer noted a rotor spin test is planned, the project is near its end, and testing the prototype will be valuable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated the project is relevant for VTO ELT technologies.

Reviewer 2

The reviewer asserted improving the system power density is important, but it comes at the expense of efficiency and the level of complication and cost.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted the project is sufficiently resourced.

Reviewer 2

The reviewer observed the project started in 2019 and is close to coming to an end.

Presentation Number: ELT215
Presentation Title: Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form
Principal Investigator: Iver Anderson, Ames Laboratory

Presenter

Iver Anderson, Ames Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

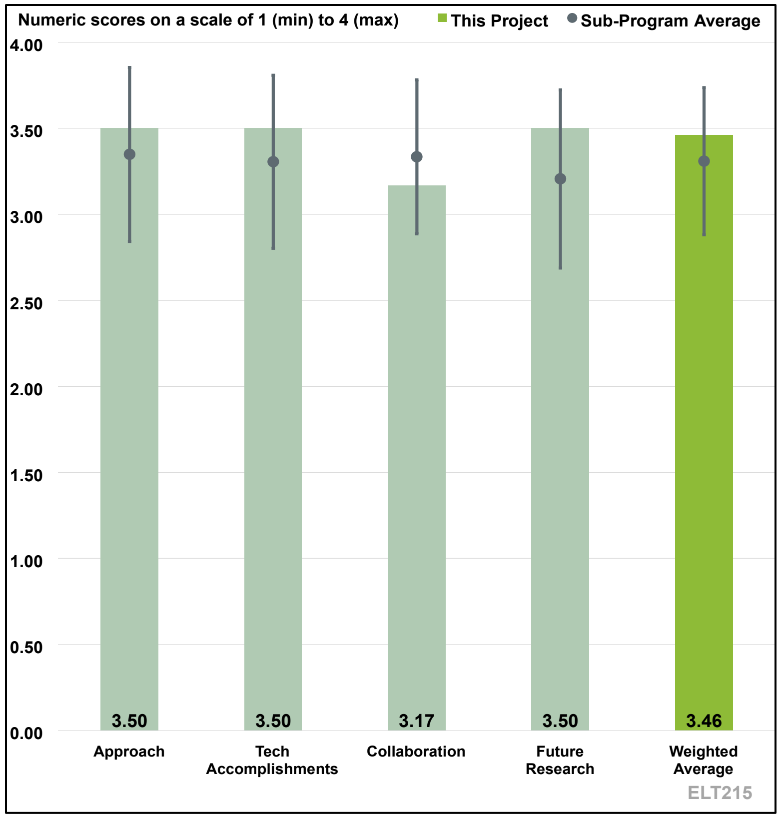

Figure 2-5. Presentation Number: ELT215 Presentation Title: Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form Principal Investigator: Iver Anderson, Ames Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that goal is to develop high-energy-density PMs without expensive and scarce HRE elements. The project aims to develop ultrafine grain magnets that reduce PM motor eddy current losses at high speeds, which helps reduce the motor’s cooling needs. The second part of the project develops soft magnetic materials using 6.5% Si content.

Reviewer 2

The reviewer observed the presentation covers two projects. The first project (Sustainable High Performance Magnetic Materials for Exceptional Power Density Electric Drive Motors) is focused on developing high performance motor materials and designs that can be locally sourced (from the U.S.) for energy security and to become a global supplier. The project leverages the expertise and facilities of Ames National Laboratory (Ames), NREL, ORNL, and SNL to do the work. The ultrafine grain HRE-free materials are a unique approach that can eliminate (or significantly reduce HRE use). The second project (Soft Magnets to Achieve High-Efficiency Electric Drive Motors of

Exceptional Power Density) is focused on developing a process to manufacture 6.5% Si steel (which improves motor performance) that can be mass produced.

Reviewer 3

The reviewer stated the goal of having HRE free magnets as well as thin laminations of 6.5% Si is an important one.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed the project processed commercial (HRE-free) powders (4 to 2.5 μm, 1-5 runs) with a new jet mill placed in a glove box. The project found that ultrafine powders (2.5 μm) resulted in more uniform size (improved coercivity) and rounded edges (better aligned). The project developed a modified jet milling system to passivate powder immediately post-milling.

Reviewer 2

The reviewer noted the first project's powder particle size processing/refinement and passivation process, and grain boundary engineering are impressive. The reviewer further noted the second project modified an existing melt-spinner to produce a low volume sample spool of the 6.5% Si steel showing the potential. The reviewer observed the project evaluated several alloying additions to improve performance, with the boron addition found to be beneficial and feasible.

Reviewer 3

The reviewer mentioned it is not clear how the expected properties and cost compare to what is commercially available.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the project collaborates with: ORNL for motor design, NREL for mechanical modeling, and SNL.

Reviewer 2

The reviewer noted Ames is the lead, with ORNL, NREL, and SNL adding to the team with unique expertise and facilities. There appears to be good collaboration, with each laboratory contributing.

Reviewer 3

The reviewer observed there seems to be reasonable collaboration among multiple organizations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer pointed out the project identified future research, remaining challenges, and opportunities. It appears that there are many important scientific observations and knowledge generation happened from this project. It appears that there is more research to be done in this area by solving the remaining challenges. For example, it is mentioned that there is more work to do to obtain ultrafine grain HRE-free PMs.

Reviewer 2

The reviewer noted the project is 94% complete. The presenter highlighted the remaining uncertainties in the findings that need to be better understood and then integrated into material supply and manufacturing processes to have a pathway to commercialization.

Reviewer 3

The reviewer noted it is important to be clear about the expected properties and how the result will be better than what is commercially available.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted the project is important because the proposed solution attempts to eliminate HRE elements, such as dysprosium, from PMs currently used in many electric vehicle (EV) traction motors.

Reviewer 2

The reviewer asserted the project is directly relevant to removing critical materials and HRE materials from magnets for improved cost and energy security. The reviewer mentioned soft motor material research is relevant to improving motor cost and performance. Both are critical (if successful and transitioned to industry to commercialize) for decreasing PEV costs.

Reviewer 3

The reviewer noted eliminating HRE material as well as having very low loss lamination have the potential of significantly improving the performance of high-speed motors.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted from the project presentation that multi-jet milling can produce ultrafine powders from commercial strip cast/heavy duty particles but handling the fine powder without the loss of properties to native oxidation remains difficult. The reviewer raised the question of whether additional investment can help to solve this issue.

Reviewer 2

The reviewer commented that the project includes very technical work, with unique facilities, labs, and staff, and the budget appears to be in line.

Reviewer 3

The reviewer noted resources seem to be sufficient.

Presentation Number: ELT216
Presentation Title: Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines
Principal Investigator: Todd Monson, Sandia National Laboratories

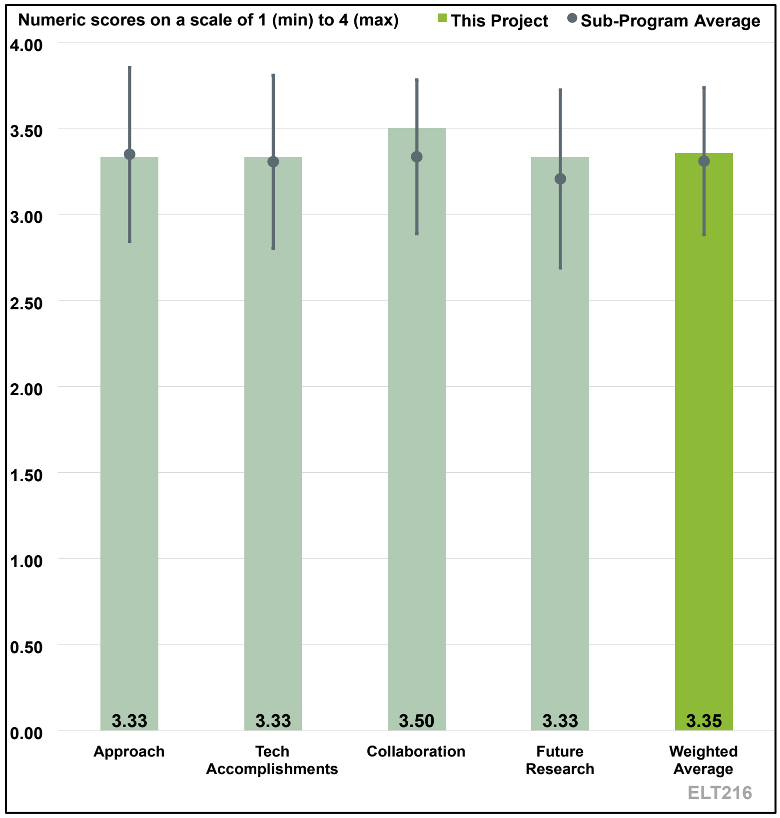

Figure 2-6. Presentation Number: ELT216 Presentation Title: Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines Principal Investigator: Todd Monson, Sandia National Laboratories

Presenter

Todd Monson, Sandia National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted the project aims to develop soft magnetic materials, which are timely subjects for electric machine design. The goal is to design machines without RE element materials, so it is important to design machines with soft magnetic materials. Dual homopolar machines without using PMs are proposed. A demonstration of net-shaped bulk iron nitride soft magnetic part consolidated using spark plasma sintering (SPS) and evaluation of saturation magnetic polarization is aimed.

Reviewer 2

The reviewer affirmed the approach of using low-cost materials (Fe, N) and composite (epoxy) to provide strength and durability to meet DOE targets and targeting near net shape to simplify manufacturing is good.

Reviewer 3

The reviewer remarked it was hard to tell if the proposed approach will lead to better properties compared to other available sheet molding compound (SMC) materials.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed the project received and installed SPS and received an initial Fe_4N sample fabricated using SPS. The project also worked with Ames to investigate SPS protocols for ultrafine-grained NdFeB.

Reviewer 2

The reviewer noted an example of the Fe_4N composite near net shape rotor was produced. Design improvements were identified to remove stress cracks.

Reviewer 3

The reviewer noted the saturation level of 1.18 T seems low and needs to be improved. Specific core loss data and mechanical properties are needed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer expressed the project worked closely with Purdue University on machine design. It is nice to see that the development of new materials does not stay at the level of the material, but actual implementations of electric machines happen. This increases the impact of the project with the final product in mind. The project's collaboration with Purdue and other national laboratories is well described.

Reviewer 2

The reviewer expressed the team contributions were not described in detail but are described in the presentation. The project team seems to be a good combination of expertise, staff, facilities, which complement each other and do not duplicate.

Reviewer 3

The reviewer praised the good collaboration among multiple organizations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed the project clearly defined the future work, including: the evaluation of SPS Fe_4N soft magnetic parts and the completion of fabrication and evaluation of ultrafine-grained HRE-free PMs. The reviewer further noted if the soft magnetic is implemented in the motor design by the end of this project, this will be a great accomplishment.

Reviewer 2

The reviewer noted the project was 94% done at the Annual Merit Review (AMR), so the final remaining items (Slide 17) are all that remain.

Reviewer 3

The reviewer said the specific core losses and mechanical properties are needed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted the project is relevant as it tries to eliminate HRE materials from motor design, particularly PMs. Developing this soft magnetic material is very important for attaining machine design without HRE materials. This project aligns with DOE goal of reducing or eliminating HRE materials from motor designs.

Reviewer 2

The reviewer noted the project addresses identifying alternative motor (complete and component) designs and manufacturing approaches to remove/reduce RE materials from motor designs for cost and energy security reasons.

Reviewer 3

The reviewer observed that if the project results in an SMC with improved properties, this can potentially improve the performance of some high frequency electrical machines.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project has sufficient resources to achieve the milestones. The project received the FUJI Dr. Sinter Lab Jr.™ SPS and successfully used it in the project. Initial Fe_4N samples were fabricated using SPS.

Reviewer 2

The reviewer observed the presentation did not state the total project budget, but rather the (low) annual funding in the $125,000 to $150,000 range. Given this, and the relative high costs of national laboratories and universities, the project outputs are impressive.

Reviewer 3

The reviewer stated the resources are sufficient.

Presentation Number: ELT217
Presentation Title: Integrated/Traction Drive Thermal Management
Principal Investigator: Bidzina Kekelia, National Renewable Energy Laboratory

Presenter

Bidzina Kekelia, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

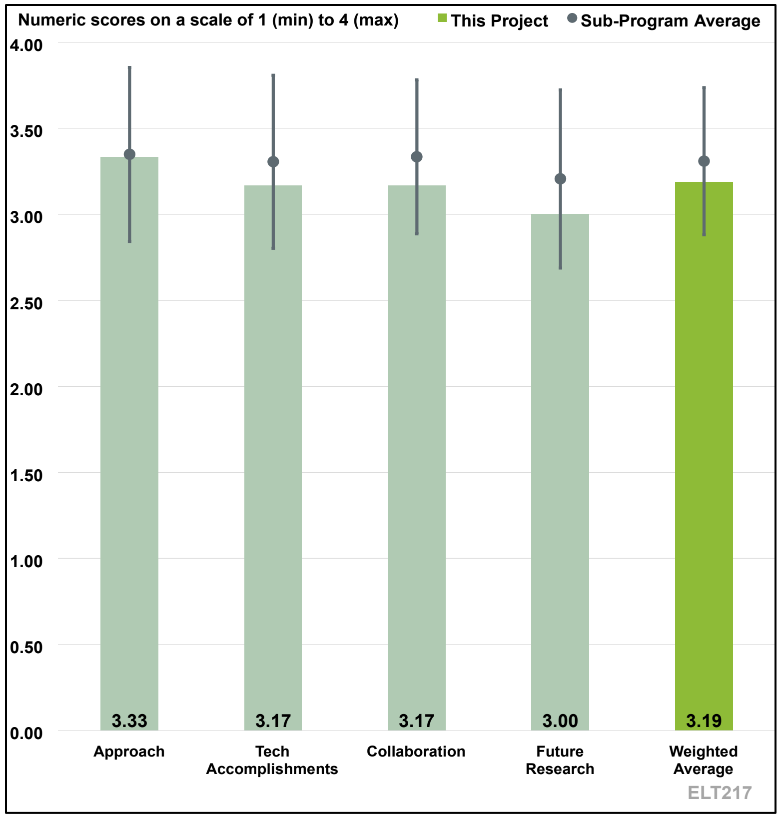

Figure 2-7. Presentation Number: ELT217 Presentation Title: Integrated/Traction Drive Thermal Management Principal Investigator: Bidzina Kekelia, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project had a well thought out approach for developing a thermal management system for the tractive drive, with the purpose of electric-drive integration and the power density increase. The approach includes various cooling strategies evaluation, cooling materials selection, and design, modeling and testing of the thermal management system.

Reviewer 2

The reviewer noted the proposed approach of embedding cooling in integrated drive/motor is challenging and ambitious but is a must for the future’s high-voltage and high rpm EV powertrains.

Reviewer 3

The reviewer noted limitations in results exist in that the heat exchanges within the housing manufacturing made from ceramic aluminum with 3D printers within the aluminum oxide manifold were not completely leak proof and need continued testing. Also remaining challenges and barriers are in the material selection process with regards to cost reduction, power density reliability and lifetime thermal conductivity not short circuiting. The project appears to be well designed and the timeline reasonably planned for results in the short-term, but long-term results may differ.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted outstanding simulation work and excellent initial proof-of-concept experimentation.

Reviewer 2

The reviewer mentioned the technical progress is on track, as the project inputs have led to measurable milestones of generated output in the last 6 years and the project is 90% completed.

Reviewer 3

The reviewer commented that the project team has made reasonable progress in design and simulation of the thermal management system, but the challenge of the cracking during thermal post-processing does not seem to be resolved yet.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the team members are from national laboratories and universities. It is not very clear the tasks assigned to each of the partner. It seems there are two teams working in parallel on the design of the heat exchanger.

Reviewer 2

The reviewer noted excellent collaboration with the university and commercial partners.

Reviewer 3

The reviewer noted interactions and collaboration exist with multiple national laboratories as well as universities. Collaboration between laboratories and universities is sufficient for the needs of the project based on others conducting similar research projects, which can allow for comparison of results. More collaboration could possibly be used with reaching out to the housing manufacturer, EDM Technologies, to consider how to improve on existing limitations affecting results.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the team has identified a list of the remaining tasks, such as finalizing assembly of the coolant manifold disk, 3D printing of the heat exchangers, and finalizing the design and manufacturing of the cylindrical inverter housing. Considering the project timeframe, completing the listed tasks seem to be challenging.

Reviewer 2

The reviewer noted the purpose of future work is clearly defined. The likelihood of achieving future work will largely depend on the delivery of components from partners.

Reviewer 3

The reviewer noted future research and purpose will be to finalize system components and analysis of inlet/outlet of the thermal exchange in the production housing. Results of modeling are intended to be presented at the American Society of Mechanical Engineers (ASME) InterPACK Technology Conference in October 2024, but these proposed plans for future research to achieve meaningful targeted results appear to be slightly ambitious and not completely attainable given the limited amount of time remaining until the next conference presentation and the amount of remaining technical challenges and barriers.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the aspect of transportation electrification in overall DOE objectives.

Reviewer 2

The reviewer affirmed the project supports the overall VTO ELT objectives.

Reviewer 3

The reviewer noted the project is very relevant to the overall VTO subprogram objectives, as developing a new technology for various methods of heat removal for cooling electric and power electronics components would generate a profound impact on the performance of machine systems in many industries and would indirectly improve supply chain manufacturing efficiencies and/or likely help improve the reduction of the carbon footprint output.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources for the project are sufficient, and the project is mostly on track.

Reviewer 2

The reviewer commented that more funding will help speed up the progress.

Reviewer 3

The reviewer observed multiple industry leading national laboratories and nationally recognized educational institution partners are collaborating on this project, so the resources provided appear to be sufficient to achieve stated milestones in a timely manner, as long as the goals are reasonable.

Presentation Number: ELT218
Presentation Title: Advanced Power Electronics Packages
Principal Investigator: Douglas DeVoto, National Renewable Energy Laboratory

Presenter

Douglas DeVoto, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

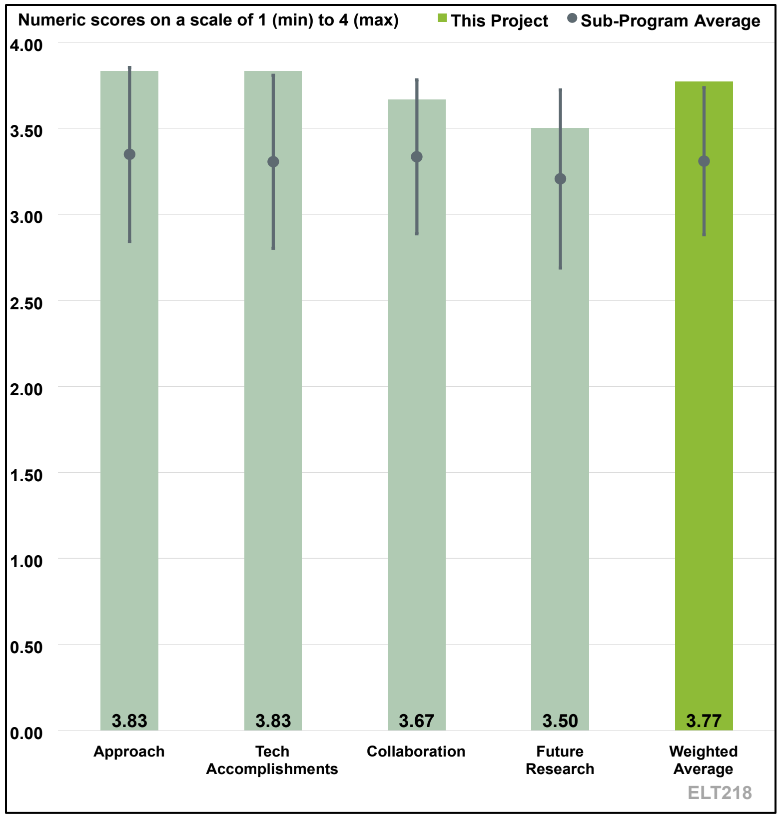

Figure 2-8. Presentation Number: ELT218 Presentation Title: Advanced Power Electronics Packages Principal Investigator: Douglas DeVoto, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted the project is working towards new thermal packaging, which is a common challenge to achieving high power density and thermal performance. The new technology focuses on redesigning thermal substrate for high power chips. Use of a new unique material provides scope for lowering the device footprint. The timeline is reasonably planned.

Reviewer 2

The reviewer noted wide-gap semiconductors provide performance benefits (especially in power density), which can help in reaching VTO's power electronics performance targets; therefore, it makes sense to look for improved packaging designs, which can accommodate those semiconductors and to anticipate and address any issues that may be encountered in using them. This project seems to be well-focused on that singular objective. This reviewer found its approach and its sequence of steps to be logical and intuitive. Material analysis was conducted on polyimide to narrow optimum laser power and cutting speed; its stability was validated experimentally by fabricating a power electronics module in which it was incorporated, and multiphysics design optimization techniques were used in the design. The timeline seems to have been reasonably planned (although it was somewhat affected by unanticipated supply-chain issues).

Reviewer 3

The reviewer commented that the project addresses critical barriers associated with thermal performance and cost of packaged power modules for traction inverters.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted technical progress is adequate and as per the timeline.

Reviewer 2

The reviewer commented there was great progress made with testing DuPont's Temprion polyimide film.

Reviewer 3

The reviewer noted this multi-year project is now well into in its final year. It appears to have made excellent progress and completed many of the steps it set out to accomplish. However, thermal and reliability issues for the new packaging technology are not yet fully evaluated. Because the end objective is to demonstrate superior performance over traditional packaging in several areas (e.g., including superior thermal performance and greater reliability under thermal cycling, thermal aging, vibration, power cycling, and electrical high potential), it appears that a good amount of experimental work remains to be done, which might be challenging to complete in the relatively short amount of time remaining.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed this work is a major collaboration between NREL and ORNL, with support from industry partner DuPont. ORNL is involved from design perspective while NREL has been leading with material and component testing.

Reviewer 2

The reviewer noted NREL has maintained collaboration with two entities: DuPont and ORNL. DuPont provided the polyimide material, which met a basic need for this project, so that collaboration was essential. The contribution of ORNL is specified only broadly in the presentation but appears to have been in completing multiphysics modeling of the packaging system, an area in which ORNL may have good expertise. That expertise seems to have been well-utilized.

Reviewer 3

The reviewer mentioned there was great collaboration with university and commercial partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted proposed future research carries forward this work to device testing of the component. Future work is very likely to achieve its targets.

Reviewer 2

The reviewer commented future work was clearly defined.

Reviewer 3

The reviewer observed this multi-year project is now currently in its final year, so ideally not too much future research would remain. However, thermal and reliability issues for the new packaging technology have not yet been fully evaluated and might require more time to complete. Because the end objective is to demonstrate superior performance over traditional packaging in several areas (which require experimental work) it might be challenging to complete all of that in the relatively short amount of time remaining.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer mentioned the project aims to meet VTO ELT subprogram goals. Thermal design is very important and relevant technical work for achieving high power density targets.

Reviewer 2

The reviewer observed decreasing the thermal resistance pathway in power electronics packages is crucial to maximizing the performance of wide-bandgap devices. This can be accomplished by either replacing package layers with new materials that enable greater thermal, electrical, and reliability performance or eliminating layers and components through new packaging designs. Safe and robust operation of the power electronics requires electrical isolation of the high-voltage circuitry within the power electronics module and other considerations related to performance. Therefore, this reviewer considers this project as highly relevant to VTO ELT subprogram objectives.

Reviewer 3

The reviewer mentioned the project supports the overall VTO ELT objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project is adequately resourced.

Reviewer 2

The reviewer noted this is a six-year project (now in its final year) in which DOE put in $1 million. Of that, $150,000 was spent during the final year. So, the spending rate seems to have been well-matched to the resources that were planned.

Reviewer 3

The reviewer mentioned more funding would help speed up the progress.

Presentation Number: ELT221
Presentation Title: Integrated Electric Drive System
Principal Investigator: Shajjad Chowdhury, Oak Ridge National Laboratory

Presenter

Shajjad Chowdhury, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

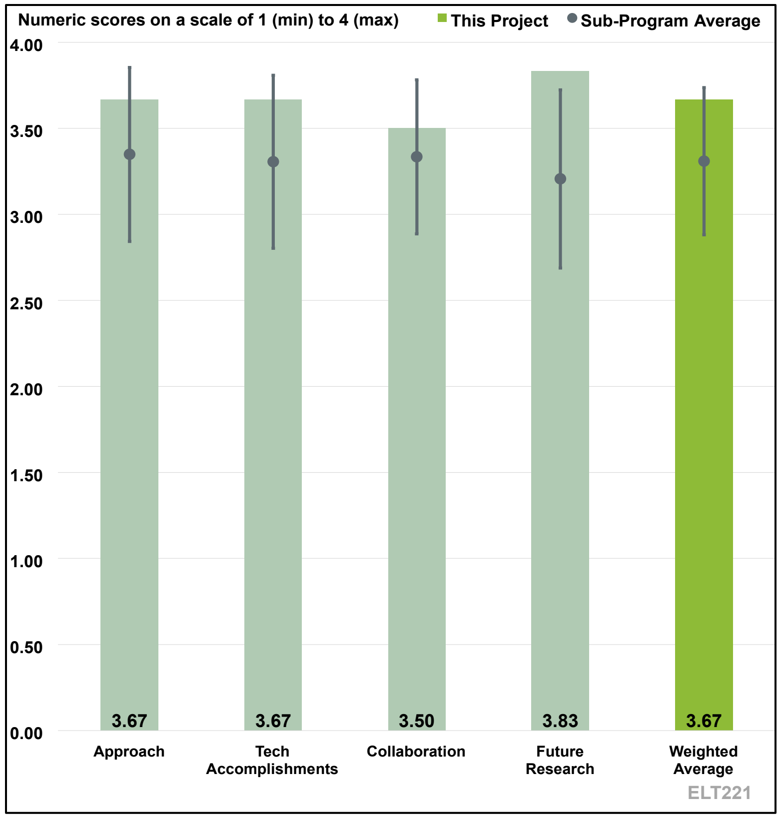

Figure 2-9. Presentation Number: ELT221 Presentation Title: Integrated Electric Drive System Principal Investigator: Shajjad Chowdhury, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented the project targets designing and testing of motor and power electronics components in the electric drivetrain using newly designed materials and parts. It is well designed to provide an integrated view of the drivetrain. The project is well designed, and the most important technical barriers are addressed to enable high power density.

Reviewer 2

The reviewer noted 2025 DOE targets for motor drive for power-density is 33 kW/L. Putting an inverter in the cavity of the outer rotor motor will eliminate connectors and cables between the inverter and motor power terminals, resulting in development of a drive system that meets this power density target (33 kW/L). The project approach and technical progress are towards 33 kW/L power-density target. The reviewer questions whether the "commercialization pathway should be described in future reports submitted to DOE."

Reviewer 3

The reviewer asserted this is an ambitious project that integrates active, passive, sensing, protection, and cooling elements of an electric drive, which is necessary for increasing the power density.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted the project designed a power block and various components that enable high power density performance. A new cooling design has been invented to address rotor-stator-power module geometry.

Reviewer 2

The reviewer commented that direct bonded copper and substrate assembly is characterized (power loss versus device temperature rise) over 25º C to 65º C coolant temperature. Static and dynamic performance evaluations of power module are completed. The power module front end module is completed. The Pro-E assembly of the power block is included in Slides 13 and 14 of the project report and looks quite impressive.

Reviewer 3

The reviewer noted great progress with the assembly and testing of the integration effort.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed this project includes collaboration among ORNL, NREL and Ames. Direct involvement of an industry partner would be beneficial.

Reviewer 2

The reviewer noted NREL, SNL and Ames are contributing to execution of project activities.

Reviewer 3

The reviewer mentioned great collaboration with all the partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented proposed future research will help in achieving 100 Kw/L power density. Future work is likely to achieve its target.

Reviewer 2

The reviewer noted electrical and thermal performance of the developed power boards of the inverter will be characterized. A prototype of a six-phase inverter will be assembled, followed by the inverter characterization.

Reviewer 3

The reviewer affirmed the future plan was clearly defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated the project is very relevant to the ELT subprogram.

Reviewer 2

The reviewer concluded the project activities are related to DOE 2025 targets for electric drive that include both inverter and motor.

Reviewer 3

The reviewer mentioned the project supports the overall VTO ELT objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the resources for the program are sufficient.

Reviewer 2

The reviewer commented that the project team is staffed enough and has necessary financial resources. ORNL has excellent facilities to successfully execute tasks of this project.

Reviewer 3

The reviewer mentioned the project resources are sufficient.

Presentation Number: ELT236
Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture
Principal Investigator: Watson Collins, EPRI

Presenter

Krish Gomatom, EPRI

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

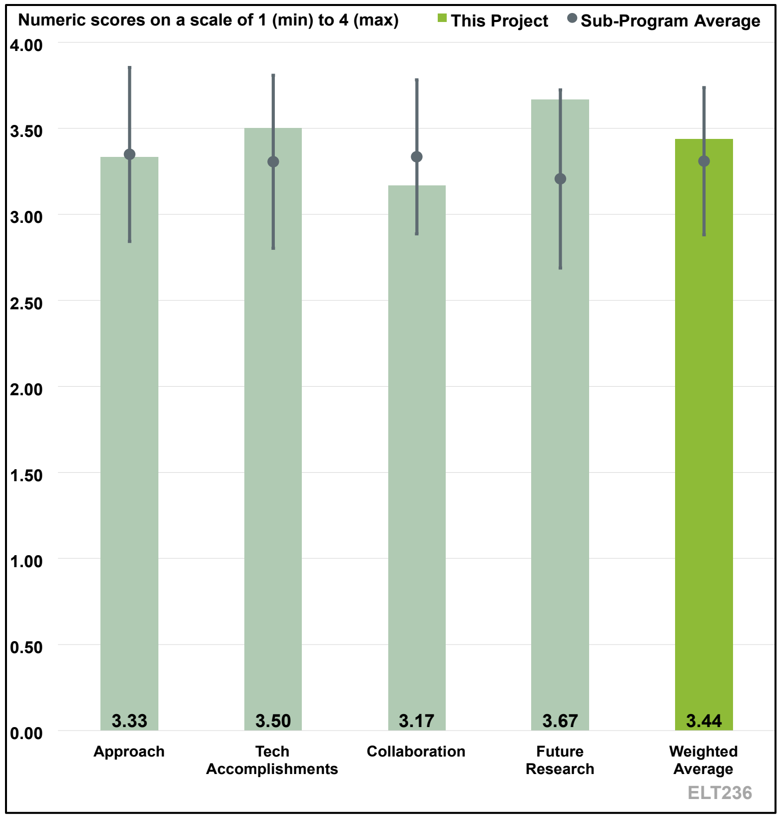

Figure 2-10. Presentation Number: ELT236 Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture Principal Investigator: Watson Collins, EPRI

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the approach taken by the research team is sound and effective.

Reviewer 2

The reviewer noted the approach was excellent on developing a foundational system for direct current (DC) connected EV charging that integrates with devices such as distributed energy resources (DERs), solar, wind and energy storage. The project addressed technical barriers of producing a 1 MW DC charging system. In relevance to DOE Grid and Charging Infrastructure Program Goals of developing an extreme fast charging (XFC), this project develops and tests DC technologies for XFC while minimizing impacts to the grid. This research helps to identify opportunities for interoperability and technical transfer activities. It also provides opportunity for EV grid integration and services. DC technologies could facilitate the integration of DERs to minimize the impact on the grid.

Reviewer 3

The reviewer said the technical and practical barriers to success were sizeable. Loss of a supplier for the solid-state transformer (SST) is a notable setback, and supply chain issues are a broad challenge to EV grid and infrastructure development. The pending success of the team securing a new SST vendor will speak for itself. The timeline seemed reasonably planned, with understandable adjustments given the unforeseen supplier and supply chain hurdles. Still, the work is timely and critical to help reduce cost and increase economic efficiency of EV charging infrastructure.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said there was strong progress and accomplishments by the team.

Reviewer 2

The reviewer noted the technical accomplishments and progress in this project are excellent. The SST providing a medium-voltage converter module design has been completed and prototype cells are tested. The team evaluated multiple vendors capable of supplying an SST prototype solution. The project is significantly behind schedule due Covid-19 supply chain issues and vender churn rates.

Reviewer 3

The reviewer mentioned supplier and supply chain challenges notwithstanding, substantial progress was evident in this project, and it appears to be headed toward completion, though with a tight timeline ahead. Completions of designs and prototypes for the SST and DC load center support this, as has the delivery of the load center to NREL for standalone testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted collaboration across teams is good.

Reviewer 2

The reviewer commented that the collaboration has been excellent with the core group. The reviewer noted the Electric Power Research Institute (EPRI), as the Project Lead, Tritium, NREL, Argonne National Laboratory (ANL) and Missouri University of Science and Technology have all been good partners. There needs to be a stronger vetting process for contract vendors.

Reviewer 3

The reviewer mentioned the progress was understandably impeded by the loss of a hardware supplier partner. It is unclear if the project team could have known the likelihood of this loss in advance, but this could speak to room for improvement in selection/collaboration of the team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted proposed future work is good.

Reviewer 2

The reviewer commented future research includes additional integration testing of DC microgrid with medium voltage converters, testing of hybrid plants within a DC microgrid, and analysis of dynamic response of multi-level converters to unexpected system conditions and failure modes. Reliability and resiliency monitoring of the DC infrastructure and DC distribution for fleet EV charging also needs to be analyzed.

Reviewer 3

The reviewer noted proposed future work, including new integration testing, hybrid plants, failure mode/reliability/resiliency monitoring are all critical. Megawatt charging (MWC) with fleet tests will be essential contributions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports infrastructure development for fast charging.

Reviewer 2

The reviewer said the project is very relevant to relief of the grid to provide charging infrastructure for EV charging. This project develops and tests DC technologies for XFC while minimizing impacts to the grid.

Reviewer 3

The reviewer noted reducing the complexity and cost of AC/DC conversion equipment for XFC sites is highly relevant to VTO objectives. The importance of EV charging infrastructure refinement cannot be overstated.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer mentioned resources provided for this project appear to be adequate.

Reviewer 2

The reviewer noted the project has sufficient resources.

Reviewer 3

The reviewer mentioned additional resources for this project and the future research areas identified by the team will be research funds well spent.

Presentation Number: ELT238
Presentation Title: Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection
Principal Investigator: Srdjan Lukic, North Carolina State University

Presenter

Srdjan Lukic, North Carolina State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

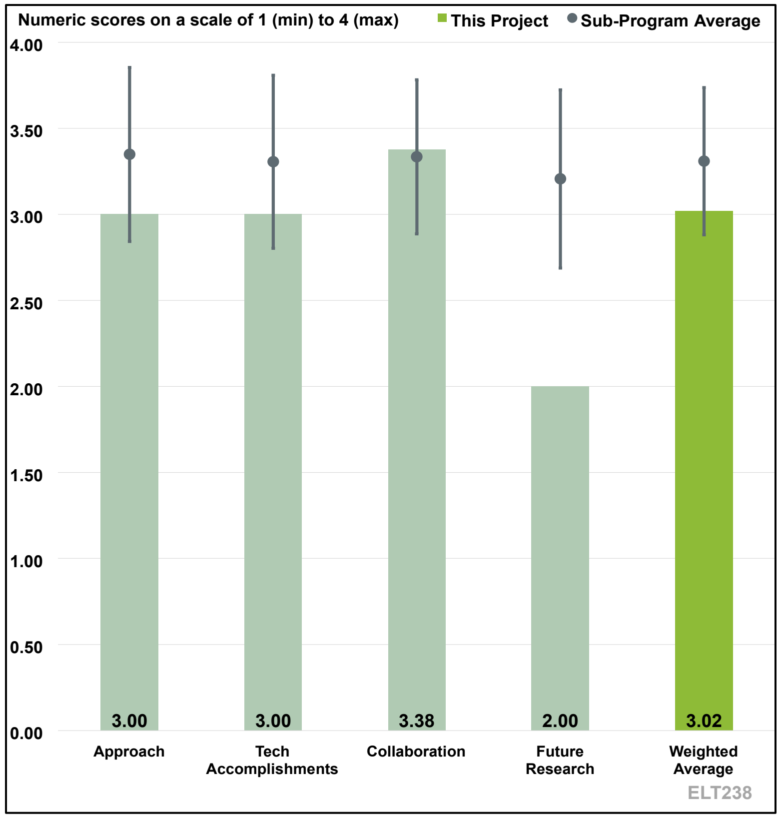

Figure 2-11. Presentation Number: ELT238 Presentation Title: Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection Principal Investigator: Srdjan Lukic, North Carolina State University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the proposed modular XFC system appears to be a good and timely approach to address the barriers of integration of charging infrastructure at distribution voltage levels and DC protection.

Reviewer 2

The reviewer noted the project was able to accomplish the main goal of SST and DC distribution.

Reviewer 3

The reviewer noted the barriers are addressed well through the development, testing, and demonstration of the megavolt (MV) to DC charger, and the DC protection system. The potential cost increase or decrease is very important, but it does not appear to be within the scope of the project.

Reviewer 4

The reviewer commented that although there was a complete program plan, it relied on success at every level, including part lead times, cost and quality construction. When working with full prototype systems additional time for optimal tuning of required systems and the possibility of delays in parts is recommended.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project was completed by meeting all the project objectives and well addressing the barriers such as the system integration.

Reviewer 2

The reviewer commented that the project has a deployed system and has secured additional funding for future deployment.

Reviewer 3

The reviewer mentioned there were good technical accomplishments presented, showing the laboratory evaluation of prototype a megavolt (MV) SST, active front end (AFE), and the SST. The reviewer noted the field deployment was stopped due to a transformer failure and planned for re-deployment in fall 2024. The field demonstration was not accomplished within this project.

Reviewer 4

The reviewer commented that the ability of the team to overcome the transformer failure and incorporate a new design is noted as a success, but the chance of having a fully tested system is in jeopardy. The project made good advancements in a number of areas, but it is hard to deem the project as successful due to the limited testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the team members are from a university, industry and power authority. Each team member has contributed to the project from different perspectives, such as design, testing, and deployment, which indicates an effective collaboration.

Reviewer 2

The reviewer noted strong partnerships with North Carolina State University, and New York Power Authority.

Reviewer 3

The reviewer remarked that the team was comprised of the necessary organizations for the proper design, development, evaluation, and demonstration of the technology at the 1 MW scale.

Reviewer 4

The reviewer said although the team members seemed to complete most of their stated tasks, when some difficulties were encountered by the lead team, there might have been opportunity for other partners to leverage supply chain or technical design resources to facilitate a more robust design option or to alleviate parts shortage issues.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed the project has ended. The team has clearly identified a list of the future work, which appear to be appropriate and well thought out.

Reviewer 2

The reviewer stated not applicable.

Reviewer 3

The reviewer mentioned the proposed future work includes the re-deployment of the system in fall 2024, but noted the project is listed as 100% complete and raised the question of how this re-deployment will be accomplished.

Reviewer 4

The reviewer noted continued testing with designed and fabricated componentry would yield valuable information to the community with regards to SST, AFE and solid-state protection. The plan was not well described for fall 2024 redeployment, and with funding spent, it may be difficult for the team to follow through with future research plans.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the overall DOE objectives, in the aspect of transportation electrification. The proposed XFC system particularly supports the aspects of smaller system footprint and higher efficiency at lower system-level cost.

Reviewer 2

The reviewer noted the project supports VTO program goals for ELT.

Reviewer 3

The reviewer observed the reduction of the number of conversion stages from the grid distribution feeder to the EV charging infrastructure directly supports DOE objectives for improving efficiency and potentially improving costs.

Reviewer 4

The reviewer pointed out that technologies that advance the state of the art for high power charging deployments are all relevant as DOE looks to gain knowledge with industry as to the capabilities and flexibility of designs intended to expand the adoption of EVs. Examples of high-power chargers connected to MV utility lines offer advantages in deployment time, cost and efficiency.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources for the project are sufficient, and the project has completed by meeting all the objectives and addressing the barriers.

Reviewer 2

The reviewer noted overall resource commitment to the project was sufficient when initially funded. Circumstances changed during the program (many programs were affected) due to Covid-19 and supply chain issues, which impacted the program deliverables.

Reviewer 3

The reviewer mentioned resources are sufficient given the power level and size of the technology development and demonstration (approximately 1 MW). However, the field demonstration was not successfully accomplished in the project.

Reviewer 4

The reviewer noted the inability of the team to complete the project was impacted by funding levels, but it was not the primary reason for the incomplete results. The focus now would be whether the redeployment has the opportunity to be field tested and how those results are reported.

Presentation Number: ELT262
Presentation Title: Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging
Principal Investigator: Ryan Reed, Kenworth

Presenter

Ryan Reed, Kenworth

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

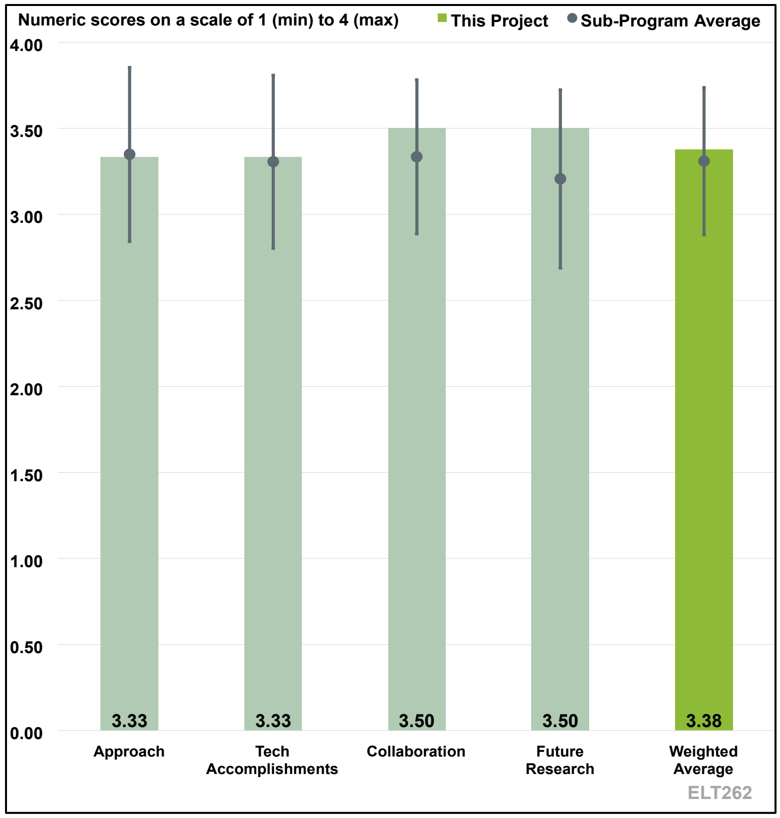

Figure 2-12. Presentation Number: ELT262 Presentation Title: Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging Principal Investigator: Ryan Reed, Kenworth

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the approach is excellent by starting with laboratory testing while designing the vehicle system for testing. The static is well defined, but the dynamic could use some definition as to the length of the primary coil for the road. The SAE J2954/2 standard identifies up to 500 kW power. The reviewer asked the question as to whether 1 MW is being proposed for the next update.

Reviewer 2

The reviewer praised the adjustments made by the project team, given this project is at 85% complete, like moving to an e-axle and moving to Utah instead of just plowing forward without regards to the outcomes for the project.

Reviewer 3

The reviewer praised the researchers for their thorough understanding of the many difficulties involved in carrying out their proposed plan and excellent team to address the challenges. However, the reviewer could not tell from the level of detail in the review document how the major issues are being attacked. For example, the truck needs a better, lighter battery, and it was not clear how this would be achieved.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer pointed out the equipment and laboratory effort show excellent planning, but also noted adding modeling of the efficiency, misalignment tolerance, and electromagnetic compatibility (EMC) levels should also be included. A comparison of using 500 kW energy transfer or other power levels to meet the goals should also be included. Size and weight of the secondary coil should be included in the presentation. Including polyphase is a proven means to reduce coil size and EMC and a good choice. There was no mention on how megawatt charging system (MCS) will be used for comparison to wireless power transfer (WPT). Is the MCS added to the United Transportation Union (UTU) site or used on the route?

Reviewer 2

The reviewer noted the team is finalizing the deliverables to complete the final testing to prove the project meets expectations 2 phase-shift operations, etc.

Reviewer 3

The reviewer observed all major issues are being addressed and most milestones have been met, but the remaining timeline seems to be overly optimistic. All of the major components have been designed, but there are key parts that have not been built yet, let alone installed. And there are still issues with actually getting stuff delivered. Permits are not in place, which could be a showstopper. The project started in 2019 and is supposed to end this calendar year, with a number of key milestones—installation, testing, operation—having been completed. The reviewer questioned how many milestones will be achieved. Perhaps the original schedule was unrealistic.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that updating the Utah State University site is a good means to leverage existing effort while updating the power level. The goal is targeted at demonstrating a known route with mature suppliers to meet project goals using static, dWPT along with the MCS option.

Reviewer 2

The reviewer noted there appeared to be good cross collaboration on the project in general and on specific decisions that were made that the PI shared. The reviewer would have liked to see more evidence supporting this. The reviewer would like to see in future AMRs more specifics about what the project achieved.

Reviewer 3

The reviewer commented that the team has excellent skills, and all of the key areas seem to be well covered. The reviewer reiterated that installing and testing the equipment in the truck is the best proof of potential outcome.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that combinations of primary and secondary coils could be useful (circular, double D and polyphase). Perhaps a mix of power levels between the primary and secondary coils and their efficiency results could also be useful.

Reviewer 2

The reviewer noted there remains a good bit of work to complete on this project, and planned efforts could overrun or not be completed given 15% of the overall budget is remaining.

Reviewer 3

The reviewer observed the goals are clear and appropriate but noted there is insufficient technical detail to judge whether the goals, in terms of charging speed and range, can be achieved from this work. The reviewer suspects the project may not meet its schedules.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer observed that higher power is identified for this class of delivery vehicles. The reviewer noted 200 kW was identified in the past as the optimal power level and a comparison to 1 MW results is needed along with effects of route distance and terrain variations.

Reviewer 2

The reviewer commented that full electrification of heavy-duty (HD) trucks is a key goal useful for achieving decarbonization of transportation. Key issues are sufficient range and charging speed, both of which are addressed by this project.

Reviewer 3

The reviewer did not complete their remark.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed this project has managed resources between labs, suppliers, vehicles and test sites to maintain the full spectrum of effort required.

Reviewer 2

The reviewer noted the resources seem sufficient but is concerned about the project finishing.

Reviewer 3

The reviewer stated it is difficult to answer this question without additional detail on the costs of individual components of the program. Some of the costly components have not yet been built.

Presentation Number: ELT264
Presentation Title: Demonstration of Utility Managed Smart Charging for Multiple Benefit Streams
Principal Investigator: Stephanie Leach, Exelon/Pepco Holdings Inc.

Presenter

Stephanie Leach, Exelon/Pepco Holdings Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

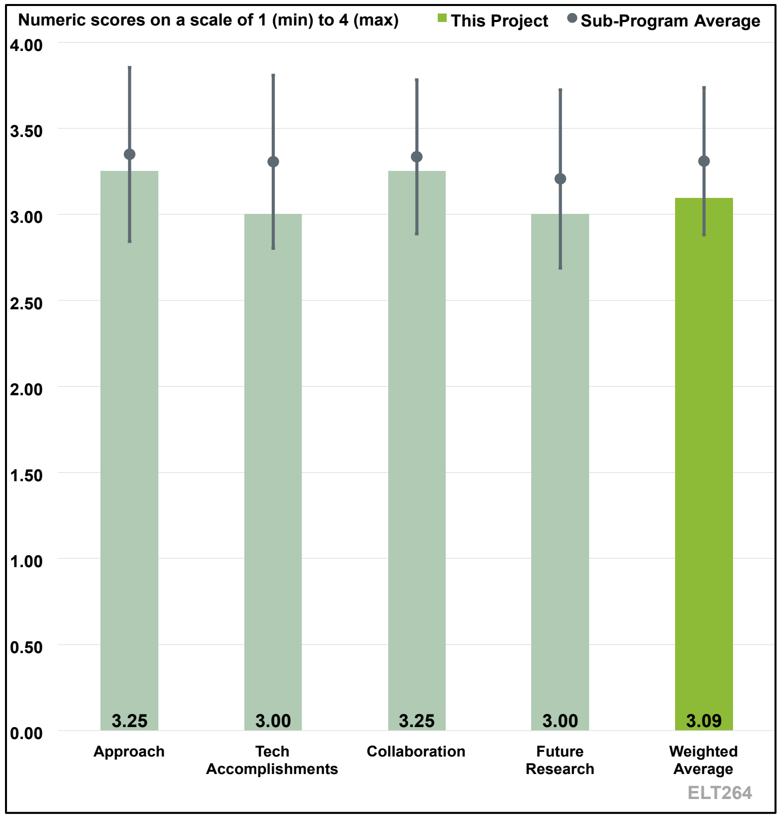

Figure 2-13. Presentation Number: ELT264 Presentation Title: Demonstration of Utility Managed Smart Charging for Multiple Benefit Streams Principal Investigator: Stephanie Leach, Exelon/Pepco Holdings Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted the barriers of smart charge management (SCM) across residential, commercial, and public charging infrastructure are addressed through collection of customer data and modeling/simulation.

Reviewer 2

The reviewer remarked that most vehicles already have time of day and time of departure charging. This system uses similar techniques to manage grid loads and cost. The reviewer added that if this system is dropping customers from the best charging rate times so that the overall load is balanced, the customers could opt out more and force charging if cost savings are better than the rebate.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted excellent technical accomplishments were demonstrated by the residential program. Numerous customers were enrolled, and operational data was collected on time-of-use (TOU), Pennsylvania-New Jersey-Maryland Interconnection, and distributed asset protection. Replacing the commercial program with a vehicle-to-home (V2H) program is appropriate. No accomplishment yet shown for V2H program as recruitment starts spring 2024.The presentation does not show accomplishments for the cyber-physical security (CPS) threat model, vulnerability assessment, and resilience matrices. Have the results and findings been published? (i.e., recommended best practices, findings or lessons learned, etc.). Was this work executed in previous years of the project (Budget Period [BP] 2 or BP 3), or is the cyber threat model development a future task?

Reviewer 2

The reviewer noted that while vehicle-to-gird (V2G) is not part of the project, promoting V2H will help getting to a more robust V2G solution.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the team is comprised of the necessary members to successfully complete the project goals.

Reviewer 2

The reviewer observed that all contributors are communicating and producing results as described by the presenter.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted the proposed future work of sharing the key outcomes from the cost benefit analysis is very important and beneficial. The addition of the V2H demonstration and operation is also appropriate for future work. The reviewer raised the questions of whether cybersecurity and CPS findings and best practices will be reported/published from the phases of the project (including residential, commercial, public, and newly added V2H residential). The reviewer noted the project was reviewed in 2023 but there are no responses to previous reviewer comments. [DOE Program Clarification: 2023 AMR comments were not available to PIs prior to the 2024 AMR.]

Reviewer 2

The reviewer noted the project is ending in 2024.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project scope directly supports VTO's mission to improve the cost and benefits of EV charging infrastructure.

Reviewer 2

The reviewer noted the project will help with decarbonization of energy use as it will provide more reliable grid to charge EVs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that resources are sufficient to complete the project goals.

Reviewer 2

The reviewer commented that the project is concluding in 2024.

Presentation Number: ELT265
Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale
Principal Investigator: Duncan Woodbury, Liberas

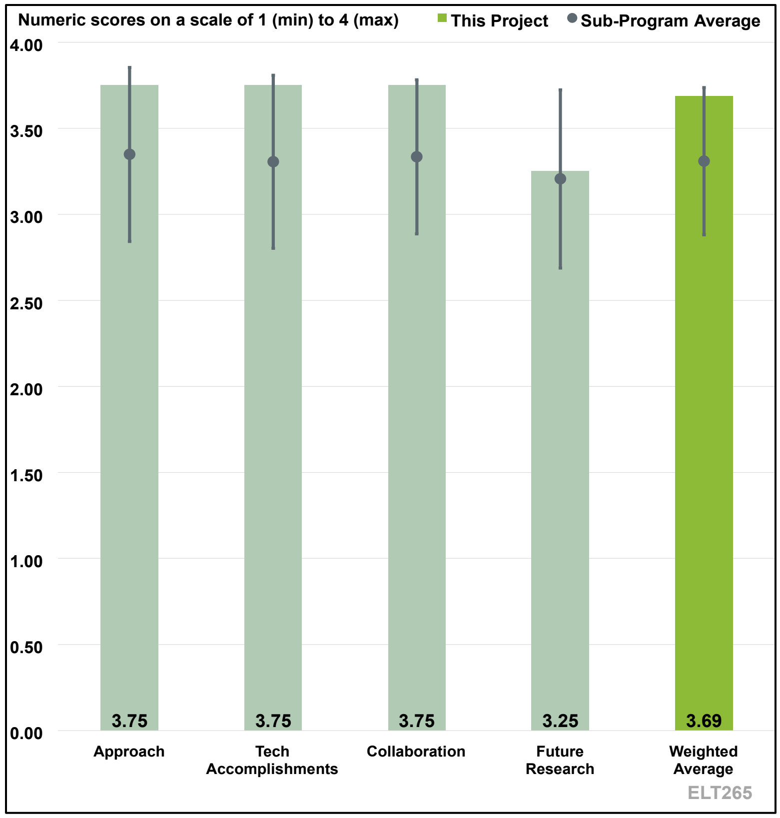

Figure 2-14. Presentation Number: ELT265 Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale Principal Investigator: Duncan Woodbury, Liberas

Presenter

Duncan Woodbury, Liberas

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the implementation of a flexible middleware layer relies on the OpenFMB standard. This approach is appropriate given the diverse mix of system interfaces and applications being integrated. The project is on track timewise.

Reviewer 2

The reviewer commented that the project has clearly identified objectives, including to research and develop "an open source SCM system based on existing open standards with secure interoperability solutions that provide a standardized, extensible, and scalable interface to interact with legacy, modern, and future energy operational technology (OT) assets." The reviewer noted the project has clearly identified key barriers, including the lack of a standard interface, non-interoperability, and non-standardization of control/communication interfaces. The technical approach is presented at a high-level through five primary steps. The reviewer also noted the project and timeline appear well planned over a five-year period, evolving from demonstration of the OpenFMB implementation, laboratory demonstration of project use cases, and demonstration of system achievement of project goals. The reviewer concluded that each phase culminates with a go/no-go milestone and the identified sub-activities appear logical and appropriate.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted the primary objective of the project to demonstrate SCM over a widely distributed network of devices was achieved. The project tasks for BP 1 and BP 2 were completed successfully and the current tasks appear to be on track.

Reviewer 2

The reviewer concluded this project achieved prolific technical progress and appears on track to achieve its objectives. Recent accomplishments include: (1) first ever implementation of a remote SCM interface for a dWPT system, demonstrating relevance to multiple market segments and key industry-transforming technologies; (2) fielding and demonstrating the SCM, interoperability, and cybersecurity capabilities in six technology readiness level (TRL) 6 sites under a wide variety of scenarios; (3) transitioning to two wide-scale demonstration partners (Newlab and Michigan Central) with configurations for demonstration of more than 50 ports in 2024, as well as formalization of a partnership agreement for further wide-scale demonstration. The reviewer concluded by saying this was an impressive list of accomplishments over the last year.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the relevant partners needed have been assembled for a demonstration of the technology (a utility, software developers, NREL, and ORNL).

Reviewer 2

The reviewer observed the project has a well-balanced and diverse project team, which includes a utility; two demonstration partners; three industry partners to support system integration, cybersecurity, and technology demonstration; and two laboratory partners for modelling, simulation, dWPT integration, and cyber testing. The reviewer noted sufficient collaboration across the spectrum of project requirements is demonstrated, with no notable deficiencies.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer mentioned that the next steps are appropriate to further the work already completed. There seems to be an issue with getting EV drivers to sign up for the demonstration.

Reviewer 2

The reviewer noted the remaining challenges and barriers are identified at a high level, with “Integration with utility protection control systems” and “Integration in live DSO/ISO market programs” particularly noteworthy. The reviewer remarked that Further details and discussion with respect to specific challenges of integration, regulatory aspects, and cybersecurity, and how they will be overcome, would have been beneficial. The reviewer also noted the balance of activities for Fiscal Year (FY) 2024-FY 2025 appear to be continuation of the SCM platform integration and widescale demonstration of 50 or more charge points (CP)/DER and additional grid services. The reviewer expressed the expectation the project will successfully achieve these ends but noted the identification/development of a critical path/roadmap is needed to further achieve commercial viability and widespread implementation of the EVs-at-RISC SCM platform.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted the project supports development of flexible EV charging infrastructure that can leverage widely distributed resources to achieve the desired charging demand.

Reviewer 2

The reviewer remarked that successful development and implementation of SCM is essential to enable widespread EV market penetration, relatively seamless vehicle grid integration (VGI), and minimize impacts to the grid. Furthermore, SCM is essential to enable broad vehicle-to-everything (V2X) application.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the budget appears adequate to complete the tasks described. The PI did not mention budgetary constraints in implementing the work.

Reviewer 2

The reviewer noted this project is sufficiently resourced to meet its current objectives and milestones. Significant value has been achieved from VTO’s investment in the EVs-at-RISC SCM platform. The reviewer also said additional resources should be considered for identification/development of the critical path/roadmap to overcome remaining technical and non-technical barriers to achieve widespread implementation.

Presentation Number: ELT274
Presentation Title: eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management
Principal Investigator: James Stoupis, ABB

Presenter

James Stoupis, ABB

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

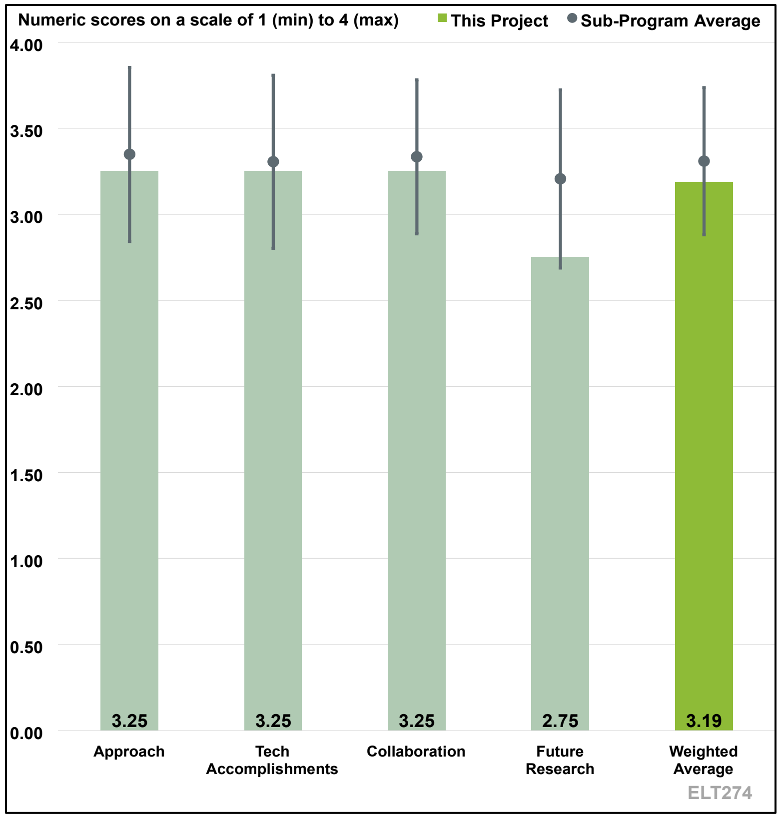

Figure 2-15. Presentation Number: ELT274 Presentation Title: eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management Principal Investigator: James Stoupis, ABB

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer mentioned this monitoring and behavior modification can help blend peak demand where capacity limits will affect the grid. Long dwell might become a customer dissatisfier and protecting against overstaying reservations might become issues that need addressed later on.

Reviewer 2

The reviewer commented the project has identified clear objectives, with the primary being to “develop a scalable, secure, and resilient eMosaic (local and cloud) platform to provide localized and bulk grid services and SCM (load or congestion management), load forecasting, and dynamic reservations.” The reviewer further noted the project outlines its approach in great detail including upfront through identification of multiple subtasks, as well as under approach within the discussion of the four use cases. The reviewer concluded the project and timeline appear well designed, focused upon the identified barriers, and on schedule.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the four potential use cases look well thought out and purposeful to the objective defined by “Grid Operators need more control to balance the load and avoid downtime.”

Reviewer 2

The reviewer observed that in the last year, the project has achieved a substantial number of accomplishments with regards to approach/methodology validation, and specific technological advances. This includes installation of 200 or more new communicating Level 2 (L2) charging ports at Rocky Mountain Power, Utah State University, and various public sites, it also includes development and use of a reinforcement learning (RL) agent to generate the price factor based on grid conditions and development of a local price-responsive algorithm to control L2 sessions. It includes deployment and demonstration of bus charge planning including charging rates at the station and discharge rates along the route and development of the solution architecture and demo/deployment planning for “fast demand response (DR)” and “slow DR / load limit setting” scenarios. The reviewer noted new features were added to the Reservations App, including limited booking access and restrictions, and visibility of reserved slots. The reviewer noted, regarding cybersecurity, the project conducted a representational state transfer (REST) application programming interface (API) test with Postman, confirming connections cannot be made without valid transport layer security certificates. The reviewer concluded, overall, the project achieved a strong list of accomplishments and adhered to the established timeline.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted all parties and researchers are developing material to achieve the stated goals. The deployment plan at Utah State University and the Utah Transit Authority appears to be complete and functional.

Reviewer 2

The reviewer observed the project has a strong, lean team with clearly defined roles and has identified internal/external communications and coordination mechanisms. Specific contributions are identified for each program participant. No notable areas are identified for more collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer agreed with the points on Slide 21 of gathering data to support development of the software functions/features. Adding charge ports will promote the use case participation needed for scalability studies.

Reviewer 2

The reviewer observed remaining challenges have been identified including: (1) maintaining embedded edge, server, and remote cloud infrastructure; (2) integrating, coordinating, and testing pilot sites, and (3) validating feasibility of development algorithms. Next steps have been identified including (1) gathering data, (2) finalizing and maintaining edge, server, and cloud infrastructure that has been commissioned, and (3) scaling up as necessary to effectively support the pilot charger installations. The reviewer stated, though, that a clear pathway has not been presented to successfully commercialize this approach/technology that leads to widescale implementation. Future research should include the identification of specific future challenges and steps to achieve this end, and, at a minimum, this would encompass system/technology cost targets, other business challenges, privacy and regulatory issues, and further cybersecurity implications.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that a reliable grid will assist the move to EVs, hence reducing CO_2 emissions from energy use.

Reviewer 2

The reviewer noted successful development and implementation of a robust, interoperable, and secure SCM and grid services system will promote greater EV market penetration, smoother VGI, and the reduction in grid impacts.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that all future objectives appear to be funded.

Reviewer 2

The reviewer concluded resources are sufficient to achieve currently identified objectives and milestones.

Presentation Number: ELT275
Presentation Title: Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management
Principal Investigator: Ayman El-Refaie, Marquette University

Presenter

Ayman El-Refaie, Marquette University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

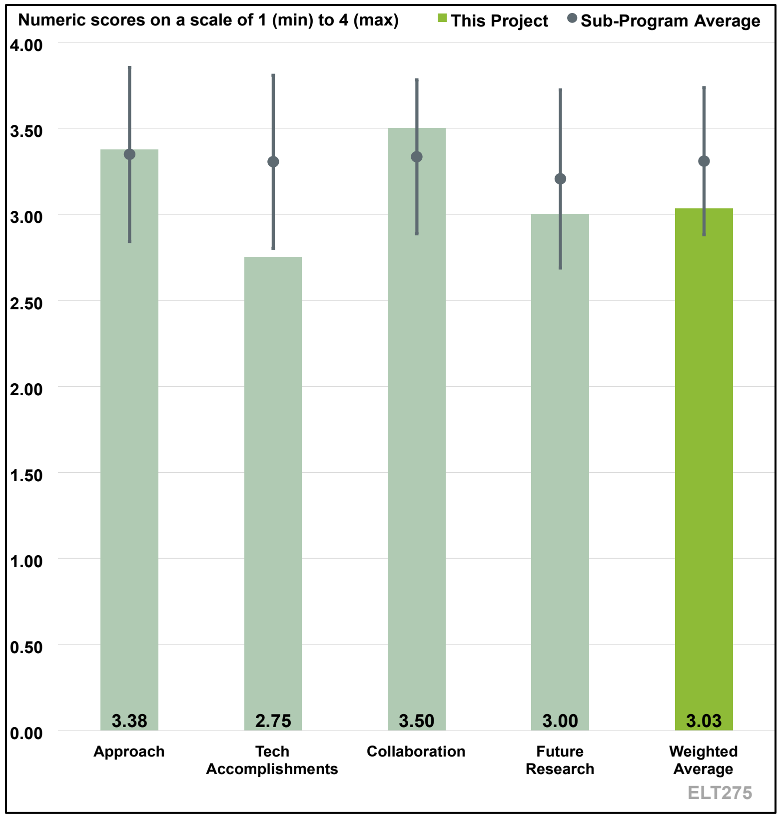

Figure 2-16. Presentation Number: ELT275 Presentation Title: Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management Principal Investigator: Ayman El-Refaie, Marquette University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed the program targets to deliver a non-RE motor with density greater than 12 KW/L. Technical barriers are adequately addressed and a wholesome approach is taken to resolve various assembly and component selection issues.

Reviewer 2

The reviewer remarked that the team creatively combine NdFeB and FeN magnets to mitigate the poor coercivity issue with the FeN magnets. Even saving only half of the NdFeB magnet in a motor will greatly reduce the criticality issue with the RE.

Reviewer 3

The reviewer commented that the project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer concluded the material presented lacks detail to justify how or why this approach will be able to meet the technical targets.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed technical progress has been achieved as per the original timeline.

Reviewer 2

The reviewer mentioned the project's technical progress is sufficient and appears on track with the project plan.

Reviewer 3

The reviewer noted the team is behind schedule due to the Covid-19 shutdown. The team did complete the trade-off study of various combination scenarios, but there is no report on the progress of FeN magnet development.

Reviewer 4

The reviewer observed significant budget has been consumed, yet the project has yet to make the BP 2 milestones. This seems to indicate that the aspirations of the project may be too much of a technical stretch to be accomplished.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted excellent coordination among various stakeholders has been maintained throughout.

Reviewer 2

The reviewer observed this is a large team, involving university, national lab, and industry. The PI did a good job getting everyone involved and coordinated.

Reviewer 3

The reviewer noted there is a diverse team that is well situated to provide strong technical advice.

Reviewer 4

The reviewer remarked there is a good mix and diversity of project team members. The team comprises university, national laboratory, and private industry researchers. The added that the private industry collaborators should be involved earlier in the process.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said simply, yes.

Reviewer 2

The reviewer noted 36 MGOe is an aggressive target. The reviewer added FeN nanoparticle alignment is likely to be affected during the consolidation process, so perhaps 24 MGOe is a more realistic goal in a year.

Reviewer 3

The reviewer acknowledged the project has proposed future work but did not find the researchers connected how the proposed work aligned directly with VTO objectives.

Reviewer 4

The reviewer observed that executing the proposed work will help achieve the targets; however, the reviewer questioned whether the team could sustain the work needed to accomplish the goals.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated the project is relevant to the ELT subprogram and support VTO objectives.

Reviewer 2

The reviewer highlighted that if FeN can reach 36 MGOe, it will be a game changer for the PM motor. This work directly supports VTO's ELT subprogram objectives.

Reviewer 3

Thew reviewer commented that developing low-cost magnets are important for next generation motors.

Reviewer 4

The reviewer noted this project absolutely will contribute to electrified vehicle propulsion.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer concluded this project is effectively resourced.

Reviewer 2

The reviewer observed, for a large team led by a university, the requested budget of $5 million federal dollars is sufficient.

Reviewer 3

The reviewer said the resources appear to be sufficient.

Reviewer 4

The reviewer noted the overall project resources defined for this project is sufficient, but based on the project progress, it is unclear whether the team has sufficient resources remaining.

Presentation Number: ELT282
Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)
Principal Investigator: Robert Keefover, BorgWarner

Presenter

Luca Di Carlo, BorgWarner

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

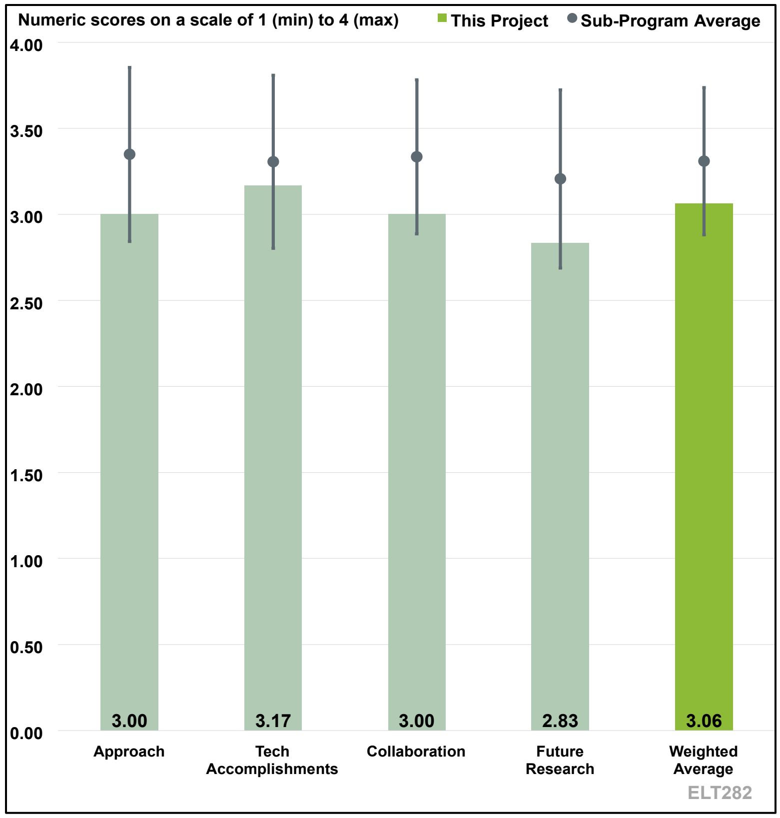

Figure 2-17. Presentation Number: ELT282 Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE) Principal Investigator: Robert Keefover, BorgWarner

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the project is sufficiently designed.

Reviewer 2

The reviewer commented that the project is focused on reducing costs and increasing the efficiency and reliability of higher-power direct current fast chargers (DCFCs). The approach focuses on developing 60 kW modules that can be configured together for over 150 kW units, particularly a 360 kW unit based upon six modules. The project plans to install the unit at a demonstration site as part of the validation process, though that installation is planned for almost at the end of the project, so there will not be much demonstration operation time examined.

Reviewer 3

The reviewer remarked the team has a solid plan for researching simplified architecture for DCFC, and results should lead to cost reduction and possibly improved reliability of units. The team has a straightforward plan laying out requirements, engaging models of architectures under study and simulated hardware evaluation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project team has completed design, validation plan, component readiness review, and system control plan. Most if not all milestones appear on schedule, though the design has changed a bit, adding some issues. The 60 kW design fits in a housing typically used for 30 kW units. Cooling was a particular area of investigation—the project team has developed an innovative top side cooling system. It appears the modulation system will allow increased efficiency, appearing to be in the area of 94% to 97%.

Reviewer 2

The reviewer remarked there were good technical accomplishments and progress on the timeline, though slightly behind schedule. The team has shown the ability to adapt from initial barriers and challenges and is progressing with the buildup of modules for higher power charge rates.

Reviewer 3

The reviewer remarked the project should have been done with the go/no-gos by the time of the AMR but it did not appear to be completed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the project has assembled a team that should allow for sufficient collaboration for project success. In particular, it is admirable that the team has included a construction firm and fleet to serve as the demonstration site. That is key for ensuring that the validation process can proceed in a useful manner. It is also interesting that the team has included the state as a partner, which could assist in future deployment.

Reviewer 2

The reviewer commented the project team appears a little deficient on theoretical support and suggested the team should include a national laboratory.

Reviewer 3

The reviewer observed the validation testing will go on beyond the current end of project, and questions if there would be a no cost extension. Once installations are done, that is when the full collaboration process will be able to be fully evaluated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that there was not a lot of discussion on the future proposed work.

Reviewer 2

The reviewer noted the project team identified the key remaining challenges as optimizing the complex control technique, completing final packaging (which is both power and component dense), and defining the final cooling system. These are significant issues to address.

Reviewer 3

The reviewer observed the plan to continue testing after installation will produce data that will need analysis and possibly partner assistance. The first hardware builds look good, but only when the fully assembled system is installed and tested in the field will the team be able to evaluate designs, including the cooling system. The ability of the partners to produce variations in source power will help with the evaluations of upstream transformer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project supports VTO objectives.

Reviewer 2

The reviewer commented that the project is focused on improving charging technology, targeting high-power units. Greater deployment of EVs will require improved charging technology, particularly for public and fleet DCFCs.

Reviewer 3

The reviewer noted the project is very relevant based on the projections for continued increase in EV adoption and electric vehicle supply equipment (EVSE) network build up.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented there appears to be sufficient resources.

Reviewer 2

The reviewer noted no indication was made that the resources are not sufficient.

Reviewer 3

The reviewer mentioned that, though sufficient, it would be advantageous after successful initial deployments to have another set of hardware be produced for deployment in a hotter climate.

Presentation Number: ELT283
Presentation Title: A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint
Principal Investigator: Bogdan Borowy, Eaton

Presenter

Bogdan Borowy, Eaton

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

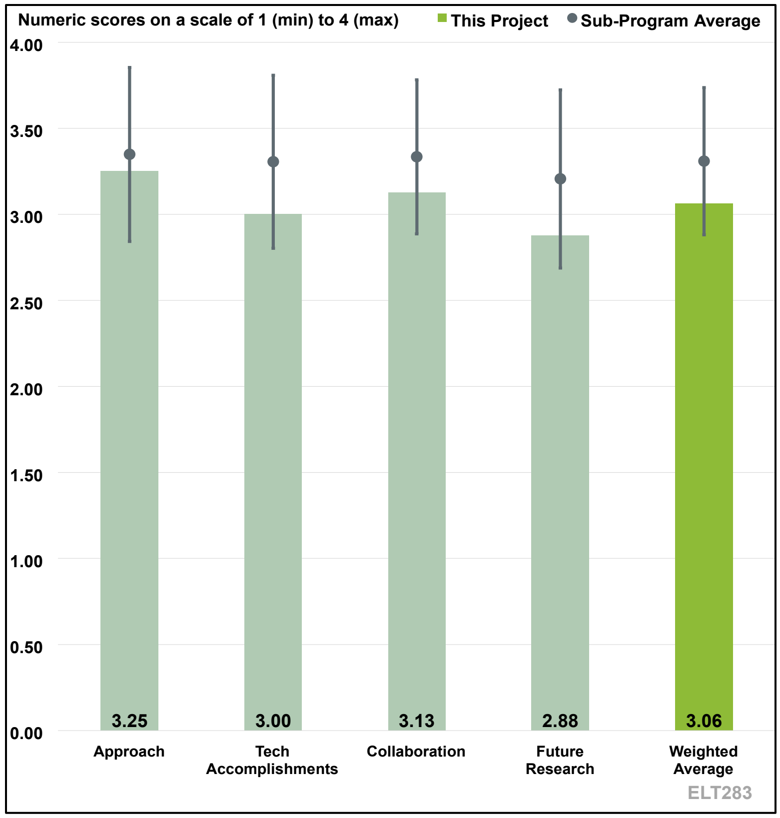

Figure 2-18. Presentation Number: ELT283 Presentation Title: A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint Principal Investigator: Bogdan Borowy, Eaton

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the proposed solid-state technology enabled, integrated, modular charging system, appear to be a good approach to address the barriers of the footprint of EV DC charging infrastructure and the interoperability and grid connection compliance of the MWC infrastructure.

Reviewer 2

The reviewer remarked that the project is executing against technical barriers. The work is on track to meet the target of lowering cost for key components and packaging.

Reviewer 3

Thew reviewer commented that appropriate barriers are addressed by this project, including the cost of medium voltage connected components and reducing the footprint of the charging infrastructure.

Reviewer 4

The reviewer remarked this project has great architecture and encompasses many aspects of the high-power charging system as components of the overall MWC environment. If successful, the project will yield paths to quicken installations at medium voltage connections to further enable the grid to support commercial vehicle electrification.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project is almost on track. Some subsystems have been completed, such as the transformer, AFE, and dual-active bridge (DAB) stage. However, these components have yet been integrated for analysis and testing.

Reviewer 2

The reviewer concluded technical objectives are being met within magnetics, power electronics, battery charger, thermal, utility interface, and packaging.

Reviewer 3

The reviewer noted several design, modeling, and development accomplishments are detailed from numerous partners for packaging, thermal management, medium voltage interface, AFE, magnetics, and power electronics.

Reviewer 4

The reviewer mentioned there was good progress in many of the technical areas and design phases, but the hardware seems to be trailing some of the program timelines. As the project end date is just over a year out, the hardware phases need to progress without any issues to meet deployment and test cycles. If the deployments are met, there may still be the issue of proper variation in environmental conditions to ensure the field demonstration is adequately stressed with temperature ranges at various load states.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the team members are from industry, national laboratories and universities, and each team has carried out different tasks of the project, which indicates and effective collaboration.

Reviewer 2

The reviewer observed roles and tasks for program partners have been clearly defined.

Reviewer 3

The reviewer noted the team is comprised of good partners for the technical development of the SST system. For demonstration/pilot, planning for technology transfer, and utility requirements/standards for EV charging infrastructure connection to medium voltage consider including an electric utility partner as well as a charge service provider.

Reviewer 4

The reviewer commented, with site and other integration processes selections and definitions complete, the hardware success and testing of the integrated cooling system remain the project critical elements. Further, the identification of the lack of SST to utility standards and other barriers provide guidance for other future research and preparations areas.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the team has clearly identified a list of the remaining tasks and barriers, which appear to be appropriate yet challenging.

Reviewer 2

The reviewer said no comment.

Reviewer 3

The reviewer raised the question of whether future work will include a pilot or demonstration of this technology. Many accomplishments have been demonstrated through modeling and design of systems and subsystems used for this SST medium voltage charging infrastructure. A demonstration will highlight the full system capabilities and evaluate/validate the improved efficiency and smaller footprint benefits. No information was provided about BP 3 goals or tasks (i.e., Sept. 2024 – Aug. 2025). BP 3 appears to be a majority (around 70%) of the funding since the BP 1 and BP 2 funds total around $1.2 million, which is about 30% of the total DOE funding of $4.4 million. The reviewer noted there were no prior year reviewer comments. [DOE Program Clarification: 2023 AMR comments were not available to PIs prior to the 2024 AMR.]

Reviewer 4

The reviewer noted the project leads have identified a number of proposed research areas, and these are within the capability areas of the project team. These areas will need validated hardware to ensure the future research areas can be tested thoroughly. The long lead parts supply issues may need a plan “B” to get systems installed in time for full testing to take place.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports the overall DOE objectives in the aspect of transportation electrification.

Reviewer 2

The reviewer concluded the project addresses VTO’s ELT subprogram goals.

Reviewer 3

The reviewer stated this project supports the improvements of EV charging infrastructure by focusing on improved efficiency and reduced footprint for medium voltage charging infrastructure.

Reviewer 4

The reviewer observed that, if successful, the project will enable quicker deployment of high-power chargers. The technology and processes being investigated will benefit the industry with a more flexible response to vehicle charging needs and allow for some of the quality control previously done on the installation site to be done in the factory prior to shipment to the site. The advancements in magnetics and bridge technology will enable medium voltage connections, which will help bring lower cost multiport EVSE deployments to the national network.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources for the project are sufficient.

Reviewer 2

The reviewer said resources are sufficient to achieve milestones.

Reviewer 3

The reviewer said resources are sufficient for the four partners of the projects to accomplish the project goals in BP 1 and BP 2.

Reviewer 4

The reviewer noted the resources are sufficient for this project, but the timeline for long lead parts will remain the critical item for project completion.

Presentation Number: ELT285
Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3)
Principal Investigator: Maarten Meijer, PACCAR

Presenter

Maarten Meijer, PACCAR

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

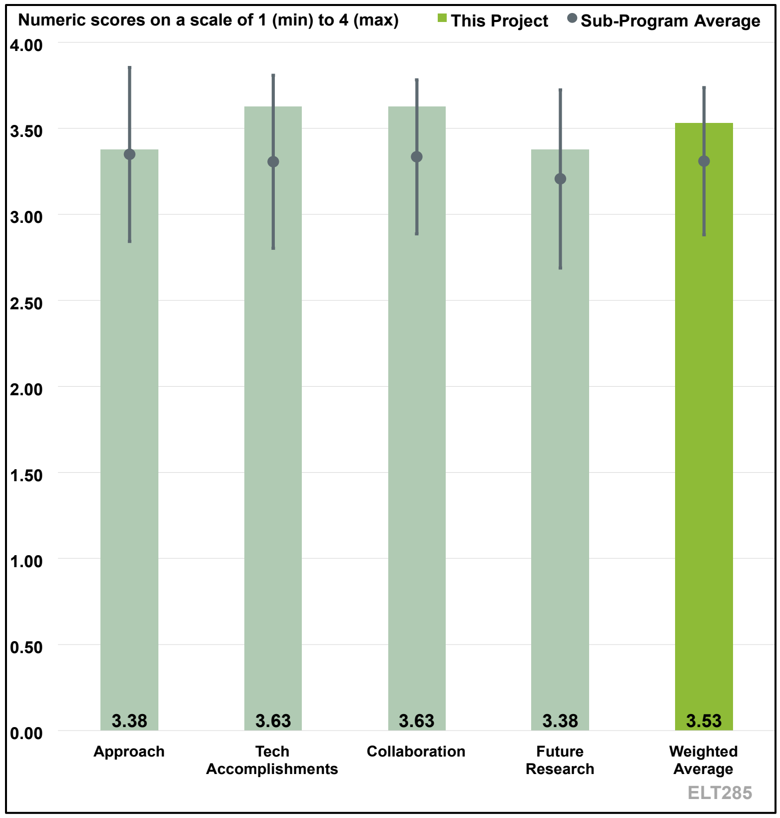

Figure 2-19. Presentation Number: ELT285 Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3) Principal Investigator: Maarten Meijer, PACCAR

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project directly addresses technical barriers to deployment of long-haul Class-8 electric tractor-trailers such as high electric powertrain cost, low vehicle range, and the lack of charging infrastructure. The reviewer noted that the project is designed to achieve the objectives of a 75% or greater fleet-level CO2 reduction versus diesel and a 30% or greater total cost of ownership (TCO) versus current production Class 8 EVs by developing generation (Gen) 2+ and Gen3 vehicles, designing and installing megawatt charging facilities, and data acquisition and analysis to document vehicle and charging system performance. The reviewer indicated that the project is at the 40% completion point on a five-year timeline which appears to be sufficient to complete all activities.

Reviewer 2

The reviewer stated that in this BP the focus of the project was on deploying Gen 2 battery electric vehicles (BEVs), defining the components of Gen 2+ and Gen 3 BEVs, working on L2 advanced driver assistance systems (ADAS) and Fleet Connectivity Design, and the definition of the fuel cell electric vehicle (FCEV). The reviewer noted that the PACCAR nomenclature was difficult to follow and suggested reconsidering the Gen 2+ name.

Reviewer 3

The reviewer commented that PACCAR's SuperTruck 3 development approach, based on iterative and revolutionary improvements to the Class 8 long haul tractor, appears logical and well thought out. The reviewer mentioned that the PACCAR team will be able to see the gains made by the zero emission vehicle (ZEV) battery electric technology over different alternative solutions by assessing various levels of improvements, and that PACCAR's understanding of grid limitations has led the team to develop an off-grid 1.6MW recharging solution for these vehicles at the PACCAR Technical Center.

The reviewer affirmed the eTruck challenge as an excellent approach for engaging with college students, and expects similar results to EcoCAR and SAE-sponsored college vehicle activities.

The reviewer observed that PACCAR's enhancements to the eMotor align with the target specifications of the higher power SuperTruck 3 vehicle, and that novel solutions like steer-by-wire and new design for an air compressor are being integrated as part of the SuperTruck 3 design but cautioned that the proposed solution appears to be ignoring aerodynamic and possible tire improvements needed for the SuperTruck 3 vehicle.

Reviewer 4

The reviewer noted that it is a huge project with many iterations of electric trucks needing tracking and a significant number of analyses, and expressed concern that the team is overextending itself and will later on not be able to deliver to the plans.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer acknowledged an impressive project with a very discerning partner in Knight Swift and noted that a lot of decisions will be made with big goals. The reviewer affirmed that the accomplishments to date are solid and indicated that the reviewer is really rooting for this project to deliver answers to many BEV questions, including how to deliver sleepers.

Reviewer 2

The reviewer noted that progress on all technical activities is on track including 10 fast chargers installed at the Knight transportation micro-grid with battery energy storage and solar charging array nearing completion, and design work underway for 2026 deployment of MCS high-power charging at the PACCAR Technical Center. The reviewer commented that the Gen2+ BEV scope definition features increased range and charging rate and a 30% TCO reduction with vehicle retrofit starting in the third quarter of 2024 and that the Gen3 BEV concept definition is complete, and featuring an integrated 1 MWh battery pack, 1000V architecture, high-efficiency e-axles, and optimized accessories.

Reviewer 3

The reviewer noted that the progress seems appropriate as BEV connectivity is on-vehicle for proof of concept, vehicle-to-vehicle (V2V) perception data collection is underway, and there is work on vehicle architecture integration.

Reviewer 4

The reviewer commented that the project is well balanced with technical achievements, modeling and outreach, along with baseline trucks on the road collecting data. The reviewer remarked that the microgrid 1.6 KW charging solution is an excellent solution to alleviate grid charging challenges, and that modeling fuel cells as part of the solution will provide critical data needed to make powertrain decisions. The reviewer noted that other impact areas for electric drive vehicles such as thermal management strategy, battery and fuel cell storage, hydrogen for fuel cells, eAxle drive solutions, and eAuxiliaries, are being addressed in a well-balanced approach, and mentioned that improvements in aerodynamics and tire design should be considered when the SuperTruck 3 design is finalized.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer affirmed the strong, well-integrated project team given the PACCAR umbrella and identified partners.

Reviewer 2

The reviewer noted that PACCAR Tech Center is the project leader with vehicle design, integration, and testing responsibilities. Schneider Electric is the microgrid and charging infrastructure lead. LG Energy Solution provides the high-energy density batteries. Cummins Accelera provides the e-axle systems. Argonne is the analysis lead, determining greenhouse gas (GHG) and TCO reductions. Knight Swift is the fleet partner, operating the vehicles in regular service. University collaborations include OSU (ADAS, V2X), University of North Texas (V2V), and University of Washington (e-Truck Challenge).

Reviewer 3

The reviewer stated that the PACCAR team composed of the PACCAR original equipment manufacturers (OEMs) Peterbilt and Kenworth, Schnider Electric, Knight Transportation and Swift Transportation, LG, Accelera, Argonne National Laboratory, OSU, University of North Texas and University of Washington are strong partners with discrete responsibilities. The only suggestion to enhance this team would be the addition of a tire manufacturer since these trucks will have significantly different weight and torque profiles than conventional trucks.

Reviewer 4

The reviewer acknowledged that collaborators were named but was confused on what the deliverables are from each.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that this project appears to be addressing all required areas needed for the development of a successful SuperTruck 3. Data collection is occurring on several iterations of vehicles, fleet testing and feedback is occurring, modeling is underway regarding alternative drivetrain configuration, battery system and charging system design is nearly complete, and eAuxiliaries are being assessed and integrated into the final design. However, the addition of a tire impact assessment and the addition of a tire manufacturer to the team would strengthen the final SuperTruck 3 design.

Reviewer 2

The reviewer stated that specific areas proposed for future continued development include battery performance and life, connectivity deployment, and MCS/high-power charging deployment.

Achieving Gen 3 BEV targets is high risk and therefore appropriate for government-industry co-funding, but additional R&D to achieve TCO reduction beyond these targets will be necessary to reach cost parity with existing diesel powertrains in long-haul applications.

Reviewer 3

The reviewer remarked that the proposed work is in line with project objectives, but significant challenges remain in battery performance and life, connectivity deployment, high voltage architecture, and high-power charging.

Reviewer 4

The reviewer observed that a lot of future work is planned and expressed concern about enough resources and budget to do them all well.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project is extremely relevant to program, VTO, EERE, and DOE objectives.

Reviewer 2

The reviewer remarked that the project is highly relevant to DOE goals and supports overall VTO subprogram objectives. ZEVs are the focus of the program and developing a ZEV Class 8 long haul tractor proof of concept fits well within the office's portfolio.

Reviewer 3

The reviewer indicated that the project is incredibly relevant and one of the most important projects DOE is funding right now. There is a strong need for 400+ miles on a single charge without huge weight and cost issues.

Reviewer 4

The reviewer said that the project supports VTO subprogram objectives in Analysis, Batteries, Electrification, EEMS, and Materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that project resources are sufficient to achieve the stated milestones to meet the program schedule. Generation 2+ and 3 BEVs are under development, the charging microgrid is being installed, and the analysis activities are underway.

Reviewer 2

The reviewer stated that resources seem sufficient at this point.

Reviewer 3

The reviewer indicated that resources allocated to this project appear to be sufficient to bring it to completion but expressed uncertainty whether the redesign of a microgrid solution for the 1.6 MW charging station was covered under the original proposed budget. If the redesign was covered, kudos to PACCAR for pivoting quickly and developing a flexible solution within the original budget.

Reviewer 4

The reviewer commented that it was difficult to tell if resources are sufficient for the project given what was presented.

Presentation Number: ELT286
Presentation Title: A Zero Emission Freight Future (SuperTruck 3)
Principal Investigator: Eric Bond, Volvo

Presenter

Vivek Sunjan, Volvo

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

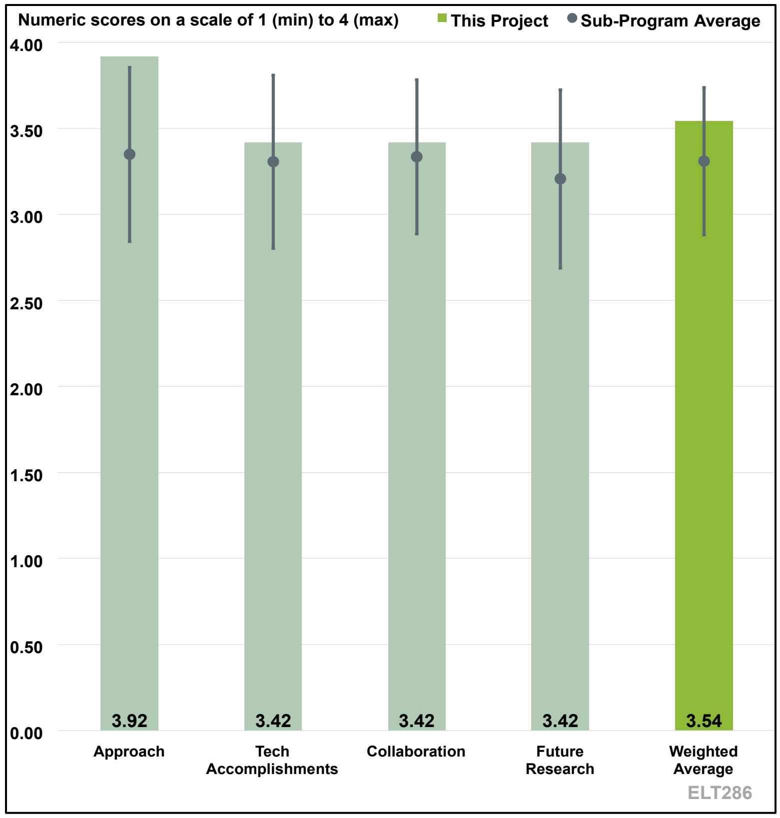

Figure 2-20. Presentation Number: ELT286 Presentation Title: A Zero Emission Freight Future (SuperTruck 3) Principal Investigator: Eric Bond, Volvo

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the SuperTruck 3 program continues to have some of the most impressive projects in the VTO stable, with some of the most incredible results. This project is no exception. The approach to achieving a 400 mile Class 8 BEV vehicle is comprehensive and builds upon the learnings from Super Trucks 1 and 2. The project planned demonstration requires the balance of 3 challenging areas with further improvements in efficiency, payload, and energy storage.

Reviewer 2

The reviewer noted that the timeline is reasonably planned, if also ambitious, for completion over 4 years. Tradeoffs are numerous among component packaging, durability, axle configurations and axle loads, rolling resistance, thermal management, aero, steel vs. aluminum castings, range, etc. End user practicality, serviceability, charging, and generalized costs are also vital considerations.

Reviewer 3

The reviewer noted that the heavy emphasis on the coupling between battery weight and the tire design is well justified. The team’s approach is comprehensive.

Reviewer 4

The reviewer commented that the team is taking the requirements incredibly seriously and benefits from having delivered Super Truck (ST)1 and ST2 projects. Many tradeoffs around weight, cost, range, charge time, etc., are needed and will be interesting to follow. The reviewer like to see the use of waterfall charts for these projects.

Reviewer 5

The reviewer stated that the project directly addresses the technical barriers to deployment of long-haul Class-8 electric tractor-trailers. These barriers are high electric powertrain cost, low vehicle range, and the lack of high-power charging infrastructure. The project objectives are to develop and demonstrate a Class 8 BEV capable of 400 miles with a representative payload correlated to a defined freight corridor and urban area freight models and to demonstrate a 75% or greater fleet-level CO2 reduction versus diesel with an improvement in TCO. The project is at the 25% completion point on a four-year timeline that appears to be sufficient to complete all activities.

Reviewer 6

The reviewer stated that the work builds on SuperTruck 1 and 2 which was based on fuel efficiency. The baseline of SuperTruck 2 vehicle is an excellent starting point for a zero-emission solution. The BEV SuperTruck 3 and MCS address the 2 main barriers of the long-haul Class 8 electric truck solution: range and refueling time. Also, by using an existing Volvo shipping route, it allows a direct comparison to existing commercial operations and eliminates the risk of finding a committed fleet partner. Active drive axle balance and tire selection will be critical to obtaining maximum traction and minimum rolling resistance. Modeling the impact of a Fuel Cell powertrain system could show that a hybrid system is the better option. The work done on Freight Origin-Destination Synthesis (FODS) is not needed to be part of this project; other modeling such as alternate drive train configurations should be prioritized over FODS modeling. Also, the approach does not appear to include the eMotor when assessing the impact of the other vehicle parameters. The Volvo SuperTruck 3 eMotor performance parameters have not been determined (or shared because the eMotor parameters may be considered intellectual property by the project team).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that progress on all technical activities is on track as summarized in the project Gantt chart shown on Slide 4. The chassis has been designed with 15% greater crashworthiness to protect the battery pack. A 20% lower rolling resistance is the target for drive and trailer tires. Battery pack requirements have been set and several cell form factors and chemistries are being evaluated. Analysis of the ST2 and production VNL cabs has been conducted with low drag optimization with an EV powertrain. Freight modeling is underway with a benchmark vehicle to enable future determination of effects of zero-emission trucks on the I-81 corridor.

Reviewer 2

The reviewer stated that simulation and analysis work leading to comparisons with real-world I-81 corridor freight flows will be very helpful for baseline/modeling/outcome comparison and assessing technical progress.

Reviewer 3

The reviewer noted that there is a lot to do, but the PI presented it well and with completeness and transparency. It becomes obvious when a project cannot share items given intellectual property situations like the detailed chemistry of the battery decision making. There will be some critical decisions to be made in the next six months to keep this project on track.

Reviewer 4

The reviewer commented on excellent progress on the weight management, battery technology downselect, and aerodynamics, but expressed confusion about the milestones shown on Slide 4 that indicate “Fuel Cell Model Developed” and “Fuel Cell Model Available” as part of the freight modeling. Also, the FODS part of the freight modeling was not explained very clearly, so it is not clear how it contributes to the project’s objectives.

Reviewer 5

The reviewer remarked that significant technical progress has been made. The energy storage system (ESS) investigation has established the structure of a solution that could meet the objectives. Battery cell types (form/chemistry), energy/power density/capacity, charging performance, cycle life and cost are parameters that need to be optimized for this application. Other areas that are being addressed include thermal management strategy, aerodynamics, and drivetrain/axle balance. The reviewer believes that the FODS modeling has little value to this project.

Reviewer 6

The reviewer noted phenomenal progress across multiple technical areas—chassis assembly, tire development, freight modeling, and thermal management. Work is ongoing on aerodynamics and energy storage. There are difficult trade-offs in balancing range/vehicle weight, payload capacity, and cost for a HD long haul truck. There are significant barriers to be overcome in energy density versus total weight (which has impact on payload capacity) and costs that will be difficult to make progress on.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that Volvo is the project lead, performing simulations, system development, complete vehicle integration, testing and demonstration. ORNL is conducting vehicle and traffic modeling and simulation, scenario analysis, and TCO characterization. Rensselaer Polytechnic Institute is responsible for freight analysis and modeling of activity in the I-81 corridor and metro area. Michelin is the tire technology developer and manufacturer. Science, technology, engineering, and mathematics (STEM) related outreach is through Bluefield State and Pennsylvania State Universities. The fleet partner providing operational input and feedback to goals and deliverables has not yet been identified.

Reviewer 2

The reviewer stated that the scope of SuperTruck 3 demands strong collaboration among national laboratory, university, supplier and user partners. Depending on the fleet user identified, there could be charging supplier/partner coordination opportunities in the future.

Reviewer 3

The reviewer commented that Volvo Group North America has a good list of partners for collaboration: Michelin Tire, ORNL, Rensselaer Polytechnic Institute, Pennsylvania State University, and Bluefield State University. However, the team is significantly into the project and does not have a fleet partner identified. To alleviate this risk, an alternative approach has been employed by the project team by selecting an internal Volvo I-81 shipping route that matched the parameters needed to assess the SuperTruck 3 concept vehicle.

Reviewer 4

The reviewer mentioned that collaborators are named but would like to see more definition of what each is doing.

Reviewer 5

The reviewer noted that the collaborations appear to be a mixed bag as there are some very strong partnerships in this project, for example with partners such as ORNL, Rensselaer Polytechnic Institute, and Michelin and then there are weaker collaborations (Bluefield State, Pennsylvania State University) that are listed as “STEM-related outreach” with no details given.

Reviewer 6

The reviewer wondered what exactly the STEM university outreach is doing that is related to this project. Fleet partner / customer is an important touch point, so need to identify them very soon.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that Volvo will continue development of the ESS to increase energy density and overall system performance. Thermal management system simulations will continue to maximize efficiency and reduce heat loss. The impact of replacing the under-cab crossmember will be evaluated due to space availability in the frame. The team will continue to develop and calibrate detailed vehicle models for baseline and BEV trucks, developing micro-traffic simulation for I-81 corridor, and employing Real-Sim and Real-Twin capabilities to conduct high fidelity vehicle and micro-traffic co-simulation. This provides insight into the most promising use cases, defines the urban area base case and scenarios to be analyzed by the battery management system (BMS), and enables simulations of various ZEV systems and complete vehicle solutions for both BEV and FCEV vehicles. Volvo will initiate construction of charging site and place orders for long lead-time items.

Reviewer 2

The reviewer stated that both modeling/simulation and vehicle development are areas for future work potential. Continued simulation toward higher fidelity for broader virtual environments and expanding into wider operational domains, such as urban areas, will likely bring resultant innovations closer to deployment.

Reviewer 3

The reviewer noted that future activities to address the remaining challenges and barriers are clearly defined, including leveraging the modeling work that will accelerate the SuperTruck 3 vehicle design. Assuming the information surrounding the eMotor is proprietary and cannot be shared, the project team should determine if the infrastructure is sufficient for the MCSs. If it is not, the project team should engage with utilities or charging system provider to determine if any near-term potential solutions are possible.

Reviewer 4

The reviewer remarked that planned next steps in the project could have been clearer in the presentation. The needed steps are understood but more clarity would be helpful.

Reviewer 5

The reviewer remarked that there are significant barriers to be overcome in energy density versus total weight (which has impact on payload capacity) and costs that will be difficult to make progress on.

Reviewer 6

The reviewer questioned FCEV freight modeling as part of the future work plan, and requested an explanation about how it is relevant to this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer indicated that the project is incredibly relevant in that 400+ miles on a single charge without huge weight and cost issues is needed. It is one of the most important projects DOE is funding right now.

Reviewer 2

The reviewer said that yes, this project covers the objectives of multiple programs in VTO such as batteries, electrification, and EEMS.

Reviewer 3

The reviewer noted that the project is relevant to VTO priorities. The Class 8 long haul tractor segment is the most difficult to electrify. This project will provide the information VTO needs to determine if a battery electric class 8 long haul tractor is feasible.

Reviewer 4

The reviewer stated that the project clearly supports program, VTO, EERE, and DOE objectives.

Reviewer 5

The reviewer stated that the project broadly supports VTO objectives for heavy truck decarbonization. Modeling and simulation can contribute to Analysis area. Materials, Batteries and Electrification also benefit from this project.

Reviewer 6

The reviewer commented that the project supports VTO subprogram objectives in Analysis, Batteries, Electrification, EEMS, and Materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that project resources are sufficient to achieve the stated milestones to meet the program schedule. The program is in the second phase. The requirements to support concept decisions have been documented, and the design of the complete vehicle demonstrator is progressing, while simulation and analysis activities will continue into FY 2025. All technical milestones have been achieved, as well as the go/no-go preliminary design milestone. An investigation led the team in a new direction for the cab to be used on the demonstrator, and progress has been made regarding the energy storage and thermal management systems. Freight modeling activities involving university and national laboratory partners is underway, and the charge site is fullyapproved with construction ready to begin.

Reviewer 2
The reviewer commented that resources appear to be sufficient at this point.

Reviewer 3
The reviewer noted that funds are significant ($18 million in DOE funds + matching cost share). The project is still early, so will be able to better assess as the project matures.

Reviewer 4
The reviewer stated that funding appears sufficient; however, the project team should consider adjusting the modeling effort from FODS simulation and focus more on the alternative (Fuel Cell) powertrain configuration.

Reviewer 5
The reviewer stated that the project is ambitious, but funding is sufficient to achieve stated milestones, with some give and take anticipated as challenges are encountered. There is also ample future work of interest to VTO identified by the project team.

Reviewer 6
The reviewer commented that assessing resources is difficult. .

Presentation Number: ELT287
Presentation Title: Cummins High Power Density Inverter
Principal Investigator: Santhosh Krishnamoorthi, Cummins

Presenter

Santhosh Krishnamoorthi, Cummins

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

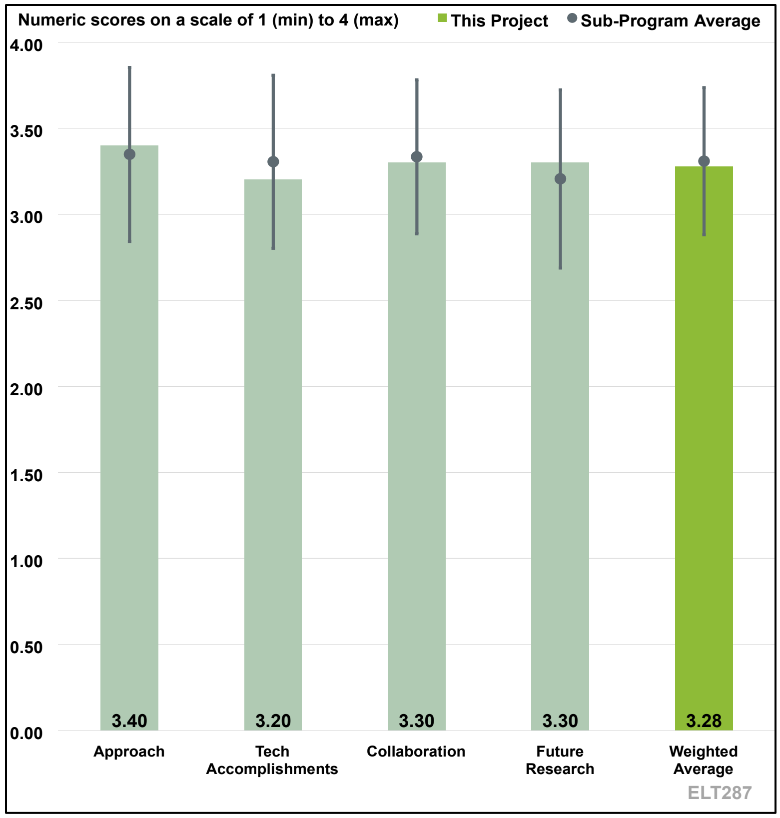

Figure 2-21. Presentation Number: ELT287 Presentation Title: Cummins High Power Density Inverter Principal Investigator: Santhosh Krishnamoorthi, Cummins

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project is well designed and the timeline reasonable.

Reviewer 2

The reviewer stated that the objective of the project is to develop and demonstrate a high-power density traction inverter for commercial vehicles to meet or exceed DOE's 2025 targets. The Cummins design goals are Peak Power ≥ 300 kW (which exceeds DOE 100 kW), Power Density ≥ 100 kW/L, Volume 100 kW/L, Operating DC Voltage ≥ 1000V (which exceeds DOE ≥ 650 V), Lifetime ≥ 750,000 miles (which exceeds DOE ≥ 30,000 miles) and Cost ≤ 2.7 $/kW. The project is designed to achieve power density using a suitable topology with tight packaging and an integrated gate driver and current sensors. DC bus voltage of 1000V is achieved with 1.7 kV SiC devices and high voltage capacitors. The project is at the 40% completion point with a June 2025 completion date that may have to be extended six months to complete all activities, due to initial component supply delays.

Reviewer 3

The reviewer noted that the project is focused on barriers that are key to seeing significant inroads of electrification in the medium-duty (MD) and HD space. This is accomplished by understanding the drive cycles and addressing component configurations that allow a value-driven electrified system to be produced.

Reviewer 4

The reviewer remarked that the project's approach and technical progress indicates that activities are closely tied to overcoming barriers as the inverter is targeted for needs in commercial on-road HD vehicles. Application-specific requirements need customized components for the WBG inverter. The customized components for the Cummins inverter include a double-sided cooled SiC power module, a high energy density capacitor where the element fits in a customized package, and heat sink and electromagnetic interference (EMI) filter. The power module needs more careful considerations for thermal design.

Reviewer 5

The reviewer stated that the project addresses the technical barriers of high-power inverters. This project is well designed. However, it seems that the team spent too much time in initial system design such that the time scheduled for components fabrication and system integration may not be enough.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the power module design was complete and initial fabrication completed identifying build issues/learnings. The gate drive fabrication and testing were completed successfully. Initial bus bar design was completed and then Iterated. Heat sink design and fabrication, and manufacturing learnings have occurred. Capacitor selection and inverter packaging have occurred. EMI filter design options and their testing has occurred. Control board design and software have been completed. The analysis, fabrication of parts along with component level testing has identified some issues that are being addressed early. All in all, solid progress.

Reviewer 2

The reviewer noted that the project has made necessary progress and that technical accomplishments include gate drive and control board development.

Reviewer 3

The reviewer commented that the power module design was completed, and fabrication process was started. Die metallization, silver sintering/soldering with Mb posts, kelvin pins and terminals were completed but impurities were found on the surface of the dies metallized using a sputtering process requiring the use of pre-metallized dies from another supplier. The first version of the gate drive board design along with the power supply was completed and successfully tested. The bus bar design was changed to combat effects of high temperature on components and higher cost of using multiple heavy copper layers. Fabrication and assembly of heat sinks and power modules on either side of the bus bar board revealed crushed heat sink fins, an interference issue which still must be mitigated.

Reviewer 4

The reviewer remarked that technical progress for the project is good.

Reviewer 5

The reviewer commented that good progress has been made in heat sink fabrication, but it seems that the team has not made progress in the fabrication of key components such as the control board and film capacitor.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the Cummins led project has drawn team members from Virginia Tech, ORNL, and NREL. These entities are contributing in successful execution of project tasks.

Reviewer 2

The reviewer commented that Cummins is the project lead, developing requirements, designing the control board, developing software, building the inverter package, leading motor testing, developing cost models, and creating the final report. Virginia Tech is leading topology selection, determining the inverter system architecture, developing the power module, gate driver, sensors, fabricating and demonstrating the power stage, and developing lifetime models. ORNL is developing and testing capacitors, heat sinks, and EMI filters. NREL is developing thermal models and the cooling system, evaluating, refining, and verifying models, and supporting packaging development.

Reviewer 3

The reviewer acknowledged that the collaboration with partners appears sufficient.

Reviewer 4

The reviewer stated that the project is led by Cummins with the support from Virginia Tech, ORNL and NREL. ORNL has made significant contribution in heat sink development. The role of NREL in this project is to support the development of simulation model and model validation. After reviewing progress, it seems that the team should seek collaborators in high power electronics. The roles assigned to ORNL may be beyond its capability in this area.

Reviewer 5

The reviewer remarked that collaboration is excellent, but the reviewer would like to see Cummins leading the topology selection process instead of Virginia Tech. The reviewer believes this is a missed opportunity to better ground the design from a pragmatic standpoint.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the project plan is solid, and the next steps are clear.

Reviewer 2

The reviewer stated that future research includes improvement in SiC power module, control board build, and inverter's packaging. In FY 2025, the project team plans to test/verify the inverter with a 300 kW motor in addition to developing market plans and TCO analysis.

Reviewer 3

The reviewer stated that future project milestones are well defined, and it appears that future work will achieve targets. The FY 2024 milestones are: demonstrate bus bar prototype with distributed capacitor, demonstrate power module, demonstrate1 kV inverter phase-leg prototype with 99%

efficiency, complete optimized capacitor board and heat sink to achieve power density target, complete standalone 300 kW inverter tests, complete inverter tests with a 300 kW motor and complete technology to market plan and TCO analysis. In FY 2025, the tasks are: complete control board hardware build, complete integration of inverter components and prototype packaging and go/no-go 2, complete component validations and demonstration of 3 L inverter prototype package integration, and finally, complete WBG device lifetime assessment under full-operational mission profile for 750,000 miles.

Reviewer 4

The reviewer noted that the proposed future work appears to be on track to achieve its targets.

Reviewer 5

The reviewer commented that the future work proposed is well aligned with the purpose of this project. The team will achieve its target but may need longer time in system fabrication and demonstration than planned.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is relevant to electrification and supports VTO’s objective in transportation electrification. The proposed work is excellent.

Reviewer 2

The reviewer commented that the project is critical in understanding the application of MD and HD drive cycles on inverter design.

Reviewer 3

The reviewer noted that the project supports VTO subprogram objectives in analysis, electrification, and materials.

Reviewer 4

The reviewer commented that the project supports VTO’s objectives.

Reviewer 5

The reviewer remarked that one of the topics in the funding opportunity announcement (FOA) was power-dense inverter, the project activities are closely tied to the FOA objective, and the Cummins inverter is being developed for on-road HD vehicles, which has relevance with Cummins products.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project is staffed enough and has necessary financial resources. Supported by the Virginia Tech, ORNL and NREL teams, the Cummins project team has necessary resources to successfully execute this project.

Reviewer 2

The reviewer stated that project resources are sufficient to achieve the stated milestones and to meet the program schedule.

Reviewer 3

The reviewer noted that resources appear to be sufficient for this project. Progress is what the reviewer would expect, and the fundamental issues are being addressed.

Reviewer 4

The reviewer remarked that the resources appear to be sufficient to meet the milestones.

Reviewer 5

The reviewer stated that it seems that this team has enough funding and knowledge, but less expertise in know-how, and resources in component fabrication and system integration. This team may need another team member in the power electronic area. The difficulty and challenge in key components fabrication may be beyond the capability of Cummins and ORNL. ORNL is an excellent partner in providing technical support, but it may be difficult for ORNL to complete the fabrication of the capacitor and related components with cost and time in consideration. Such a concern is supported by the delay in component fabrication and system integration. The support from a partner with recourses in component fabrication other than buying components from a vendor will help this team.

Presentation Number: ELT288
Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter
Principal Investigator: Harsha Nanjundaswamy, BorgWarner

Presenter

Harsha Nanjundaswamy, BorgWarner

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

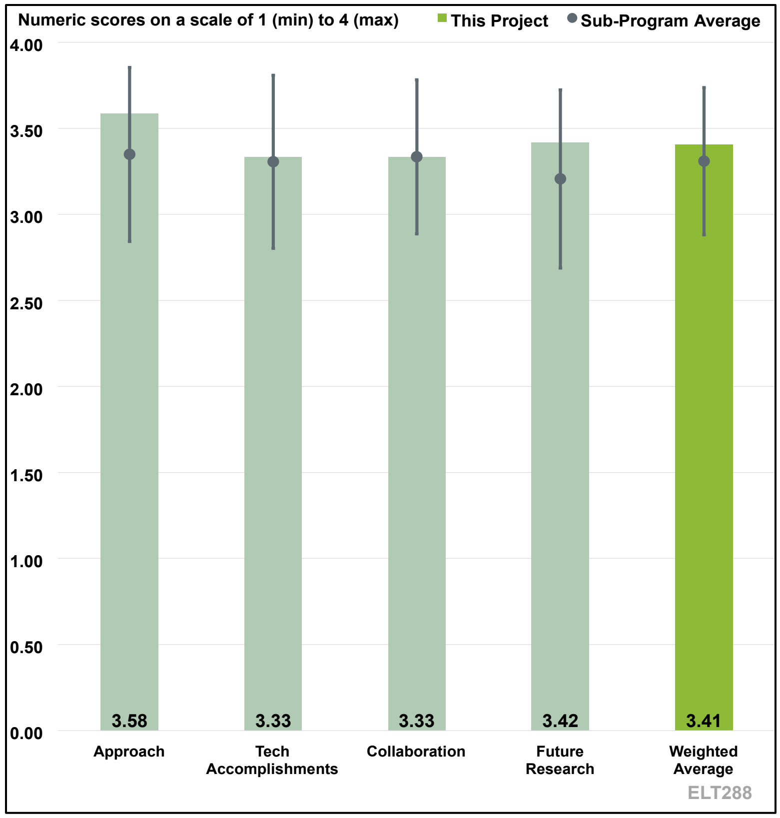

Figure 2-22. Presentation Number: ELT288 Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter Principal Investigator: Harsha Nanjundaswamy, BorgWarner

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the objective of this project is to develop and build a traction inverter with a new power module design in conjunction with a novel thermal solution and high temperature capacitor technology as well as new control architecture. This design will meet DOE’s 2025 targets of power density ≥ 100 kW/L, operating voltage ≥ 800VDC (exceeds 650VDC DOE target) and $2.7/kW cost. The project is at the 66% completion point on a three-year timeline that appears to be sufficient to complete all activities by December 2024.

Reviewer 2

The reviewer stated that the technical thrust is right on with the addition of increasing flexibility of the design to accept different manufacturer die which is an often-overlooked aspect of these types of projects. BorgWarner is systematically attacking all the elements of the inverter design.

Reviewer 3

The reviewer noted that the team leverages BorgWarner’s unique power module technology to develop a traction inverter that meets the DOE VTO’s aggressive 2025 cost and power density targets.

Reviewer 4

The reviewer commented that the technical barriers were addressed. The project is well designed with a reasonable timeline.

Reviewer 5

The reviewer stated that the project work is tailored to meet a $2.7/kW cost target and 100kW/L power-density target; these metrics are included in 2025 DOE-VTO targets for power inverters. The project approach includes necessary activities for developing the power module, cooling of this module, and the high temperature capacitor. Micro and application-specific integrated circuit (ASIC)-based compute devices will be used to control system and for product safety (automotive safety integrity level D [ASIL-D]). SiC power module will use up to 8 die bare-die in package and form to deploy an exotic heatsink. Epoxy molding is used for fabrication and environment treatment of the SiC power module. The reviewer requested that the project team address the issue of coolant leaks and asked what the approach would be to make sure coolant flow is sealed from high voltage power electronics.

Reviewer 6

The reviewer commented that the project develops an inverter for EVs, which is a key component. The project is to some extent well designed and the timeline is reasonably planned. However, the effort has focused on system structure and less information is available about the cooling load requirement and its potential removing the heat generated, although the researcher may have presented the information last year. The reviewer expressed surprise with the large budget in BP 1 and BP 2 compared to the work completed in this project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted excellent progress with the hardware construction.

Reviewer 2

The reviewer commented that progress on all technical activities is on track as summarized in the project milestone chart shown on Slide 4. The power module employs a single switch architecture with a patented topology to handle various sized SiC bare dies from separate manufacturers on the same pad layout without alteration of the core structure and the manufacturing process. The cooling module incorporates a patented fin design and a phase-change film with 40% lower pressure drop, 3.3% lower SiC die junction temperature, and 11° lower temperature deviation among the six power switches. The controller engineering sample has been released and features a single printed circuit board (PCB) assembly with micro controller, gate driver circuits, and two INSSAs.

Reviewer 3

The reviewer stated that the project has made necessary and appropriate progress.

Reviewer 4

The reviewer stated that progress is in line with what would be expected. Design, analysis, and fabrication of parts indicate a well-run project. The only thing that would be of concern is thermal stack up of the power module to the heat sink. Have any issues been identified in the parts that have been assembled?

Reviewer 5

The reviewer stated that technical progress appears to be behind to the project plan.

Reviewer 6

The reviewer commented that the project has been delayed for 4 months, and it not 100% sure that this team has completed the component fabrication and system integration and has the target inverter ready in April 2024. There seems no data supporting the delivery of test results of the current heat sink. The data shown in Slide 9 is simulation results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that BorgWarner has a complete and well-integrated team given the timely results they have achieved.

Reviewer 2

The reviewer noted great collaboration with university, labs, and vendors.

Reviewer 3

The reviewer commented that collaborative team members are drawn from PolyCharge, NREL, and Virginia Tech. It seems like collaborators are contributing in execution of relevant tasks in their functional area.

Reviewer 4

The reviewer commented that there appears to be good collaboration between project partners.

Reviewer 5

The reviewer stated that BorgWarner is the project lead responsible for design, fabrication, integration and testing of the inverter system. PolyCharge America developed and built the NanoLam block specification for 800VDC system, conducted thermal simulation/analyses and electronic system level (ESL) simulation and value extraction for the bulk capacitor assembly. NREL performed heat sink modeling and design as well as clamp plate design and analysis. NREL also ran the power cycle test to evaluate the power switch and cooling module. Virginia Tech ran the Saber model of a simplified SiC MOSFET die that enabled switch level analysis.

Reviewer 6

The reviewer noted that NREL is one of the two active partners in this budget period. However, it is not clear if NREL has completed the thermal resistance measurement and performed shear stress test for thermal interface material (TIM). The pressure distribution data of the clamp plate is not available in the presentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that all the critical steps necessary for proving the technology works are identified in future research.

Reviewer 2

The reviewer noted that the work proposed for future research is excellent and the main deliverable of this project. With current progress in consideration, this project may need a no-cost extension as components fabrication, system integration and demonstration may take much longer than expected.

Reviewer 3

The reviewer stated that the plan for the remaining work has been clearly defined.

Reviewer 4

The reviewer stated that specific areas proposed for future continued development are well-defined. These activities include build and test of the initial 350 kW Inverter prototype hardware on an inductive load test bench, validation of the components and/or subassemblies in life and environmental tests (electrical and mechanical) relevant to overall project goals, and, finally, demonstration of the final 350 kW inverter performance and efficiency under adequate electric traction drive system conditions on a power-hardware-in-the-loop (P-HIL) test bench.

Reviewer 5

The reviewer remarked that the 350 kW inverter will be built and its verification will be carried out followed by demonstration in an application such as a driving electric motor using the BorgWarner inverter.

Reviewer 6

The reviewer commented that the proposed future work appears to be on track to achieve its targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project addresses all specified criteria and will contribute to the overall success of electrification.

Reviewer 2

The reviewer commented that the project work is related to DOE-VTO 2025 targets for power electronics and it seems like BorgWarner activities and their inverter metrics are approaching to meet 2025 VTO targets.

Reviewer 3

The reviewer stated that yes, the project supports the overall VTO ELT objectives.

Reviewer 4

The reviewer noted that the project is relevant to electrification, and supports the overall subprogram objective in promoting transportation electrification.

Reviewer 5

The reviewer indicated that the project supports VTO’s objectives.

Reviewer 6

The reviewer commented that the project supports VTO subprogram objectives in electrification and materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the scope of work for the project is appropriate and progress is moving along as expected. This is well spent money!

Reviewer 2

The reviewer remarked that the project has necessary financial resources and facilities and collaborators are supporting execution of projects tasks and delivery of milestones.

Reviewer 3

The reviewer commented that the team has sufficient resources to complete the project.

Reviewer 4

The reviewer stated that resources appear to be sufficient to meet the milestones.

Reviewer 5

The reviewer stated that the project resources are sufficient to achieve the stated milestones to meet the program schedule. The project lead will build and test of the initial 350 kW inverter prototype hardware, validate the components against overall project goals, and perform a final demonstration of the 350 kW inverter performance and efficiency under electric traction drive system conditions.

Reviewer 6

The reviewer commented that the team has sufficient resources for this project to achieve the milestones on time. However, it should be noted that this project may need a no cost extension. Such a extension is not due to the lack of resources but the time and effort needed in system fabrication, integration and demonstration.

Presentation Number: ELT290
Presentation Title: Behind-the-Meter-Storage
Principal Investigator: Anthony Burrell, National Renewable Energy Laboratory

Presenter

John Kisacikoglu, National Renewable Energy Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

50% of reviewers felt that the project was relevant to current DOE objectives, 50% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 50% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

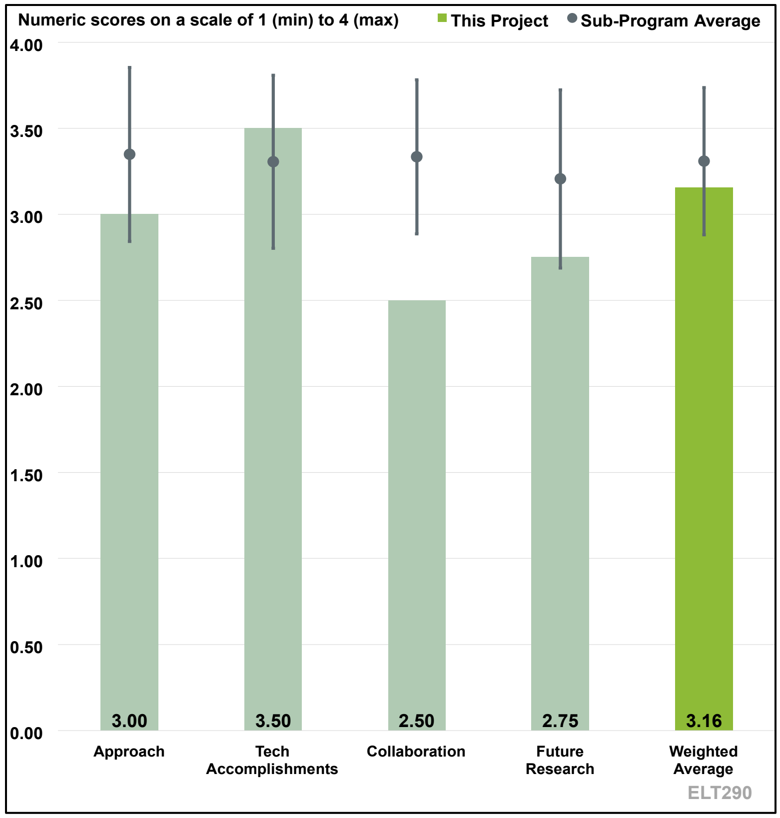

Figure 2-23. Presentation Number: ELT290 Presentation Title: Behind-the-Meter-Storage Principal Investigator: Anthony Burrell, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project directly addresses the cost, performance, and safety technical barriers to deployment of behind-the-meter energy storage (BTMS) to enable XFC of EVs and enable energy efficient grid interactive buildings to reduce vehicle charging costs. The project is at the 75% completion point on a five-year timeline that appears to be sufficient to complete all activities.

Reviewer 2

The reviewer remarked that two critical issues were not addressed by this study: whether electric utilities will legally authorize behind the electric meter storage because everything that is behind the meter (BTM) is in the legal domain and sovereignty of the electric utility, and whether there is a necessity for this work when the majority of EV users are commuters who can easily charge up their EVs at home after work hours during periods of non-peak electricity demand, do not require fast charging, and can afford the less than $3 per gallon equivalent charging cost. Only a minority of EV users will require fast charging during the daytime working hours; such EV users should pay the premium (i.e., more than $3 per gallon charging equivalent) for fast charging during periods of peak electricity demand.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that progress on all technical activities is on track as summarized in the project milestone chart shown on Slide 5. The battery rack design and battery management system for active safety measures have been completed. Selection of non-flammable electrolytes for the cell build is complete and new LTO cells are on test at Idaho National Laboratory (INL). Engineering of high energy cells for delivery to SNL for safety testing in 18650 format is on track. Thermal and electrical testing in a less than 1 KWh rack is underway for delivery to SNL for safety testing. Design specifications for the fourth quarter FY 2024 rack build are under development.

Reviewer 2

The reviewer stated that investigators were able to complete the design of a BMS for active safety; select non-flammable electrolytes for the battery cells; optimize cost, cycle life (more than 18,000 cycles) and safety for the battery materials by focusing on lithium titanium oxide (anode)/lithium manganese oxide (cathode) at high voltage; demonstrate feasibility of mixing cells of different cell chemistries, densities, power, energy as well as age; and obviate maximizing energy and power density.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that NREL is the project lead, integrating contributions of the other national laboratory partners into a BTMS system design for vehicle fast charging. SNL is conducting battery safety testing at the cell and rack level. INL is performing tests on the new LTO cells. Combined testing (SNL arc flash testing) and modeling (NREL multi-scale multi-domain [MSMD] models) is addressing trade-offs between fail-safe design and module energy density.

Reviewer 2

The reviewer noted that the project team failed to include representatives from electric power utilities and from utility industry groups, such as EPRI as well as from those with expertise in electric power distribution and building engineers.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that specific areas proposed for future continued development in the BMS include exploring the potential benefits of state of health estimation for cell balancing and rack safety, use of machine learning (ML)/artificial intelligence (AI) active life models for improved BMS performance, investigating the reliability and safety of the battery management system with active balancing to mitigate thermal runaway and other failure modes. Integration of gas and temperature sensing and additional active/passive safety features into the BMS is also being investigated. In battery development, energy versus safe thermal design and LMO/LTO chemistry cost reduction will be explored. Non-flammable electrolytes and improved cycle life for higher energy cells than LTO/LMO are being pursued. Cell testing to characterize the life and performance and model development of the NMC/LTO cells to be used for controls development/demonstration and failure testing will be conducted. Work with safety standard groups to help inform safety codes will also continue.

Reviewer 2

The reviewer referenced prior comments. The critical issues the reviewer raised definitely need to be answered before the reviewer, as program manager, would allow this work to proceed. Otherwise, the work is just purely academic.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports VTO subprogram objectives in analysis, batteries, electrification, and materials.

Reviewer 2

The reviewer referenced prior comments and stated that the project is not a high priority because of the issues identified.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project resources are sufficient to achieve the stated milestones to meet the program schedule. The national laboratory team members are on schedule with sufficient funding to complete the project.

Reviewer 2

The reviewer did not think that this research project requires $2.4 million to complete.

Presentation Number: ELT293
Presentation Title: Ruggedized Mobile Fast Charger for Off-Road Vehicles
Principal Investigator: Brij Singh, John Deere

Presenter

Brij Singh, John Deere

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

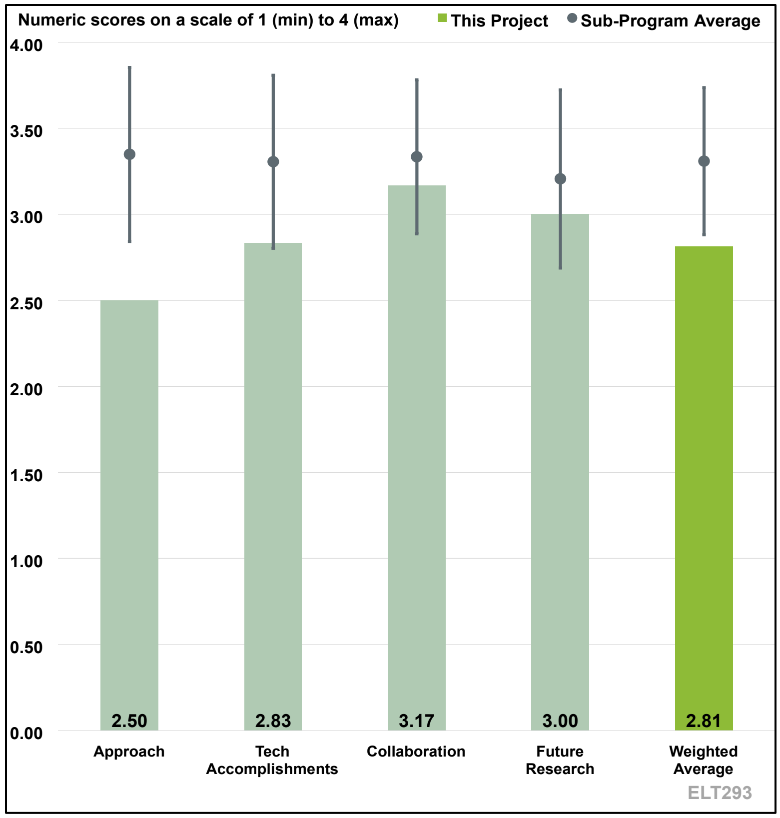

Figure 2-24. Presentation Number: ELT293 Presentation Title: Ruggedized Mobile Fast Charger for Off-Road Vehicles Principal Investigator: Brij Singh, John Deere

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the team strives to develop innovative approaches to address diverse needs for off-road vehicles by developing an early prototype using existing power electronics hardware and controllers, and testing/verifying the early prototype to collect field data on the system charging multiple vehicles. The team proposes to model and simulate to evolve design and performance data. The team will look to integrate technology innovations into the design. The will also demonstrate multiple bi-directional V2X applications. This approach does not focus on the apparent priority for this technology, ruggedized components for the mobile charger. Performance parameters are missing (Military Specification Standard [MIL SPEC], other) and should be identified to ensure ruggedized technology performance is achieved.

Reviewer 2

The reviewer noted that the project started recently, thus the basis for assessing how well the team is addressing technical barriers is limited. However, electrified off-road equipment/vehicles are comparatively new, and accessibility of grid power is much more variable in the non-road equipment/vehicle segments. The PI has outlined barriers it seeks to address. Portability, ruggedization, voltage ranges are mentioned. Ease of operation, operator knowledge and safety protections are related concerns.

Reviewer 3

The reviewer remarked that the approach is general and does not provide any specific area of work. It is anticipated that the team will figure it out what they will do after they do exploratory work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that project participants developed a mobile fast charger concept for farming and construction EVs. The team completed a loss and thermal analysis of 200 kW SiC inverter to demonstrate 600 kW capacity is possible and verified fractional power DC interface for V2V functionality in laboratory scale experimentation. It is early in the project; significant accomplishments are expected for the next review.

Reviewer 2

The reviewer commented that the project has just begun but the groundwork of identifying system requirements, modeling/simulating use scenarios, developing the concept demo for V2V charging, assembling likely off-the-shelf hardware needs and anticipating potential integrations of new hardware like an SiC inverter currently under development by Deere show progress for BP1.

Reviewer 3

The reviewer did not see the level of work expected for the project given the dollars spent. Yes, there are simulation results that look encouraging, but there is no experimentation with hardware. Battery cell work and concept prototype are positive, but it is unclear where is this going.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted a very diverse and well qualified team.

Reviewer 2

The reviewer stated that the project team collaboration will be more evident as the budget period advances and each task is achieved. Still, the team comprising a university and national laboratory with Deere is a sound collaborative start.

Reviewer 3

The reviewer commented that John Deere is the project lead, with ORNL and University of Texas at Austin supporting Deere with research. There was no mention of a cooperative research and development agreement (CRADA); the reviewer would like to see one established.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that hardware tests have been identified for next steps which are needed.

Reviewer 2

The reviewer stated that the focus should probably be adjusted to develop ruggedized charging components at a reduced cost. A power source to recharge this mobile charger appears to be an issue. Where is the power coming from to charge this mobile charger if electric grid power is not available or sufficient to recharge the mobile charger or the vehicles? What other type of recharging solutions should be considered? Other applications beyond farm equipment should also be investigated/considered. Additional markets for this technology in Department of Defense and non-military applications should be researched.

Reviewer 3

The reviewer remarked that supply chain challenges add risk for pushing project periods longer than anticipated, especially in this technology area where parts supplies can require long lead times, as noted by the PI. The future research proposed is relevant, ambitious and important.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports VTO, particularly in areas of Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA), Electrification, as well as Batteries subprograms to a certain extent.

Reviewer 2

The reviewer noted the need for John Deere to comply with: emission guidelines, Off-Road need for electrification technology, and ensuring productivity of equipment are all key elements.

Reviewer 3

The reviewer remarked that the project supports the overall VTO subprogram goals. However, other approaches to achieving a similar result may work better and at a lower cost.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that assumptions for future availability of hardware are valid but beyond control of the project team. More resources to the project would not likely impact these potential challenges. The scope of work planned seems appropriately funded and with the right partners.

Reviewer 2

The reviewer stated that adequate resources exist for this project based on the level of work being performed.

Reviewer 3

The reviewer commented that resources appear to be excessive for this project. This research is based on advancements in rugged mobile electronics. Mack Trucks has built a mobile off-grid charging system and there are other similar systems available. This technology is available today; research should focus on approaches to reduce the price of these systems.

Presentation Number: ELT294
Presentation Title: Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments
Principal Investigator: Leandro Della Flora, Beta Technologies

Presenter

Leandro Della Flora, Beta Technologies

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

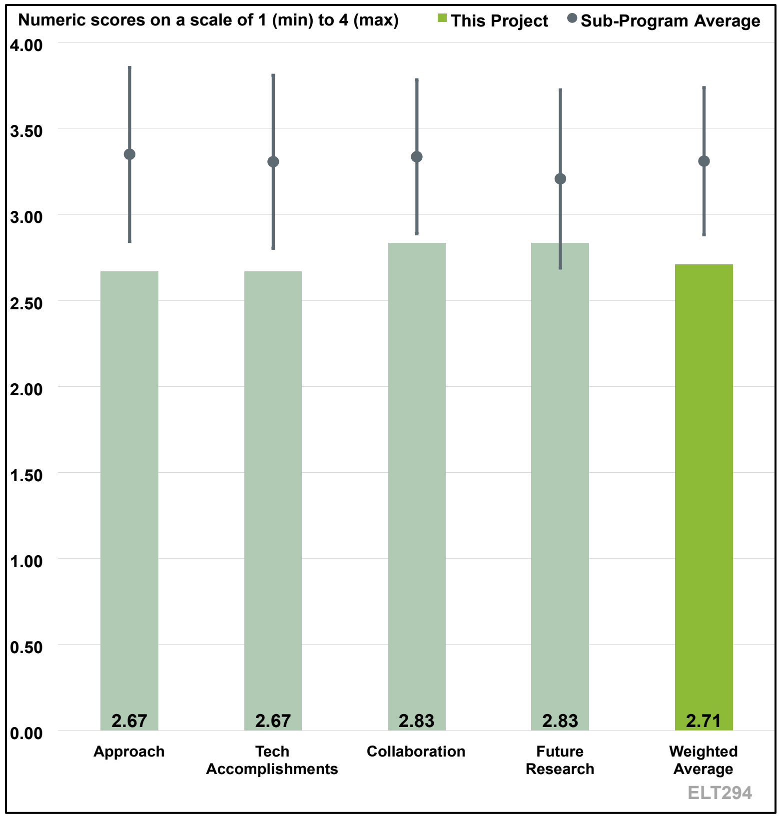

Figure 2-25. Presentation Number: ELT294 Presentation Title: Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments Principal Investigator: Leandro Della Flora, Beta Technologies

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the technical barriers are on track to be met.

Reviewer 2

The reviewer commented that the team proposed a non-road vehicle charging system, which is composed of a modular DC back bone charging architecture. It is not very clear how the proposed method can address some of the listed barriers, such as ease of use from cable management and grid communication and coordination of DER functions.

Reviewer 3

The reviewer remarked that the work is at a very early stage, and so it is very difficult to foresee what barriers the team might face. From the title of the presentation, the reviewer was thinking of vehicles like farm equipment, but the oral presentation seemed to have aircraft in mind. This difference in vehicle types would support the need for fast charge. The touch temperature goal seems more stringent than expected. Having reviewed the project using induction charging, which uses as a justification the cumbersome nature of charging cables, the reviewer wondered if just having them roll up is good enough for people charging off-road vehicles. Also, from the title, special requirements for “austere environments” were expected but none were mentioned and austere was not defined.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the project just started and appears to be on track to plan.

Reviewer 2

The reviewer stated that the project has just begun, and the team is scoping it out. They have a basic idea and now need to flesh it out to make it practical. They would do well to look at specific cases to include rather than being so generic “off-road.”

Reviewer 3

The reviewer commented that the project seems to be delayed. After more than ¼ of the project timeline has passed, the system requirements definition and power converter topology selection are the only tasks that have been started and are still ongoing as of the project review presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the team members are from national laboratories and industry, and each team has been assigned different tasks, which indicates an effective collaboration if the tasks are carried out as expected.

Reviewer 2

The reviewer commented that the laboratory partners are very strong but thinks the team could use actual users or manufacturers of off-road equipment.

Reviewer 3

The reviewer remarked that the project team is missing a strong contribution from a utility partner.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future work appears to be on track to achieve its targets.

Reviewer 2

The reviewer remarked that the basic plan is sound, but so little detail is provided that it is hard to judge the likelihood of success. The goal is fairly straightforward and logical, so no obvious pitfalls are foreseen.

Reviewer 3

The reviewer commented that the proposed future research seems to be aggressive considering the project timeline. While tasks in BP1 includes system definition, topology/component selection, and system simulation, in BP2, the tasks of sub-systems design, build and testing, and full-system assembly and demo seem to be very challenging to complete in a year.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports the overall DOE objectives, particularly in transportation electrification.

Reviewer 2

The reviewer stated that the project supports VTO's objectives.

Reviewer 3

The reviewer noted that the off-road sector is often overlooked in transportation studies, but it is very important. This sector has significant potential for electrification without reliance on the already over-stressed grid.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources for the project seem to be sufficient.

Reviewer 2

The reviewer noted that the resources appear to be sufficient to meet the milestones.

Reviewer 3

The reviewer stated that without more details, it is hard to address this question. The project budgeting should not have relied on development of anything totally new, but rather rely on already-commercial equipment put together in new ways, so would not be subject to large uncertainties.

Presentation Number: ELT295
Presentation Title: EVs@Scale VGI & SCM
Principal Investigator: Jesse Bennett, National Renewable Energy Laboratory

Presenter

Jesse Bennett, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

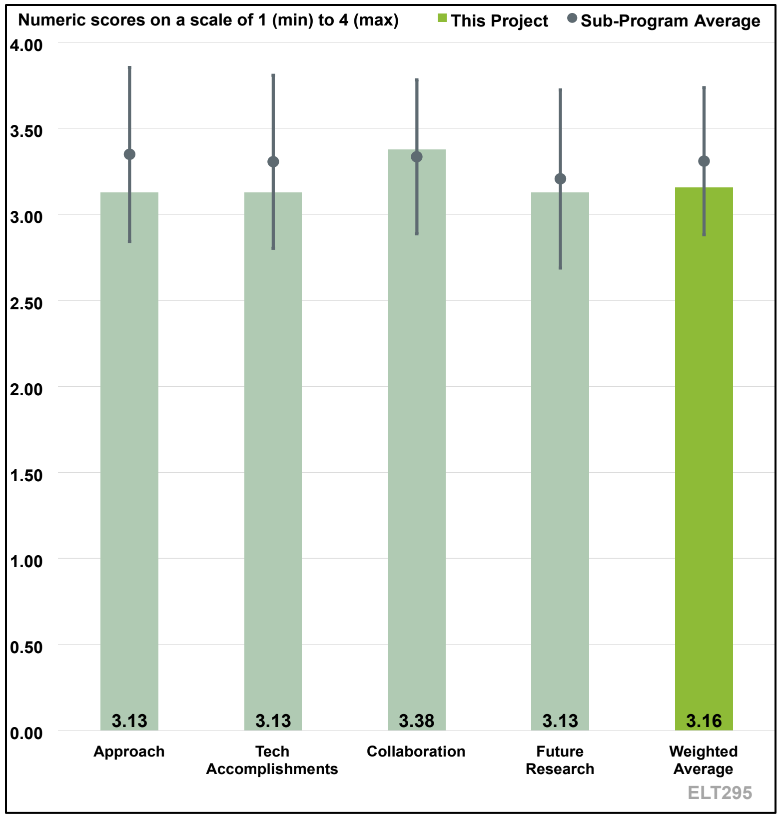

Figure 2-26. Presentation Number: ELT295 Presentation Title: EVs@Scale VGI & SCM Principal Investigator: Jesse Bennett, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that technical barriers are addressed well.

Reviewer 2

The reviewer noted an equally important focus planned on SCM/VGI analysis as well as laboratory demonstration.

Reviewer 3

The reviewer commented that the objective of the EVs@Scale Flexible Charging to Unify the Grid and Transportation Sectors (FUSE) project is to develop an adaptive ecosystem of SCM and VGI strategies and tools relevant to assess and reduce barriers to electrification throughout a wide geographic area and across numerous vocations. Outcomes include identifying limitations and gaps in existing SCM/VGI solutions and communicate the value potential in mitigating the grid impacts of EV charging to benefit the grid, EV drivers, and the public, and developing enabling technologies necessary to support a wide range of SCM/VGI solutions and demonstrating SCM/VGI approaches to identify the full ecosystems necessary to reduce grid impacts for light-duty (LD)/MD/HD EVs while accounting for operational and energy requirements.

The reviewer remarked that as it stands, the project is addressing a wide variety of barriers to the successful implementation of SCM. This includes SCM/VGI analysis activities including looking at uncontrolled charging grid impacts and the development and analysis of the effectiveness of various VGI and SCM strategies to mitigate grid impacts. Furthermore, the project is conducting SCM/VGI demonstration activities across a range of vehicles and vocations, and developing and testing the accuracy and efficacy of enabling technologies in the laboratory and with industry partners via field evaluations.

The reviewer stated that it is precisely the extremely broad and encompassing aspects of the FUSE project scope that the reviewer feels may be a liability to the overall success of the project. The potential value of SCM is undisputed, and the SCM/VGI space is complicated and will require efforts on many fronts (from multiple stakeholders) to successfully realize it benefits. Nonetheless, for FUSE, it important to focus on the areas that are most critical and appropriate for government to address and not try to cover too much of the SCM/VGI space. At this point, the reviewer believes the FUSE project would benefit from a strategic reassessment as to its best path moving forward. Specifically, this would include development of a plan with a clear critical path in consult with industry stakeholders and with the most pressing SCM/VGI challenges and potential solutions identified. Subsequently, consideration should be given to a significant narrowing of project focus, with adherence to the identified critical path, and emphasizing only the top showstoppers.

The reviewer noted that no timeline has been presented for specific FUSE projects.

Reviewer 4

The reviewer expressed concern that EV users do not want “long-dwell” and would prefer DCFC when in public. If long-dwell is a home-only solution does this become largely irrelevant? EVs owner currently tend to charge once every four days. If scheduling charging during the long dwell leaves the EV operator with less charge than expected due to change of plans, will they stop participating?

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the FUSE Project has exhibited technical progress in a number of areas including travel/charging long-dwell analysis for LD EVs and MD EV vocational applications and SCM controls applications for medium and long dwell for LD, MD, and HD vehicles and day-ahead pricing control. The project has examined various strategies such as TOU immediate/random, Feeder Peak Avoidance, Volt/Watt, BTM/DER, and others. The project developed the HELICs Co-simulation framework to outline the communication and hardware needs for SCM controls and identified mid-route/concentrated charging needs including XFC access/need. The project conducted a broad analysis of SCM in El Paso Electric and ISO New England Vermont and a grid impact analysis in Dominion Energy territory. The project developed a number of enabling technologies including OptiQ, EVrest, and the Charge Scheduler Bridge. Overall, this is a solid list of achievements across a number of fronts.

Reviewer 2

The reviewer noted that technical accomplishments to date are good.

Reviewer 3

The reviewer suggested considering expanding analysis to several days to evaluate plug-in behavior and its impact on feeder total demand.

Reviewer 4

The reviewer remarked that the analysis uses good EV adoption rates, however, maybe more recent data could conclude the 52% of the fleet being EVs might be a little optimistic for 2040. On Slide 7, what is preventing school buses from reaching 100% adoption when local freight can achieve it?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that collaboration across teams and areas is good.

Reviewer 2

The reviewer commented that Slides 14 to 18 show all participants contributing as expected and described by the presenter.

Reviewer 3

The reviewer commented that the project has successfully organized a strong laboratory team consisting of NREL, INL, ANL, and SNL. The project has utilized industry sources to obtain important travel (Wejo and Geotab) and utility feeder (Dominion Power) data to support project activities. The specific contributions of the laboratories is clearly elucidated. The reviewer asked if there is any way to include some formal industry representation on the FUSE team. This would provide a stronger business perspective and potentially help identify the most critical future pathways to pursue.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that future work plans are well thought out.

Reviewer 2

The reviewer noted that all research proposed on Slide 19 fits the project goals.

Reviewer 3

The reviewer commented that proposed future research/next steps encompass four broad areas: travel/charging analyses, SCM/VGI controls, grid analysis impacts, and demonstrations. The reviewer expressed a perspective that that there are too many activities spread across too many fronts. A key question is, “How does everything fit together in the bigger VGI/SCM picture?” Are the critical VGI/SCM barriers being addressed to the extent feasible by FUSE? Furthermore, it may be beneficial to downscale any focus on long-term projections and place additional focus on immediate barriers impeding implementation of SCM. For example, how can enabling technology get into the hands of industry and be utilized? As mentioned above under the “Approach” section, the development of a specific plan with industry input and clearly defined critical path would be beneficial in guiding future FUSE research activities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that this project addresses the challenge of smart EV charging and helps to maximize the utilization of the infrastructure to cover as much of the EV population as possible.

Reviewer 2

The reviewer commented that the successful development and implementation of VGI/SCM technologies is essential to enable and manage the introduction of ever greater numbers of EVs in a cost-effective manner while reducing associated grid impacts. This project clearly supports overall VTO subprogram objectives.

Reviewer 3

The reviewer stated that a reliable grid will enable more robust EV charging experience and faster decarbonization of energy.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the identified resources of $3.15 million per year are sufficient to meet FUSE objectives in an acceptable timeframe.

Reviewer 2

The reviewer remarked that resources allocated are adequate.

Reviewer 3

The reviewer noted that all proposed work fits within the funding proposed.

Presentation Number: ELT296
Presentation Title: Charging Infrastructure Interconnection Simplification Resource CIISR
Principal Investigator: Watson Collins, EPRI

Presenter

Jennifer Robinson, EPRI

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

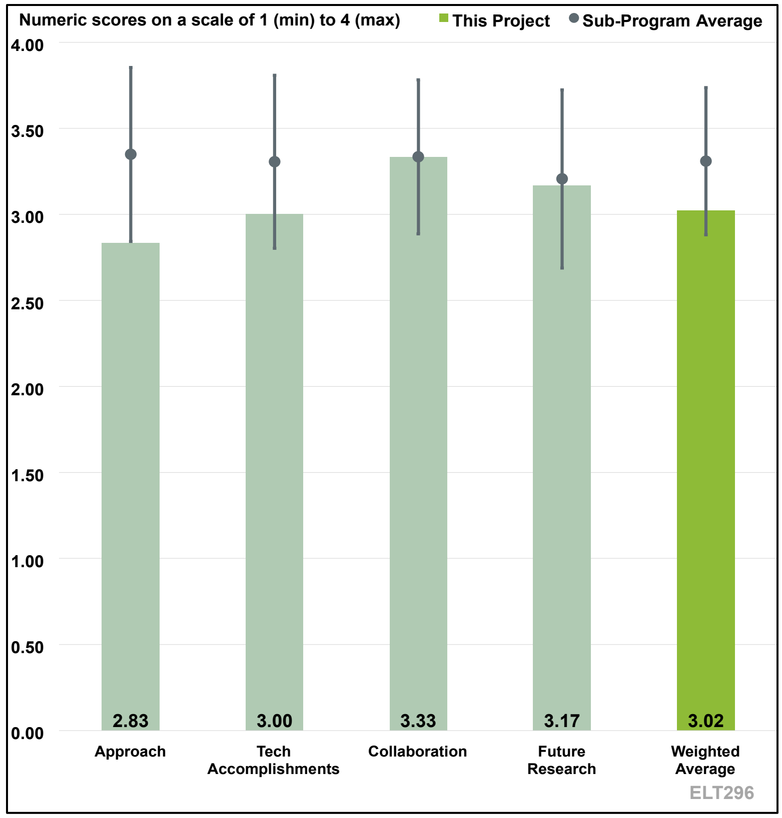

Figure 2-27. Presentation Number: ELT296 Presentation Title: Charging Infrastructure Interconnection Simplification Resource CIISR Principal Investigator: Watson Collins, EPRI

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project is addressing technical and educational barriers regarding utility connection. Additional clarity on types of interconnection being worked on and class of utility customers would be helpful as the project progresses.

Reviewer 2

The reviewer offered that one general comment is that there was extensive use of acronyms in the slides which were not spelled out which makes it difficult to understand what is being referenced. The problem as the reviewer understands it is to capture the needs of the customers and then communicate these to the electricity/grid suppliers to create a strategy on how best to meet both parties' needs. The project appears to be very focused on reaching out to various groups of customers but the reviewer did not see a clear plan on how these were to be collected and presented to the suppliers. Furthermore, it was not clear to the reviewer who is responsible for brainstorming ideas or if there would be regional differences in the grid/electricity supply which would need to be considered for any generalized solution.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the advisory structure has been set and that workshops have been scheduled for this summer and fall.

Reviewer 2

The reviewer commented that unfortunately Slide 4 (Milestones) did not include notation of whether individual milestones were completed or not and the timing. Slide 17 also did not indicate amount of completion, which makes it difficult to assess. Another issue is that this project aims to “Accelerate new grid service connections...” yet no baseline rate of connections was provided, and it is not apparent that the rate of connections was a metric being tracked. Also, since the project does not have the control over making said connections, “creating new grid service connections” is not a reasonable metric to assess this project. Slide 5 clearly states that the approach is to “Launch support website” which the reviewer assumed is the interconnection platform, and the successful launching of this would seem to be a good metric to evaluate the success of this project. The project presentation focused significantly on the data collection, and very little on the development of the support website and how GridFAST would be integrated. That appears to be the single largest technical hurdle which was not really addressed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project is doing a very good job of reaching out to other groups and organizations both regarding the stakeholder advisory group as well as ad-hoc connections as listed out on Slide 9. One idea for collaboration would be the effort to commonize the EV charger interface as this is the point where the EV customer and utilities connect.

Reviewer 2

The reviewer commented that the project has multiple stakeholders from utilities, community and workforce, and Clean Cities coalitions.

Reviewer 3

The reviewer noted that it is not clear how the end customer is represented in the advisory stakeholder list.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project can achieve its targets. The timeline is tight but collaborators and partner are coordinated. The project would benefit from outreach to other DOE-funded programs which are deployment based such as EMPOWER and AMP.

Reviewer 2

The reviewer noted that this project has a singular focus to speed new grid service connections. This is a significant challenge in of itself but if successful, there are no lingering research questions that the reviewer sees.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project addresses the softer barriers to deployment of EVSE's at scale.

Reviewer 2

The reviewer commented that increasing grid service connections will reduce the activation energy for potential EV customers and speed the overall EV adoption.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project is resourced sufficiently.

Reviewer 2

The reviewer stated that of the six partners listed for this project, it is not clear what each partner will be contributing so it is a bit difficult to assess the overall committed resources.

Presentation Number: ELT297
Presentation Title: Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility
Principal Investigator: Ed Gilliland, irecusa.org

Presenter

Ed Gilliland, IREC

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

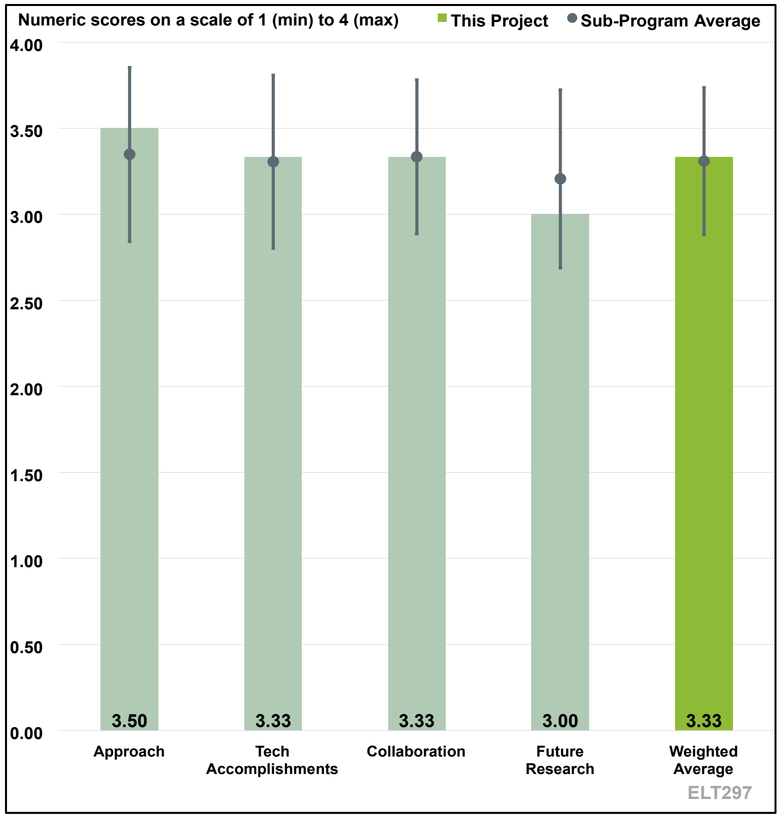

Figure 2-28. Presentation Number: ELT297 Presentation Title: Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility Principal Investigator: Ed Gilliland, irecusa.org

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project aims to break down barriers to planning and installing EVSE within communities and municipalities. It is based on a successful project for planning and installing solar within communities.

Reviewer 2

The reviewer commented that the project approach addresses barriers to EV charging infrastructure readiness by providing tools and information based on previously successful technical assistance programs.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project has been piloted within 5 states in 2023 and early 2024.

Reviewer 2

The reviewer stated that this project defines the criteria status of EV charging readiness, and this project held kick-off meetings with several state entities. The project also states technical accomplishments for 2023 and 2024 in several states, but details are not provided. Details of technical accomplishments would be beneficial for this AMR review. What actions and impacts can be detailed as resulting from this DOE-funded project? There is one slide example of a New Jersey permit for EV charging in parking lots. The reviewer is unsure if this is a successful change because of this project or an example for other states to follow. Are there other examples of successful changes accomplished by this project? There was no information or details on tasks, scope, or accomplishments associated with infrastructure modeling tools, or industry partner involvement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged a strong project team with public and industry partners.

Reviewer 2

The reviewer commented that the team is comprised of good partners. It is unclear as to the involvement of the industry partners and the modeling tool team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the team will continue to launch new communities in 2024 with build out of program guide.

Reviewer 2

The reviewer noted that the proposed future work is good for including new states, but showing successful accomplishments of previous states as well as any lessons learned to enable improvements to the process is important prior to moving forward with new, additional states. How are lessons learned incorporated back into this process? Was this project reviewed last year? There was no information provided on last year's reviewer comments.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the VTO electrification goals.

Reviewer 2

The reviewer commented that enabling and improving EV charging infrastructure deployment is very relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the program is adequately resourced.

Reviewer 2

The reviewer stated that the resources are sufficient.

Presentation Number: ELT298
Presentation Title: Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity
Principal Investigator: Steven Sokolsky, CALSTART

Presenter

Omer Onar, ORNL

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

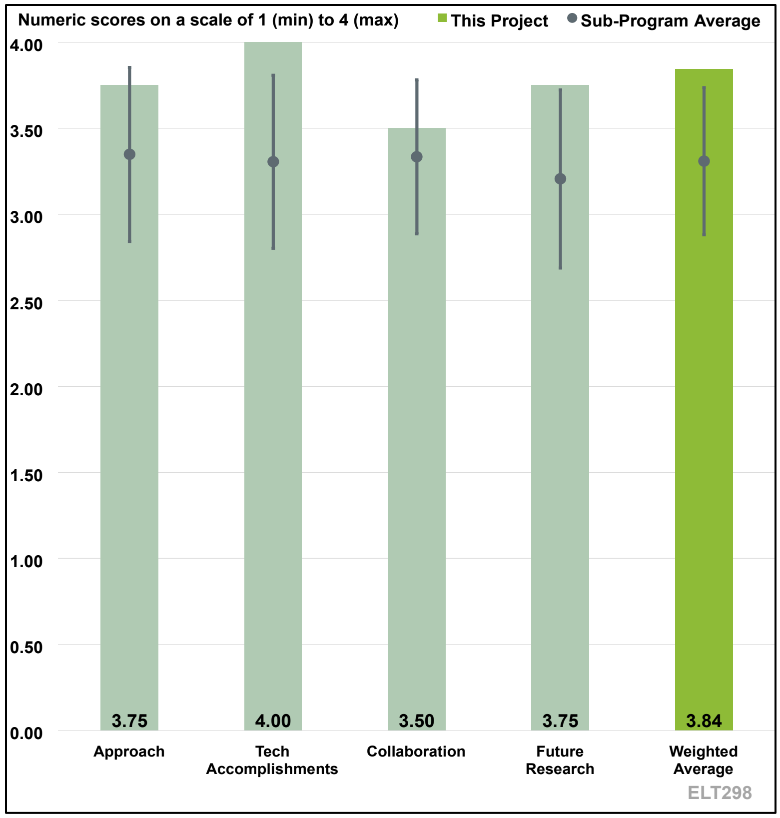

Figure 2-29. Presentation Number: ELT298 Presentation Title: Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity Principal Investigator: Steven Sokolsky, CALSTART

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the approach is excellent by starting with V2G (grid following) and including some of the regulation requirements for ride-thru. Other exporting requirements per Rule 21 in California and other states should also be tested. V2H where the inverter is grid-forming is also a desired option to include. This also shows a double D approach; circular and polyphase designs should also be considered.

Reviewer 2

The reviewer commented that this project team has been super careful to check out every possible function of their system since the project began. The team has also made sure to allow sufficient lead time so that glitches or redesigns could be accommodated without disrupting the flow of the research. This is especially obvious when contrasted with other similar projects with much higher budgets. The level of technical detail provided in the review is impressive, unfortunately time and space precluded explanations of the details for reviewers not intimately familiar with the technology. That is an inherent shortcoming of the review system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project adds an application interface as to placement of the primary and secondary coils for loading docks that is not included in standards to date. The project also points out additional features to interface with the vehicle during charging/discharging, etc., for the complete system approach.

Reviewer 2

The reviewer noted that these guys actually seem to get stuff built and tested and actually running, and on schedule. The reviewer is impressed and really wants to see how the truck and charging system operate in real-world situations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the system approaches are excellent with support from potential customer, OEM, project management and communication.

Reviewer 2

The reviewer stated that the pieces seem to fit together at the end, and that is the test of the collaboration. The reviews provide no picture of how the interactions among the partners actually worked, unless clear gaps are revealed, which did not happen in this project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer suggested that combinations of primary and secondary coils could be useful (circular, double D and polyphase). Perhaps a mix of power levels between the primary and secondary coils with efficiency results could also be useful.

Reviewer 2

The reviewer expressed eagerness to see how this works when it is all put together and the truck is driving around in service and charging inductively. The reviewer is looking forward to advances in inductive charging so that plug-in hybrid EVs actually get charged, whether the owners care or not.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that bidirectional power is already being deployed for Alternating Current (AC) and DC systems and WPT needs to be demonstrated and applied too.

Reviewer 2

The reviewer noted that both electrified transportation and inductive charging will help to advance decarbonization of the transport sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that this project has managed resources between labs, vehicles and test sites to maintain the full spectrum of effort required.

Reviewer 2

The reviewer commented that the team seems to be pretty good at figuring out how much it is going to cost to build stuff.

Presentation Number: ELT299
Presentation Title: EVs@Scale High Power Charging Pillar
Principal Investigator: John Kisacikoglu, National Renewable Energy Laboratory

Presenter

John Kisacikoglu, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

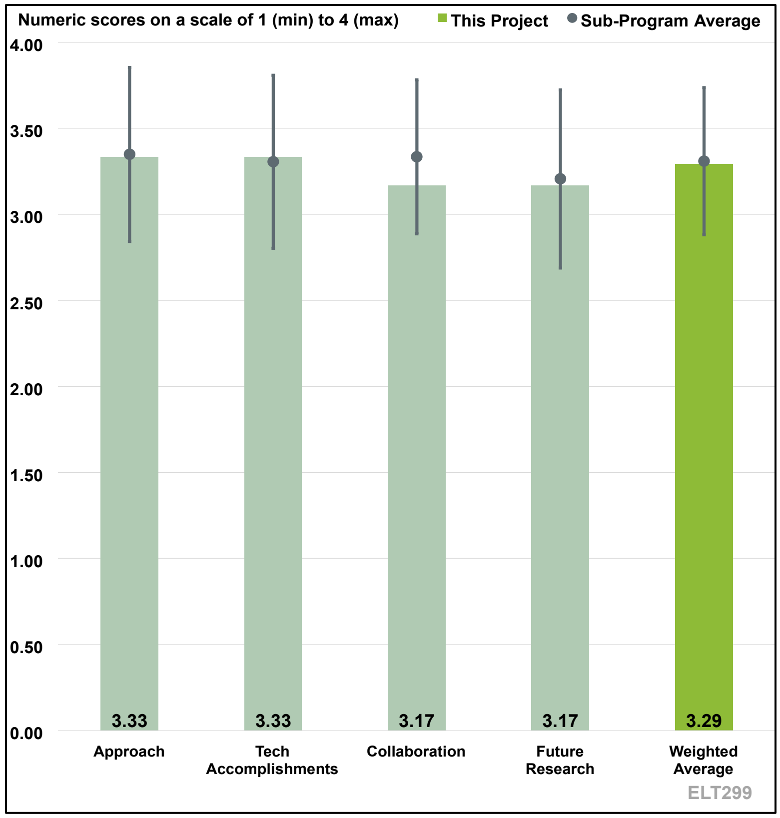

Figure 2-30. Presentation Number: ELT299 Presentation Title: EVs@Scale High Power Charging Pillar Principal Investigator: John Kisacikoglu, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted a good work plan with well laid out timing, milestones and target definitions. It was easy to read and follow during the presentation.

Reviewer 2

The reviewer stated that the project combines both 400V and 800V vehicles along with DC, pantograph and WPT charging. DC and WPT may have similar charging use cases for passenger and freight vehicles, but pantograph may have unique profiles such as buses. These should be separated as demand charges would also vary for the vehicle use case variations, not combined.

Reviewer 3

The reviewer commented that the EVs@Scale high power charging pillar is broken into two tasks: Next Generation Profiles (NGP) and the Electric Vehicle Charging Integration Hub Platform (eCHIP).

The principal barrier, objective, and intended outcomes are clearly and concisely identified for the NGP task. The NGP project is divided into three clearly defined areas: EV profile capture, EVSE characterization, and fleet utilization with the assets, conditions, edge cases, and cadence defined for each. Fleet utilization, additionally, is divided by time-series categories and analysis types. A strong NGP timeline is provided, with specific milestones, and a clear delineation of tasks. The technical barriers are clearly being addressed. The project is on or even somewhat ahead of schedule. Especially noteworthy is that milestones and activities for FY 2024 and FY 2025 of the project have already been scoped out at a high level.

The two principal barriers, objective, and intended outcomes are clearly and concisely identified for the eCHIP task. The overall approach is largely presented via discussion of the DC hub hardware platform and site energy management system (SEMS) based on ANL's Common Integration Platform (CIP.io). Further discussion of the approach is provided with regards to the universal power electronics regulator (UPER) / SpEC integration. It appears the technical barriers are largely being addressed; however, no specific eCHIP timeline, nor milestones, have been provided. The project is behind schedule is some areas, most notably UPER/SpEC integration/testing which is 6 months behind schedule with a currently planned completion in the fourth quarter 2024.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that significant technical accomplishments have been achieved for NGP. Four technical reports were completed at the end of calendar year 2023 and a procedures draft document completed in March 2024. The team successfully secured additional assets including 6 EVs, 2 EVSEs, and 5 fleets in 2024. The team also finalized a thoughtful approach to dissemination of information policy to balance the availability of key data without de-incentivizing participation. The team captured 167 EV profiles across a wide swath of conditions and multiple charging types (connected charging system (CCS), pantograph, North American charging standard NACS, J3400, and WPT). The team conducted conductive and non-conductive power transfer EVSE characterization tests, high utilization tests, and XCEL Energy scaled profile tests. The team conducted EV and EVSE fleet analyses and increased the scope of capabilities. Overall, this is a very impressive list of technical accomplishments.

eCHIP has successfully demonstrated automated DR capability of the DC hub platform using battery energy storage system (BESS) support. Bidirectional power transfer (BPT) has been demonstrated for functionality and readiness. Further progress has been demonstrated in development of the controller hardware-in-the-loop (C-HIL) platform and the UPER. Despite being behind schedule, UPER/SpEC module integration/testing is progressing with the test specs and the ORNL integration test bed nearing completion in late June 2024. Integration/testing is planned for 4Q2024.

Reviewer 2

The reviewer noted great work in building the charging profiles and the use case for impact on the utility side of the EVSE connections. As charger deployment grows, the grid's capacity and DER plans will require this type of information for future improvements and planned implementations of new technology solutions. Identification of potential limitations and gaps in distribution capability is a strong suit for eCHIP. The everything-in-the-loop (XIL) testing for C-HIL serves to build predictions for EV adoption and the control plans for multiport EVSE hubs.

Reviewer 3

The reviewer commented that the profiles captured are low state of charge to 100% where low state of charge to 80% values should be compared to demand charge level requirements. The lower power levels of 80% to 100% could be the offset to allow continued charging but a time to not curtail higher power charging for other vehicles.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that combining resources at all four laboratories provides a mix of vehicles and charging equipment. As expected, the 800-V vehicles are not as plentiful as desired for this project but the later years should increase that.

Reviewer 2

The reviewer commented that collaboration and coordination within the NGP laboratory team (ANL, INL, NREL, and ORNL) appears well-developed and strong. NGP interacts and coordinates with OEMs and industry for procedures development, testing assets, and report feedback and is demonstrating success securing testing assets from vehicle and EVSE OEMs, as well as lining up fleet partners. Collaboration and coordination of the eCHIP team with the NGP laboratory team appears reasonably well-developed, but may need adjustments based upon evidence of project timeline slippage. There is no mention of direct contributions to eCHIP from outside entities such as industry.

Reviewer 3

The reviewer noted a good group of national laboratory partners but wondered about utilities and industry or charging consortium. If there are laboratory personnel on other team calls, it should be linked to this project to indicate the scope of the information network.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that mid-way through the project, there is good alignment with other ELT projects. The project has built a solid foundation for the advancement of EVSE controls/operations with profiles and grid side impact. Gaining additional testing assets (which is the plan) will help to build a representation of future needs and possible complications for the grid/EVSE network and vehicle load variation.

Reviewer 2

The reviewer noted that specific future challenges and barriers have been identified spanning NGP and eCHIP. There do not appear to be any real showstoppers with NGP and continued progression of the very successful NGP project is expected to continue on schedule as outlined in the project timeline. Appropriately, the proposed future work is largely continuation of business as usual. The platform, eCHIP, still faces some significant challenges including interoperability, DC protection, and reliable and scalable SEMS operation. Proposed future work includes implementation of more advanced SEMS, integration of UPER. SpEC modules in DC hub, scaling up the C-HIL platform, and continued demonstration of real world use cases. It is suggested that a timeline/milestones be established for the proposed future activities going out for at least 2 years. Furthermore, methodologies should be explored to encourage/enable greater industry participation in the eCHIP project potentially in an advisory capacity, as a technology contributor, and to provide ongoing business perspective.

Reviewer 3

The reviewer stated that it is not clear what the goal of V2X is for this project, other than showing photovoltaic (PV), ESS and perhaps hydrogen as DER resources. Optimizing these with DR and combinations of vehicles is an option for future research.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted very relevant work in providing a capable and consistent charging experience for users. This will be a more important aspect of EV adoption as the EV registrations grow in the coming years.

Reviewer 2

The reviewer commented that yes, both the NGP and eCHIP projects contribute to the overall VTO subprogram objectives. The development of high power charger (HPC) DC hub architectures that successfully integrate HPC for LD, MD, and HD EVs, as well as integration of BESS and renewable energy sources, are important to the continued growth of EV transportation and smooth VGI. A clear, consistent understanding of HPC profiles under different use cases and conditions is a primary enabler in this effort.

Reviewer 3

The reviewer stated that this project summarizes the goal of meeting charging requirements while not overloading the grid.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that this project has sufficient managed resources between labs, suppliers, vehicles and test sites to perform the full spectrum of effort required.

Reviewer 2

The reviewer stated that the resources identified are sufficient for both the NGP and eCHIP projects.

Reviewer 3

The reviewer commented that EVs@Scale is a wide range of projects, and each has shown good progress with resources available. As commercial vehicle electrification begins to ramp up, considerations for additional funding may be required to facilitate the creation of a larger representative and variable load case to test the grid responses.

Presentation Number: ELT300
Presentation Title: EVs@Scale Codes and Standards Pillar
Principal Investigator: Ted Bohn, Argonne National Laboratory

Presenter

Ted Bohn, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

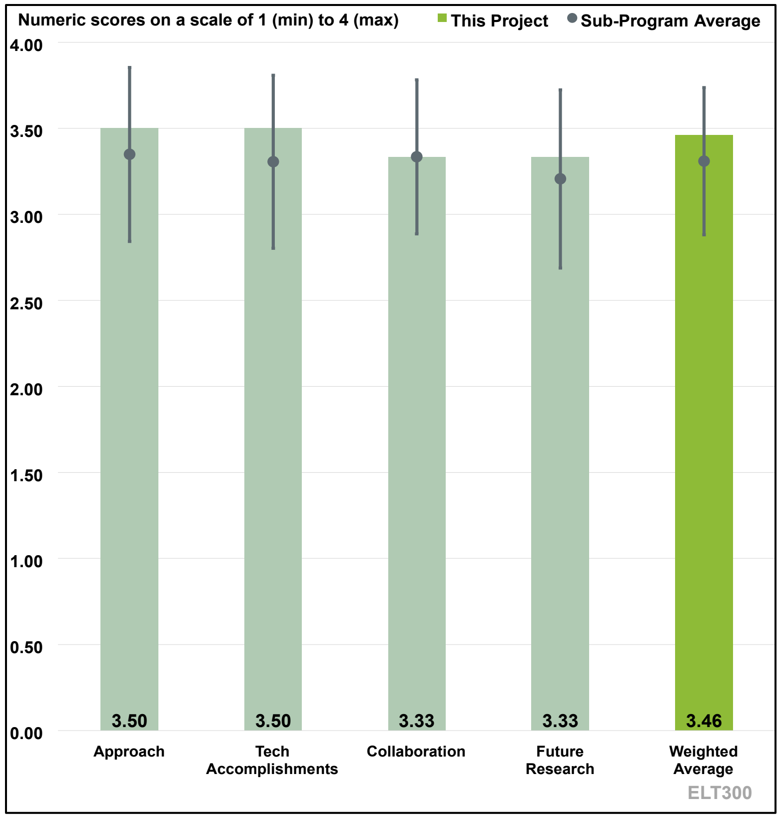

Figure 2-31. Presentation Number: ELT300 Presentation Title: EVs@Scale Codes and Standards Pillar Principal Investigator: Ted Bohn, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that these are necessary standards for the industry to move to higher power charging and connector variations along with expanded utility factors and the associated effort. The SAE and Institute of Electrical and Electronics Engineers (IEEE) standards are continuing to be updated and the leadership from this project that includes testing provides the bases for this effort to move from info reports to standards.

Reviewer 2

The reviewer commented that the Codes and Standards pillar objective and expected outcomes are clearly and concisely identified upfront. The overall project is well designed and technical barriers are being directly addressed. A timeline of near term (FY 2024) activities is provided. The Codes and Standards piller has clearly defined priorty areas including scaling of charging capabilities for EVs@Scale standards, electric power delivery oriented standards, vehicle oriented system standards, and high power WPT standards.

The Codes and Standards pillar has adopted a “divide and conquer” approach with respect to standards. A very clear delineation of laboratory responsibilities has been identified therein. Given the high importance and extensive need with respect to to codes and standards and limited resources, this appears to be the correct approach. However, within this context, consideration should be given to a modest narrowing of project scope, eliminating support to some lesser standards activities and increasing support to only the very most critical ones, thereby accelerating their development (for exemple J3400).

Reviewer 3

The reviewer noted that though the research areas are vast, the project lead has done a great job managing the scope of topics and building engagement with industry stakeholders. There needs to be a little work on the flow of the presentation and some limitations to the content on each slide.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that steps taken are appropriate to lead to a mature system for the industry to follow. System level approaches provide the basis for what is required, then OEMs and equipment suppliers can focus on a common solution for AC, DC and wireless charging at various power levels and obtain interoperability.

Reviewer 2

The reviewer stated that the Codes and Standards pillar has demonstrated outstanding and prolific technical accomplishments across the board in the last year, including completion of the DOE/ANSI Roadmap of Standards and Codes for EVs@Scale, IEEE P2030.13 DCaaS functional specification for charging system feed, SAE J3400 NACS (expedited and extensive progress), megawatt level standards progression (J3271, AIR7357, International Electric Code [IEC] 8005-4, and extendable mobile control suite [xMCS]/mining), energy services exchange (ESX) implementation, weights and measures (meter drift study, handbook (HB) 44 test tool, and HB105 transfer standard guide), other SAE/IEEE standards on interoperability, reliability, safety, and recycling, an NREL-hosted MCS connectors testing event, an EV variability study, and wireless power standards (J2954/1) published, J2954/2 HD Technical Information Report released, J2954/3 dynamic charging.

Reviewer 3

The reviewer commented that this type of project needs some accountability to the various stakeholders and their engagement with consortia required to build acceptable industry standards. Even if difficulties arise, this would allow DOE to recognize trouble spots and/or gaps where additional support is required to meet with the expected pace of progress in technologies leading to EV adoption. Top 10 standards area coverage is a good start, but how do we prepare for the next “NACS” industry focus change (how OEMs switched charging port format very late in the game, etc.)?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that each laboratory is adding their strengths to the project with design, testing and updates to the standards. The schedules are reasonable and with initial publication to additional testing and validation, the standards can be quickly moved to the next level of maturity.

Reviewer 2

The reviewer noted that good collaboration and coordination appears to exist amongst the five laboratory team members including ANL, INL, NREL, ORNL, and the Pacific Northwest National

Laboratory (PNNL). Each laboratory member has a clearly designated area of responsibility. Extensive industry collaboration exists primarily through the wide-ranging standards participation and development processes. Interaction/collaboration with other governmental entities (such as the National Institute of Standards and Technology [NIST]) is clearly evident.

Reviewer 3

The reviewer commented that the scope of this project really becomes the question. There is so much ground to cover in a number of related, though different technologies and application areas; this type of report out may require separate task/PI interaction at AMR to ensure that details (and possible needs) can be brought into the light.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that it was identified that WPT did not include BPT however this is nearly identical to DC BPT and needs to be included in the performance and communication standards. Additional testing should accommodate this but WPT wall box should be capable of V2G (grid following) and V2H (grid forming), same as the DC EVSE.

Reviewer 2

The reviewer commented that a clear description of near-term FY 2024 milestones/deliverables and next steps is provided. This includes input to, progression, and validation of specific standards and functional specs; test plan development; progress and testing report development; and work group and event participation. The Codes and Standards Pillar covers extensive ground with very limited funding. As mentioned above, consideration should be given to narrowing the project scope to fewer standards development activities in order to accelerate only those most critical.

Reviewer 3

The reviewer stated that with great laboratory participation, there is the question of industry, utility and academic participation. How is the whole consortia architecture understood? Are there any expectations of industry for support of plans for the next set of critical standards or provide data/information to help to create sensitivity projections to help highlight where resources should be applied next?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the Codes and Standards pillar unquestionably directly supports the overall VTO subprogram objectives. Codes and standards development is critical to furthering the successful implementation of EVs in the nation’s fleet along with smooth VGI. Ultimately, it is likely the most fundamentally salient area with regards to successful EV deployment. Unfortunately, codes and standards face numerous challenges across government, industry, and third parties including a significant lack of financial resources, the atherosclerotic nature of the standards process itself, the high-level of turnover of skilled standards personnel, requirements for global harmonization, and others.

Reviewer 2

The reviewer noted that the project is very relevant, and creation of industry standards and evaluation techniques is a fundamental role of the government. This work will help to encourage technology adoption and allow for policies to be created to help industry make commitments and build sustainable business strategies.

Reviewer 3

The reviewer stated that this project summarizes the goal of meeting charging requirements while not overloading the grid.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that MCS and higher power WPT is essential to meet automotive, truck, and bus requirements. The MCS connector interface and communication complements the existing connectors and the option of NACS will provide customers with additional charging stations to meet existing and future releases of vehicles. Seamless retries and extensible session description protocols (SDPs) are included in these updates as they lead to improvements in interoperability.

Reviewer 2

The reviewer stated that given the critical importance, overall cross-cutting nature, and the generally inherent long/arduous development processes (as a result of the industry consensus-based approach within the United States) of codes and standards, strong consideration should be given to significantly expanding the level of resources in support of codes and standards development.

Reviewer 3

The reviewer remarked that the scope of technology covered under this project requires a high level of support to properly engage industry and track progress for these and future required standards. Though there is a good mix of national laboratories involved, the progress on some of the tasks was less clear for specific project timeliness and impact of any late standards development on the industry. Additional task reporting may be a consideration as the project continues.

Presentation Number: ELT301
Presentation Title: EVs@Scale Cyber-Physical Security Pillar
Principal Investigator: Richard Carlson, Idaho National Laboratory

Presenter

Richard Carlson, Idaho National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

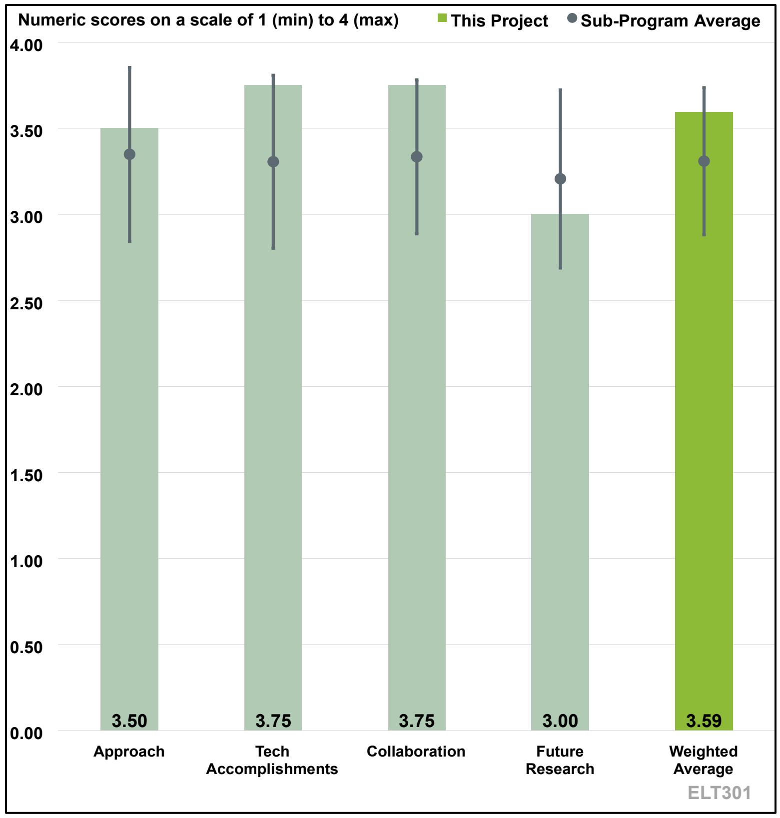

Figure 2-32. Presentation Number: ELT301 Presentation Title: EVs@Scale Cyber-Physical Security Pillar Principal Investigator: Richard Carlson, Idaho National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the approach has 4 pillars which are all relevant. First is laboratory testing and emulation of state-of-the-art charging infrastructure and communication protocols. The second is analysis of attack vectors and potential impact severity. The third is reporting of results, findings, and best practices. The fourth is cybersecurity tools and mitigation solutions development. The approach does not have end users involved. There needs to be a fleet partner involved as this will be the community most impacted by cyber breaches.

Reviewer 2

The CPS pillar has identified a strong list of holistic cybersecurity barriers facing widescale implementation of EVs in the United States and successful vehicle-grid integration (VGI). Upfront, it may be beneficial to more clearly indicate which ones the CPS pillar is currently specifically addressing or planning to in the near future. It may be good to more sharply define the overall CPS pillar objective and include a timeline and a few high-level milestones.

Overall, the high-level approach is sound and includes conducting analysis of attack vectors and potential impact severity, conducting laboratory testing/emulation of state-of-the-art charging infrastructure and communication protocols, developing CPS tools and mitigation solutions, and reporting results, findings, and best practices. The pillar is well designed and addresses specific technical barriers. The CPS pillar is clearly divided into two projects: CyberPUNC and Zero Trust (ZT) Architecture / Post-Quantum Cryptography (PQC). The objective, outcomes, and scope, as well as supporting background, of the ZT/PQC project are very clearly defined and explained, which is especially beneficial given the complicated nature of this domain.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the technical accomplishments include testing environment creation (aligned with industry needs and developments), completing first automated testing of many EV-EVSE device interactions, completing an EVSE security control catalog for cybersecurity risk assessments, developing mitigation solutions tools, continuing support of the Cyber Auto Challenge in colleges around the United States to help develop future cyber-crime fighters, and developing EVSE upstream and backend system analysis tools.

Reviewer 2

The reviewer remarked that the CPS pillar has demonstrated a prolific and impressive list of accomplishments over the last year. Notable CyberPUNC accomplishments include PKI testing environment creation, creating a scalable, repeatable environment for scenario evaluation and extends prior and upcoming EV charging industry public key infrastructure (PKI) testing events with SAE; identifying existing industry cyber tools, solutions, and capabilities, and mapping of these to EVSE security functions and needs; designing and demonstrating Cerberus, an R&D 100 award-winning cyber-physical anomaly detection and exploit mitigation solution; designing and implementing AcCSS, a system to evaluate CCS communication vulnerabilities and identifying exploitable vulnerabilities in some DC chargers; completing the first automated testing of EV-EVSE device interactions; completing an EVSE security control catalog for cybersecurity risk assessments; continuing support of the Cyber Auto Challenge; conducting an EVSE upstream and backend system analysis with open source intelligence gathering, processing, and analysis of backend systems; and developing cyber best practices for high power charging infrastructure (via the Office of Cybersecurity, Energy Security, and Emergency Response [CESER]).

Notable ZT/PQC accomplishments include identifying security objectives and assessing four prototypes to gauge ZT approaches; identifying traditional public key applications and exploring PQC adoption challenges; designing and developing an open change point protocol (OCPP) security service to counter grid-related high consequence events; and identifying a number of test and measure findings with respect to PQC keys, signatures, ciphertexts, and cryptosystems.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the CPS pillar encompasses six national labs, numerous collaborative partners, and industry work groups. Essentially the entirety of CPS pillar activities have extensive and ongoing collaboration with numerous industry, third party, and university stakeholders. Specific contributions are being made by all these entities. This is excellent and should continue to be aggressively pursued.

Reviewer 2

The reviewer commented that the project team is very strong as far as technical acumen is concerned. The laboratories involved are all very strong partners, and industry partners are very strong as well. The missing entity is a business end user.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that future research on this project will help develop tailored cybersecurity mitigations and prioritized action items for the assessment outcomes, test facility-specific EVSE cybersecurity controls progress and needs, and maintain and update EVSE tools site and build connections between needs and solutions. The project should include inductive charging systems as well.

Reviewer 2

The reviewer stated that at a high level, the CPS pillar effectively identifies remaining challenges and future research. For many of the technical activities, future proposed activities/next steps are identified, while for others they are not; additional details on those not identified would be beneficial. Consideration should be given to laying out proposed future activities and associated milestones for the next 2 years or so.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project has relevance in the fact that CPS is essential due to potential exploitable vulnerabilities impacting safety, grid impacts, hardware damage, denial of service, and theft or alteration of information. Continuous development and improvement to mitigation solutions is required to stay ahead of evolving threat actors and malicious exploits.

Reviewer 2

The reviewer commented that there is no question with respect to the relevance of CPS and that the pillar activities directly support VTO subprogram objectives. CPS is essential due to the large number of exploitable vulnerabilities, the potential severity of associated consequences, and the need for continuous development and improvement to mitigation solutions to stay ahead of evolving threats.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that few areas are more critical than cybersecurity to the widescale implementation of EVs, successful VGI, and ultimate sustainment. At $4.05 million per year, the CPS pillar appears to be underfunded. Consideration could be given to increasing pillar resources.

Reviewer 2

The reviewer noted that the project has sufficient resources.

Presentation Number: ELT302
Presentation Title: EVs@Scale EV Modeling Toolkit
Principal Investigator: Andrew Satchwell, Lawrence Berkeley National Laboratory

Presenter

Andrew Satchwell, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

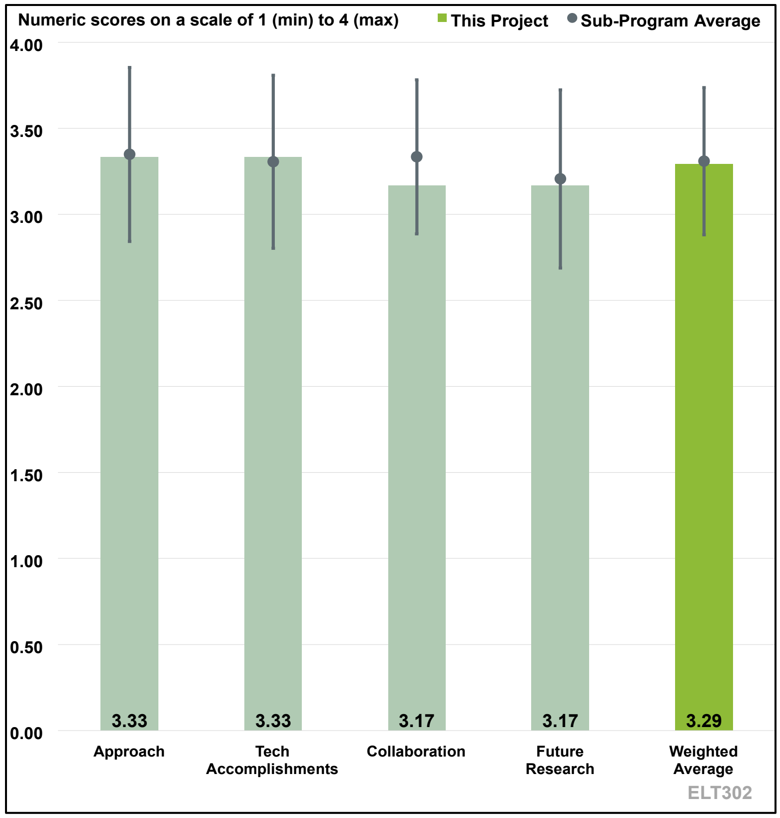

Figure 2-33. Presentation Number: ELT302 Presentation Title: EVs@Scale EV Modeling Toolkit Principal Investigator: Andrew Satchwell, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the EV Toolkit project satisfactorily identifies three salient barriers, the project objective, and impacts, although improved clarity and delineation therein would be beneficial. Four primary areas of interest have been identified and targeted including electricty system impact and planning, future EV adoption and load impacts, benefit-cost analysis, and EV infrastructure siting. These areas of interest were identified via comprehensive stakeholder consultation with four primary stakeholder groups including state utility regulators and state energy offices, third party providers and charging network operators, electric utilities and power system operators, and state Departments of Transportation. The work plan (task flow) appears logical and sound, with appropriate FY 2024-2025 milestones. The importance of ongoing efforts via Task 2 (stakeholder needs and gaps assessment) throughout the project duration can not be overstated. A reasonable, though somewhat ambitious, high-level timeline is provided.

Reviewer 2

The reviewer commented that the approach is appropriate for the task to the extent that knowing what tools are available and making them visible is a good first step. Providing links to the tools and some information on their use is also a good idea. The project description does seem to imply some level of integration of the tools which is not clearly articulated.

Reviewer 3

The reviewer noted that regulators, charge network operators, and utilities are the focus, but should not this also be inclusive of OEMs and EV customers? Unidirectional smart charging (V1G) and V2G may need to be separated in the tool such that managed charging vs. DER functions have variations to their focus, capabilities and revenue.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that sorting the available tools by function is an excellent first step. Engaging the potential users of the proposed web site is another excellent and necessary idea.

Reviewer 2

The reviewer remarked that to date, a solid listing of technical accomplishments has been demonstrated. This includes a tool inventory; identification of stakeholder needs and gaps broadly sourced from a 3-part DOE/national laboratory workshop, written summaries of stakeholder workshops and events, individual stakeholder discussions, and participation in industry events (the reviewer likes that results have been concisely categorized into three priorities of EV adoption, EV grid impacts, and VGI costs and benefits); website design and planning; and a draft overview of data and report library content and structure. Currently, the project appears on track, but it would not be surprising if there is timeline slippage mostly as a result of the scope of Task 4 activities.

Reviewer 3

The reviewer noted that ANL, INL, NREL, ORNL and PNNL have defined roles, but the role of Lawrence Berkeley National Laboratory (LBNL) is not identified other than just “leading” the project. The project objectives are clear but it is unclear what this project is adding that is not already in existing websites.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the tool owners and the PI are well coordinated and appear to be cooperating well in achieving the task aims.

Reviewer 2

The reviewer remarked that each laboratory is adding their effort and the workshops with utilities and regulators is included to make sure the tool meets their requirements.

Reviewer 3

The reviewer noted that the EV Toolkit project team consists of 6 labs, with the roles of each laboratory identified at least at the highest level but it is not clear how well the laboratories are coordinating their efforts. Contributions from industry and other external entities comes strictly through information and feedback to inform project activities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that future tasks are appropriate but very broadly defined and will probably need refinement.

Reviewer 2

The reviewer remarked that separation of V1G and V2X along with a combined VGI should be considered.

Reviewer 3

The reviewer commented that the remaining challenges and barriers have been identified and largely appear appropriate which include tool enhancements, website design, and toolkit dissemination. The proposed future research for FY 2024-2025 has been outlined and seems reasonable.

However, the reviewer strongly recommends two additional activities under future research: develop, implement, and actively monitor credible and salient EV toolkit metrics starting in FY 2025, and for FY 2025, clearly define exactly what development of a “sustainable” toolkit means and looks like. “Sustainable” is a very fluid term and a clear definition should be established early in the project. This will help eliminate confusion, frame current and future activities, and provides a basis moving forward.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project aims to bring together tools for EV charging infrastructure development in one place to make them easily accessible to the people and organizations responsible for making EV infrastructure deployment a reality.

Reviewer 2

The reviewer stated that this project intends to consolidate and simplify the decision process for EV adoption and reduce grid impacts.

Reviewer 3

The reviewer remarked that yes, this project supports overall VTO subprogram objectives. There is a strong need to get analysis tools and other information materials in the hands of stakeholders to make educated VGI decisions. VTO has an extensive inventory of existing modelling and analysis tools; unfortunately, they have often been more geared to researchers as opposed to the broader swath of general stakeholders. Improved user-friendliness and reconfiguration is an excellent way get more bang for the buck out of prior VTO investments in modelling, simulation, and analysis tools.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources identified for the EV Toolkit are sufficient to meet identified objectives and milestones in a timely manner.

Reviewer 2

The reviewer stated that the stakeholders are expected to be provided with a user friendly site to simplify decisions based on data from the industry that is maintained and updated as needed.

Reviewer 3

The reviewer noted that the resources are certainly sufficient. It is a bit unclear how much budget is needed if the simplest form of the website (collecting links to existing tools and information) is implemented.

Acronyms and Abbreviations – ELT

Abbreviation	Definition
AAM	American Axle and Manufacturing
AC	Alternating current
AFE	Active Front End
AIR7357	SAE International MegaWatt and Extreme Fast Charging for Aircraft
AMP	Colorado-based recycling technology vendor AMP (formerly Amp Robotics)
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
BEV	Battery electric vehicle
BMS	Battery management system
BP	Budget Period
BPT	Bidirectional Power Transfer
BTM	Behind the meter
BTMS	Behind-the-meter energy storage
CCS	Combined Charging System
CPS	Cyber-Physical Security
DC	Direct current
DCaaS	Data Center as a Service
DCFC	Direct current fast charger
DER	Distributed energy resource(s)
DOE	U.S. Department of Energy
DR	Demand response
DSO	Distribution system operator
EEMS	VTO Energy Efficient Mobility Systems subprogram
EERE	Office of Energy Efficiency and Renewable Energy
ELT	VTO Electrification Technologies subprogram
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference

Abbreviation	Definition
EPRI	Electric Power Research Institute
ESS	Energy storage system
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCEV	Fuel cell electric vehicle
FOA	Funding opportunity announcement
FODS	Freight Origin-Destination Synthesis
FUSE	Flexible charging to Unify the grid and transportation Sectors for EVs at scale
FY	Fiscal Year
Gen	Generation
HB	Handbook
HD	Heavy-duty
HPC	High power charger
HRE	Heavy rare earth
IEEE	Institute of Electrical and Electronics Engineers
INL	Idaho National Laboratory
ISO	Independent system operator
J2954	SAE International standard for Wireless Power Transfer (WPT) for EVs
J3271	SAE International standard for Megawatt Charging System for Electric Vehicles
J3400	SAE International standard charging connector
KW	Kilowatt
L2	Level 2
LD	Light-duty
LG	LG Energy Solution Ltd.
LTO	Lithium titanium oxide
MCS	Megawatt charging system
MD	Medium-duty
MOSFET	Metal–oxide–semiconductor field-effect transistor
MV	Megavolt

Abbreviation	Definition
MW	Megawatt
MWC	Megawatt charging
NACS	North American Charging Standard
NGP	Next Generation Profile(s)
NMC	Nickel manganese cobalt
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
P2030.13	Draft guide for creating a functional specification for electric vehicle (EV) fast charging stations
PACCAR	Successor company to the Pacific Car and Foundry Company
PEV	Plug-in electric vehicle
P-HIL	Power Hardware-in-the-Loop
PI	Principal investigator
PM	Permanent magnet
PNNL	Pacific Northwest National Laboratory
PQC	Post-Quantum Cryptography
Q3/Q4	Quarter 3/Quarter 4
RE	Rare earth
SCM	Smart charge management
SEMS	Site energy management system
SMC	Sheet molding compound
SNL	Sandia National Laboratories
SPS	Spark plasma sintering
SST	Solid-state transformer
ST1/ST2	SuperTruck 1/SuperTruck 2
STEM	Science, Technology, Engineering, Mathematics
SUNY	State University of New York

Abbreviation	Definition
TCO	Total cost of ownership
TMR	Tunnel magnetoresistance
TOU	Time-of-Use
UPER	Universal power electronics regulator
V1G	Unidirectional smart charging
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything
VDC	Volts direct current
VGI	Vehicle grid integration
VNL	Volvo VNL heavy-duty truck
VTO	Vehicle Technologies Office
WBG	Wide bandgap
WPT	Wireless power transfer
XFC	Extreme fast charge
ZEV	Zero emission vehicle
ZT	Zero Trust (ZT) Architecture

3. Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA) Technologies subprogram supports RDD&D to develop and deploy new propulsion and efficient vehicle technologies in off-road, rail, marine, and aviation applications that reduce GHG emissions and achieve a net-zero economy by 2050, all while creating good paying jobs with the free and fair chance to join a union and bargain collectively.

The goal of this portfolio is to conduct coordinated research with industry, universities, and the national laboratories through Cooperative Research and Development Agreements (CRADAs).This subprogram conducts industry-led RDD&D for off-road medium and heavy-duty (HD) vehicles, including engines used for marine, rail, and aviation, focused on electrified and hybrid systems as well as powertrains that can utilize renewable fuels, such as advanced biofuels, H2, renewable diesel and e-fuels. The subprogram will coordinate with and utilize expertise from other Offices and VTO programs as needed.

The subprogram supports cutting-edge research at the national laboratories, in close collaboration with industry, while working closely with other agencies including the Environmental Protection Agency and Department of Transportation's Federal Railroad Administration and Maritime Administration, to achieve goals for decarbonization of these subsectors. It will use a multi-laboratory initiative, including high performance computing and hardware in-the-loop resources, for research to optimize vehicle efficiency which also will be applicable to hard to electrify on-road HD vehicles.

The subprogram also supports industry needs to develop predictive, high-fidelity sub-models and simulation tools that are scalable and can leverage future exascale computing capabilities. The activity will fund research of renewable fuel properties utilizing chemical kinetics modeling of different molecules to determine their impact on combustion efficiency and emissions. It will also develop numerical routines and sub-models of complex chemical reactions that can reduce the computational time and increase the accuracy required for high-fidelity engine models, making them viable for use by industry.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 3-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA001	Overcoming key barriers to H2ICEs—mixing pre-ignition and ultra-lean operation.	Ales Srna (Sandia National Laboratories)	3-7	3.25	3.50	3.38	3.13	3.38
DORMA002	Alcohol combustion in CI engines—understanding mixing ignition and pollutant emissions	Dario Lopez-Pintor (Sandia National Laboratories)	3-13	3.17	3.25	3.25	3.00	3.20
DORMA003	Soot Predictions from DNS of a lab-scale combustor with sustainable aviation fuels	Bruno Souza Soriano (Sandia National Laboratories)	3-21	3.50	3.50	3.50	3.13	3.45
DORMA004	Mixing-controlled compression-ignition combustion with low-lifecycle-CO_2 fuels	Chuck Mueller (Sandia National Laboratories)	3-28	3.63	3.50	3.75	3.63	3.58
DORMA005	Alcohol spray and H_2 jet experiments and modeling	Lyle Pickett (Sandia National Laboratories)	3-33	3.60	3.50	3.50	3.40	3.51
DORMA006	Low Lifecycle Carbon Fuel (LLCF) combustion and emission models	Scott Wagnon (Lawrence Livermore National Laboratory)	3-39	3.63	3.50	3.75	3.63	3.58

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA008	Slashing Platinum Group Metal (PGM) in Catalytic Converters An Atoms-to-Autos Approach	Kevin Gu (General Motors)	3-43	3.50	3.50	3.58	N/A	3.51
DORMA010	Off-Road Decarbonized Fuel Transient Performance	Muni Biruduganti (Argonne National Laboratory)	3-49	3.33	3.17	2.83	3.17	3.17
DORMA012	Enabling Hydrogen Combustion for Large-Bore Locomotive Engines through Advanced CFD Modeling	Muhsin Ameen (Argonne National Laboratory)	3-53	3.13	3.13	3.25	3.25	3.16
DORMA014	Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec	Dean Edwards (Oak Ridge National Laboratory)	3-58	3.30	3.20	3.40	3.20	3.25
DORMA015	Predictive CFD Tools for Low-Carbon Fueled Off-road Internal Combustion Engines	Riccardo Scarcelli (Argonne National Laboratory)	3-63	3.00	3.33	3.00	2.83	3.15
DORMA016	Renewable methanol-fueled engines for marine and off-road applications	Jim Szybist (Oak Ridge National Laboratory)	3-66	3.50	3.50	3.67	3.33	3.50
DORMA018	SAF Combustion and Contrail Formation Research	Julien Manin (Sandia National Laboratories)	3-69	3.25	3.00	3.25	3.00	3.09
DORMA019	Multi-phase flow studies of SAFs for industry-relevant conditions and geometries	Brandon Sforzo (Argonne National Laboratory)	3-73	3.83	3.67	3.67	3.83	3.73

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA020	Sustainable Aviation Fuel (SAF) Contrail Modeling	Matt McNenly (Lawrence Livermore National Laboratory)	3-79	2.83	2.83	3.17	2.83	2.88
DORMA021	Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains	James McCarthy (Eaton)	3-83	3.70	3.70	3.50	3.60	3.66
DORMA022	Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition	Adam Dempsey (Marquette University)	3-88	3.75	3.75	3.25	3.50	3.66
DORMA025	Fully Electric Powered Hydraulic Assisted Compact Track Loader	Perry Li (University of Minnesota)	3-92	3.33	3.67	3.67	3.33	3.54
DORMA026	Articulated Dump Truck (ADT) Electrification—Greenhouse Gas Reductions and Commercialization of New Technology	Brij Singh (John Deere)	3-95	3.67	3.33	3.17	3.50	3.42
DORMA027	Control of aldehyde emissions from alcohol-fueled non-road engines	Sreshtha Majumdar (Oak Ridge National Laboratory)	3-99	3.30	3.30	3.40	3.20	3.30
DORMA028	Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles	Andrea Strzelec (University of Wisconsin-Madison)	3-105	3.13	3.13	3.63	3.25	3.20

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA029	Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System	Hailin Li (West Virginia University)	3-109	3.33	3.17	3.17	3.33	3.23
DORMA030	Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System	Ming Huo (Achates Power)	3-112	2.80	3.20	3.30	2.80	3.06
DORMA032	High Efficiency Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project	Tim Lutz (Cummins)	3-118	3.63	3.63	2.38	3.50	3.45
DORMA033	High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines	William de Ojeda (WM International Engineering)	3-122	3.17	3.67	3.17	3.50	3.46
DORMA037	Sustainable Aviation Fuel Characterization	Gina Fioroni (National Renewable Energy Laboratory)	3-125	3.40	3.50	3.50	3.10	3.43
DORMA038	Towards Accurate Combustion and Emissions Modeling of Sustainable Aviation Fuels	Debolina Dasgupta (Argonne National Laboratory)	3-131	3.83	3.50	3.33	3.50	3.56
DORMA040	Optimized Low Carbon Fuel Range Extender (HyREX)	Jon A. Dickson (Cummins)	3-136	3.38	3.38	3.25	3.25	3.34
DORMA041	Low greenhouse gas NO_x control	Dhruba Deka (Pacific Northwest National Laboratory)	3-140	3.50	3.20	3.30	3.50	3.33

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA042	Unforeseen challenges with renewable fuels	Konstantin Khivantsev (Pacific Northwest National Laboratory)	3-146	3.00	3.00	3.33	3.00	3.04
DORMA043	Low-load cycle emission control	Yong Wang (Pacific Northwest National Laboratory)	3-151	3.70	3.50	3.80	3.50	3.59
DORMA045	Biodiesel poisoning of close-coupled SCR catalysts for off-road engines	Todd Toops (Oak Ridge National Laboratory)	3-156	3.63	3.38	3.50	3.25	3.44
DORMA046	Ammonia for 4-stroke Marine Dual Fuel and Gas Engines (Retrofits and New)	Scott Curran (Oak Ridge National Laboratory)	3-161	3.50	3.75	3.00	3.00	3.50
DORMA047	High-Efficiency Mixing Controlled Compression Ignition Combustion of Propane Dimethyl Ether Blends	Sage Kokjohn (University of Wisconsin)	3-165	2.83	3.00	3.00	2.67	2.92
DORMA051	Fuel effects on aviation engine emissions – a modeling tool for SAF screening	Dario Lopez-Pintor (Sandia National Laboratories)	3-169	3.50	3.50	3.38	3.13	3.44
DORMA052	Simulation of Jet Engine Performance using SAF Blends	Shashank Yellapantula (National Renewable Energy Laboratory)	3-174	3.50	3.50	3.83	3.50	3.54
Overall Average				3.39	3.38	3.36	3.26	3.37

Presentation Number: DORMA001
Presentation Title: Overcoming key barriers to H2ICEs—mixing pre-ignition and ultra-lean operation
Principal Investigator: Ales Srna, Sandia National Laboratories

Presenter

Ales Srna, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

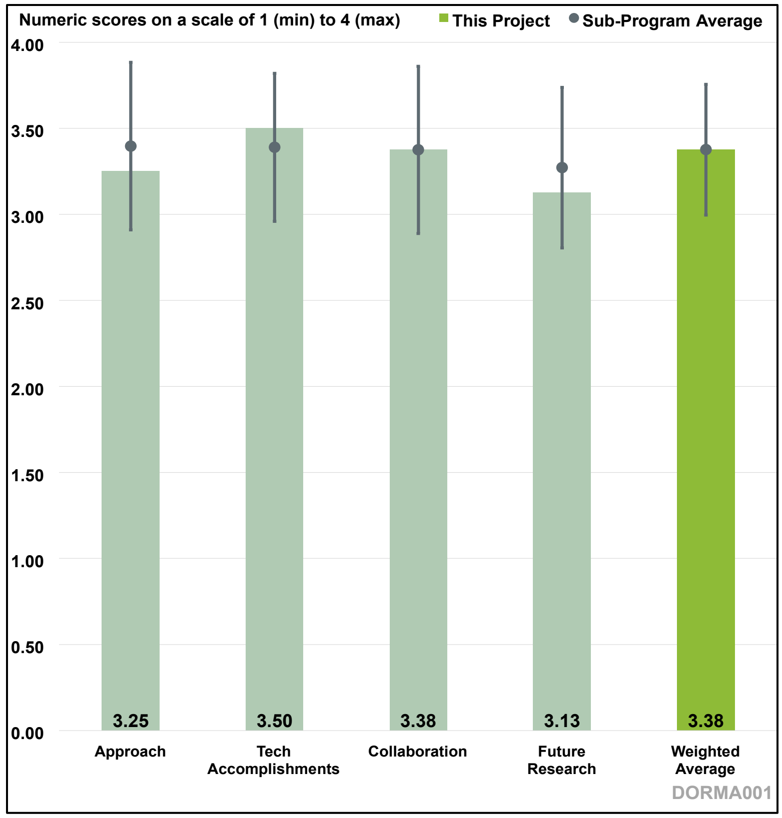

Figure 3-1. Presentation Number: DORMA001 Presentation Title: Overcoming key barriers to H2ICEs—mixing pre-ignition and ultra-lean operation Principal Investigator: Ales Srna, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the project focuses on hydrogen (H_2) internal combustion using both a pilot ignition source and pre-chamber spark ignition, noting that both approaches are likely in the future. The reviewer suggested considering both retrofit and new engine design approaches. The reviewer asked whether homogeneous charge compression ignition is possible with H_2 fuel in internal combustion engines (ICEs) and whether high compression ratio allows for late injection compression ignition of H_2 direct injection (DI) fuel. The reviewer remarked that the future design space is varied and unclear and acknowledged that efforts to organize the possible operation space would be useful to the engine community.

Reviewer 2

This reviewer stated that the project’s tasks are designed to overcome barriers that have impeded the wide-spread use of H_2-fueled ICEs. According to this reviewer, the ultimate goal of the project is for H_2-fueled ICEs to command a significant market in the transportation sector, thereby reducing the harmful emissions from conventional liquid-fueled combustion engines and achieving zero GHG emissions. The reviewer observed that a CRADA with Caterpillar and other entities from industry and academia provides a framework for investigating combustion in a single-cylinder engine. The project also includes computational fluid dynamics (CFD) to simulate in-cylinder H_2 injection and flow dynamic processes.

The reviewer considered the single-cylinder engine configuration appropriate for the project's intended purposes. The reviewer urged the principal investigator (PI), however, to make clear which results and processes in this configuration will carry over to the more complex multi-cylinder configuration of commercial engines, acknowledging that the PIs posed a related question on Slide 28 asking whether optical engine results are fully representative of production/metal engine performance.

This reviewer deemed the use of zero-dimensional (0D) or one-dimensional (1D) models to understand complex combustion processes a reasonable approach, noting that low-order transport configurations can provide significant insight and data to validate detailed numerical models of combustion. The reviewer explained that there are aspects of combustion that are not necessarily impacted by differences in transport (e.g., the size of soot precursor particles is independent of the flaming configuration). The reviewer suggested that future presentations should identify which information from 0D or 1D models is relevant to the more complex in-cylinder environment of an engine, where turbulence, swirl, three-dimensional (3D) transport, etc., exists, since it was not clear in this presentation. The reviewer also questioned the broader applicability of models that require significant tuning to capture H_2 heat flux, referring to Slide 16 and noting that the presentation did not discuss how tuning would be carried out or the broader applicability of the models to the results.

The reviewer pointed out that the project addresses many basic in-cylinder processes associated with fuel injection, mixing, swirl, ignition, flame/wall interactions, engine operation under different conditions of injection pressure, mixture distribution, injector configurations, effects of lubrication oil droplets, etc. The reviewer found it challenging at times to understand the rationale for selecting conditions to investigate and how the results obtained would inform a predictive CFD capability. The reviewer observed that the project is focused on engine testing, where operational conditions are set, and the results are discussed. While results from individual components were clearly presented, the reviewer was unable to discern from the presentation, in the limited time available, how the components fit together to provide a clear path to the ultimate long-term objective of the project. For example, the term 'phenomenology' on Slide 17 was not specifically defined and was therefore difficult to link to something measurable. Similarly, photos of a multi-port injector were shown, but it was not clear what quantitative information or data were obtained from the injector (e.g., penetration rate, width of the jets) or how this data would be used in modeling). The reviewer recommended that future presentations include a flow chart or other graphic showing how the individual parts fit together and contribute to the whole.

The approach to close the knowledge gap impeding H_2 ICE development by conducting experiments using optical and laser-imaging diagnostics in a heavy-duty engine with computer modeling was unclear to this reviewer, who commented that computer modeling usually involves measurements followed by predictions. The reviewer observed that the presentation did not specify what is being measured by laser imaging, how the measurements are used in simulations, or what inputs were used for the computer modeling and numerical framework.

The reviewer remarked that the role of oil droplets was not clearly presented, pointing out that Slide 4 shows droplets of lubricating oil on the surface of a piston while Slide 16 shows photos of oil droplets from a single-hole injector, raising questions about the origin of the oil droplets shown on Slide 16. The reviewer expressed a need for clarification of the oil droplet concern.

Lastly, this reviewer mentioned a need for more clarity regarding the choice of operating conditions employed in the investigation of in-cylinder mixture formation, e.g., what guided the choice of swirl ratios of 0.5 to 3.5.

Reviewer 3

This reviewer concluded that the project is well designed and will contribute to addressing some of the challenges with H_2 ICEs. The timeline was deemed by the reviewer to be reasonable for the scope of the project. The reviewer pointed out that the combustion studies' operating conditions are limited and recommended expanding the studies to include high-pressure injection (200 – 300 bar), which has the advantage of high brake efficiency and power density, as well as port fuel injection, which may reduce particulate emissions compared to direct injection.

Reviewer 4

The reviewer stated that the project presents a comprehensive summary of the technical barriers to H_2 ICEs and asserted that the long list of challenges and the itemized list of knowledge gaps highlight the need for extensive research. The reviewer questioned whether an H_2 ICE product can be quickly launched in the market to gain customer acceptance, as the project perspective on Slide 4 suggests, without compromising performance or emissions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This reviewer praised the team's mixture preparation experiments and modeling and highlighted the importance of the project's collaboration with Lyle Pickett to understand the possibility for in-homogeneity. The reviewer also affirmed the usefulness of the early versus late injection results and the hydrocarbon-induced pre-ignition studies for future engine designers.

Reviewer 2

The reviewer acknowledged that extensive engine testing was carried out during this reporting period but noted that it was not always clear how the many individual components of the testing program fit together. The reviewer stated that the snapshots of results revealed significant technical accomplishments that were achieved in this reporting period, observed that there are many parts to this project, and commended the PIs for summarizing key results. The person concluded that most of the barriers to implementation of H_2 ICE technology are being addressed with the possible exception of H_2 supply and storage infrastructure, which is outside the scope of this project but may be appropriately addressed within the DOE Bioenergy Technologies Office or the DOE Hydrogen Program.

Reviewer 3

This reviewer praised the project's combustion results, which provide valuable insights on pre-chamber fueling, the impact of swirl and H_2 interaction on in-cylinder mixture distribution, and the effect of H_2 on auto-ignition of hydrocarbons.

Reviewer 4

The reviewer appreciated the clear outline of the milestones completed in 2023 and those in progress in 2024. The reviewer commended the project's experimental work, documentation of the engine swirl effects, insightful data, and visualizations of H_2 ICE pre-chamber ignition and in-cylinder processes. The reviewer found the characterization of differences relative to natural gas combustion helpful.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that Slide 6 mentions a number of collaborations. The connection with Lyle Pickett was described by the reviewer as excellent. This reviewer indicated that it would be helpful if involved partners were identified within the results slides.

Reviewer 2

The reviewer observed that the team is quite large, encompassing about nine components, with Caterpillar being the lead. With so many team members, it was not always clear to the reviewer how the components fit together. For example, it was not clear how Argonne National Laboratory's (ANL's) in-cylinder CFD of H_2 ICEs, which includes pre-ignition studies, fits together with the University of Duisberg-Essen's CFD on in-cylinder H_2 mixture formation. The reviewer questioned whether ANL is using CONVERGE and the academic partners a different numerical framework, noting that the presentation did not identify which codes were used. The reviewer pointed out that CFD will require inputs such as property data and kinetic mechanisms for combustion simulations, as well as assessments of uncertainty in the simulations, yet no discussion of the accuracy of the simulations was incorporated. The reviewer questioned how the international universities in the project were selected for the CFD modeling effort, expressing particular interest in knowing the unique competencies that motivated the choices. Since the presentation provided little information on the CFD modeling, the reviewer found it difficult to assess the modeling component of the project (e.g., inputs required, numerical methods used, adaptive gridding [if incorporated], computational time, validation). The reviewer presumed that Caterpillar has assessed these matters during the biannual meetings among the team members.

Reviewer 3

The reviewer commented that collaboration and coordination with other institutions is well documented and encouraged the team to keep it up.

Reviewer 4

The reviewer stated that the work is part of a CRADA with Caterpillar and that the project includes collaboration with Sandia National Laboratories. The person observed that the project also receives input from a wide range of industrial original equipment manufacturers (OEMs), government, and universities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer can affirm that pre-ignition was likely driven by residual gas. Noting that residual-gas-driven pre-ignition was mentioned in the presentation as a future topic, the reviewer affirmed the importance of investigating this mechanism and encouraged the team to spend time on it. The reviewer remarked that both the future mixture preparation and pre-chamber work will be useful.

Reviewer 2

The reviewer observed that future plans were presented in general terms. The future plans include addressing in-cylinder mixture formation, pre-ignition, and wall heat loss, among other aspects. The reviewer noted that science-based correlations for pre-ignition mechanisms were mentioned, but it was not clear what precisely would be correlated and what experiments would be required.

The reviewer was interested in the modification of the optical engine to permit interchangeable swirl combustion geometries, although. The motivation for this modification (i.e., the gaps that needed to be filled, such as the swirl level) was not presented.

This reviewer recommended that a pictorial representation of the project be incorporated in the presentation to show how the components fit together, including national lab, industry, and academic partner contributions. Some detail on the CFD efforts would also be useful, such as a property database, the kinetic mechanism for combustion simulations, validation, etc.

The reviewer remarked that comments on the hydrogen infrastructure for production, supply, storage, delivery, etc., would be useful to include in order to provide context to the overall goal of deploying H_2 ICEs in the market by the 2027 timeframe noted in the presentation. The reviewer acknowledged that the DOE Hydrogen Program may already be solving hydrogen infrastructure issues but asserted that studies such as this one would be enhanced by the deflection of concerns about storage, supply, safety, etc.

This reviewer pointed out that in the introduction (Slide 3), the PIs have headings entitled "Relevance" and "Long-Term Objective." The reviewer suggested that it would be helpful to have a box with the heading "Approach."

Reviewer 3

The reviewer applauded the proposed future research, adding that it will contribute to overcoming in-cylinder mixture formation and pre-ignition challenges as well as ignition system challenges and wall heat loss. The reviewer recommended addressing additional challenges affecting the commercialization of this technology, such as the impact of water produced on the ICE components, in the proposed future research.

Reviewer 4

This reviewer reported that the project plans to continue to investigate the mixture formation and pre-ignition in the combustion cylinder as well as to expand the scope to investigate ignition systems and wall heat losses. The reviewer asserted that providing the next period's milestones would improve the presentation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer expressed an expectation that H_2 ICEs will be important in the medium- and heavy-duty high-power, high-duty-cycle domain and affirmed the usefulness of this project's work for future H_2 ICE research and development (R&D).

Reviewer 2

The reviewer concluded that the project's H_2 ICE R&D is highly relevant to the VTO subprogram objectives in that H_2 ICEs have potential to help decarbonize emissions when integrated into the market. The reviewer observed that the team combines many elements in its development of H_2 ICEs, all of which are incorporated to address performance and emissions.

Reviewer 3

This reviewer stated that the project supports the overall VTO subprogram objectives for decarbonization of difficult-to-electrify sectors with high-power-density applications by helping to close the knowledge gaps pertaining to H_2 ICE in-cylinder processes and control strategies.

Reviewer 4

The reviewer affirmed that the work is relevant, noting that H_2 ICEs are being actively developed by OEMs for decarbonization of difficult-to-electrify industrial sectors.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer remarked that the project's resources appear to be sufficient.

Reviewer 2

The reviewer said that the resources seem adequate for this large project but cautioned that more details (e.g., overhead rates, scientist and technician salaries, equipment costs, etc.) beyond the bottom-line costs for the project provided in the presentation are needed for the reviewer to adequately evaluate the project's resources. The person added that an ultimate judgement would have to come from a cost/benefit analysis based on DOE's investment relative to the commercialization potential of the technology under investigation.

Reviewer 3

This reviewer observed that the project is on track and milestones are being met with the current funding level.

Reviewer 4

The reviewer concluded that the resources and experimental facilities for this project are adequate.

Presentation Number: DORMA002
Presentation Title: Alcohol combustion in CI engines—understanding mixing ignition and pollutant emissions
Principal Investigator: Dario Lopez-Pintor, Sandia National Laboratories

Presenter

Dario Lopez-Pintor, Sandia National Laboratories

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

83% of reviewers felt that the project was relevant to current DOE objectives, 17% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

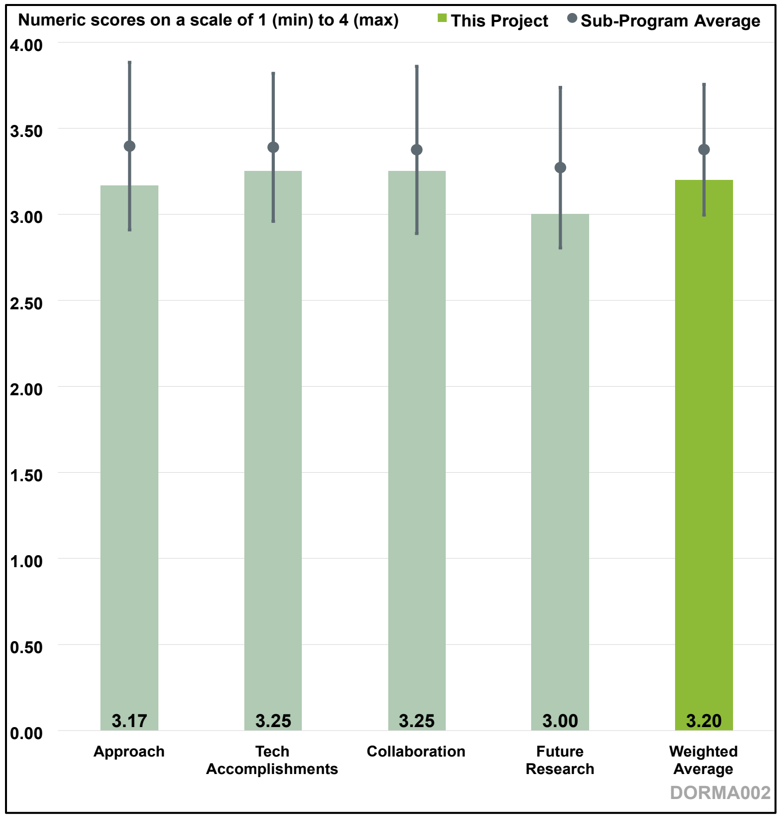

Figure 3-2. Presentation Number: DORMA002 Presentation Title: Alcohol combustion in CI engines—understanding mixing ignition and pollutant emissions Principal Investigator: Dario Lopez-Pintor, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project is on track and technical barriers are adequately addressed. According to the reviewer, a logical approach to synchronize work across mixing, ignition, and combustion tasks was laid out early in the presentation and then discussed in the technical accomplishments section. The reviewer noted that the technical accomplishments exhibit a clear progression to a dual-fuel solution with an active pre-chamber and observed that results from literature were used to guide active pre-chamber work.

Reviewer 2

The reviewer gave this project a rating of “fair” for its approach to performing the work of addressing technical barriers related to the use of lower carbon intensity alcohol fuels, namely ethanol and methanol. The reviewer pointed out that the project’s approach of studying the ignition and combustion of high-octane, low-cetane alcohol fuels (methanol and ethanol) in a direct compression-ignition engine configuration is not novel and does not contribute to alleviating barriers to methanol or ethanol utilization. Direct compression-ignition of highly ignition-resistant alcohol fuels has been studied in various research programs and has been implemented commercially in a small number of vehicles and vessels. The reviewer observed that despite being commercially deployed for over a decade, direct compression-ignition has not seen significant growth. The reviewer asserted that methanol and ethanol are fundamentally well-suited to spark-ignition combustion processes because of their extremely high octane numbers, but they are poorly suited to direct compression-ignition combustion because of very low cetane numbers. The reviewer further noted that alcohol ignition chemistry has been shown repeatedly in the literature to be particularly unresponsive to both commercial and experimental ignition improvers, and this project only re-confirms those results. The reviewer recommended that the project shift to commercially and technically relevant approaches to utilization of lower-carbon-intensity alcohol fuels. These approaches include both pilot-ignition processes for large-bore, low-speed marine engines and spark-ignition processes for higher-speed, smaller-bore boat and off-road engines.

Reviewer 3

This reviewer acknowledged that the project addresses some key aspects of mixing-controlled compression ignition (MCCI) combustion of the alcohol fuels, such as spray penetration, lift-off length, ignition delay, and 3D CFD simulation. However, the reviewer pointed out that some of the project's research areas are not well aligned with MCCI combustion. The relevance and motivation behind port fuel injection (PFI) spray characterization and PFI-led passive pre-chamber combustion characterization in the optical engine were unclear to the reviewer. Although the reviewer found the concept of active-pre-chamber-assisted MCCI combustion interesting, the reviewer questioned whether it is a pragmatic solution considering the cost, complexity, and controllability challenges. The person asserted that doping a large quantity of 2-ethlyhexyl nitrate is also impractical. This reviewer concluded that the project is not sharply focused on developing practical solutions that address the key technical barriers for MCCI combustion, including robust and efficient low-load combustion, cold startability and emissions, and full-range combustion strategy considering emissions and efficiency.

Reviewer 4

The reviewer stated that the project addresses important issues to enable methanol and ethanol, two potential renewable fuels, for off-road applications. The reviewer affirmed the importance of all focus areas of the project, including mixing, ignition, and combustion, and suggested including emissions as an equally important area for investigation, noting that it has been well-established that the pollutant emissions from methanol and ethanol fuels significantly differ from those of conventional diesel. The reviewer conjectured that different emission control catalysts and engine control strategies will likely be needed for the systems to meet the low tailpipe emission standards. The reviewer explained that emission control technology has advanced to the stage that it is now a part of engine/fuel system rather than an aftertreatment system; thus, including emissions measurements in the early stages of the project and studying how the engine-out emissions are affected by various parameters is beneficial for the development of the entire system.

Reviewer 5

This reviewer conveyed that ethanol and methanol were identified as the most promising fuel candidates to replace diesel in an effort to decarbonize the off-road vehicle fleet. According to the reviewer, this project attempts to characterize the mixture formation of ethanol/methanol, understand ignition, and develop fundamental understanding of combustion strategies for engines using these fuels to achieve a similar performance to that of diesel compression ignition engines. The project structure is focused on three main tasks: mixture formation, ignition fundamentals, and engine performance and emissions. The reviewer affirmed that the project's approach to gaining a fundamental understanding and characterization of alcohol fuels in direct injection engines is sensible and recommended evaluating how emissions for ethanol and methanol combustion compare to those for diesel combustion to confirm the continued relevance of this project to meet VTO goals.

Reviewer 6

The reviewer remarked that the three focus areas within the project's approach are well explained and make sense. The reviewer questioned whether in-cylinder chemical species measurements, which may have been mentioned as proposed future research, are possible within the ignition focus area, asserting that such measurements along with thermal mapping seem appropriate and would further detail the changes imposed in oxygen concentration.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This reviewer commented that the project's technical accomplishments clearly follow the project schedule, with challenges identified and progress made at each step. The reviewer asserted that wall wetting from observed deep penetration of liquid methanol can be mitigated with fuel/intake heating. The reviewer noted that ether blends were found to be infeasible for MCCI because of the high amounts required. The reviewer noted identification of alcohols scavenging radicals and suppressing ether ignition. This can be addressed by burning ether before injection of alcohol. The reviewer added that active pre-chamber is needed to avoid the misfire that is observed with passive pre-chamber.

Reviewer 2

Acknowledging that the project has made technical accomplishments and progress, the reviewer rated the project's progress "satisfactory" because of weaknesses in the accomplishments that were highlighted. This project has used a variety of experimental and modeling techniques to study in-cylinder behavior (including injection processes) of methanol. However, the technical accomplishments presented focus on physical and chemical phenomena related to the direct compression-ignition of methanol and ethanol. The reviewer conveyed that these learnings, such as the significant challenges associated with igniting these high-octane fuels, already existed in literature. Specifically, prior literature has already documented the 1,000 Kelvin ambient environment threshold for achieving autoignition with methanol and ethanol and the large amounts of ignition improvers that must be added to methanol or ethanol to significantly impact thresholds for ignition. The reviewer commended the project for studying PFI of methanol and ethanol for use in a pilot or dual-fuel or pre-chamber combustion system, noting that these technical findings addressed barriers to utilization of these fuels. Further work on utilization of methanol and ethanol with high-energy ignition systems was recommended by this reviewer.

Reviewer 3

The reviewer conveyed that the project is on track against the plan. The reviewer's main concerns are the relevance of some of the tasks to MCCI combustion and the extent to which the project contributes to the advancement and adoption of the MCCI combustion technology for alcohol fuels.

Reviewer 4

The reviewer commented that technical progress in most of the project's focus areas was well demonstrated in the presentation. Noting that emission measurements for nitrogen oxides (NO_x) were presented for the fuels with additives, the reviewer observed that emissions of aldehydes, which have very low thresholds, were not reported in the presentation. The person cautioned that aldehyde emissions can be critical and may strongly influence the mixing/ignition/combustion strategies. It was not clear to the reviewer how the baseline engine-out NO_x emissions for the diesel case were determined. The reviewer recommended using the best available diesel fuel technology as the baseline.

Reviewer 5

Pointing out that the U.S. DRIVE Net-Zero Technical Team and the 21st Century Truck Partnership Internal Combustion Engine Technical Sector Team roadmaps have identified ethanol and methanol as fuels with near-net-zero-carbon potential, this reviewer affirmed that the project is on track to help characterize these non-petroleum fuels and provide an understanding of fuel property effects on NO_x and particle emissions. The reviewer remarked that these alcohol fuels are not suitable for MCCI in modern diesel engines due to low ignitability, lower energy densities, compressibility, lubricity, and material compatibility challenges. The person reported that the project has developed a database with OH radical, infrared, and liquid imaging of in-cylinder processes of pre-chamber-ignition methanol combustion for CFD development and validation. The project has also established the minimum level of ether mixing needed for reliable ignition across a range of operating conditions that span typical off-road duty cycles. The project is currently characterizing various mixing regimes and has revealed various challenges with methanol port injection and high latent heat of vaporization. Finally, the reviewer conveyed that the project has been able to achieve stable combustion at a wide range of operating conditions through pre-chamber fuel mixing and addition of large amounts of ethers (40%—50% diethyl ether and diethylene glycol diethyl ether).

Reviewer 6

The reviewer remarked that the measurements and observations are progressing in line with the project plan. The reviewer questioned whether there is a crank angle window to inject a pilot that allows the kernels to form, and how much timing flexibility (efficiency) that leaves. The reviewer also questioned whether the project data indicate which changes are needed in the engine combustion chamber (or injector/nozzle) to enable methanol and/or ethanol to be used in a practical application. The reviewer expressed interest in an explanation of the directions for any aftertreatment and a projection of how the results differ from current fuels with such catalyst formulations, asking whether the results point to a likely need for greater precious metal content or different catalyst approaches versus current applications.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that although bowl design is very important to controlling NO_x and soot with MCCI, the only mention of bowl design in the presentation was a statement that a production bowl was utilized. Collaboration with current industry partners to investigate improved geometry for DI of alcohols. The reviewer suggested that a CFD design of experiment could be used to evaluate sensitivities of ethanol and methanol to a number of bowl design parameters. The reviewer also suggested that industry partners validate the CFD with data from Sandia National Laboratories.

Reviewer 2

This reviewer was impressed by the collaboration and coordination across the project team and external partnerships, noting the importance of this collaboration and coordination in maximizing the value of experimental capabilities that exist within the project.

Reviewer 3

The reviewer remarked that the mix of partners for this project is good but observed that the activities are scattered across a wide range of different technical topics. It was not clear to the reviewer how these different tasks complement each other to advance MCCI combustion for alcohol fuels.

Reviewer 4

This reviewer recommended that partners in emissions research and emissions control catalyst development be added to the team to ensure that emissions control is an integrated part of this project.

Reviewer 5

This reviewer described the project's collaboration and coordination as outstanding, with a mix of industrial partners, multiple national laboratories, and several universities. The reviewer also noted that the project is conducted in close cooperation with U.S. industry through the Advanced Engine Combustion Working Group.

Reviewer 6

The reviewer suggested showing the contributions of each collaborator on the results slide to provide reviewers with a better understanding of where and how collaboration contributes to the findings and conclusions, pointing to Slide 22 as an example.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer conveyed that three future research tasks were proposed. The reviewer remarked that the first task, characterizing heat transfer and wall temperature in a methanol-fueled MCCI engine, will be useful for industry partners to evaluate this fuel as drop-in with current hardware but noted that the utility of this point was not explicitly covered in the presentation. The reviewer asserted that piston and injector specifications will impact heat transfer and recommended identifying sensitivities related to these specifications. The second and third tasks, exploring methanol premixed combustion with a pilot and developing and validating kinetic models, respectively, were described by the reviewer as a natural progression from the technical accomplishments to date.

Reviewer 2

The reviewer remarked that this project's proposed future research is only somewhat aligned with alleviating barriers to utilization of lower-carbon-intensity methanol and ethanol fuels in off-road and marine applications. The person asserted that future work should focus on industry-relevant combustion systems that rely on high-energy ignition of premixed methanol or ethanol. This can include a broad range of physical systems, such as pilot ignition, pre-chamber ignition, or direct spark ignition, all of which present different barrier/opportunity tradeoffs and are being pursued by industry.

Reviewer 3

This reviewer commented that the proposed future work captures some key areas of MCCI combustion for alcohol fuels. Piston and cylinder head surface temperature and heat transfer measurements, for example, are of practical significance, and dual-fuel combustion can be a feasible path. The reviewer encouraged the project's efforts that deepen the understanding and generate relevant engine test data toward developing high-fidelity, predictive combustion models. The person affirmed the importance of future research on ignition chemistry but noted that flame propagation measurements may not be strongly relevant, considering the nature of compression ignition. The reviewer recommended that the project team think strategically about the framework of the MCCI combustion approach on which the project will focus to address the key technical barriers (i.e., cold start, low-load performance, full-range combustion strategy). This will help make the proposed future research more organized and cohesive.

Reviewer 4

Because emissions measurements are planned only during the final period of the project, the reviewer concluded that the project plans to employ an after-treatment emissions control solution. With the stringent emissions regulations for aldehydes, it is unlikely a simple after-treatment device can solve the problem or can be a cost-effective solution, according to the reviewer.

Reviewer 5

This reviewer related that the project, as presented, is 50% complete, with significant milestones yet to complete in Fiscal Year (FY) 2024. If the current year milestones are all met on time, proposed future research includes developing an understanding of piston and cylinder head heat transfer for a methanol-fueled MCCI engine, establishing a database detailing the evolution of ignition and combustion for premixed alcohol ignited by pilot injections of a highly reactive dual-fuel (diesel and dimethyl ether [DME]), and additional CFD modelling and chemical kinetics to capture ignition and flame propagation of methanol. The reviewer affirmed that these tasks are a logical continuance to further the understanding of mixed alcohol MCCI combustion. The reviewer recommended undertaking an investigation and analysis of NO_x, GHG, and particulate matter (PM) emissions under experimental conditions to verify modeling predictions, as the current mixing modeling does not capture the experimental results. The reviewer asserted that alcohol combustion in compression ignition engines should produce lower criteria emissions than diesel but expressed interest in seeing experimental results showing the extent of the emission reductions.

Reviewer 6

This reviewer concluded that the project's proposed future work is reasonable. The person remarked that improving the environmental impact of difficult-to-electrify applications while allowing these applications to perform as expected requires continued evaluation of replacement or modified fuels that can easily be managed by the supply chain within the current U.S. production stream.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports VTO subprogram objectives to minimize formation of emissions and develop a better understanding of how fuel properties affect advanced combustion systems.

Reviewer 2

This reviewer stated that the project's current implementation and approach are not relevant to the VTO objective of increasing utilization of next-generation, lower-carbon-intensity fuels (methanol and ethanol). However, by changing the approach to focus on practical combustion systems, the project could reduce barriers to utilization of these fuels, thereby delivering relevance to the VTO objectives.

Reviewer 3

Asserting that MCCI combustion should be the primary path for alcohol fuels in off-road applications, the reviewer concluded that the high-level technical relevance of the project is sound. However, the reviewer expressed concern that some of the tasks are not strongly tied to MCCI combustion and that there is insufficient focus on some of the known challenges for compression ignition of fuels with lower autoignition reactivity, considering the large body of works in this area.

Reviewer 4

This reviewer deemed the project highly relevant to advanced engine and fuel technologies, noting that methanol and ethanol are two renewable fuels that can potentially accelerate the decarbonization of the transportation sector, particularly the hard-to-electrify off-road engine.

Reviewer 5

The reviewer remarked that this project supports the decarbonization of the off-road transportation sector, a major objective of the VTO DORMA program, through fundamental research to understand alcohol combustion in compression ignition engines. The characterization research conducted through the project is a first step toward enabling the use of net-zero-carbon fuels for off-road transportation. The reviewer conveyed that the U.S. National Blueprint for Transportation Decarbonization, which states that 79% of the total fuel consumed today by off-road vehicles is diesel, identifies the use of sustainable liquid fuels and the reduction of ethanol carbon intensity as vehicle improvement strategies for the off-road transportation sector.

Reviewer 6

This reviewer concluded that the project's identification of candidate fuels for advanced engine technologies is well aligned with the VTO DORMA program's objective of enabling difficult-to-electrify applications to continue to perform and improve their environmental impact. The reviewer observed that this project seeks to improve the applicability of available fuels.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer stated that the project is well organized, spreading responsibilities across a variety of facilities, including Sandia National Laboratories' Combustion Research Facility (CRF), Argonne National Laboratory, and multiple universities. The reviewer asserted that the project's resources are sufficient to meet the milestones.

Reviewer 2

The reviewer described the project's FY 2023 budget of $1,050,000 as excessive and the FY 2024 budget of $450,000 as sufficient.

Reviewer 3

This reviewer remarked that the project's resources are adequate for its milestones and timelines.

Reviewer 4

The reviewer observed that the team had adequate resources and was making good progress in the project.

Reviewer 5

This reviewer concluded that the project's funding is sufficient to meet its fundamental research objectives in FY 2024 and that the project is well organized and on track to meet its stated milestones. The person noted that while the presentation showed FY 2023 funding of $1,050,000 and FY 2024 funding of $450,000, it was not clear how much funding was utilized during which fiscal year and over the various tasks of the project.

Reviewer 6

The reviewer remarked that the project seems well managed. The objectives are being met using the skillsets of the project's contributors. Analysis details are thorough and support the plans and directives. The reviewer observed that the project's timeline, contributors, and facilities were adequate to support progress.

Presentation Number: DORMA003
Presentation Title: Soot Predictions from DNS of a lab-scale combustor with sustainable aviation fuels
Principal Investigator: Bruno Souza Soriano, Sandia National Laboratories

Presenter

Bruno Souza Soriano, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

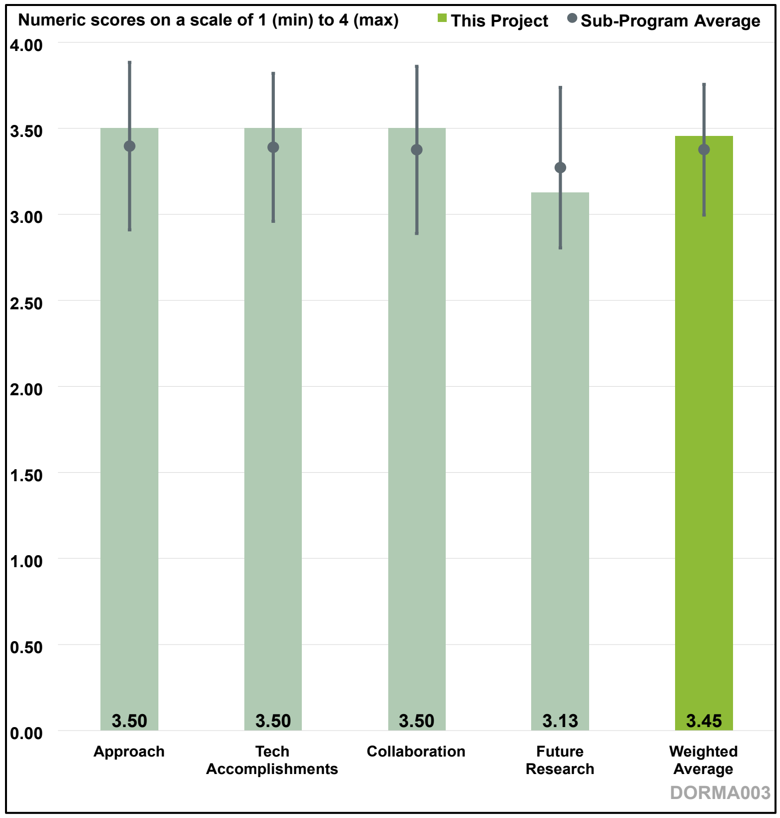

Figure 3-3. Presentation Number: DORMA003 Presentation Title: Soot Predictions from DNS of a lab-scale combustor with sustainable aviation fuels Principal Investigator: Bruno Souza Soriano, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer remarked that the project is addressing potential shortcomings in turbulent combustion modeling and soot modeling for Jet-A and sustainable aviation fuel (SAF) in flow conditions suitable for capturing the key processes occurring in gas-turbine combustors. The person noted that direct numerical simulations (DNS) completed and planned have the potential to provide high-quality data for improving combustion and soot modeling applicable to large eddy simulations (LES) and that progress to date indicates a high probability of meeting the overall goals of the project.

Reviewer 2

The reviewer conveyed that this project is working toward overcoming barriers to SAF adoption by addressing the lack of understanding of soot production processes for SAF combustion. This reviewer affirmed that the project will advance understanding of soot emissions by creating DNS simulations of relevant turbulent flames that implement multiphase fluid dynamics, polycyclic aromatic hydrocarbon chemistry, and soot chemistry models. According to the reviewer, the investigators aim to produce simulations of turbulent soot-producing flames with fidelity exceeding the current state of the art. The investigators will use LES to establish DNS boundary conditions for a swirl-stabilized flame. DNS-simulated soot measurements will be compared with experimental observations. The reviewer described the project tasks as well-chosen and logical and the timeline as reasonable.

Reviewer 3

This reviewer reported that the project is addressing the multi-faceted technical challenge of accurately predicting soot produced by gas turbine combustion of SAF-relevant fuels, which requires accurate modeling of the combustion, soot inception and growth, soot oxidation processes, and other processes. The project will leverage DNS to capture the multi-modal multi-phase spray swirl combustion that occurs in the gas turbine engine, evaluating the DNS techniques and soot modeling approaches with laminar configurations before applying them to more challenging combustor setups. The reviewer affirmed this approach and mentioned the project team's collaboration with several other groups to facilitate achievement of project objectives. Noting that the project's two-year duration is short for a project of this scope, the reviewer nonetheless observed that the project team is not only on track to achieve the research goals, but is also mining data from the DNS to extract key information about the combustion process (e.g., effect of backscatter, flame propagation modes) and has developed a neural network based technique to advance flamelet strategies. The reviewer applauded the team's elucidation of key underlying physics in these areas, adding that the project's findings will significantly add to the research community's knowledge base on SAF performance in gas turbine engines.

Reviewer 4

This reviewer stated that the approach of this project is to use experimental results from various combustion configurations to understand processes associated with soot formation and to validate numerical models for soot produced from jet fuels (Jet-A and C1) in the configurations selected. The configurations include a laminar flame configuration ('canonical configuration,' though that term was not defined in the presentation), a counterflow flame, and a burner with spray injection at the bottom. The reviewer described the configurations (excepting the Cambridge burner) as "rather fundamental in their operation." The reviewer explained that a range of simulation tools and models are applied to these configurations to provide data for evaluating models of soot formation and kinetic mechanisms for oxidation.

The reviewer pointed out that the configurations selected by the project (e.g., a laminar counterflow burner with no turbulence present) are often used in fundamental studies to elucidate certain aspects of combustion physics in isolation. Premixed flames, counterflow burners, etc., are appropriate for this purpose and can shed light on fundamental processes associated with soot formation, gaseous GHG emissions, and turbulence models. The reviewer highlighted that results from fundamental burner designs need to then be linked to inform operation and design of more efficient engines. It is not clear which specific fundamental results (e.g., oxidation chemistry, soot model, turbulence models) can be carried over to a practical engine, or how the results obtained from this project would reduce emissions that affect GHG or contrail formation. As an example, the reviewer asked whether the finding that 'premixed flames have a larger contribution to the heat release rate' is also relevant to the environment of a jet engine.

The reviewer observed that the Cambridge burner configuration incorporated spray injection at the bottom, to which adaptive mesh refinement reactive flow solvers, including spray, soot, and radiation models, were applied. However, the reviewer noted that the models were not described, so it was not possible to know how detailed the spray modeling was. The reviewer expressed interest in determining optimal conditions for rapid evaporation of the injected spray to initiate combustion, which was not discussed during the presentation.

According to this reviewer, soot and turbulent flow models were mentioned during the presentation, but it was not evident to what extent the models validated with the basic burner designs are applicable to a real jet engine. The reviewer would have appreciated a discussion of the models' applicability to real engines.

The reviewer also reported that the presentation was missing a discussion of the reason naphthalene was chosen as a representative soot precursor in the model. The reviewer asked why C_2H_2 or some other molecule was not chosen.

The reviewer noted that the presentation repeatedly referred to modeling and experiments for Jet-A and pointed out that Jet-A itself is too complex for modeling. A surrogate must be developed for it. No surrogate was noted in the presentation that the reviewer could recall, so the reviewer was unable to evaluate its efficacy or applicability and the circumstances for validating it.

The reviewer recalled that the configuration used in the project for soot modeling was a counterflow flame. The connection of this configuration to a practical combustor or engine was unclear to the reviewer. In this configuration, liquid is completely eliminated by vaporization, and the flow is one-dimensional, which is dissimilar from a jet engine, where multiphase effects could be present and the flow is not one-dimensional. The reviewer asked whether the project team expects that a robust soot model will result from simulations of soot using validation data from this burner. Acknowledging that a connection likely exists between the model configuration and a practical engine, the reviewer remarked that the link was not clear in the presentation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This reviewer stated that the DNS simulations of the Cambridge swirl burner with Jet-A and C-1 have found that backscatter of turbulence energy from small to large turbulence scales is occurring for certain conditions and may be important for lean blow-out (LBO) predictions. LBO is an important combustor operability characteristic for assessing SAF impacts. The project has developed and validated deep neural network (DNN) subgrid models for three dissipation rates appropriate to manifold (or flamelet) approaches to modeling turbulent combustion and demonstrated a significant improvement in accuracy in predicting these dissipation rates for the Cambridge burner burning C-1, which was not used for training the DNN subgrid models. The reviewer remarked that the current Jet-A and C-1 fuel soot chemistry and soot evolution modeling in two-dimensional DNS simulations of counterflow flames is showing good comparisons with low-pressure experiments (or DNS with the more detailed Lawrence Livermore National Laboratory chemistry). The reviewer was encouraged by these results, describing the project's work as an excellent step in preparing for the more complex DNS simulations with soot and radiation for the Cambridge swirl burner.

Reviewer 2

This reviewer found that the study has been productive so far, remarking that the multiphase DNS simulating a University of Cambridge swirl-stabilized burner is working. The reviewer acknowledged the investigators for identifying complex extinction and reignition behaviors and determining the relative heat release rate for premixed and non-premixed zones of the flame. The project has demonstrated that extinction and reignition events are related to turbulent backscatter, which is only captured with DNS and cannot be captured with LES. The team has identified fuel effects on LBO behaviors. Simulations using a reduced jet fuel mechanism for a laminar counterflow flame were used to demonstrate that this mechanism could accurately predict the location of soot precursors. The results of the simulation were compared with a counterflow experiment; the location of soot production was very accurately identified, though the soot volume fraction was somewhat overpredicted. The investigators explored fuel effects and strain rate effects on soot production. The reviewer praised the team for its accomplishments to date.

Reviewer 3

The reviewer acknowledged the thoroughness of the PIs' analysis of past DNS results from the swirl combustor setup. The reviewer remarked that premixed edge flames have been shown to dominate the combustion process through modal analysis, adding that the results further show the effect of deflagration fronts working with ignition fronts to sustain the turbulent flame. The reviewer is interested in seeing an evaluation of the particular effects of these modes at conditions very close to LBO. This is already partly addressed in the project through correlating LBO to edge flame displacement speed, which itself correlates to derived cetane number. The reviewer is also interested in the turbulence back-scatter and its stabilizing effect on LBO, which suggests possibilities of tuning turbulence to suppress LBO and illustrates the need for LES models to incorporate back-scatter. The reviewer affirmed that the constrained DNN approach shows good agreement with DNS and offers an improved approach to multi-modal flame modeling.

Reviewer 4

The reviewer commended the team for getting a lot of results from their efforts over the past year. The reviewer was impressed by the DNS of the complex environment of the lab-scale aero-combustion, the turbulence modeling, and the soot modeling. The reviewer was interested in the LBO correlation with flame displacement speed and the finding that LES turbulence models do not capture back-scatter extinction regions and found the effort of 'training dataset selection' potential useful.

The reviewer presumed that a Jet-A surrogate was used in the soot modeling effort but noted that it was not specified. Likewise, the kinetic mechanism was not described, and the modeling of soot volume fraction (SVF) was not very clear. The reviewer pointed out that the role of thermal and transport properties in the simulations was not discussed but could have an effect on discrepancies.

The reviewer refuted the assertion that the conditions of the counterflow flame configuration were similar to those of swirl flames, pointing out that the counterflow configuration ostensibly produces a well-defined transport while transport within a spray flame is more chaotic, with both turbulence and swirl being present. Since the counterflow flames completely eliminated the liquid phase by vaporizing it, there were no fuel evaporation effects in the counterflow environment, whereas fuel evaporation effects would be present for a swirl-stabilized spray flame. The reviewer suggested that some discussion of how counterflow burner results can be connected to, or inform, operation of a jet engine would be appropriate.

This reviewer described the soot experiments in the counterflow configuration as impressive but questioned the assertion that the SVF results show satisfactory agreement, noting that some of the comparisons seem to show significant differences. For example, while broad trends of SVF are captured by the numerical modeling, comparing measured and simulated SVFs for ethylene with models from Lawrence Livermore National Laboratory and the PeleLMeX code illuminates some discrepancies; in some cases, differences of an order of magnitude exist between measured and simulated SVF, and in other cases, differences are 30% or more, as shown in Slides 19 and 20. The reasons for the differences and a strategy to close the gap were not discussed. The reviewer suggested that there are many potential reasons for these differences, including failure to validate a kinetic mechanism that incorporates soot precursor chemistry in a way that would promote its generality (i.e., using data from only one combustion configuration vs. several), inaccuracies of thermal and transport properties (e.g., diffusion coefficients, gas thermal conductivity), rate constants in the kinetic mechanism not being known to a high degree of accuracy, choice of reactions in the mechanism, and an insufficient number of soot precursor reactions being incorporated.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer applauded the project's excellent use of existing experiments and collaborations with both Lawrence Livermore National Laboratory and the University of Illinois at Urbana-Champaign on chemistry models for Jet-A and SAF that include soot precursors. The reviewer suggested that additional collaborations may be needed in the future to validate the models at higher pressures using sooting flame experiments with Jet-A and/or SAF at pressures higher than a few atmospheres.

Reviewer 2

This reviewer conveyed that Sandia National Laboratories leads the project and coordinates with two other national laboratories and three universities on DNS implementation, soot modeling, experimental data, and chemical mechanism development.

Reviewer 3

This reviewer commended the project's collaborations, remarking that the collaborations were strategically chosen to provide support with soot modeling, mechanism reduction, and experimental validation of computational approaches. Acknowledging the likelihood that the current collaborators significantly contributed to the progress of this work, the reviewer did not see a need for more collaborators.

Reviewer 4

The reviewer remarked that the project team is excellent. It incorporates two national laboratories and three academic partners, with one being international. The team has considerable expertise with experiments and modeling. The data produced seem accurate and the numerical modeling rigorous.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project plans to complete the Cambridge burner simulations with correct geometry, both without soot and including soot and radiation. This reviewer expressed confidence that the planned work would be completed, considering the simulations already completed. The reviewer noted, however, that the timeline for future work on higher pressure simulations or improved soot modeling was not clear from the presentation.

Reviewer 2

The reviewer affirmed that the next steps in this project are well-planned and expressed an expectation that the project's goals will be achieved, considering the promising results to date. Building off previous soot model validation and multiphase DNS success, the next steps are to implement soot and radiation models within DNS and to refine the boundary conditions. At a later time, the project will explore pressure effects on soot behavior, though experimental measurements at elevated pressure are not available for validation.

Reviewer 3

The reviewer related that the PIs have defined several pathways for future research. First, the team will complete DNS of the Cambridge combustor with the reduced mechanisms and developed soot model. Proposed future efforts would extend simulations to higher pressure conditions, implement a new soot model, and leverage ongoing work on molecular dynamics simulations to advance capabilities to predict soot in greater detail through particle size distribution, chemical composition, and morphology. The reviewer acknowledged that these are challenging tasks but affirmed the value of the proposed work in aiding understanding of soot effects over a wide range of scales.

Reviewer 4

While this reviewer stated that the plan for future research, especially the plan to compare and improve models, made sense, the person cautioned that the presentation did not include specifics of how this comparison and improvement would be carried out or discussion of the associated consequences. The reviewer recommended that the team validate the inputs to the simulation tools (e.g., soot models, kinetic mechanism with improved rate constants, property database appropriate for the temperature and pressure conditions of interest) prior to beginning experiments/simulations at elevated pressures. The reviewer pointed out that if the 1 atm differences cannot be resolved, going to higher pressure will introduce more complications, and more adjustments will be needed to close gaps between experiments and numerical simulations.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is working on improved subgrid turbulent combustion models that may improve simulations of combustor operability (such as LBO and ignition), which is important to assessing fuel impacts. The project is also working to improve soot modeling, which will contribute to improved predictions of aircraft engine emissions of soot and can be an input to contrail formation models.

Reviewer 2

This reviewer concluded that the project is relevant to the VTO objectives. The project is using high-fidelity simulations to understand soot emissions from SAF. The reviewer remarked that a predictive soot model would enable faster and more cost-effective screening of SAF candidates, leading to cost savings for the aviation industry and environmental benefits through emissions reduction.

Reviewer 3

This reviewer asserted that the project supports and is relevant to the DORMA program. The reviewer remarked that SAF has the potential not only to aid decarbonization through a net-zero-carbon approach, but also to reduce soot emissions, because of the fuel's inherent chemical composition and/or physical properties. Thus, SAF should be leveraged to reduce emissions.

The reviewer commented that the DNS efforts of this project and subsequent predictive modeling capabilities have potential to alleviate the 50% blending requirement with Jet-A, leading to use of 100% SAF with lower sooting tendencies. The findings of the detailed analysis of DNS data improve understanding of the combustion and LBO processes and facilitate ideas for implementing techniques to enhance engine safety by addressing issues such as LBO. Furthermore, the DNS work is leading to pathways that can be followed by LES for improved turbulent combustion modeling. Noting that LES is the approach of choice for evaluation of practical combustion systems, the reviewer commended the PIs for extremely useful and relevant work.

Reviewer 4

This reviewer affirmed that the project is relevant to combustion of SAFs in aviation systems, stating that the project, if successful, will influence the achievement of net-zero-carbon aviation. The project's goal is ultimately to achieve a predictive and efficient numerical solver to evaluate the combustion of alternative fuels. The reviewer noted that the PIs expect to improve turbulent and soot formation models in combustion systems through this study. Included are soot models under what are referred to as realistic configurations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer deemed the project team, codes, and high-end computing capabilities of this project to be sufficient, noting that the work builds on expertise and capabilities developed over many years, thereby improving and extending these capabilities.

Reviewer 2

This reviewer concluded that the resources of the project are sufficient and the budget is reasonable, adding that the investigators have the computational infrastructure and technical expertise to perform the simulations outlined in the presentation.

Reviewer 3

While the computational resources seemed sufficient to the reviewer for the project to make progress toward its goals, the financial resources ($125,000) seemed limited and the timeframe seemed short for a project of this scope and technical difficulty.

Reviewer 4

This reviewer concluded that the resources are adequate for the proposed and accomplished work.

Presentation Number: DORMA004
Presentation Title: Mixing-controlled compression-ignition combustion with low-lifecycle-CO2 fuels
Principal Investigator: Chuck Mueller, Sandia National Laboratories

Presenter

Chuck Mueller, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

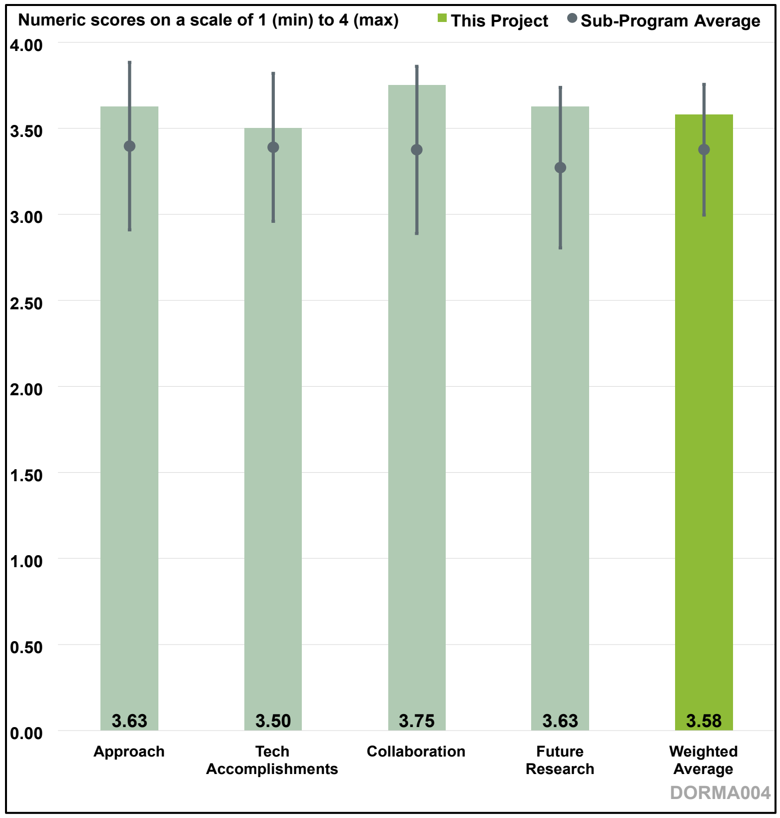

Figure 3-4. Presentation Number: DORMA004 Presentation Title: Mixing-controlled compression-ignition combustion with low-lifecycle-CO2 fuels Principal Investigator: Chuck Mueller, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commended the testing with the Deere six-cylinder engine, noting that using a production engine for this evaluation is likely a key step in achieving broader application of the technology. The companion modeling with various partners was also deemed beneficial by the reviewer. The reviewer remarked that work to visualize low-carbon fuels at Sandia National Laboratories would be beneficial to the engine community.

Reviewer 2

This reviewer praised the project for determining the conditions to control gaseous and particulate emissions from diesel combustion processes, noting the project's excellence. The PI has assembled a team with a wide range of expertise, including OEMs, partners from academia and national laboratories, and no less than 20 industry partners. The approach combines testing of ducted fuel injection (DFI) in a multi-cylinder metal engine and experiments in the Sandia National Laboratories optical engine. The fuels being investigated include biodiesel (i.e., methyl ester mixtures), a renewable diesel, and dimethyl ether, among others. The milestones include targets for engine testing, spray systems, life cycle analysis, commissioning of a DME fuel injection system, and ultimately an assessment of the benefits of DFI as a technology for reducing particulate and gaseous emissions.

Reviewer 3

The reviewer described this project as well designed, noting that the timeline is reasonably planned and the sound approach builds on prior work with ducted fuel injection for reduced diesel particulate matter. Pointing out that engine durability is a key concern for off-highway customers, the reviewer recommended establishing or quantifying the DFI durability with respect to diesel combustion before exploring the extension of DFI in low-lifecycle-carbon-dioxide (CO_2) fuels.

Reviewer 4

This reviewer commended the project for its steps toward moving DFI into multi-cylinder engines, which is very important in bringing this technology from the laboratory to the field. The reviewer also commended the project for performing sensitivity studies on the misalignment of the ducts with injector sprays rather than just on injector holes. Lastly, the reviewer commended the project for exploring the LLCF space to leverage the low-emissions capability of DFI with LLCF. The reviewer remarked that the results are promising, although it is still unclear whether the multiscale engine work will be successful.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the production engine DFI alignment work and sensitivity analysis and the low-carbon fuels interaction study, which includes oxygenated fuels, are useful and interesting. The simulations on misalignment are also helpful from the production engine perspective. The reviewer highlighted the importance of understanding fuel sensitivity to DFI.

Reviewer 2

The reviewer noted that the project reported an extensive array of technical accomplishments, which are discussed below.

The reviewer found the DFI retrofit especially interesting, presuming it would not require a complete engine design to implement but rather could be installed on an existing engine platform. The reviewer recalled that the PI noted issues with cavitation in alignment. It was not clear where cavitation would occur and what supersaturations could be sustained for the fuel systems investigated to create conditions favorable for cavitation to occur. The reviewer asserted that more research is needed to better understand conditions where cavitation could occur.

In the study of rotational misalignments, soot reduction was considered possible with misaligned injectors. The connection between soot and injector alignment was not clear to the reviewer. Although CFD results were shown, the connection with soot was not discussed.

The reviewer found the development of the multi-cylinder engine installed at Excel Engineering impressive. The complexity of the engine hardware seems quite extensive to the reviewer. The reviewer observed that the initial DFI engine results seem conflicting. The table in Slide 12 shows changes in soot to be enormous, depending on the operational torque mode. It is unclear whether soot with an upward arrow (ΔSoot) means less soot production or more soot production. If it means more soot production, then some of the numbers indicate huge increases in soot depending on the operational mode. The reviewer was unsure of the correct way to interpret the table.

The simulation of DFI combustion was unclear to the reviewer because details were lacking. While some results were shown, the details of the simulations were not discussed.

The reviewer observed that DME is a popular fuel being considered for commercialization and asked about realistic expectations for DME commercialization and the prospects for a 'DME economy.'

Reviewer 3

The reviewer said the preliminary results on the application of MCCI combustion with low-lifecycle-CO_2 fuels are promising and offer valuable insights on the importance of fuel oxygenation to engine-out NO_x and particulate emissions.

Reviewer 4

This reviewer commended the project for its promising technical progress to date, expressing hope that the most recent emissions results will demonstrate the project's capacity to shift the soot–NO_x tradeoff even farther. The reviewer acknowledged that the actual market penetration of LLCF in each respective DORMA market and the amount of low carbon leverage these markets can provide remain uncertain.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised the experiments and testing with the Deere engine and the modeling at King Abdullah University of Science and Technology, describing them as outstanding. The reviewer observed that other institutions are also exploring DFI technology and highlighted the importance of having numerous R&D institutions exploring the technology in preparation for future DFI adoption.

Reviewer 2

This reviewer observed that there is significant collaboration and coordination among the partners. This is an enormous project with more than 20 CRADA partners. Each team has its own set of deliverables. Some of the descriptions of the deliverables seemed perfunctory to the reviewer. For example, Georgia Tech is responsible for DFI experiments and theory, along with other collaborators.. But there was no substantive discussion so it was not possible for this reviewer to evaluate.

Reviewer 3

This reviewer remarked that the collaboration and coordination within the project team, which includes partners from industry, academia, and national laboratories, is well documented in the presentation.

Reviewer 4

The reviewer commented that the PI has assembled an excellent team of collaborators and participants for this project. Engine OEMs, universities and national laboratories are all part of the team working on this technology. It was clear to the reviewer that the PI has been successfully gathering collaborators for quite some time.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer mentioned that a comment was made about reduced DFI efforts at Sandia National Laboratories. This reviewer expressed hope that others will continue efforts to understand and optimize the technology, as the reviewer believes the concept has merit, especially in high load applications. The reviewer remarked that the interaction of DFI with newer low- and zero-carbon fuels will be very useful.

Reviewer 2

The reviewer stated that future work will continue multi-cylinder and single-cylinder engine testing of renewable diesel, DME, biodiesel, and blends. The reviewer asked what feedstock is used to produce the renewable diesel. The reviewer noted that the plan includes investigation of volatility effects of oxygenated fuels. The reviewer recommended that the PI develop a flow chart highlighting the role of each entity in achieving the overall objectives, if such a flow chart does not already exist, to enable audiences of presentations such as this to better understand how the various components are being organized to achieve the overarching objective of the project. The presentation should then elaborate on a few specific elements selected by the project team.

Reviewer 3

The reviewer described the proposed future research as comprehensive. The CRADA focuses on multi-cylinder metal engine and single-cylinder optical engine testing of DFI with low-lifecycle-CO_2 fuels, while the core focuses on testing of low-lifecycle-CO_2 fuels with conventional diesel combustion.

Reviewer 4

This reviewer observed that the project is fast approaching a critical phase, where multi-cylinder engine results will need to be put forth, with tolerance and manufacturing information, to move the engine from the lab to the real world. While the reviewer viewed the proposed future work as the correct work, they acknowledged uncertainty as to whether this technology can be successfully commercialized. The reviewer expressed concern that if the project stalls, there may not be many opportunities to optimize any of the variables, such as number of injector holes, injector hole diameter, and stand-off distance to the duct.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believes this technology could have a significant impact, especially in compression ignition engine applications that run high-load duty cycles, where soot formation is most problematic. The reviewer commended the project for its outstanding focus on lower soot and modifying the classic NO_x–soot tradeoff curve. The reviewer acknowledged that the additional complexity and cost are a concern but said the impressive performance improvements are likely to encourage others to utilize the technology.

Reviewer 2

This reviewer commented that the project is exceptionally relevant to the VTO program with its emphasis on emissions from operation of combustion engines in ground transportation systems.

Reviewer 3

This reviewer explained that the project supports the overall VTO subprogram objective of providing low-cost, secure, and clean energy technologies to move people and goods by helping to close the knowledge gaps pertaining to the development of combustion strategies that simultaneously lower engine-out NO_x, soot, and lifecycle CO_2 emissions.

Reviewer 4

The reviewer expressed the opinion that this project's work is important to the future of DORMA technologies, both from a fuels point of view and an emissions reduction point of view. The reviewer pointed out that DFI and LLCF support the DOE mission to decarbonize and comply with future air quality emissions regulations in hard-to-electrify markets.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources appeared to be sufficient to this reviewer.

Reviewer 2

This reviewer noted that there are a lot of partners for this project and that the budget seems realistic for the work that is being done.

Reviewer 3

The reviewer stated that the investigators are on track to meet the milestones outlined in the project plan with the current funding levels.

Reviewer 4

This reviewer observed that the resources appear to be sufficient to continue and maintain progress on this project.

Presentation Number: DORMA005
Presentation Title: Alcohol spray and H2 jet experiments and modeling
Principal Investigator: Lyle Pickett, Sandia National Laboratories

Presenter

Lyle Pickett, Sandia National Laboratories

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

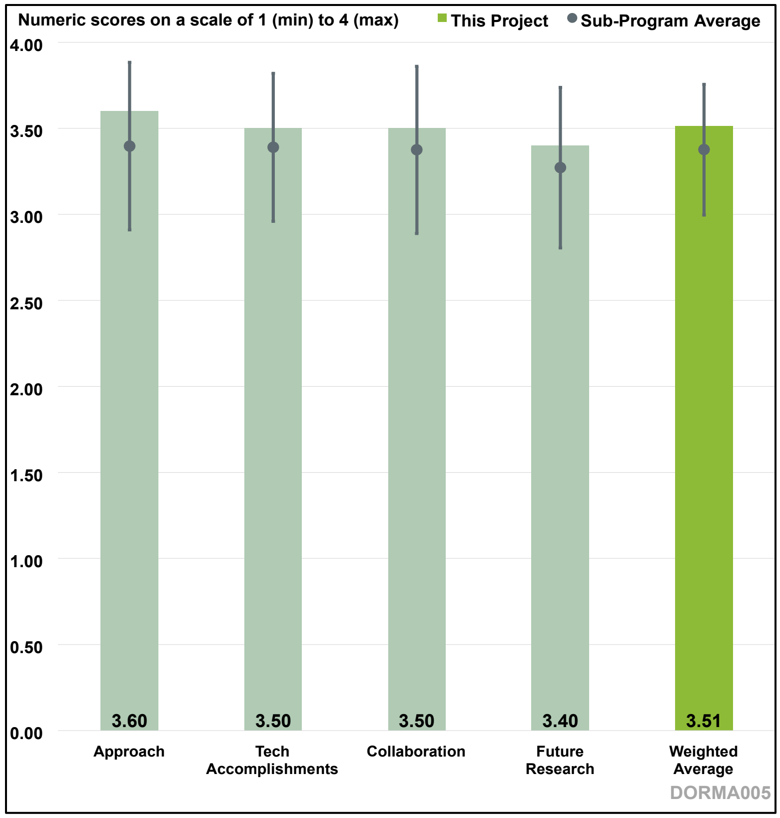

Figure 3-5. Presentation Number: DORMA005 Presentation Title: Alcohol spray and H2 jet experiments and modeling Principal Investigator: Lyle Pickett, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This reviewer commented that the project is well designed. The reviewer noted that more time may be needed to address H_2 injection barriers. The reviewer conveyed that the project handles methanol vaporization challenges with intake/fuel heating and multiple injections. The proposed future work presented included improved methanol modeling to fill an identified need. The reviewer cautioned that mixture fraction and temperature modeling of supersonic H_2 flow modeling may take more time than scheduled given the diagnostic and modeling challenges presented, which include supersonic flow, temperature distribution of the under-expanded jet, and hardware acquisition/fabrication.

Reviewer 2

The reviewer stated that this project is applying state-of-the-art experimental spray diagnostic techniques to the new challenges of understanding spray physics for non-conventional fuels (hydrogen and methanol). It is also effectively leveraging CFD “virtual experiments” to supplement the experimental diagnostics that are being carried out, in order to determine where gaps in the predictive capabilities of CFD exist. The reviewer concluded that the work being carried out under the project directly contributes to addressing technical barriers related to the direct utilization of lower-carbon-intensity hydrogen or methanol in combustion engines. The only weakness the reviewer identified in this project is the use of light-duty gasoline injector hardware for the methanol work. The reviewer acknowledged that this may have been a necessary compromise to begin the project work and take a “first look” at methanol spray physics but stressed that it will be essential to rapidly transition the work to more representative injector hardware, as major differences in the spray configuration can impact which physical processes are dominant in the development of the spray and which physics are most important for CFD software to capture to allow for predictive modeling.

Reviewer 3

The reviewer affirmed that the technical approaches used by the project to address key areas in characterizing spray behavior of low-carbon fuels are sound. The reviewer emphasized the importance of the H_2 jet characterization and modeling for designing appropriate fuel–air mixture formation in H_2 engines. Regarding methanol spray, the reviewer stated that further clarification is needed on the decision to investigate gasoline direct injection (GDI) spray instead of diesel-like high-pressure direct injection spray. If the team intends to study dual-fuel MCCI using GDI to introduce methanol to the engine cylinder, this needs to be clearly communicated.

Reviewer 4

This reviewer praised the approach that is being taken to address the technical barriers and acknowledged the steps being taken to address the key problems arising from the fluid properties.

Reviewer 5

This reviewer commented that the project uses outstanding experimental capabilities to generate and provide crucial information on spray behavior, ignition, and other combustion phenomena. The reviewer observed that the application of these capabilities to the understanding of fuel mixing, ignition, and combustion of low-carbon-intensity methanol and hydrogen for off-road vehicle systems is timely and needed. The reviewer asserted that improving the efficiency of combustion and generating the understanding that permits robust engine design (e.g., preventing or minimizing preignition of H_2) will eliminate barriers to technology implementation. The reviewer noted that methanol’s high latent heat of vaporization is both a barrier and a benefit, as it cools the chamber but may extend spray penetration, leading to wall impingement.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the methanol spray experiments and corresponding CFD work have been completed, but challenges remain with respect to matching experimental data. The reviewer pointed out that the use of multiple small injections may limit scalability to high-load conditions. The reviewer also stated that H_2 jet experiments and corresponding CFD work have been completed, and the project plans to address new barriers with supersonic flow and a cold jet temperature.

Reviewer 2

This reviewer remarked that the project has made effective progress against the project plan. The team has identified the role of flash boiling on methanol spray collapse and the challenge of predicting this behavior using commercial CFD codes. The reviewer noted that this important result directly guides DOE and industry work toward resolving gaps in the predictive capabilities needed to design internal combustion engines capable of utilizing lower-carbon-intensity methanol fuel. The reviewer also observed that the project has made important discoveries regarding hydrogen sprays and the role that hydrogen cooling and sonic phenomena have on spray performance.

Reviewer 3

The reviewer commended the project for excellent progress toward generating high-quality experimental data and for providing insightful findings on the fundamental physics involved during the fuel injection process for methanol and H_2.

Reviewer 4

This reviewer remarked that the examples and measurements presented provide the intended insight. Noting that the project is doing fundamental work to provide insight, the reviewer asked if the team has thought about cell size, cell count, or geometric sensitivity. The reviewer asked if the variation in nozzle orifice geometry altered the approach to meshing and if the effect of supersonic flows (mentioned as a computation challenge) altered the approach to mesh generation.

Reviewer 5

The reviewer commented that this work on methanol and hydrogen combustion has extended the understanding of flow, mixing, ignition, and combustion phenomena in important ways. The reviewer asserted that combining CFD with high-fidelity experiments is providing new and deeper insights than most other research has been able to provide. For example, these experiments have shown a very complicated response of methanol liquid spray mixing to mild fuel heating. Moreover, these experiments have shown the underlying liquid interactions when using a split injection, which explain the origin of benefits for methanol spray from multiple injection strategies. In the case of hydrogen gas jet, the combination of hydrogen injection and gas dynamics phenomena (shock waves, reflecting waves, Mach disk structures) during H^2 injection. The reviewer noted that this work enables the design of advanced engines by providing the information to develop better fuel injection simulation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer commended the excellent collaboration within CRF facilities for simultaneous experimental and modeling work and noted that additional collaboration exists with Argonne National Laboratory, Convergent Science, and the Engine Combustion Network. The reviewer mentioned some collaboration with Caterpillar in relation to DORMA002, which is also conducted at the CRF.

Reviewer 2

The reviewer praised the project for being an example of effective collaboration and coordination across DOE and industry efforts. The use of a variety of collaborative structures, including a CRADA, the Sandia-organized Engine Combustion Network, individual external collaborations with Argonne National Laboratory and Convergent Science, and internal coordination with adjacent DOE projects within Sandia National Laboratories, demonstrates to this reviewer that the project team is actively pursuing opportunities to disseminate its findings and transfer learnings as efficiently as possible.

Reviewer 3

This reviewer stated that the project is well connected to partners and that the project's spray characterization data is foundational to partners' activities. The reviewer expressed a desire to see more engagements from industrial partners to steer the scope of the project and provide critical inputs on hardware selection and operating boundary conditions.

Reviewer 4

The reviewer remarked that the exchange of findings between the collaboration partners appeared to be effective and useful. The reviewer appreciated seeing the contributors, by topic, in the slides. The reviewer suggested that input from injection system manufacturers, if not already included, would help guide the range of variation.

Reviewer 5

This reviewer observed that the project is characterized by broad engagement and that it connects with the engine and combustion community through the Engine Combustion Network, a platform for sharing experimental and numerical data. The person also noted that there is CRADA support from Caterpillar on both methanol and hydrogen in addition to the DOE project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer concluded that the proposed future work addresses most barriers described in the preceding slides. The person cautioned that relying on intake manifold heating creates cold-start and low-load operational and packaging challenges while increasing cost. The reviewer recommended exploring and testing methods for pre-heating the fuel prior to injection as a substitute to intake heating.

Reviewer 2

The reviewer asserted that the project's proposed future research is well aligned with the DOE mission to alleviate barriers to lower-carbon-intensity fuel utilization. Further, the proposed research is regarded as well aligned with the experimental capabilities of the lab and the expertise of the researchers. The reviewer commented that the diagnostic development for hydrogen sprays is an excellent use of the lab and DOE resources, as it yields high-fidelity data that will be critical to advancing predictive tools, yet it is an area in which industry is unlikely to invest because of the precompetitive nature of the effort.

Reviewer 3

This reviewer strongly encouraged the project team to gather adequate input from the industry on the most representative hardware and testing boundary conditions, suggesting that the HDEV4 may not be the most relevant selection for H_2. The reviewer also highlighted the importance of coordinating and aligning on the injector hardware between the constant volume combustion chamber spray characterization and the fuel–air mixture formation characterization planned for the optical engine at Sandia National Laboratories. The reviewer stated that it is imperative to clarify what type of fuel injection system and overall combustion strategy are intended for the methanol spray characterization.

Reviewer 4

This reviewer observed that mentioning the challenge of obtaining injectors without proprietary protection seems misplaced for such fundamental work. The reviewer recommended normalizing the variation in hole geometry such that an understanding of large variations in geometries is presented to determine model prediction impacts, leading to increased simulation confidence.

Reviewer 5

This reviewer affirmed that the plan for future experiments will lead to new knowledge of the essential physics and chemistry of the spray and combustion behavior of the fuels investigated and illuminate ways to overcome the technology barriers that limit the effective implementation of the fuels. The reviewer noted that the detailed future plans are targeted toward addressing key barriers that need to be understood for fuel injection system and engine design.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports VTO subprogram objectives to develop a better understanding of how fuel properties affect advanced combustion systems.

Reviewer 2

This reviewer remarked that the project is relevant to DOE goals to remove barriers to the introduction of lower-carbon-intensity fuels for off-road and marine transportation. The project directly contributes to removing barriers to implementation of hydrogen and methanol by providing high-fidelity data and understanding of key spray physics for these novel fuels.

Reviewer 3

The reviewer expressed the opinion that the project is well aligned with the VTO subprogram objectives but highlighted the need to strengthen the project's relevance to practical applications. For instance, it was not clear to the reviewer how GDI spray characterization for methanol contributes toward the application of MCCI combustion strategy for off-road applications. The reviewer also pointed out the need to align the selection of an H_2 injector and operating boundary conditions with the practice in the industry.

Reviewer 4

This reviewer observed that the project investigates less-known details of spray mechanics for candidate low- or zero-CO_2 fuels. The person said that the complications of implementing the two fuels studied within the project, compared to incumbent fuels (diesels), warrant revisions to simulation models. The reviewer affirmed that the project's objectives support advanced engines and fuels.

Reviewer 5

The reviewer remarked that this project is highly relevant to DOE goals and objectives and that it addresses research needs to support the utilization of low-carbon fuels in future engines.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer stated that direct collaboration with an engine and/or injector OEM could greatly enhance the project. An OEM collaborator could assist with acquiring hardware (a noted challenge), fuel heating, and scaling injections for high load conditions (a noted barrier).

Reviewer 2

The reviewer expressed concern that the project's resources are slightly insufficient to accomplish the broad range of work needed to support both hydrogen and methanol utilization.

Reviewer 3

This reviewer asserted that the project's resources are sufficient to support the tasks and the timeline.

Reviewer 4

The reviewer observed that the project is timely and is on track to meet its objectives. However, the reviewer felt that there should be more emphasis on the model implications of the findings and assessments of the predictions included.

Reviewer 5

This reviewer remarked that the project's funding appears to be sufficient and is spread over a long enough period to achieve highly impactful outcomes, noting that continuity of support has enabled an extremely important capability at Sandia National Laboratories.

Presentation Number: DORMA006
Presentation Title: Low Lifecycle Carbon Fuel (LLCF) combustion and emission models
Principal Investigator: Scott Wagnon, Lawrence Livermore National Laboratory

Presenter

Scott Wagnon, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

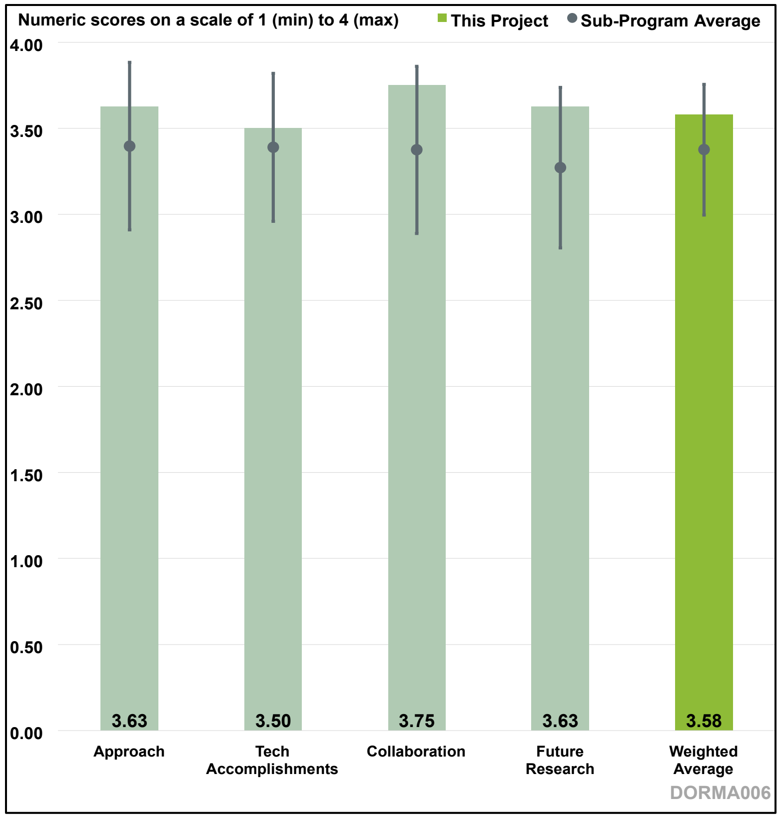

Figure 3-6. Presentation Number: DORMA006 Presentation Title: Low Lifecycle Carbon Fuel (LLCF) combustion and emission models Principal Investigator: Scott Wagnon, Lawrence Livermore National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commended the project for excellent developments. The reviewer questioned whether there are fundamental ways to speed up or automate part or all of the process. The reviewer asked if a fuel molecule could be input from first principles, leading to production of an initial detailed chemical kinetic model.

Reviewer 2

This reviewer concluded that the project is well designed, technical barriers of the work scope are being reasonably addressed, and the timeline is reasonably planned, with the project currently 42% completed.

Reviewer 3

This reviewer emphasized the importance of developing and improving the kinetics models to the decarbonization efforts in DORMA. The person added that developing surrogates that accurately predict fuel behavior, and validating that behavior, are very important. The reviewer praised the project for addressing each of these barriers in a very positive and successful way.

Reviewer 4

The reviewer remarked that the work supports an improved understanding of a variety of future fuels and provides essential information to enable the design of future combustion systems for transportation. The person pointed out that predictive modeling remains a grand challenge for DOE and that the kinetic modeling tools need to be developed to allow robust modeling.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This reviewer stated that the Jet A and SAF chemical kinetic developments will be useful for the R&D community and that the validation work in the rapid compression machine and University of Connecticut burners is essential. The reviewer was glad to see the Zero-order Reaction Kinetics (Zero-RK) solver software and Global Pathway Selection Zero-RK reducing software published for open use.

Reviewer 2

The reviewer acknowledged that the project is doing challenging work and affirmed that reasonable technical progress has been made toward accomplishing the goals of the project plan. The person expressed concern, however, that many of the milestones have not yet been met. It was not clear to the reviewer how well the research community understands the kinetic mechanisms for these lighter fuels based on the results presented in the report.

Reviewer 3

This reviewer was impressed by the progress the project has made to date, particularly in the modeling and validation portion of the project, and by the nine-component surrogate that almost identically matches the target fuel. The reviewer recommended considering the use of artificial intelligence/machine learning to explore fuels even more thoroughly and rely less on expansive (and expensive) experimental validation.

Reviewer 4

The reviewer praised the project for its productive work on models of jet fuels to support SAF development. The models include combustion properties such as sooting tendency. The reviewer mentioned that the project's improvements to software for combustion chemistry modeling (Zero-RK) have reduced the run time for simulations that incorporate detailed chemistry, and the software has been publicly shared via GitHub. The project has also made improvements to global pathway selection software and shared it publicly.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that most of the collaboration presented is with Argonne National Laboratory and the University of Connecticut. The reviewer encouraged the project to continually reach out to other researchers to validate the models in different combustion contexts.

Reviewer 2

This reviewer praised the project's collaboration and coordination with other institutions and industry partners.

Reviewer 3

This reviewer found the project team impressive, noting the national laboratory and university representation. The reviewer observed that the team has coalesced well and is collaborating excellently on experiments and simulation. The reviewer commended the project for skillfully leveraging the limited resources of global participants.

Reviewer 4

The reviewer stated that this team has broad collaborations worldwide and has a history of active engagement with industry, academia, and other national laboratories. The team remains highly collaborative, as it has been in the past.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

This reviewer concluded that the cyclo-alkane chemical kinetic and SAF model developments will be useful.

Reviewer 2

The reviewer described the proposed future research as exhaustive and clearly defined but expressed skepticism about the likelihood that the project will achieve its targets. Nevertheless, this reviewer recommends the inclusion of artificial neural networks (machine learning models) for future research of reduced models to use in simulation.

Reviewer 3

This reviewer observed that the future work for this project appears to be aiming at reducing the barriers even further and building upon recent successes. The reviewer commended the project for improvements to the simulation tools and for making these improvements available to the community at large, describing these developments as excellent.

Reviewer 4

This reviewer asserted that the expansion of the kinetics studies to consider more fuels and fuel blends and further improvements of these kinetics are of great value to the community and will help overcome barriers and enable robust design calculations. The past and present contributions from this team were described by the reviewer as outstanding. The reviewer expects the outputs of this work to remain highly impactful. The reviewer remarked that key elements of the work are not only enabling high-fidelity considerations of combustion chemistry but accelerating the speed of simulations to enable practical design simulations with adequate consideration of chemistry.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the renewable fuels mechanisms are very important and suggested that the R&D communities would benefit from confirmation that good models also exist for other popular low-/zero-carbon fuels.

Reviewer 2

This reviewer said the project will help to close the knowledge gaps of low-lifecycle-carbon fuels and that it supports the overall VTO subprogram objectives for decarbonization of difficult-to-electrify sectors.

Reviewer 3

The reviewer stated that this project is very relevant to DOE's DORMA program objectives, noting that it supports both experimental and simulation efforts to enable decarbonization.

Reviewer 4

The reviewer conveyed that this project yields combustion chemistry models that enable alternative and advanced fuel utilization. The SAF and low-carbon-fuels work are considered by the reviewer to be essential. The reviewer pointed out that the kinetic mechanisms and detailed understanding of combustion chemistry produced by this project are needed for model-based design.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This reviewer stated that the project's resources appear to be sufficient.

Reviewer 2

The reviewer was not sure the project's current funding levels will be sufficient to address the remaining challenges and barriers outlined in the report, given that so many milestones have not yet been completed.

Reviewer 3

This reviewer remarked that the resources appear to be sufficient to achieve the goals of this project.

Reviewer 4

The reviewer mentioned that the good levels of long-term funding enabled the project to develop highly useful outcomes for combustion kinetics.

Presentation Number: DORMA008
Presentation Title: Slashing Platinum Group Metal (PGM) in Catalytic Converters An Atoms-to-Autos Approach
Principal Investigator: Kevin Gu, General Motors

Presenter

Kevin Gu, General Motors

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 17% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

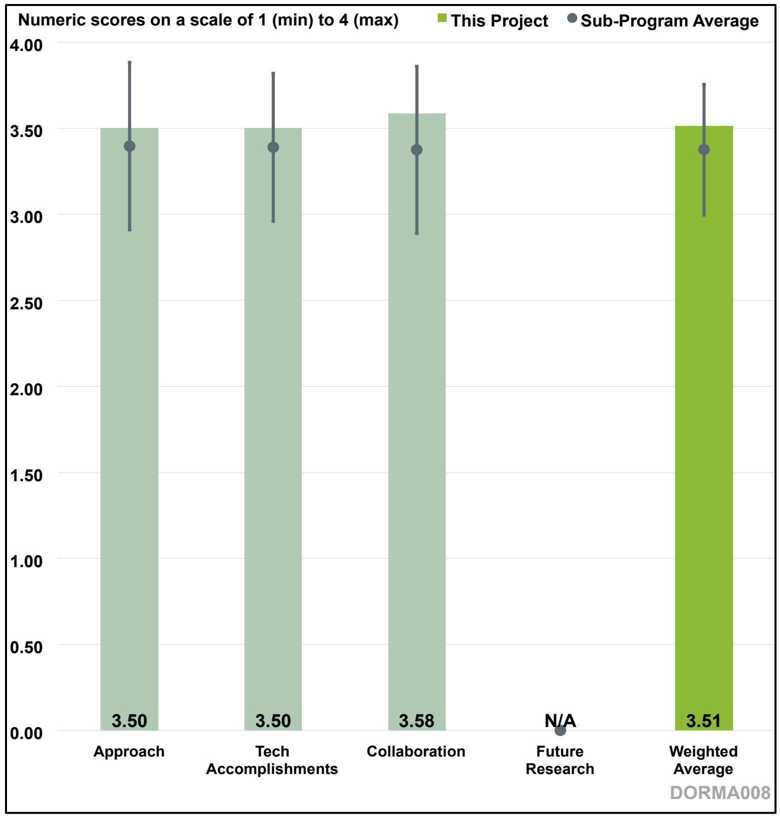

Figure 3-7. Presentation Number: DORMA008 Presentation Title: Slashing Platinum Group Metal (PGM) in Catalytic Converters An Atoms-to-Autos Approach Principal Investigator: Kevin Gu, General Motors

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the team has the expertise, technical support, and industry partners needed to complete the research project. The reviewer noted that the research project follows a well-established technical approach used in the past, which starts with core samples in a chemical lab and includes vehicle products. The timeline is considered well planned. The reviewer expects that the project will be completed as planned based on the evident planning, available resources, and expertise and effort of the team.

Reviewer 2

The reviewer conveyed that the team developed a group of ceric oxide-modified aluminum oxide (Al_2O_3) supports and demonstrated that those supports enhanced the three-way catalyst (TWC) performance of palladium (Pd) and rhodium as compared with the Al_2O_3-supported catalysts. The team evaluated the catalysts after aging the samples under well-established industrial catalyst aging protocols and on an engine dynamometer to ensure that the results were practically relevant. The reviewer noted that while these accomplishments are remarkable, the presentation lacked sufficient information to compare the newly developed catalysts to the state-of-the-art commercial TWCs that are designed for similar applications. The reviewer asserted that TWC technology has advanced to the stage that sophisticated selections of support materials and placement of PGM are commonly implemented in commercial catalysts. A major objective of those industrial approaches, according to this reviewer, is to reduce PGM usage. The reviewer recommended, therefore, that the goal of PGM reduction for this project be based on the best available technology in the market rather than a set of simple base cases.

Reviewer 3

This reviewer stated that the research plan was laid out well to achieve its goals and the partners were well chosen for their contributions.

Reviewer 4

This reviewer described the Atoms to Autos approach as a clever, multi-pronged approach to achieving a 50% reduction in PGM loadings while maintaining emissions performance meeting the super-ultra-low-emission vehicle 30 standard. The reviewer noted that reducing the size of the PGM particles allows for a nearly atomic dispersion that has strong resistance to migration and aging.

Reviewer 5

It was clear to this reviewer that the project addresses technical barriers related to reducing PGM loadings. The reviewer conveyed that the project also achieved prolonged lifetime and improved durability with the support modification. The strategy to achieve the goals was considered reasonable by the reviewer; the use of alumina–metal oxide supported catalyst particles allows comparison to a baseline catalyst (metal–alumina supported catalyst). The reviewer stated that the presented results show significant advantages with avoidance of large particles and ability to create a more robust catalyst while decreasing PGM content.

Reviewer 6

The reviewer said that a new lean/rich aging protocol was established and light-off temperatures were characterized before and after aging.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Noting that a limited amount of data was presented, this reviewer observed that progress has been made in this project and that the progress is well supported by the two patents granted, one patent pending, and one paper published.

Reviewer 2

This reviewer stated that the team developed a group of supports with surface modification to enhance the TWC activity of the PGM component. The team scaled up the sample preparation process and prepared a reasonable quantity of samples to prepare sets of full-sized catalysts for engine dynamometer testing. The team then aged the catalysts under industry-recognized protocols and finally demonstrated that the newly developed catalysts could reduce the PGM usage. The reviewer noted that although the results did not demonstrate achievement of the original PGM reduction target of 50%, the targets were very nearly achieved, and the project demonstrated the feasibility of a 25% PGM reduction. The reviewer remarked that the important finding from this project is that PGM reduction is feasible on TWC, even after nearly 50 years of intensive academic/industrial research and development effort.

Reviewer 3

The reviewer commended the project for achieving many great technical accomplishments, including meeting the required NO_x and hydrocarbon standards, in spite of various constraints on the project, including loading. The person noted that the project does not appear to have met the carbon monoxide (CO) standards within these same constraints. The improvements in maintaining smaller particle size and particle size distributions with the preparation and aging processes used appear to the reviewer to be technical accomplishments that have not yet been reported to the extent possible. The reviewer expressed hope that these accomplishments will be included in publications.

Reviewer 4

This reviewer praised the project for the excellent progress that has been made. The person conveyed that a design concept was prepared, optimized, and aged, and that the design demonstrated thrifting in excess of the target (60% versus 50%). Currently there is a prototype device being canned for engine and vehicle testing.

Reviewer 5

The reviewer remarked that the milestones in all three funding periods appear to have been met except for the one involving ongoing engine performance testing. Some milestones experienced delays of 3–4 months because of complexities arising from partnering agreements. The reviewer was glad to see that the formulation was able to be modified and prototype scaling/testing continued. The reviewer observed that the project appears to have met its metrics in mid-2023, and the last year has been spent conducting aging testing and final testing, which is ongoing. The reviewer stated that the data presented provides a clear picture of progress toward a catalyst that is more durable, contains less PGM, and is able to be scaled. Additionally, the reviewer asserted that the use of metal–oxide support keeps particle size down when compared to baseline catalyst, and the lower particle size likely plays a significant role in helping to maintain activity of the catalyst. Beyond the milestones, the reviewer found the project's two granted patents, one pending patent, and one publication worth noting. The publication is in a high-profile catalysis journal and provides a modified chemisorption method that could have impact for the broader catalysis community.

Reviewer 6

This reviewer's evaluation was only done for the third budget period, since the review is constrained to just the past year. The project demonstrated 50% reduction in PGM and filed three patent applications, with two granted so far.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer conveyed that the team collaborates with one national laboratory, one OEM, one catalyst supplier, and two universities. The contribution from Pacific Northwest National Laboratory was not clear to the reviewer. The reviewer asserted that the current team has all the expertise needed for the success of this project, so no additional collaborators are needed.

Reviewer 2

This reviewer stated that close collaborations among the academic institutions, catalyst manufacturer, and OEM are apparent. The team successfully translated novel ideas from lab scale to engine dynamometer demonstration. The reviewer recommended including a state-of-the-art commercial TWC from BASF in the evaluation to fully assess the practical potential of the technology developed in this project.

Reviewer 3

This reviewer remarked that the project's team of collaborators was very well suited to implementing its approach, relying in large part on work from the University of Central Florida for its approach to catalyst preparation.

Reviewer 4

The reviewer commended the project team for excellent research collaborations between an OEM (General Motors [GM]), a Tier 1 supplier (BASF), a national laboratory (Pacific Northwest National Laboratory), and multiple universities with clear roles.

Reviewer 5

The reviewer observed that the diverse project team brings unique expertise to the project and asserted that a project of this type requires expertise in single-atom catalyst development, catalyst scale-up, catalyst characterization, and understanding kinetics/mechanism of activation and deactivation. Both GM and the University of Central Florida team members have expertise in single-atom catalyst development; it was not clear to the reviewer why both groups were needed and how their contributions were unique and not duplicative. The reviewer was surprised that the project did not include some economic modelling, at the least to demonstrate the impact of the PGM reduction. The person speculated that the project may be at too premature of a stage for economic modelling at this time.

Reviewer 6

The reviewer commended the project for having a nicely formed team with clearly defined roles. The reviewer recommended showing the contributors on the technical accomplishment slides in the future.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that no future work is proposed because the project is supposed to be completed soon.

Reviewer 2

This reviewer stated that the project is ending in June 2024.

Reviewer 3

This reviewer remarked that the project has ended from a practical view, except for one more potential publication with additional results.

Reviewer 4

The reviewer conveyed that the project is 90% complete, noting that ongoing work will be finished to end the project.

Reviewer 5

This reviewer said that the project is basically at the end of the funding period, with 90% of funds having already been expended. The reviewer did not identify any issues with the presented information but did have some questions. First, the reviewer asked if atomic layer deposition methods might offer better results or control of the catalyst composition. The reviewer asked if the reason atomic layer deposition methods were not considered is because they are not cost competitive relative to the solution coating methods followed by calcination that were used. Second, the reviewer asked why the alumna is needed at all if the CeO_x could serve as a support and if this choice is also driven by the economics.

Reviewer 6

The reviewer reported that the project ended in June 2024.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This reviewer concluded that the project is relevant to advanced engine and fuels technology. The person asserted that reducing the catalyst by 50% will reduce dependence on imported material and improve the competence of the U.S. vehicle industry.

Reviewer 2

The reviewer asserted that PGM is critical for internal combustion engines to meet environmental emission regulations. The person noted that reducing PGM usage has been a challenging task and that decades of research and development effort have been devoted to it because of the scarcity of PGMs. The reviewer observed that the results from this project demonstrate that there is still room for improvement in this area, and the reward can be significant.

Reviewer 3

This reviewer remarked that reducing the use of PGMs by 50% to meet emission standards would result in major cost savings for automotive OEMs on ICE-powered vehicles using new low-carbon fuels. Thus, the project is relevant.

Reviewer 4

The reviewer said the project is extremely relevant to DOE goals to reduce reliance on precious metals.

Reviewer 5

This reviewer concluded that the project goals and approach are well aligned with VTO interests in developing improved catalysts or formulations for engine systems. The reviewer noted that reducing PGM content is imperative and expressed the view that the connection between performance and understanding composition and dynamics at the atomic level is critical. The reviewer observed that the project team missed an opportunity (to a minor degree) to make the connections between the atomic level and performance a little more strongly throughout the presentation. While the reviewer felt that the overall vision demonstrated these connections well, they could have been reinforced more strongly throughout the presentation.

Reviewer 6

The reviewer pointed out that reduction of PGM usage in engine exhaust aftertreatment is an objective of the VTO program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the team has excessive resources, including equipment, space, industry support, and expertise, for the success of this project.

Reviewer 2

This reviewer commended the team for making good progress with the research funding, observing that the industrial partners (GM and BASF) contributed significant effort to the project.

Reviewer 3

The reviewer said the institutions and their capabilities were sufficient for this project.

Reviewer 4

This reviewer concluded that the resources are sufficient because the project is nearly complete.

Reviewer 5

The reviewer observed that the project had all the resources it needed given the diverse skill sets of the partners and their expertise in all the areas needed to develop the catalyst, understand how it operates, and scale/test it.

Reviewer 6

This reviewer conveyed that the project was completed with the allocated budget, although with delays that were not a result of insufficient funds.

Presentation Number: DORMA010
Presentation Title: Off-Road Decarbonized Fuel Transient Performance
Principal Investigator: Muni Biruduganti, Argonne National Laboratory

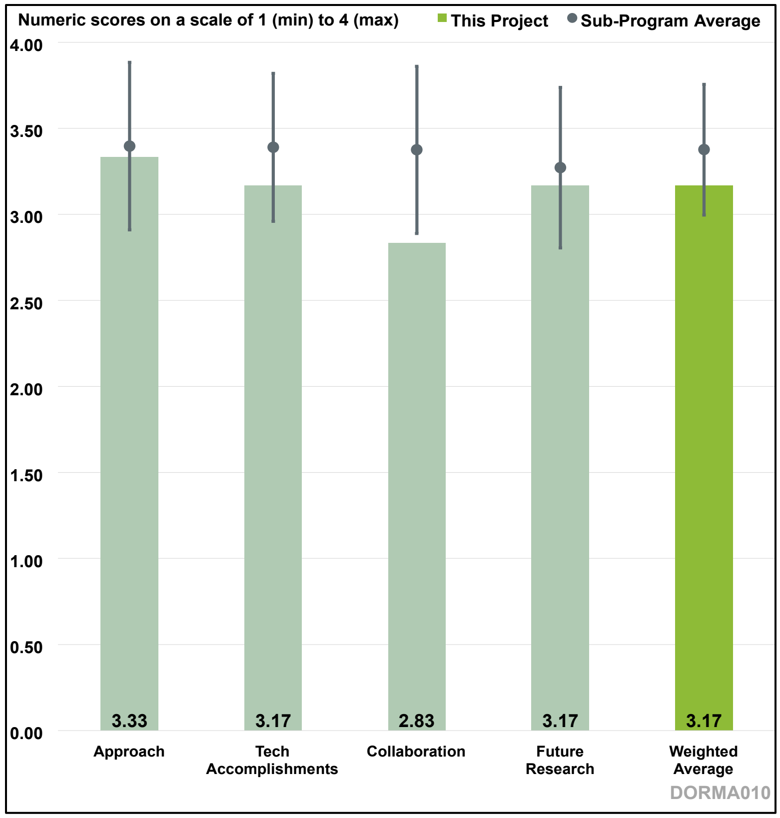

Figure 3-8. Presentation Number: DORMA010 Presentation Title: Off-Road Decarbonized Fuel Transient Performance Principal Investigator: Muni Biruduganti, Argonne National Laboratory

Presenter

Muni Biruduganti, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer asserted that the use of a powerful tool (Autonomie) for this powertrain development study promises valuable outcomes. Combining engine combustion and development studies coupled to the powertrain simulation should lead to an effective powertrain design. Using the engine-in-loop approach has been shown many times in the past to be an effective way to design and anticipate propulsion challenges of different powertrain options. That application in this case—for off-road systems where the duty cycle and engine and powertrain needs to serve can vary widely across the off-road sector and vary extensively from on-road design—is a strength of this project.

Reviewer 2

The reviewer noted the project is evaluating H_2 ICE transient performance for non-road applications and using hardware-in-the-loop to simulate the application while operating the engine in the test cell. The reviewer added the real-time non-road equipment model uses Autonomie for the vehicle dynamics and transient set point to the engine controls (in the test cell).

Reviewer 3

The reviewer commented that switching engines from Navistar to Cummins seems to add technical risk to the project. Getting the engine to perform correctly in a test-cell dynamometer takes times and effort. Switching to another engine could impact product schedule and cost. The reviewer noted that there could be an impact on redoing simulation results for the transient differences between engines.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer acknowledged the ANL team currently has a Navistar 13-liter diesel engine in their test cell. The team has also upgraded the test cell to accommodate hydrogen for the Cummins B6.7H (a 6.7-liter H2 ICE engine), which is scheduled to be tested in a future year. The Cummins engine is not yet in production, so testing it will be delayed to FY 2026. An interim step will be to use the Cummins B6.7NG (a natural gas-fueled engine) in FY 2025 and to test its operation using blends of natural gas and hydrogen. ANL is also upgrading the on-site hydrogen fuel storage system from tube trailers to liquid hydrogen tanks.

Reviewer 2

The project is leveraging expertise at ANL with Autonomie and leveraging facilities from SuperTruck and existing partnerships, which has enabled good progress to this midway point in the project. The testbed appears to be mostly in place, and a new H_2 ICE will be acquired/installed to complete the project objectives. But the most challenging aspects, the advanced virtual vehicle simulation, have been developed using the existing 13-liter diesel engine. The project team has demonstrated the ability to simulate hybrid architecture. The engine will arrive in 2026, but the reviewer asked if that is guaranteed, as this will significantly impact the project timeline. The team has demonstrated the integration of engine–model signals, so that the engine is being commanded to operate as needed for the virtual vehicle to meet the duty-cycle demands, and this is further improving integration. Transient drive-cycle requirements are being emulated, albeit with some throttling of the rate of change of engine start. Nonetheless, the powertrain simulation capability looks like it is far along in the development process.

Reviewer 3

The reviewer asserted that a more detailed comparison of the five different off-road drive cycles with the engine dynamometer and engine simulation results from a transient perspective is needed. It was stated a low-inertia dynamometer was used and simulation results were compared with the dynamometer response. There seems to be some difference between the two. The reviewer would like to see the actual vehicle comparison as well. Later in the presentation, some emissions results were shown. The dynamometer response can have a significant impact on emissions results during transients.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer indicated the presentation shows good collaboration between different project team members and organizations.

Reviewer 2

The reviewer remarked that the team is primarily ANL with some support from Navistar and Cummins. Navistar is providing a 13-liter diesel engine as in-kind support. ANL is also negotiating with Cummins for an H_2 ICE that is expected to arrive in late 2025. This reviewer acknowledged that the national laboratories are allowed to run projects independently, but in general the reviewer's expectation is that ANL would have engaged other partners, be they the engine manufacturers or others, to support the program. For example, ANL should strongly consider getting a non-road machine manufacturer to help get vehicle duty cycles to feed into real-time Autonomie. Duty-cycle data were drawn from field data generated by the University of Helsinki on another Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA) project.

Reviewer 3

The reviewer observed that there are no universities involved in this project. The ANL–industry collaboration looks very effective from the work being accomplished, but there is a missed opportunity here for training new engineers through this project, either through summer interns, student design projects, or graduate thesis research. Since Autonomie is widely used in academia as well as by the laboratories and industry, there should be an effort to engage students in this activity. Interaction with Navistar and potentially with Cummins to enable H_2 ICE studies are both evidence of good industry engagement. But a missing element is direct involvement with an off-road equipment original equipment manufacturer (OEM). The team is making use of data from the University of Helsinki and University of Nebraska, but the presentation did not make clear whether those collaborations or resource leveraging are active collaborations under this project. In the question-and-answer period, it was clarified that these data are from other/previous DORMA projects. So, the reviewer concluded, there is no active university engagement under this project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the H_2 ICE in a range of virtual powertrain designs, exploring the engine's performance with the challenges of H_2 combustion, is an excellent topic to explore. The team seems poised to accomplish some very good work, and the most challenging systems for the hybrid powertrain design are already in place. But there seems to be risk related to the acquisition of the H_2 ICE. As a risk-mitigation strategy, the team will install a natural gas version of the desired test engine—as a step toward getting the H_2 version of the test engine—to be ready for its arrival.

Reviewer 2

The reviewer asserted the overall future tasks are clear and make sense technically. Since the study is focused on transient response, more effort should be put into comparing back to different off-road standardized cycles.

Reviewer 3

The reviewer strongly recommended doing more work to generate realistic duty cycles from agricultural or industrial equipment, noting that this is exactly the sort of thing that an external partner could provide (in-kind) or help generate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project is very relevant to support VTO objectives. Hydrogen engines are an important tool for meeting carbon-reduction goals.

Reviewer 2

The reviewer stated this project is both highly relevant to the general topic of improving efficiency and performance of off-road vehicle systems, but also to the deep decarbonization of such systems.

Reviewer 3

The reviewer affirmed the project is relevant to the VTO objectives, adding that the current relevance is limited while using the 13-liter diesel engine. It will be better once the project team has the H_2 ICE available.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the project seems to have sufficient resources for the project.

Reviewer 2

The reviewer affirmed the funding seems adequate to achieve the project objectives.

Reviewer 3

The reviewer indicated the budget of $500,000 in FY 2024 is sufficient for testing if Navistar and Cummins really provide some additional in-kind engineering support to ensure that their donated engines will operate well in a test cell.

Presentation Number: DORMA012
Presentation Title: Enabling Hydrogen Combustion for Large-Bore Locomotive Engines through Advanced CFD Modeling
Principal Investigator: Muhsin Ameen, Argonne National Laboratory

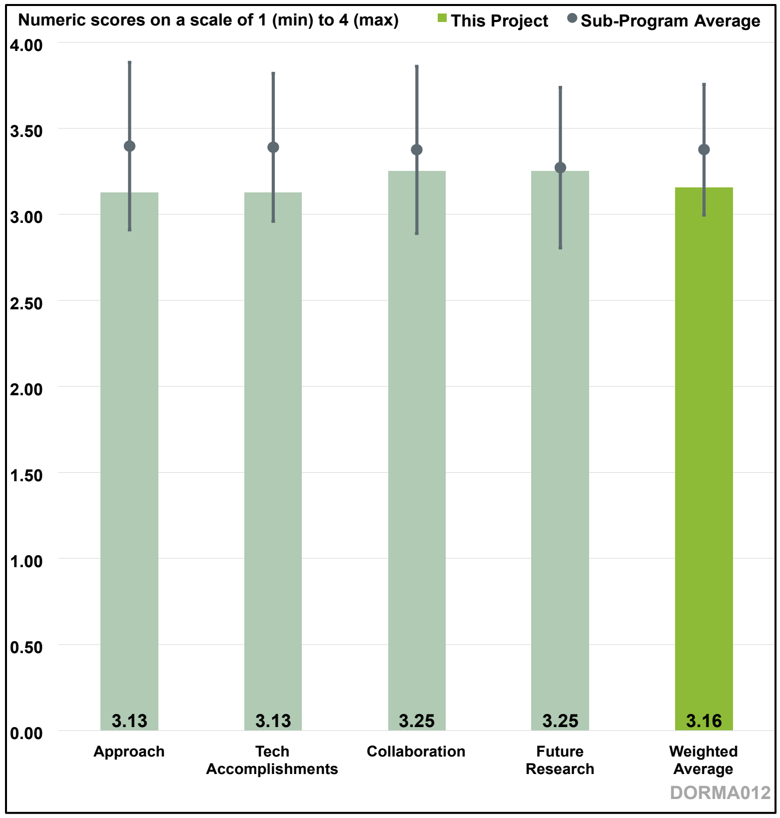

Figure 3-9. Presentation Number: DORMA012 Presentation Title: Enabling Hydrogen Combustion for Large-Bore Locomotive Engines through Advanced CFD Modeling Principal Investigator: Muhsin Ameen, Argonne National Laboratory

Presenter

Muhsin Ameen, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer believed the noted barriers are being addressed very well. There are clear tasks to either solve, eliminate, evaluate, or validate barriers. Where there is a chance that barriers may not be completed, solved, or overcome, the desired level of outcome (such as “improve”) is noted. Additionally, the project appears to be well set up to navigate any unforeseen challenges and/or unplanned results. The project team is working through an unanticipated barrier to the baseline H_2/diesel PFI configuration work—the delays at Oak Ridge National Laboratory (ORNL). Alternative mitigation plans are being worked on.

Reviewer 2

The reviewer indicated the milestones set for the project address all key barriers for hydrogen combustion in large bore engines. The approach for validating the CFD simulation with experimental data is a commendable approach to developing a dependable simulation tool for further technology advancements. Some key questions that need to be addressed include: (1) What the air/fuel ratios are for the (diesel/H_2) mixture during the different substitution rates. The 300% increase in NO_x suggests a richer mixture with increased substitution rate. The reviewer thought NO_x reduction should be placed as an important milestone in the approach. (2) The use of main injection timing (MIT) as a tool to control combustion is fairly well known in conventional diesel combustion; while this exercise is a good approach for CFD validation, the findings of control of start of combustion, peak pressure, etc., are not novel for advancing the use of hydrogen/diesel dual-fuel. It would help to understand the end result of the MIT influence and how it is going to be used for NO_x mitigation, pre-ignition mitigation, knock mitigation, etc.

Reviewer 3

Overall, the reviewer stated it is a reasonable approach for a project focused on CFD to pair with the experimental work being conducted at ORNL. The progression of validation and then CFD experiments conducted ahead of experimental work is good, since it uses the CFD to inform the experimental work conducted later. The reviewer looks forward to seeing whether and how this can accelerate the experimental program. With the objective (shown on Slide 3) to use the simulations to "...enable up to 100% operation on hydrogen and low-carbon fuels...", the reviewer expressed concern about the availability of fuel models for the low-carbon fuels. Since 100% hydrogen substitution is not applicable, there will be a low-carbon diesel component to the combustion process. There are limited, and often out-of-date, models for renewable diesel and biodiesel. There is also no mention of validation of the models with low-carbon fuels.

Reviewer 4

The reviewer commented that the technical approach is shown to be able to predict combustion events and abnormal combustion, adding that the results have not been correlated with experiments.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewed noted that the nine technical accomplishments appear to be addressing the objectives of the project well, noting the development of robust simulation tools to accurately evaluate various low-carbon fuels for use in the rail industry and eventually contribute to the development of a suitable low-carbon-fueled engine. Technical accomplishments, such as the results of the hydrogen substitution rate testing, provide clear indications of the impact on ignition performance and emissions reduction and are adequately informing future testing needs and next steps.

Reviewer 2

The reviewed affirmed that the results of the study are highly relevant and would be a rich dataset to compare against experimental data. The simulation results have covered basic engine parameter investigation that could be used to validate and refine the model with CFD data. The reviewer noted two further points: (1) Technical Accomplishment 7/9 is highly relevant for hydrogen combustion. This accomplishment would benefit further by identifying in-cylinder conditions that would influence pre-ignition, such as hot spots, residual trapped gas, etc. The current findings related to advanced MIT resulting in better flame propagation are well documented in previous literature. The value of CFD simulation would be to identify specific areas of concern in a given combustion chamber geometry that would lead to pre-ignition conditions. (2) Technical Accomplishment 8/9 is also a very important dataset related to crevice volume. For hydrogen combustion, crevice volume is highly important and its effect on pre-ignition is uncertain. The results do not seem to discuss the effect of crevice volume on pre-ignition.

Reviewer 3

The reviewer noted some delays in validation due to delays on experimental testing. The reviewer expected to see a recycle loop on some work completed thus far once the ORNL engine is operational and data are available to validate, such as some of the initial simulations report findings that are consistent with the literature and positive control authority for the diesel injection through a range of injection timings, for example. This is good validation of basic model functionality, but it is not immediately clear whether or how these types of findings represent a step forward on the path to dual-fuel diesel–hydrogen combustion, since they are broadly expected trends. Further, as this work progresses, it will be useful to re-examine many years of DOE's and other's funded work on dual-fuel combustion to understand where the outcomes of this project merely duplicate the prior findings and what material is truly unique and novel.

Reviewer 4

The reviewer appreciated the systematic parameter study and regression analysis. For the results shown on Slide 7, the reviewer requested inclusion of engine operating conditions (e.g., rated?, speed and torque, indicated mean effective pressure [IMEP], intake manifold pressure, intake manifold temperature [IMT], volumetric efficiency, and fuel quantities). The reviewer also recommended the team include results for the swirl ratio equaling zero and show global lambda values at different substitution levels, since H_2 and diesel have different stoichiometric air/fuel ratios. The reviewer indicated it was unclear if the substitution ratio is by energy content. For results shown on Slide 9, the reviewer requested inclusion of global lambda values; for combustion efficiency, the reviewer requested a breakout of diesel combustion efficiency and H_2 combustion efficiency, if possible. It is equally important to show how the presence of H_2 impedes diesel auto-ignition and ignition delay.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the project team's collaboration with industry as well as national lab and CFD software partners is showcased well.

Reviewer 2

The reviewer expressed that collaboration between the parties appears to be strong. This reviewer acknowledged potentially missing something but did not believe the delays at ORNL have anything to do with collaboration. To that end, the partners seem to be working on a potential alternative plan should delays persist.

Reviewer 3

The reviewer pointed out it was early in the project and thus difficult to see how effective the collaborations are between the different parties, though they make sense on paper. Partners at ORNL indicated good feedback and connectivity on operating maps thus far.

Reviewer 4

The reviewer noted there was nothing to add.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer indicated the proposed future research is well supported and obvious based on the technical accomplishments. Future tasks toward fine-tuning of causes of abnormal combustion, emissions modeling, and the impact of fuel mixing accuracy on wall heat transfer models should yield targeted results based on the baseline information obtained during the baseline study.

Reviewer 2

The reviewer stated the proposed experimental validation is the most critical part of this project. An in-depth validation of CFD results would be the key success criteria for this project.

Reviewer 3

The reviewer acknowledged there is a broad swath of future research topics laid out for this project It would be useful to highlight any opportunities to down select the work and focus on key, enabling topics to move the overall hydrogen engine for rail projects forward. The reviewer encouraged focusing on using CFD tools to answer significant questions that cannot be answered easily experimentally. For example, injection timing trends are very straightforward and quick to implement in an experimental project, but things like compression ratio, exhaust gas recirculation (EGR) levels and temperatures, air systems, and piston shapes are much lengthier processes to explore experimentally. By focusing the simulation work on these aspects, it can help accelerate the project more quickly than things that are readily done experimentally. In addition, using simulation to understand phenomena of the combustion process could be an area to find value using CFD.

Reviewer 4

The reviewer indicated that correlation with experiment is a key milestone to yield improvements in the predictability and quality of results in future research. For engine-out emissions prediction, the project team should include unburned H_2 prediction. To prepare for closed crankcase ventilation (CCV), the team should attempt to predict H_2 in blowby for PFI. It will be excellent if such research is able to elaborate blowby during both compression and expansion. The team should plan to highlight the differences between direct injected H_2 and PFI H_2 on blowby and how it impacts CCV.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed the project is relevant to the industry achieving 2050 net-zero emissions objectives and ensuring that any transition to low-carbon fuels or hydrogen will be feasible, economical, and efficient. Simulation models that can accurately evaluate various fuels will be key to advancing toward zero-emissions objectives and will inform the design of the next-generation locomotive engine.

Reviewer 2

The reviewer said this project is a very value-added fundamental study with nice progress shown.

Reviewer 3

The reviewer stated this project is highly relevant for the use of hydrogen in large bore engines with diesel pilot. Control of combustion in a diesel/H_2 mix is critical, and identifying conditions that result in abnormal combustion is the key unknown in hydrogen-fueled engines. Developing high-fidelity CFD simulations accelerates engine development time and reduces the cost of new technology development. However, projects like this that have an approach to validate the CFD models with focused engine experiments are highly relevant to gain confidence in further use of models for engine development.

Reviewer 4

The reviewer acknowledged the project is relevant to overall VTO subprogram objectives, focused on enabling hydrogen internal combustion engines for rail applications. The work is nicely connected to the experimental project lead by ORNL. That said, there is always a concern on the relevance of applied CFD programs completing straightforward development tasks and whether this type of work is appropriate for DOE laboratories. In this case, the reviewer concluded the connectivity to enable another project makes it reasonable for enabling the DOE objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer asserted that the computing ability of ANL and experimental capability of ORNL are more than sufficient to accomplish the goals of this project.

Reviewer 2

The reviewer said the resources, as defined, appear to be sufficient. The ability to execute at ORNL could impact whether milestones are met in a timely fashion. This reviewer expressed confidence that milestones can be met based on the contingency planning that is occurring. Project proponents are staying close to the situation and have a plan to pivot if further delays at ORNL persist.

Reviewer 3

The reviewer indicated the resources are sufficient but would have liked to see a greater in-cash cost share versus in-kind given the scale and attributes of the project.

Reviewer 4

The reviewer looked forward to seeing timely availability of experimental data.

Presentation Number: DORMA014
Presentation Title: Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec
Principal Investigator: Dean Edwards, Oak Ridge National Laboratory

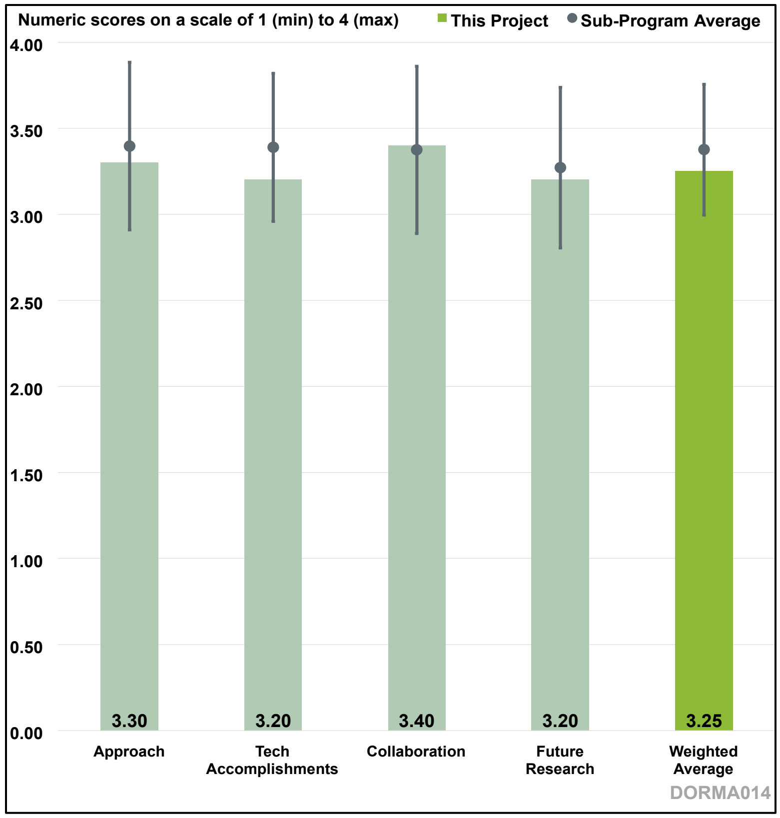

Figure 3-10. Presentation Number: DORMA014 Presentation Title: Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec Principal Investigator: Dean Edwards, Oak Ridge National Laboratory

Presenter

Dean Edwards, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that, even though delays have hindered the timeline, there is leadership support and a plan to advance immediately when infrastructure upgrades are complete. Technical barriers have been identified and predicted outcomes are realistic. Efforts to maximize hydrogen substitution rate to reduce CO_2 and NO_x emissions have been identified, while acknowledging that dual-fuel ICEs are not a zero-emissions solution.

Reviewer 2

The reviewer provided two comments. (1) Engine testing infrastructure installation is a critical milestone that was undertaken and is the fundamental platform for any future work and validation of CFD models. (2) Hydrogen fueling infrastructure is the other task that is a critical barrier to developing engine testing facilities for alternative fuels.

Reviewer 3

The reviewer acknowledged having only general knowledge in this area, but added the project plan looks excellent assuming the rail engine is made into a dual-fuel system, where H_2 is one of the most reasonable fuels to add to the system, with a goal of decarbonizing the system as much as possible.

Reviewer 4

The reviewer acknowledged impressive progress has been accomplished. Thoroughness and care have been taken into consideration to ensure safe lab operation. The team underestimated the time and effort it took for the lab upgrade, fuel supply, permit approval, etc. That said, the investment and new capability will prove highly valuable for future research.

Reviewer 5

The reviewer pointed out that the project approach involves building new facilities, baseline engine testing, and then evaluation of different hydrogen fueling systems and their impacts on the ability to increase the hydrogen substitution ratio. The work addresses a key technical space of decarbonizing rail, where locomotives are in service for extended periods of time and hydrogen is of interest as a potential decarbonization pathway. The project has a logical progression, but the scope of work compared to the timeline is very aggressive. This raises the concern that there will be insufficient depth in each stage of the project, as there is significant time pressure to complete the work. The overall timeline was unreasonable, even at the early stages where significant new infrastructure development and installation was part of the project. The significant delays so far are not surprising.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer acknowledged that the range of demanding pieces for this project is high, especially the Wabtec engine installation and testing that may be near at hand. With two years to go, next year’s results will be critical in seeing how this dual-fuel approach works.

Reviewer 2

The reviewer noted the project design is complete; however, infrastructure upgrades have been delayed.

Reviewer 3

The reviewer indicated the project has a well-thought-out plan and is making solid progress with support from leadership. The reviewer suggested considering crankcase H_2 monitoring, purging, and pressure relief as additional safety measures, as well as monitoring engine oil during operation. Emissions measurement is not mentioned in the report. In addition to standard gas and PM measurement, this reviewer suggested considering H_2 emission measurement.

Reviewer 4

The reviewer stated that the completion of infrastructure tasks is an excellent accomplishment but noted the presentation did not show any preliminary data from test-cell commissioning.

Reviewer 5

The reviewer indicated that significant progress has been made into building facilities and installing infrastructure supporting this project. The new single-cylinder locomotive engine and support systems will give a solid platform for future development in the rail-engine space. That significant progress acknowledged, the reviewer added that the work has not surprisingly run behind schedule, slowing overall progress on the project. With little technical progress, it is challenging to assess.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted there are key partnerships that are needed to make this project work. Wabtec appears to have been very active, which is critical at this stage in the project.

Reviewer 2

The reviewer commented that the collaboration between ORNL and ANL provides an excellent platform for CFD model validation, and the coordination between Wabtec and ORNL has helped in developing a modern locomotive-engine research engine test facility.

Reviewer 3

The reviewer acknowledged this is a challenging facility upgrade project requiring extensive collaboration but is impressed with the progress despite the project being behind schedule.

Reviewer 4

The reviewer indicated the planned collaboration and coordination between the different parties looks appropriate, including close connection to a supporting engine OEM with significant cost-share and another national laboratory with substantial capabilities in CFD. The constellation of teams should make for an effective project. The reviewer acknowledged that it is early in the project to have a clear view on the efficacy of the teaming.

Reviewer 5

The reviewer noted it appears that collaboration efforts are solid; however, several issues related to inflation and supply chain have hindered completion of construction.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer indicated that future work is well-defined and should achieve the desired targets.

Reviewer 2

This reviewer asserted the single-cylinder approach to maximizing the substitution of hydrogen as well as testing the impact on NO_x aftertreatment seems workable. Having time trials with other fuels than diesel would be a great effort.

Reviewer 3

The reviewer stated that, as an outcome of this research, the team should recommend the feasibility and appropriateness of retrofitting older engines without EGR. This reviewer is optimistic that, for diesel locomotive engines equipped with EGR, common rail, and highly boosted turbo, the retrofit approach for H_2 substitute will be more practical.

Reviewer 4

The reviewer acknowledged that there is a significant amount of future work proposed. However, it appears that much of that work involves the evaluation of different hardware sets: injection systems, air systems, and compression ratio. This is concerning from both an operations and scientific perspective. Work that is a series of hardware changes can be difficult to execute in a national lab, and the industry-wide scientific understanding that this ultimately delivers is reduced. Further, the extensive work, short project duration, and already behind-schedule status, is concerning and suggests the final results from the project will have too much span and too little depth to be broadly useful. This reviewer would prefer to see a reduction in scope, with a focus on a smaller set of topics that generate real learnings to drive the industry—for example, a focus on a baseline diesel-based decarbonization scenario using renewable diesel or biodiesel and a high-substitution DI hydrogen configuration. Additionally, there is room for more depth and focus on emissions, not just hydrogen substitution for decarbonization.

Reviewer 5

This reviewer made two comments. (1) The emissions measurement capability of the test facility was unclear. (2) There is no mention of validation activity between CFD and engine data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer indicated the relevance of this project is clear, since it clearly supports the DORMA goals to Decarbonize the Off-road, Rail, Marine, and Aviation sectors of transportation, which are difficult to electrify. This may be a uniquely interesting and difficult effort in this area.

Reviewer 2

The reviewer acknowledged that decarbonizing rail is challenging and requires test facilities that can cater to a range of fuels and engine designs. This CRADA provides researchers with an excellent tool to develop models as well as conduct highly relevant experiments.

Reviewer 3

The reviewer asserted this is an excellent project and very relevant.

Reviewer 4

The reviewer stated that short-term solutions for decarbonizing the rail sector and the ability to ensure existing ICEs can remain in use as dual-fuel assets are important.

Reviewer 5

The reviewed noted this project does support the VTO program objectives around identifying and evaluating technologies for decarbonization in the off-highway transportation sector. H_2 ICEs have been identified as a potential direction for decarbonization if lower-carbon hydrogen becomes available. Understanding the engine technology options for rail falls within this scope.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that ORNL management is supporting this project well and Wabtec is a strongly supportive partner. As far as this reviewer can tell, the project has planned for sufficient resources.

Reviewer 2

The reviewer asserted that industry and national laboratories collaboration provides highly valuable technical, instrumentation, and computational resources.

Reviewer 3

The reviewer offered best wishes to the team to recover from the delay and is looking forward to the data generated from the lab.

Reviewer 4

The reviewer acknowledged it appears that the project is well-supported with resources; however, the ability of its proponents to execute the necessary infrastructure upgrades to allow the continuation of the project is critical to meeting deadlines and objectives.

Reviewer 5

The reviewer stated the resources are substantial and appropriate, noting the challenge with delivering milestones in a timely fashion is less a funding issue and more a result of the aggressive timing and scope.

Presentation Number: DORMA015
Presentation Title: Predictive CFD Tools for Low-Carbon Fueled Off-road Internal Combustion Engines
Principal Investigator: Riccardo Scarcelli, Argonne National Laboratory

Presenter

Riccardo Scarcelli, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

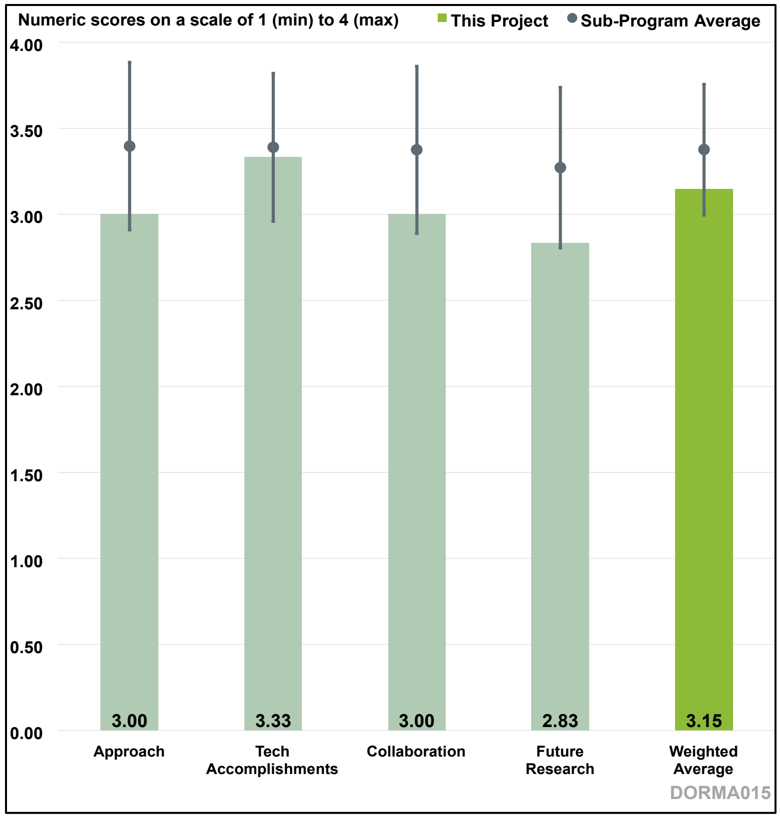

Figure 3-11. Presentation Number: DORMA015 Presentation Title: Predictive CFD Tools for Low-Carbon Fueled Off-road Internal Combustion Engines Principal Investigator: Riccardo Scarcelli, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the simulation provides valuable insights into the combustion process. Such capability will pay long-term dividends in accelerating development and issue resolution.

Reviewer 2

The reviewer asserted that the simplified intake port seems too simple, especially with PFI, and asked if there is any way to improve the model to have a more accurate geometry with both the intake valves and injector. This may have a significant impact on the cycle-to-cycle differences being seen in simulation. Additionally, the experimental data used for comparing cycle-to-cycle variation appears to be an average. This reviewer asked if there is a way to show best/worst experimental cycles for a comparison with the CFD data.

Reviewer 3

The reviewer commented this project couples a series of different topic areas focused on improvements to CFD modeling tools, with the overall effort aligned with improving these tools to aid development of engines using low-carbon fuels, particularly hydrogen and methanol. At first glance, the project is a collection of diverse topics, and the specific milestones for each one were not immediately clear from the materials, as they spanned such a range of topics. The live presentation made it clearer that these are different aspects that are important for effective models, and they are separated to address as such. Within this context, the project lays out a series of key aspects to address for improving the overall CFD toolset.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer indicated the project has made significant progress in meeting project tasks and no improvements are needed.

Reviewer 2

The reviewer asserted good overall progress thus far for a project that is in its relative infancy. Key milestones have been met, with the critical focus area identified. There are good comparisons between different fidelity models, including DNS/LES/Reynolds-averaged Navier-Stokes (RANS). The work on DNS has significantly improved over the last few years, which is exciting to see. It is, however, useful to understand the degree to which differences between DNS, with very high fidelity, and RANS, with low processor cost, are impactful for the overall utility of the results. The identification of mixing, and how mixing is being modeled, as the critical path forward is crucial for the future of the project and a good early step.

Reviewer 3

The reviewer stated that this report did not adequately describe boundary conditions such as bore, stroke, revolutions per minute, torque (%), intake manifold pressure and temperature, compression ratio, in-cylinder swirl ratio, etc. A summary table is recommended. The team suggested experimental data from Caterpillar (CAT) methane (CH_4)/H_2 testing have been used to validate the simulation but did not explain how the simulation data matched with experimental results before showing the cycle-to-cycle variation on Slide 7. The CCV discovery is quite insightful.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer indicated that the collaboration and coordination across project teams seems to be successful.

Reviewer 2

The reviewer noted adequate geometric parameters and simulation methods sharing are apparent among project partners.

Reviewer 3

The reviewer acknowledged the collaboration on this project is relatively narrow, including ANL as the lead with one OEM and a CFD code supplier. That said, the in-kind contribution from the OEM partner is appreciated. It will be important to see further signs of collaboration as the project moves forward.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer encouraged the team to predict H_2 combustion efficiency and H_2 emissions as future goals. This reviewer also posed a question to the project team, asking how to validate the conjugate heat transfer results from CFD.

Reviewer 2

The reviewer suggested perhaps adding an improved intake port model. Other than that, the future work is acceptable.

Reviewer 3

The reviewer observed the future work for the project continues to move ahead on a range of topics associated with improving CFD modeling tools. However, it was identified that the key aspect, especially for hydrogen combustion, was the mixing model. As the project evolves, this reviewer encouraged the team to consider reshaping the work to ensure this was fully addressed and would prefer to see a focus here rather than covering all topics.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the work has a clear purpose and is of value to the industry given the focus on identifying and further developing improvements to modeling tools. It is relevant, given the pressure new fuels may place on existing understanding of model performance. Industry has a clear focus on low-carbon solutions, so improvements here can help the industry as a whole move forward.

Reviewer 2

The reviewer asserted this project definitely supports efforts for decarbonization and CO_2 emissions reduction.

Reviewer 3

The reviewer noted the project is well aligned with VTO objectives and the mission for national laboratories.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer indicated that the resources with ANL, CAT, and others are adequate for the project scope and timeline.

Reviewer 2

The reviewer offered the following suggestion: a smaller PFI spark-ignited engine has been studied to run H_2 with combustion data measurement, and this reviewer wondered if it would be valuable to validate the models to such existing data then re-apply them to a large bore and lower speed engine with prechamber.

Reviewer 3

The reviewer stated that the resources seem low relative to other modeling/simulation projects.

Presentation Number: DORMA016
Presentation Title: Renewable methanol-fueled engines for marine and off-road applications
Principal Investigator: Jim Szybist, Oak Ridge National Laboratory

Presenter

Jim Szybist, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

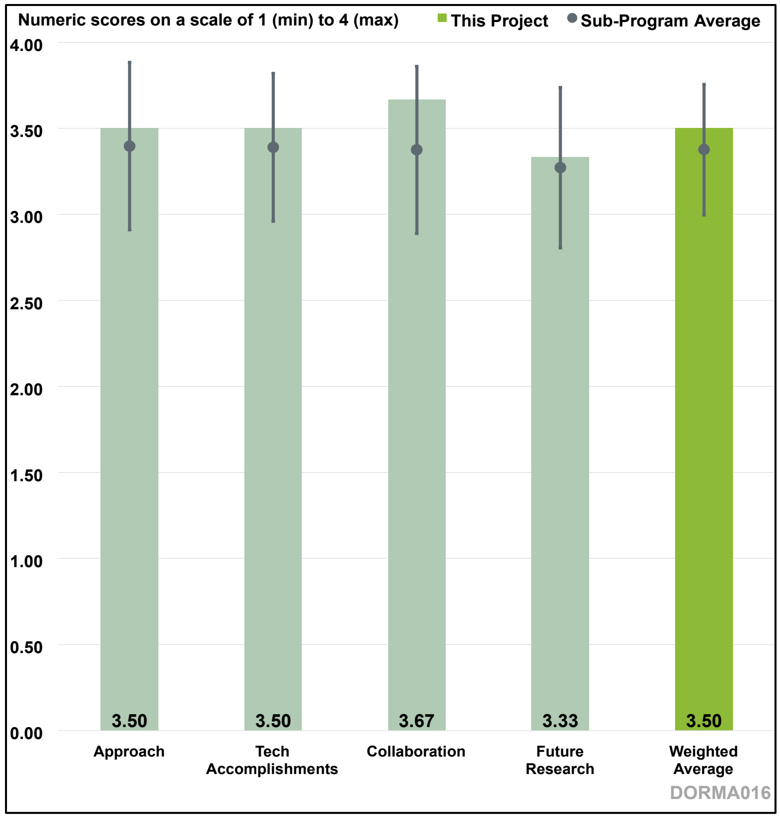

Figure 3-12. Presentation Number: DORMA016 Presentation Title: Renewable methanol-fueled engines for marine and off-road applications Principal Investigator: Jim Szybist, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted this is an extremely ambitious project, following three approach pathways simultaneously: (1) PFI methanol (MeOH) with a DI diesel pilot; (2) PFI of DME with DI MeOH, with catalytic MeOH dehydration to DME; and (3) MeOH prechamber spark ignition (SI) on three separate engine platforms.

Reviewer 2

The reviewer affirmed the project is on track.

Reviewer 3

The reviewer noted the project focused on three different combustion strategies, seeking to maximize performance. The strategies were PFI MeOH/DI diesel, PFI DME/DI MeOH, and active fueled prechamber. Engines are identified for each of these combustion modes, and a schedule is set for these. The information could have been strengthened with targets or expectations for them. The reviewer asked if there would be merit in focusing on one engine platform to consolidate the effort. The work included the development of a catalytic methanol dehydration for onboard DME production to support the second approach above. The reviewer added that the work could better clarify the state at which the effort is at.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer mentioned the project is in its early days. Engine platforms have been updated, and two have been installed and commissioned/baselined. The reviewer is looking forward to seeing the data that comes out of these test cells.

Reviewer 2

The reviewer noted solid progress has been made.

Reviewer 3

The reviewer indicated the project completed the installation and baseline of a CAT C18 engine at ORNL. Testing benchmarked discrete points using the CAT engine control unit (ECU) and ORNL open-access ECU. The project also installed and commissioned a single-cylinder version of the C18 engine at ORNL. The project fabricated a modified intake manifold for a prechamber cylinder head configuration. The aim of the prechamber was to prevent methanol pooling.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer affirmed strong partnership with CRADA partner Caterpillar and excellent working relationships with funding partners and additional collaborators. The reviewer also praised the impressive work with the senior design team at Colorado State University.

Reviewer 2

The reviewer noted that strong collaborations with an OEM and suppliers are apparent.

Reviewer 3

The reviewer observed that the project is configured as a CRADA with Caterpillar as the primary collaborator. The project features partners, Gane Energy, BASF, Colorado State University, and the Methanol Institute.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that the future work on this project is all of the exciting stuff, and they are looking forward to results coming out of these engines.

Reviewer 2

The reviewer indicated the project has a plan of tasks over four project years involving three engine platforms and catalytic methanol dehydration flow reactor experiments. The challenges indicated in the future work are similar to those noted in the approach. Having more specific metrics and targets for each of the engine configurations may be useful.

Reviewer 3

The reviewer suggested considering the delivery system and controls that are associated with the on-board DME device, including if a DME storage device is required. Ideally, water from methanol dehydration is used as a diluent for engine combustion instead of a new discharge stream.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer indicated that the project is extremely relevant to DORMA goals.

Reviewer 2

The reviewer commented that this is a very innovative approach using on-board DME from methanol for combustion assistance. The project team took a system approach considering all options and focusing on the tradeoffs of each approach.

Reviewer 3

The reviewer noted that methanol is a pathway to decarbonize the hard-to-electrify marine sector. It is relatively abundant and can be produced with a low carbon intensity. This reviewer encouraged the authors to quantify the GHG footprint from traditional means such as natural gas and biofuel sources. Technologies promoted in this project target efficient, clean, and durable operation with competitive diesel-like load capabilities.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer indicated the resources seem sufficient.

Reviewer 2

The reviewer noted that the DME production and storage system may take some time to build and requires some iterations before it will be ready for cold start and transient tests. This reviewer wished the team success.

Reviewer 3

The reviewer stated that the project aims to develop a methanol-based combustion system based on three possible approaches and engine platforms. The project has many challenges and unknowns as it moves forward. Some thought may be given as to how to maximize the effort, and if it makes sense to consolidate the effort on the two Caterpillar engines, at least with respect to the viability and merit of each of the pathways proposed.

Presentation Number: DORMA018
Presentation Title: SAF Combustion and Contrail Formation Research
Principal Investigator: Julien Manin, Sandia National Laboratories

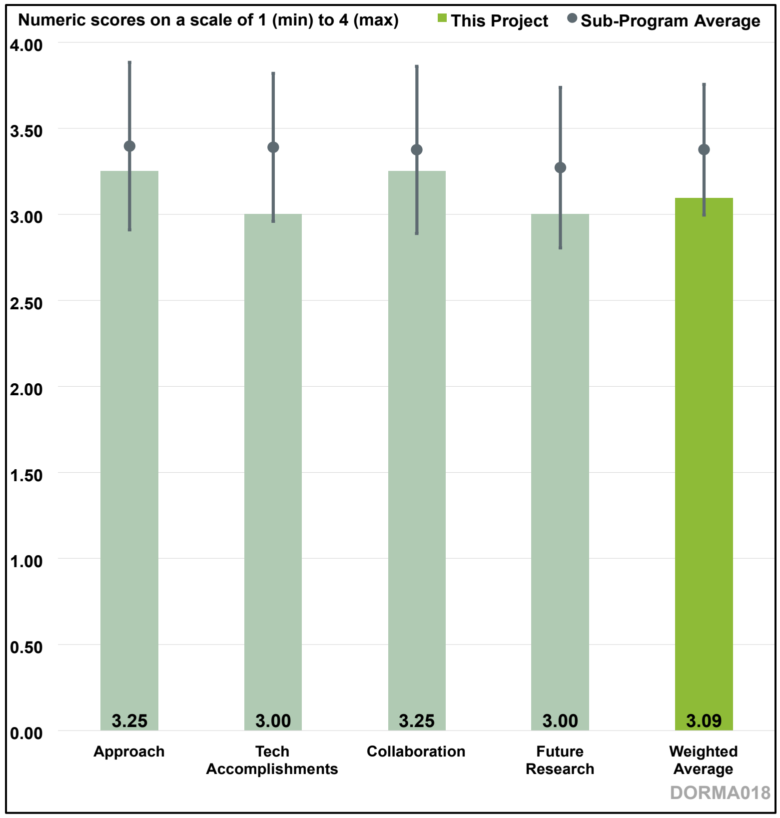

Figure 3-13. Presentation Number: DORMA018 Presentation Title: SAF Combustion and Contrail Formation Research Principal Investigator: Julien Manin, Sandia National Laboratories

Presenter

Julien Manin, Sandia National Laboratories

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The results of this work should contribute to all three of the bullets selected from the SAF Grand Challenge Roadmap. Several of the barriers are particularly challenging, specifically those related to vapor trail emissions and subsequent environmental impacts and will likely require an expanded effort. In addition, each year new (lower level) barriers are identified; hence the team has a strong, forward-looking perspective.

Reviewer 2

The effort focuses on a key research question regarding the understanding of fuel composition impacts on sooting propensity. The timeline and corresponding milestones are reasonably planned. The key milestones are the droplet nucleation altitude chamber and quantification of nucleation propensity for relevant sustainable aviation fuel (SAF) regarding fuel structure effect on sooting. Regarding the milestone on a standardized iso-paraffinic surrogate, this seems less critical and provides less unique research value given the many existing surrogate mechanisms. Differences between this work and prior existing work should be highlighted as part of this milestone.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The team has been coming up to speed to integrate themselves with the aero-engine community over the last several years. They have been doing that well and developed concepts for exploiting the fuel injection (pulsed) rig for reciprocating engines and applying it to conditions of interest (continuous combustion) to the aero-engine community. The success on simulation of the CFM combustor using reactor networks represents a new capability and an advancement to the state-of-the-art (SOA), although it remains to be seen how well this model extends to other combustor configurations. New capabilities regarding simulations using direct numerical simulation (DNS)-CFD and molecular dynamics for examining aerosol formation and plume generation are evolving well, although it will remain a challenge to validate such methods against experimental data sets resulting hopefully in new knowledge and strategies for reducing environmental impacts. The atmospheric chamber should help in this regard, but it will take a lot of work to fully characterize its capabilities and the chemical effects of different soots and sulfur on nucleation processes. The authors show in the back-up slides experimental/modeling comparisons of soot yields for different fuels. There is a substantial difference in the results for 1,2,4-trimethylbenzene (TMB). The reviewer said this discrepancy may warrant further investigation. The application of their tools to predictions near 3500 K is understandable due to computational costs etc., but there is a risk that reaction pathways may change at the lower temperatures applicable to aero-engine conditions.

Reviewer 2

The reviewer noted that accomplishments include results on the kinetics analysis of fuels on soot formation. The work aligns with previous work evaluating aromatics and other chemical classes. It is unclear what unique new knowledge this work provides or how it compares to previous studies. The work would be enhanced with these comparisons and clarifications. The other technical accomplishment on potential cycloalkane benefits on soot processes provides some value on fuel component comparisons. The work would be improved to have comparisons of this work to prior studies. Additionally, the comparison to “jet fuel with 20% aromatic” is not clearly making the case across all aromatics in fuels. Specifically, the synthetic aromatic kerosene from Virent has been shown to produce less soot than conventional aromatics. The study would be enhanced if a target blend representing the unique aromatic characteristics of potential synthetic aromatics was developed and analyzed. The results on the contaminant effect on water nucleation is a unique, valuable research effort documenting unique impacts from fuel impurities on water nucleation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project has a great set of collaborations and utilization of their experience. Pacific Northwest National Laboratory (PNNL) is linked up with Washington State University (WSU), who are doing work with cycloalkanes. Raytheon Technologies Research Center might be a good contact (Miad Yazdani) regarding their Federal Aviation Administration (FAA) contract on contrail formation.

Reviewer 2

The reviewer said the effort seems to have broad collaboration across relevant industry, academic, and government institutions. The presentation notes the research partners and areas of work, but additional details throughout the documented effort would facilitate improved understanding of where various research partners are making specific contributions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The researchers have identified a good set of specific tasks, although one or two might be missing. The first might be to characterize the soots from the “liquid fuel soot generator” and specifically how they change with different fuels to character (structure as well as hydrophobic/hydrophilic tendencies), number density, and size. A second might be to sort out the discrepancy in the soot yields from TMB. A broader topic for future research might be related to estimating the impact of different time scales (of the short-term nucleation processes for emissions from different fuels) on the longer-term climate forcing from the entire lifetime of the plume. These timescales are likely a function of local conditions (humidity, altitude, pressure, etc.) and probably variable, but ought to help focus future research efforts to the most critical needs.

Reviewer 2

The work outlines future research items with some detail on the purpose of the additional research. Additional information on the relative importance of future research would be beneficial to assess the value of the proposed work. While the proposed work includes tasks with experimental testing and sampling of flame stabilization and soot formation, it is unclear how the experimental work will be validated against available data from flight campaigns. Without proper validation, the reviewer is not clear if lab-scale experiments properly reflect real-world conditions. The reviewer said it seems likely that the proposed future work will be accomplished, but additional details are needed on the specific research objectives the proposed work intends to achieve.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The embedded links appear outdated, but the work is fully consistent for the SAF Grand Challenge Roadmap.

Reviewer 2

The project is relevant with regard to advancing new learnings for the sustainable aviation space. The reviewer commented that it was not clear from the linked VTO subprogram objectives which subprogram consideration this particular project addresses. Therefore, while the project may not clearly support a specific VTO subprogram objective, the project itself is enabling the understanding of fuel compositional effects on soot and contrail formation. This work is in a critical area as existing research gaps limit the understanding of contrail formation. Research to address these gaps may advance the ability to mitigate the global warming impact of persistent, warming contrails formed by aviation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project does not appear to be funded beyond FY 2024. The team has done well transferring their capabilities to SAF concerns and demonstrating that they can match or in some cases exceed the SOA. But to have a real impact, their work needs to continue further, and the experimental work needs to continue to support important model validation, with recognition that the experimental work is not cheap.

Reviewer 2

The project team seems to have sufficient resources to accomplish the milestones on schedule. The presentation did not indicate any resource constraints or concerns that would suggest otherwise.

Presentation Number: DORMA019
Presentation Title: Multi-phase flow studies of SAFs for industry-relevant conditions and geometries
Principal Investigator: Brandon Sforzo, Argonne National Laboratory

Presenter

Brandon Sforzo, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

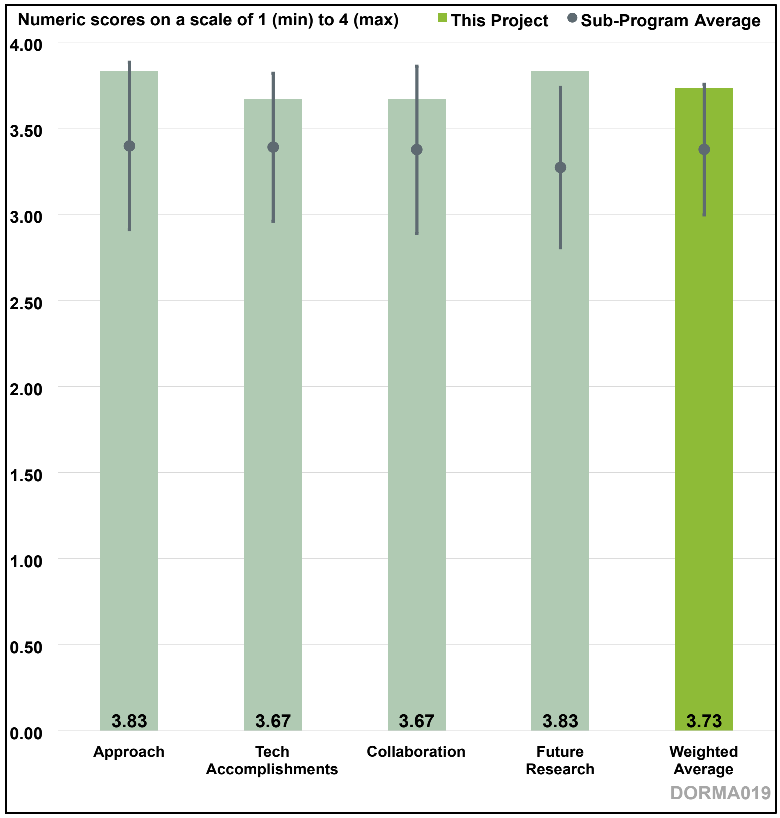

Figure 3-14. Presentation Number: DORMA019 Presentation Title: Multi-phase flow studies of SAFs for industry-relevant conditions and geometries Principal Investigator: Brandon Sforzo, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is providing unique measurements of the liquid fuel atomization process very near fuel nozzle exits using the using the high-flux X-ray source available at the Advanced Photon Source (APS) facility and is advancing the real fluid modeling of liquid injection and fuel-air mixing at elevated temperature and pressures where transition from two-phase flow to supercritical flow may occur. The testing and modeling include Jet-A and SAF fuels and are using non-proprietary injectors that use atomization techniques representative of current aircraft gas turbine engine fuel injectors. Testing at Phase 1 (1 atm, 25°C) conditions is underway with testing completed for one (pressure swirl + jet-in-cross flow) of the two 1 atm capable injectors provided under collaboration with the National Aeronautics and Space administration (NASA) and Woodward. Testing of the second (pressure swirl + pre-filming air blast) injector is somewhat delayed due to a one-year APS upgrade and the slower than expected time to get APS fully back online. Good progress was demonstrated on preparing for higher pressure (60 atm) and higher flow rate testing with window designs and rupture testing completed and hardware for higher flow rates assembled and undergoing safety inspections. CFD simulations of the first injector testing are making good progress and real fluid modeling has advanced beyond existing methods and has been demonstrated for single droplet evaporation including the National Jet Fuels Combustion Program (NJFCP) Category C fuels, C-1 and C-5. The X-ray phase contrast data very near fuel nozzle exits at any test condition is likely to help improve spray atomization modeling in general, but the largest benefit of this project is likely to come from the higher pressure and temperature testing where differences in Jet-A and SAF behavior may be more pronounced, particularly if transition to supercritical behavior occurs.

Reviewer 2

The major technical barrier that this project seeks to address is the limited available data and understanding concerning fuel-air mixing in a gas turbine engine close to the injector, with a focus on SAF. The project seeks to understand this mixing process using novel X-ray diagnostic methods and improved computational models. These models, validated through the experimental measurements, will improve understanding of SAF performance. This represents an important step towards 100% SAF adoption. The reviewer was impressed by the project’s logical approach to the problem and the clarity with which this approach was presented.

Reviewer 3

This project addresses internal flow and atomization issues as relevant to fuel injection which has critical influence on the combustion and emissions generation processes in a gas turbine engine. The experimental part of this work leverages the capabilities of X-ray imaging to overcome drawbacks of conventional light sources to obtain significantly improved understanding of the spray breakup and atomization processes. A particularly key advantage of the X-ray imaging technique is the ability to understand the internal features of the injection hardware and its subsequent influence on atomization processes. The PIs correctly identify outstanding issues with predicting transcritical spray behavior as relevant to realistic gas turbine engine operating conditions. Through X-ray imaging of spray atomization and correlation of the same through quantitative measurements with fuel physical properties, key insights can be drawn that can be essential to designing the next generation of fuel injection hardware particularly for operation with 100% SAF. Further, the detailed data about early spray properties can be very effectively used as boundary conditions for spray modeling efforts and the highly resolved results from these experiments can provide a wealth of validation data for simulation efforts. The simulation effort undertaken by the PIs rigorously addresses development of real fluid models for the trans/supercritical conditions of interest. The reviewer noted that all of these details ensure that the project is addressing critical technical barriers of interest to the aerospace and combustion communities. The project is well-designed, and the 5- to 6-year timeline seems well suited to achieve all the project goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Phase 1 testing and data analysis is making good progress. The project has completed X-ray tomography of the actual internal geometry of one non-proprietary injector (pressure swirl + jet-in-cross flow) and completed a series of X-ray phase contrast measurements for four fuels (Jet-A, SAF and high-viscosity fluid) for the Phase 1 testing (1 atm, 25°C) on one of the non-proprietary injectors. Detailed processing and analysis of the X-ray measurements has been completed for the primary fuel circuit (pressure-swirl) and is underway for the secondary fuel circuit (jet-in-crossflow). A strength of this project will be sharing the geometry, measurements, and information useful for CFD simulations (such as geometry and boundary conditions) in an open manner and the Box site is nearly ready to provide this information for Phase 1 testing of the Pre-Sec (pressure swirl + jet-in-crossflow) injector. The capabilities to perform Phase 1 testing of the second non-proprietary injector (pressure swirl + pre-filming air blast) are in place and are waiting on getting beam time in APS. The project is also making good progress in developing new capabilities to permit testing up to 60 atm and the corresponding higher flow rates needed for Phase 2 testing. Along with the higher-pressure testing capability, the project is developing real fluid modeling capabilities applicable to Jet-A and SAF. Validating these CFD models for hydrocarbon fuels with many components (such as Jet-A and SAF) is challenging. If the project can eventually perform Phase 3 testing (up to 60 atm and 700°C) the X-ray measurements may provide a unique data set for validating transcritical behavior for Jet-A and SAF under realistic conditions and with flow through realistic injector geometries.

Reviewer 2

The investigators have made excellent progress towards their objectives. Multiple atomizer configurations have been evaluated using X-ray imaging, revealing fuel atomization behavior at extremely high spatial and temporal resolution. The investigators have observed asymmetries in the fuel spray and have explained them by analyzing X-ray tomography images for atomizer defects. The PIs have characterized fuel effects on spray parameters, and their results compare well with those published in literature. The project team is developing boundary conditions for high-fidelity simulations that are accurate to the tomographic nozzle data and have a working single-phase simulation of gas flow in the atomizer. The PIs are also making progress towards models of SAF thermophysical properties and vaporization trends.

Reviewer 3

The PIs have acquired two non-proprietary atomizers. The PIs showed results for fuel effects on primary spray behavior for the Pri-Sec nozzle. The X-ray imaging very neatly shows the presence of a foreign object and helical grooves from the machining process. It is posited that the near-nozzle spray morphology is influenced by these features. There is a clearly observed asymmetry in the spray morphology resulting in variations in measured parameters including breakup length, sheet thickness, and cone angle. The PIs could have potentially tested more nozzles without these production artifacts or tested the same nozzle at different orientations to confirm their suspicions. The reviewer said it could be that X-ray imaging, given its demanding nature, made it hard for the PIs to conduct these additional tests. The PIs could add more effort to correlate their findings of the spray morphology parameters to the fuel properties through some physical underpinning of the underlying processes. The high-pressure windows needed for extending work to higher pressures seem to have been designed and tested and this should pave the way for the group to advance to transcritical conditions of interest. Upstream single-phase flows for both fuel and air have been successfully modeled. A comprehensive model for thermophysical properties of SAF has been developed using graphic processing units (GPUs)/machine learning approaches and its ability to predict properties in the transcritical region for both single component and blended fuels has been demonstrated. These efforts lay a solid framework for the proposed simulation efforts to be undertaken by the PIs.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The Aero-Spray Work Group includes members of aircraft engine manufacturers as well as other government agencies which benefits the project to acquire liquid fuel atomization data relevant to industry and next generation aircraft engine design. The project is also benefiting from some NASA funding supporting the design and delivery of non-proprietary fuel injectors for low pressure-temperature conditions and high pressure-temperature conditions. The National Renewable Energy Laboratory (NREL) testing of properties at higher pressure and temperature conditions will benefit the future CFD modeling of the testing at higher pressures and temperatures, as well as providing confidence in the lower pressure-temperature condition properties for current experiments. The real fluid modeling is a challenging area and experiments at higher pressure-temperature conditions with Jet-A and SAF being conducted by other DORMA projects may provide additional opportunities for validating the real fluid models being developed under this project. One example is the injection of Jet-A and SAF into higher pressure-temperature conditions performed in Sandia's constant volume rig.

Reviewer 2

Argonne leads the effort, performing experiments and simulations. The project relies on several partners across industry, government, and academia, for specific tasks, such as the design and fabrication of atomizers (Woodward) and the generation of fuel properties data (NREL).

Reviewer 3

The PIs are collaborating with a number of entities on this effort. This includes industry, national laboratories, and a university. The reviewer commented that there appears to be very specific contributions from each collaborator which is contributing to the success of this effort. The reviewer did not see the need for any more collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The project has a logical and achievable plan to complete the Phase I testing, analysis, and supporting CFD simulations. The project is also making good progress on developing capabilities for Phase 2 (60 atm, 25°C) testing and will have realistic non-proprietary injectors for that testing. The real fluid modeling has a reasonable plan to transition from existing cubic equations of state methods to a machine learning-based model. The largest benefit of this project is likely to occur if the project reaches Phase 3 (60 atm, 700°C) testing, but that goal may be outside of the current scope of this DORMA project unless funding outside of DORMA is provided. The unique spray atomization (or transcritical behavior, if that occurs) data collected very near the fuel nozzle exit at Phase 3 conditions for realistic injector designs is likely to provide new insights and validation data for fuel injection and atomization or transition to supercritical behavior for both Jet-A and SAF.

Reviewer 2

The proposed future work is well-defined and has a high likelihood of success. The investigators will first work on image processing for quantitative data, performing simulations on as-built atomizer geometry, and improving fluid models through FY 2025. Future phases of the project will expand beyond ambient gas conditions to higher temperatures and pressures in both experiments and simulations. A wider range of different SAF candidates will be investigated in a wider range of flow geometries.

Reviewer 3

The PIs have provided a comprehensive list of future research plans including experiments and simulations at elevated conditions of pressures and temperatures. These future proposed efforts are directly in line with the goals of the proposed research effort. The reviewer would strongly recommend adding a detailed investigation of any asymmetry effects to this list as the asymmetry would influence downstream mixing and combustion processes. Another item the reviewer would urge the PIs to consider is to add diagnostics for atomization and mixing as much as is allowed in the experimental setup. The reviewer commented that characterizing mixing quantitatively would yield very valuable information for the community.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The atomization of liquid fuels directly impacts the combustor operability and emissions since it directly impacts the location and uniformity of the fuel-air mixing. The X-ray phase contrast data very near the fuel nozzle exits provides unique data sets for improved modeling and understanding of the fuel atomization process. The most relevant testing and modeling will be at the higher pressure and temperature conditions where atomization for realistic injector designs is lacking, especially in publicly available sources. Additionally, the reviewer noted that comparisons of the atomization of Jet-A and SAF at higher pressure and temperature conditions were also lacking. In terms of real fluid modeling at higher pressures and temperatures, there are many approaches in the open literature for both ground-based and aircraft gas turbine combustor applications. The real fluid modeling developed in this project does add to the existing research. The big challenge is validating such real fluid models for realistic conditions, flow fields (or injectors) and relevant fuels (such as Jet-A and SAF). This project can potentially provide such validation data if Phase 3 testing is completed.

Reviewer 2

This project attempts to solve a problem that is key to SAF performance: understanding fuel-air mixing processes. The investigators do an excellent job explaining how X-ray diagnostics will bring about this understanding, promoting 100% SAF adoption, leading to economic and environmental benefits in the aviation industry. The reviewer stated that the project was very relevant to VTO objectives.

Reviewer 3

The project and its deliverables absolutely support the objectives of the DORMA subprogram. Spray atomization and mixing significantly affect the combustion and emissions processes. Results generated from this effort which is fine tuned for operating conditions as relevant to real engine operation will provide a wealth of knowledge for researchers. Particularly the early spray morphology and effects of nozzle internal geometry are significant inputs generated by the X-ray imaging technique. The effort to develop a model to incorporate real fuel effects at transcritical conditions and make it available to researchers is very notable. The strong collaboration with industry and NASA is very noteworthy and will ensure the results of this work are of high practical relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

There are sufficient resources to complete Phase 1 and Phase 2 testing, data analysis and CFD simulations of those experiments, and sufficient resources for the development of real fluid models. The reviewer commented that it is uncertain whether there will be sufficient resources for the Phase 3 (60 atm, 700°C) experiments which may have the largest impact liquid fuel atomization modeling for Jet-A and SAF.

Reviewer 2

The excellent experimental and simulation results that this project has so far produced demonstrate that the investigators have all the required resources to execute the planned work. The reviewer commented that project milestones are very likely to be completed on time. The budget for this project is expensive but this expense is well-justified by the X-ray diagnostic results.

Reviewer 3

The reviewer said resources, including physical and financial resources as well as collaborative support, seemed sufficient.

Presentation Number: DORMA020
Presentation Title: Sustainable Aviation Fuel (SAF) Contrail Modeling
Principal Investigator: Matt McNenly, Lawrence Livermore National Laboratory

Presenter

Matt McNenly, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

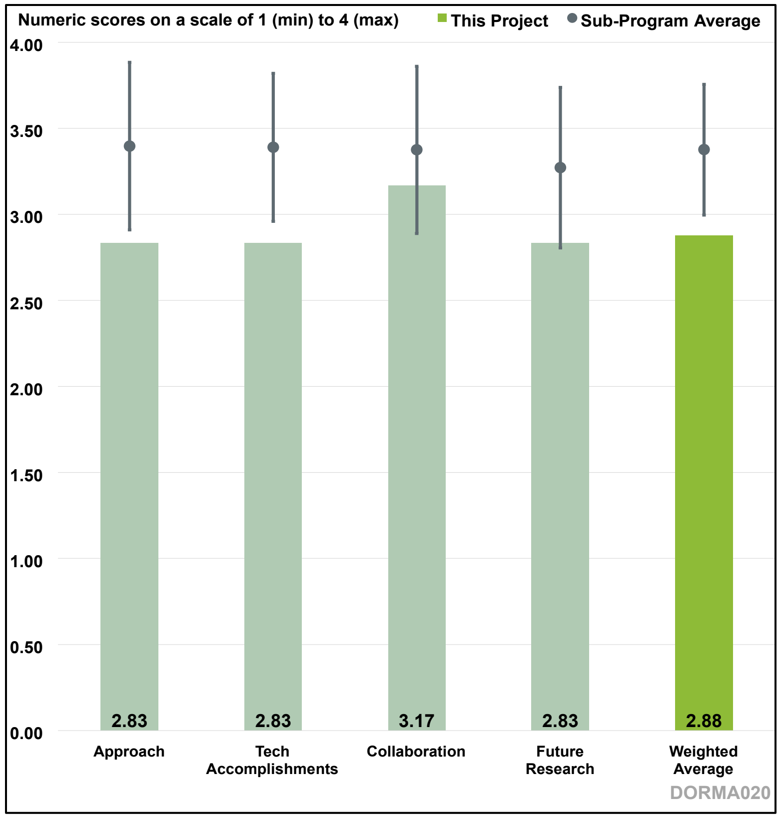

Figure 3-15. Presentation Number: DORMA020 Presentation Title: Sustainable Aviation Fuel (SAF) Contrail Modeling Principal Investigator: Matt McNenly, Lawrence Livermore National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

There are two barriers identified, the first of which is extremely vague so that any project in the general area might be sufficient. The second is much better, although very challenging. The researchers have identified critical work on understanding causes of hydrophobic and hydrophilic properties of soot as well as soot shape and surface chemistry as phenomena to be examined.

Reviewer 2

The project demonstrates DOE's strong expertise related to fuel chemistry and impacts on particle emissions. Contrails form on aircraft engine exhaust particles, and the project will connect the fuel-soot model to contrail formation via a microphysical model. It is currently thought that contrail cirrus clouds have a climate impact that is comparable to the cumulative emissions of aviation CO_2. This is an important research topic, and the project demonstrates a clear understanding of the motivation for the work.

Reviewer 3

The project outlines the two key technical barriers being addressed: insufficient data and tools for SAF performance metrics and SAF effect on contrail formation. While the proposal outlines milestones to FY 2024, the documentation indicates the project's anticipated end of FY 2027. The reviewer said it was unclear what the FY 2025-FY 2027 milestones are or what research goals are anticipated. The reviewer also said It was not clear how the planned milestones will be expanded for the variety of SAF pathways. The broad variability of SAF pathways require modeling and data for more than Jet-A and the C-1 fuel of the NJFCP. The proposed future research does not include a plan to address the still present barrier of lack of experimental data for analysis, as identified by the presentation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The application of ab-initio molecular dynamic simulations to analyze the hydrophilic character of (flat) graphene sheets with defects based on different functional groups is interesting and is a good fundamental contribution to science. The results of this theoretical work will need to be extended to soot particles, with agglomerated structures and curved surfaces. The microscale phase field modeling for ice crystal formation is a good development and should be useful in subsequent modeling of contrail evolution. Insufficient details of the Zero order Reaction Kinetics (Zero-RK) model were provided to assess its ability to model the ice nucleation and cloud models, nor compare/contrast its advantages with respect to other possible approaches.

Reviewer 2

The reviewer said the project appears to be on track to complete the major milestones on time. Fuel chemistry accomplishments to date are excellent; however, the bulk of the contrail modeling heavy lifting remains to be done. The reviewer also said it was important that the project team connect with an atmospheric science/cloud physics subject matter expert early in this process to ensure that the contrail modeling approach is realistic.

Reviewer 3

The project notes that work is mostly on track, with one delay for the testing of the coupled multi-scale ice nucleation model. The project activities and accomplishments thus far are key fundamental experimental and simulation efforts that will serve as foundational starting points for subsequent work. The work will need to demonstrate its ability to integrate these early results into more applicable tools that can be validated with real world data. Otherwise, this work runs the risk of being limited to a purely theoretical exercise with no ability to inform the direction of SAF development or contrail mitigation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the collaborations and contributions from other DOE funded groups seem well established, but the predicted sooting levels as shown in the back-up slides seem to be for fuel components of gasoline fuels rather than for SAF, perhaps suggesting that the coordination with collaborators is not sufficient. The Computational Chemistry Consortium (C3) is a great resource, and such interactions certainly should be continued.

Reviewer 2

The reviewer stated that the collaboration and coordination at Lawrence Livermore National Laboratory (LLNL) and with outside institutions seems strong. The team has a strong skill set regarding turbulent reacting flows, kinetics, and soot formation; however, there is not an obvious collaborator with expertise in plume-scale contrail or atmospheric modeling.

Reviewer 3

The effort highlights the project team members and their contributions across the various tasks. The extent of the collaboration could be further explained by highlighting specific contributors on the relevant slides where the work is shown. Otherwise, the extent of collaboration was not fully apparent to the reviewer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The description of the high-level objectives is good, but there are many pieces to come together to make all of this happen. The research direction might benefit from an analysis estimating the impact of different timescales (of the short-term nucleation processes for emissions from different fuels) on the longer-term climate forcing from the entire lifetime of the plume. These timescales are likely a function of local conditions (humidity, altitude, pressure, etc.) as well as soot particle size, structure and character, and probably variable, but ought to help focus future research efforts to the most critical needs.

Reviewer 2

Future work will focus heavily on connecting the modeled soot particle size distribution and properties to ice nucleating properties. This is an interesting research question with climate-relevant importance via natural cirrus formation pathways; however, the relevance of ice nucleation to contrail formation was not clear to the reviewer. Typically, contrail formation occurs in a two-step process within less than 1 second after leaving the engine exhaust plane. In the first step, the plume mixes with the atmosphere, which cools and dilutes the exhaust species. If, along this mixing line, the plume exceeds saturation with respect to liquid water, then liquid water will condense onto the soot and/or volatile particles forming small water droplets (the so-called Schmidt-Appleman criterion). Then, it is thought that these water droplets freeze homogeneously to form ice crystals that are sometimes assumed to be spherical or droxtal. Thus, the ice nucleating properties of the emitted particle are not relevant to near-field contrail formation. However, these emitted soot particles can influence the formation of natural cirrus clouds via traditional heterogeneous ice nucleation pathways, and it has recently been suggested that aviation soot might even have a climate-cooling impact by serving as ice nucleating particles and suppressing homogeneous nucleation in natural cirrus (this is highly speculative and uncertain!). Consequently, the ice nucleating properties of realistic aviation soot (less than 30 nm diameter) are relevant to answering these downstream aerosol-cloud interactions questions (even if the role of soot as ice nucleating particles is not relevant for direct contrail cirrus formation). There are also interesting questions that the model could be used to answer regarding the role of fuel sulfur and surface oxygenation in making the aviation soot particles hydrophilic/hydrophobic, which might be relevant for the early contrail water condensation process. In sum, the future potential of the model is significant for addressing important questions related to SAF and cloud formation. The project would benefit from including collaborators with atmospheric science and/or contrail modeling expertise to complement the outstanding DOE fuel combustion modeling expertise.

Reviewer 3

The project clearly outlines the future work but lacks defining the purpose of the future work in addressing the technical barriers. The reviewer stated it was likely that the work will be able to achieve the targets it has set for proposed future research. However, clearer connections between the proposed future research and the broader research objectives are needed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The embedded links appear outdated, but the work is fully consistent for the SAF Grand Challenge Roadmap.

Reviewer 2

The project is highly relevant to VTO. SAFs are a cornerstone of future aviation industry efforts to mitigate environmental impacts. The fundamental research outlined within this project represents an end-to-end approach linking fuels to combustion modeling to emissions modeling to contrail modeling.

Reviewer 3

The project is relevant but could be improved with a clear plan to ensure the applicability of the final work. This requires more robust data resources to validate the work to a more varied set of fuel types. It was not clear to the reviewer where the project fits under the VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Based on the progress thus far (in two years) which seems to be more on the fundamental side, the team will need to start exploring modeling complications and data needs for validation and extension to practical concerns. The remaining timeframe (three years is reasonable) ought to be sufficient to (at least partially) achieve the stated goals assuming funding support for this and aligned projects are sustained.

Reviewer 2

The reviewer stated that the project resources appeared to be commensurate with the proposed effort.

Reviewer 3

The project notes that there are research collaborators across a multidisciplinary team. The team resources seem sufficient to meet stated milestones. The reviewer said it was important that the team does additional work with and beyond the current team to gather sufficient experimental data on SAF fuels for adequate model validation.

Presentation Number: DORMA021
Presentation Title: Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains
Principal Investigator: James McCarthy, Eaton

Presenter

James McCarthy, Eaton

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

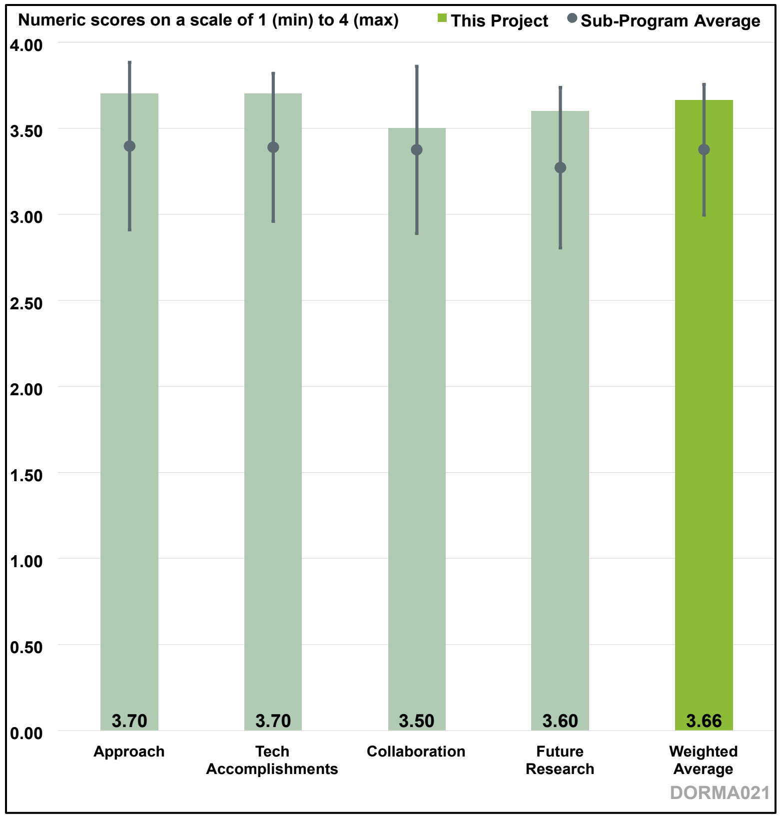

Figure 3-16. Presentation Number: DORMA021 Presentation Title: Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains Principal Investigator: James McCarthy, Eaton

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The NO_x and GHG emissions from diesel engines are the two barriers determining the future of the diesel engine in on-road and off-road applications. This project is well designed. The timeline is well planned. The testing schedule is very tight but the reviewer was confident team would make it. The test work proposed for ORNL may be challenging with the unit DOE lab environment in consideration, but the reviewer is sure this team has had a plan in mind if ORNL has difficulty in completing the research work assigned as scheduled.

Reviewer 2

The reviewer commented that the presentation was excellent, explanations were clear, descriptions were detailed, and overall, really nice. The review suggested following the review format (look at ORNL presentations as an example) to make it a little easier on reviewers. The approach to achieve the project goals is solid and on a reasonable time scale. The project schedule is reasonable and on track and there is a strong plan for multiple publications (which is fantastic and not something most PIs plan).

Reviewer 3

The project clearly addresses technical barriers related to the development of next-generation, high efficiency off-road engines. The desire to develop modular aftertreatment systems means focusing on single path scenarios is a necessity. While modest CO_2 reduction is targeted, significant NO_x breakdown is a goal. Importantly, it is also a target to quantify NO_x and GHG emissions in the systems, effectively establishing baselines for these engine of the future scenarios. As there are no current standards, this is a key part of the effort to further set the stage for the field.

Reviewer 4

The project has a very comprehensive approach toward improving efficiency and reducing emissions. There is good characterization of the varying duty cycles of the different agricultural tractor uses. The reviewer said multiple aftertreatment approaches were being considered.

Reviewer 5

The reviewer said the overall technical strategy was sound. The team is implementing the plan accordingly and reference data have been generated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This team has made significant progress in project deliverable as demonstrated in the presentation. The work prosed for Budget Period 1 (BP1) has been completed as planned.

Reviewer 2

The reviewer stated there was strong progress in both BP1 (the focus of this review) with the first paper presented at SAE WCX 2024, and into BP2. Even the baseline engine emissions were below Tier 4. The comparison between the on-road and off-road low load cycles was particularly interesting.

Reviewer 3

In general, the structure of the effort is very logical and rationally guided. In the first work period, a design and testbed build phase was completed, followed by testing in the current phase, and ending with an optimized demo build testing various aftertreatment configurations. The presenter mentioned a no cost extension for a few months will likely be requested to complete the project. Milestones generally seem to be on track, with a configuration already in hand that seems promising to make the 10% CO_2, 90% NO_x targets. The team has a clear trajectory to the Budget Period 2 (BP2) go/no-go point. The reviewer appreciated the detailed project schedule and the goal to have multiple publications result from the effort. The reviewer stated it was important to disseminate the information from the testing to establish the gold standard for quantifying the emissions in these systems. The work seems carefully done, with baseline CO_2 correctly considered. Mitigation efforts are well considered and potential issues impacting the work are adequately anticipated. The aftertreatment configurations pursued seem logical and will provide valuable data for various scenarios. This can be a good way to leverage and connect on-road and off-road data for researchers. The reviewer appreciated the cost model comparison toward the end of the presentation as it provided some idea of the scale of costs for both engine systems. While the reviewer thought lining up the five additional publications is a great way to extend the potential impact of the studies to the broader community, some more detail on these later in the presentation would have been nice, just to provide a little more detail on the topics and demonstrating the community value.

Reviewer 4

The project has done a good job mapping out the potential of the various components going into the efficiency gains as well as the aftertreatment configurations for NO_x reduction. The reviewer commented that the cost analysis was good to see, but difficult to evaluate without disclosing the baseline numbers.

Reviewer 5

Baseline emission data shown on Slide 11 does not include engine out NO_x, while emission data shown on Slide 16 does. The reviewer questioned if the indent of researchers was to keep the engine out NO_x the same for comparison of GHG with the “future” engine. The review said it appeared to create confusion with the EGR pump reducing “NO_x by 33%” from 9-6 g/kWh. It was not clear to the reviewer what the stock engine CO_2 grams per kilowatt-hour was. For the emission data shown on Slide 16 with aftertreatment (AT), the researchers did not state if the AT is the stock production configuration of diesel oxidation catalyst (DOC)-SCR. The reviewer also recommended researchers elaborate if an EGR cooler is installed or the EGR pump is meant to function as “hot EGR” without a cooler. If possible, the reviewer would encourage the team to report engine CO_2 and CO_2 from diesel exhaust fluid (DEF) moving forward. Reducing engine out NO_x requires less DEF therefore less CO_2 from DEF. For the “future” engine emission results without AT on Slide 16, PM emissions are 0.4 g/kWh which is very high. The reviewer suggests double checking the result. No explanation was provided on differences of cycle work when tested at Southwest Research Institute (SwRI) vs. ORNL (Slide 16). The reviewer commented that a comparison of torque curves of baseline versus “future” engine would have been useful or there may be a lab-to-lab variation. Slide 21 appears to have an error of about “>=90% lower GHG.”

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This team has a well-organized collaboration consisting of Eaton, SwRi, Fiat, ORNL, and Tenneco. The hardware needed for this project has been made available. The inclusion of industry partners such as the Fiat Powertrain (FPT) in this project is significant. The reviewer is sure SwRI has made significant contribution in technology development beyond test work.

Reviewer 2

The reviewer stated there was strong collaborations with Fiat, ORNL, Tenneco, and SwRI but would have liked to seen university participation.

Reviewer 3

Overall, the team is comprised of a diverse set of entities that bring singular skill sets to the project. Given the many moving parts in a project like this, it is obvious that experts in engines and their optimization, catalyst testing, and aftertreatment are needed. The partners from the various companies and the national lab group bring these needed skills and appear to be working together well to complete the various milestones in a timely manner.

Reviewer 4

The reviewer said the project team seems to have all the relevant aspects of the project covered. The reviewer also said It was difficult to tell specifically what the contributions were from Fiat, however, engine testing was clear between SwRI and ORNL.

Reviewer 5

The report reflects strong collaboration among team members for hardware design, controls, tests, and cost analysis. The project has a very broad scope with many variables. The reviewer stated to keep up the good work and collaborations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The project has clearly defined the purpose of future work. With the deliverable completed in BP1 and the work proposed in BP2, the reviewer is confident that the future work will highly likely achieve the goal of this project.

Reviewer 2

The future work for BP2 seems reasonable, but what earns this project the score of outstanding is the recognition that the BP3 plans may need to be revisited based on the data.

Reviewer 3

The path forward for the project is clear with a series of aftertreatment configurations needing to be tested, the results disseminated in the publications to some degree, and an optimized system tested and further tuned. There appear to be no major hurdles at this stage to completing the work in BP2 and BP3.

Reviewer 4

The team seems confident that the go/no-go target for BP2 will be achieved, however, it seems the BP3 goal may need some re-direction to achieve.

Reviewer 5

The reviewer was concerned on time/resource of testing different configurations and recommended the team to consider simulations moving forward. For cost analysis, the reviewer recommended the team show a boundary diagram with what is included in the analysis and what is out of scope. For example, the reviewer questioned if a 48 V electrical system or a battery was included in the cost analysis. The predicted cost reduction of -6.7% with added aftertreatment content of a diesel particulate filter (DPF), dual dosing, e-heater to a stock production system DOC-SCR appeared to be optimistic to the reviewer and recommended further cost refinement.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is closely relevant to advanced engine and fuel technologies, and it supports the overall VTO subprogram objectives in NO_x and GHG reductions.

Reviewer 2

The review commented that the project is relevant to VTO goals.

Reviewer 3

The project goals and approach are well-aligned with VTO interests in developing new engine and exhaust configurations for off-road applications that reduce GHG emissions and keep NO_x conversion high. Beyond the information on the new systems, the careful baselining of multiple configurations is of value to the research community.

Reviewer 4

A 10% GHG reduction and a 90% NO_x reduction does fit the VTO objectives. The reviewer suggested modifying the GHG reduction goal to get closer to 50% for more relevance towards the U.S. National Blueprint for Transportation Decarbonization.

Reviewer 5

The project addressed both CO_2 and emission reductions. The project further considers the CO_{2eq} contribution of nitrous oxide (N_2O) and CH_4 and feasibilities of meeting them individually. They are aligned with California Air Resources Board (CARB) Tier 5 regulations which has limits for N_2O and CH_4. This team is thinking very comprehensively including future emission regulations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

With strong support from FPT, SwRI and ORNL, this project has excessive resources for them to complete the research work proposed. The reviewer felt that this project was under-budgeted, this team may have spent more money or has more hardware support from their partners.

Reviewer 2

The reviewer said the project has sufficient resources.

Reviewer 3

Given the diverse skill sets of the partners and that they cover all the areas needed to develop the engine and aftertreatment configurations and test them fully, all needed resources were present.

Reviewer 4

The reviewer stated that the resources seemed appropriate for a project that does not require a machine demonstration.

Reviewer 5

The reviewer was concerned on the team’s ability to test all hardware combinations which would further include calibration optimizations.

Presentation Number: DORMA022
Presentation Title: Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition
Principal Investigator: Adam Dempsey, Marquette University

Presenter

Adam Dempsey, Marquette University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

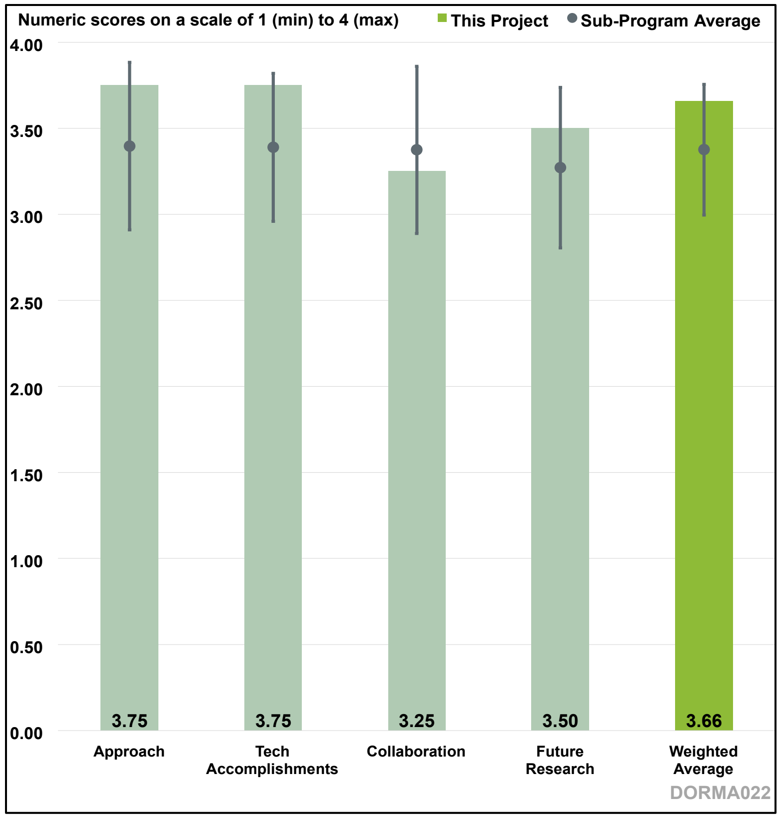

Figure 3-17. Presentation Number: DORMA022 Presentation Title: Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition Principal Investigator: Adam Dempsey, Marquette University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said this is a well laid out project in which the tasks are being executed as planned. The modeling tasks are clearly being used to guide the design and implementation. Moving from modeling to single-cylinder experiments to multi-cylinder experiments is the right level of scale-up and design. The fact that the prechamber system is operating as predicted by the modeling is a major success for the project team.

Reviewer 2

The project addresses key questions and barriers linked to prechamber ignition. The project is also designed well to address translating the engine design from a low technology readiness level (TRL concept to higher TRL. The analysis of cylinder head fatigue is a great approach to address applicability of technology in a production environment. The intended total cost of ownership (TCO) assessment tasks were also important for commercial acceptance of the technology.

Reviewer 3

This project has a well thought out approach, starting with the modeling, single-cylinder engine, and validation with the multi-cylinder engine. The reviewer was unclear on how the CFD modeling of the rapid compression machine (RCM) fit in for mechanism and surrogate selection and that the timeline seemed to indicate that work would be part of this review period.

Reviewer 4

The reviewed commented that the research was outstanding on ethanol prechamber enabled mixing-controlled combustion (PC-MCC) combustion. The reviewer said CFD modeling and single-cylinder engine testing was very good and that the results have been analyzed and presented in a very good format. This project is very well designed and is important in reducing GHG emissions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project team is collecting experimental results from custom hardware and the design and implementation of the custom hardware was guided by the modeling studies conducted early in the project and function as expected. The reviewer said this demonstrates that the project is answering the technical questions that are needed to develop this combustion strategy to implementation. The studies being conducted have both a scientific curiosity component and are pragmatic. For instance, the approach taken to understand the effect of equivalence ratio on prechamber stability laid out the tradeoffs that one could expect in a much better way than had been seen before. Thus, the reviewer's understanding of this effect is greatly improved, as is the practical nature of what needs to be done from an engine operation standpoint.

Reviewer 2

The completion of CFD modeling for the design and combustion strategy development has been conducted in a timely manner and the results are very promising. Fabricating the prechamber components is a key milestone of the project as it is a very critical element of combustion control. The start of single-cylinder testing is also an impressive accomplishment. The reviewer was not clear on the combustion stability with PC-MCC combustion in 98% ethanol, 2% gasoline (E98) fuel or what the IMEP comparison between -20° and +4° spark was for PC-MCC.

Reviewer 3

This project team has made quite a lot of progress and a large number of accomplishments. The team showed great results demonstrating the benefit of prechamber over conventional spark ignition.

Reviewer 4

The reviewer commented that there was great progress on CFD modeling, single-cylinder engine testing, and analysis.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project team includes a second university (University of Wisconsin-Madison [UW-Madison]), an off-road OEM (John Deere), as well as Clear Flame Engines and Missouri Corn Merchandising Council. Thus, there is good representation across a spectrum of perspectives. However, the project seems to be driven by Marquette with relatively minor contributions from the other stakeholders. For instance, it was not clear to the reviewer what Clear Flame Engine is bringing to the project other than serving as a location to test the multi-cylinder engine. However, more collaboration may not be necessary to accomplish the project goals.

Reviewer 2

The presentation did not clearly mention the coordination process and specific tasks accomplished by the various partners. Project partners that include MAHLE and John Deere are excellent, but the reviewer noted specific inputs provided by these partnerships would be useful.

Reviewer 3

It was not clear to the reviewer how the UW-Madison task is linked in with regard to the surface temperature measurements. The reviewer said it appears to be an experimental task, but it was not clear what engine is being used or if it was the same CAT C9. The reviewer also questioned what differences there will be in moving to the John Deere 9.0-liter platform.

Reviewer 4

The reviewer commented that the overall results show good collaboration between project team members.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future proposed research consists of additional single-cylinder engine experiments at higher load and then moving the concept to a multi-cylinder engine with heavy involvement from an OEM. This is the right development path to be able to introduce a new technology and have an impact on the industry in a short timeframe.

Reviewer 2

The future tasks planned are highly relevant and provide a complete overview of the pros and cons of this strategy.

Reviewer 3

The reviewer was not clear on whether the validation tests were planned to be done only on a dynamometer or in a vehicle (Clear Flame Engines). The reviewer noted some of the connections between tasks got lost in the presentation.

Reviewer 4

The reviewer stated there were clear targets on future research tasks including multi-cylinder engine testing and technology assessment.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is directly aimed at off-road decarbonization by enabling the use of a low carbon fuel in compression ignition engines.

Reviewer 2

This project addresses a highly relevant topic of using low lifecycle GHG fuels in existing engine platforms. The modifications of existing engine architecture to prechamber to maximize the efficiency is a novel approach and the project is well designed to address critical barriers.

Reviewer 3

The project is a nice demonstration of lowering the carbon intensity using mostly conventional engine technology.

Reviewer 4

The project is clearly relevant by supporting VTO objectives in reducing CO_2 emissions for off-road vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the project appears to be well-resourced and on-track. There is no evidence of a lack of resources, nor is there any evidence of an overabundance of resources.

Reviewer 2

The reviewer commented that academia and industry collaboration provided the necessary resources for the project.

Reviewer 3

This team is getting great output at the current funding level.

Reviewer 4

The reviewer stated the project seems to have sufficient resources for completing required tasks and project plans.

Presentation Number: DORMA025
Presentation Title: Fully Electric Powered Hydraulic Assisted Compact Track Loader
Principal Investigator: Perry Li, University of Minnesota

Presenter

Perry Li, University of Minnesota

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

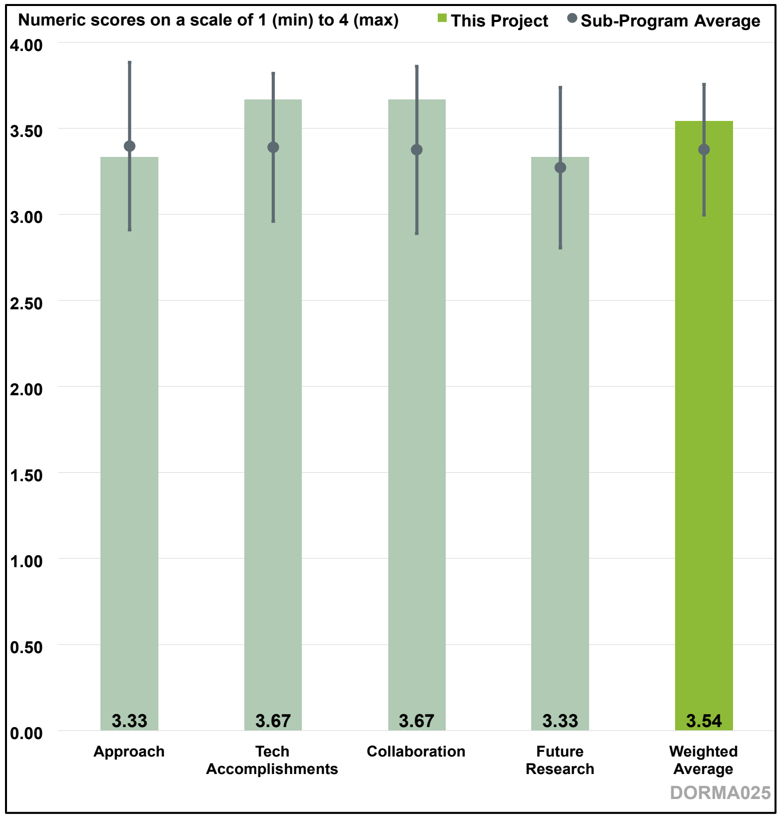

Figure 3-18. Presentation Number: DORMA025 Presentation Title: Fully Electric Powered Hydraulic Assisted Compact Track Loader Principal Investigator: Perry Li, University of Minnesota

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The overall effort in designing the hybrid hydraulic-electric architecture system and overcoming technical challenges compared to the baseline track loader is good.

Reviewer 2

The project shows all around fantastic work. The project is well-designed, and the timeline is reasonably planned. The reviewer appreciated the novelty of this technology and due diligence by the investigators with regards to the implementation in compact construction equipment. The critical commercialization challenges with regards to battery size selection to reflect realistic customer duty cycles, controllability of the switching digital displacement pump, and scalability of this technology are being investigated in a comprehensive and well thought out manner. The reviewer also said the project was well done.

Reviewer 3

The approach of this project is to selectively improve off-road electrification efficiency by significantly improving the hydraulic portion of the vehicle by maximizing the effectiveness of the electrification. This approach makes a lot of sense and has already demonstrated significant improvement in improving the electrification efficiency of the vehicle by essentially doubling the battery in-use time from 1-2 hours to 3-4 hours. The project uses advanced hydraulic valves and an advanced control scheme algorithm to optimize the ability of the vehicle to adapt to real-time changes in vehicle operation and use. This is an important aspect to this project. There is uncertainty that the in-use operation of a typical 75 kWh battery will ever reach the desired 8+ hours, which is a major challenge in electrifying this market segment. At the moment, there is no engine-hybridization option being explored. There is risk that even if the project is very successful, the end-goal of a “day’s work” using only the battery as energy storage may not be achieved. There may be some merit in exploring additional differentiation between the work circuit and the propel circuit and their relative power and energy sources.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project showed good progress on improving energy efficiency over e-motor replacement design.

Reviewer 2

The technical progress that has been made compared to the project plan has been impressive from the baseline machine performance testing, estimation of energy saving potential and battery charge duration, feasibility evaluation of alternate electric assist approach, construction of laboratory work circuit and propel testbed, real-time rail-selection and rail-filling algorithm, rail-switching loss minimization and component sizing, as well as sourcing for the demo machine. The reviewer encouraged the PI to keep up the good work. The reviewer looks forward to the results from the demo machine.

Reviewer 3

Effectively doubling the in-use time of the battery is a significant achievement. The novel approach has allowed for significant technical progress to occur. Additional work on the control scheme and further investigating the external assistance scheme (as shown in the presentation as external levers/linkages driven by the e-motor), in addition to the hydraulic pump assistance is a good idea.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that all members of the project team seem to work together effectively.

Reviewer 2

The reviewer said the collaboration and coordination between the partners which include academia, OEM, and critical component suppliers are well documented.

Reviewer 3

There are excellent partners in this project. CNH is an OEM that has provided significant access to their machines and test facility. Parker and Danfoss are industry leaders in hydraulic technology. The University of Minnesota has shown to be a leader in controls and hydraulic actuation technologies.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Base goals are listed in the future research slide. The reviewer suggests adding one or two stretch goals to further improve battery life compared to a diesel compact track loader.

Reviewer 2

The proposed future research is reasonable with clearly defined purpose and the investigators are very likely to achieve the project targets based on the consistent progress that has been made on this project over the years.

Reviewer 3

Future work aims to improve efficiency further by improving valve switching speed and reducing pressure losses. This should provide assistance in additional improvement in energy efficiency. However, these improvements alone are not likely to result in an additional “doubling” of battery in-use run time, from 3-4 hours to 6-8 hours which is the desired outcome.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project is extremely relevant to improving efficiency and CO_2 reductions of off-road tracked vehicles.

Reviewer 2

The project introduces a novel architecture to address cost and power density challenges with electrification of off-highway equipment which supports the overall VTO subprogram objectives for decarbonization of difficult-to-electrify sectors.

Reviewer 3

This project definitely supports the DOE goal of improving energy efficiency of off-road vehicles and decarbonization of same. The technical progress is quite good to this point. This type of optimization work will be applicable to a variety of off-road technologies. The primary concern of the reviewer is that the scale of operating the vehicle on the battery is still too low to really be impactful in this marketplace. Either additional battery capacity would need to be explored, or the possibility of a downsized engine hybrid mixed with the electrical system may need to be explored.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources seem to be sufficient in meeting project targets and timeline.

Reviewer 2

The project is on track to meet the milestones outlined in the project scope with the current funding levels.

Reviewer 3

The resources allocated to this project appear to be sufficient to support achieving the target goals.

Presentation Number: DORMA026
Presentation Title: Articulated Dump Truck (ADT) Electrification—Greenhouse Gas Reductions and Commercialization of New Technology
Principal Investigator: Brij Singh, John Deere

Presenter

Brij Singh, John Deere

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

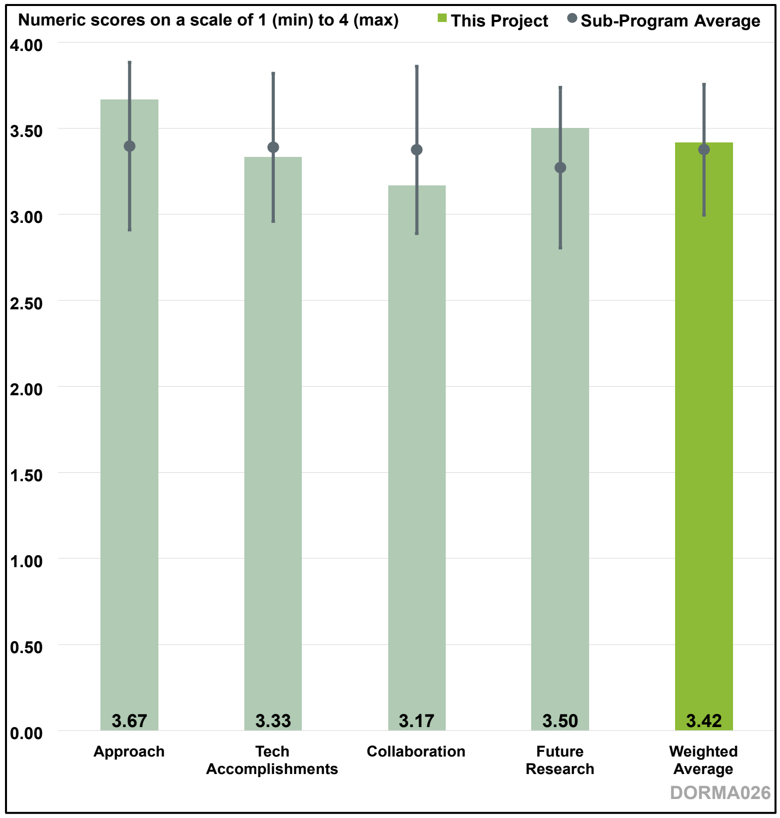

Figure 3-19. Presentation Number: DORMA026 Presentation Title: Articulated Dump Truck (ADT) Electrification—Greenhouse Gas Reductions and Commercialization of New Technology Principal Investigator: Brij Singh, John Deere

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project is sharply focused on vehicle-level integration to achieve a diesel-hybrid (electrified diesel) ADT in order to reduce the GHG emissions associated with the large (78%) idle times experienced by the vehicle. Eliminating ADT idling is challenging, as it requires replacing the conventional hydrostatic drivetrain with a diesel-electric hybrid powertrain, which does not currently exist, and make the design shock-proof for the rugged environment. To create this novel diesel-electric hybrid (which has further application beyond just the ADT) requires integration of a silicon carbide (SiC) inverter, SiC non-isolated direct current-to-direct current (DC-DC) converter, SiC/SI isolated DC-DC converter and a battery pack in order to accomplish a dual path for power flow between the downsized engine and traction system. To accomplish this, the team is making use of dynamic system modeling to represent the ADT test bed drivetrain, optimizing the design of both power inverters, doing a life assessment of the 700 V Li-ion battery pack, doing durability analysis of the new hybrid ADT powertrain, and defining the specifications for the necessary power electronic components. This process is well-designed to accomplish the project goals. By taking a pre-existing production vehicle and designing the electrified ADT architecture to integrate into the existing system, the project team are leveraging past work and not spending excessive timing designing from the ground up. The reviewer said while this might cause some integration challenges, it seems like a smart and efficient approach.

Reviewer 2

The reviewer commented that in Budget Period 1, concentrating on identifying the components needed for the powertrain with a focus on the shortcomings of available inverters is a sound approach.

Reviewer 3

The reviewer stated the approach is sound by using a downsized engine with an electro-assisted infinitely variable transmission and a battery pack. Parallel flow power is also a good approach that optimizes each system based upon power demand. Reaching for technology advances in inverter and DC-DC converter technology is also a favorable aspect to this project. The reviewer noted one uncertainty is that SiC inverter/converter technology will be scalable in time for the project goals and needs. There is a sound backup plan to use conventional insulated-gate bipolar transistor technology if SiC is not ready in time.10 kW SiC machines are a good starting point but not imminently close to the 100 kW or 200 kW SiC inverters that would be preferred. The fact that this work is at a university and not an inverter supplier implies that it is further out technology than imminent. The reviewer said it was a good risk to take, but it is a risk. There is also some slight risk in using nickel manganese cobalt (NMC) cylindrical batteries instead of other chemistries. NMC batteries tend to have shorter cycle lives and tend to need extensive immersion cooling (which is provided here) to operate safely and sensibly. Even though the project partners may not have immediate access to other battery types, it may be worth exploring lithium iron phosphate-based chemistries for cost, cycle life, and reduced cooling demand purposes.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Despite several reviewer questions, it was not clear how much the success of this project relies on the SiC technology working out. While the team has a backup plan that will allow them to accomplish the overall goal of hybridizing, it is unclear how much that would impact the efficiency or GHGs associated with the project.

Reviewer 2

The reviewer said the project looks good but there still appears to be significant risk on the scaling up of the soft-switched SiC inverter. The reviewer suggested to focus more on making significant progress with that.

Reviewer 3

The project has achieved all relevant milestones for the budget period. The project is on-track to accomplish all the target goals of the project on its current trajectory.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Each of the university partners has a task to focus on and work closely with Deere on. The reviewer noted that this seems like an excellent way to leverage these resources.

Reviewer 2

The reviewer said it was hard to judge the effort that goes into collaboration within the Deere organization. The universities appear to have well-defined roles and are contributing nicely to the project.

Reviewer 3

The primary participants in the project are different portions of John Deere. There are two universities, the University of Arkansas and North Carolina State University, working on the electrification portions of the project. These universities appear to be making excellent progress in their respective technical areas. However, there is no partner with experience mass-producing inverters and DC-DC converters involved. There is some risk that even if SiC breakthroughs occur, there may not be the right partner involved to capitalize upon those breakthroughs.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted there are anticipated challenges.

Reviewer 2

The reviewer commented that it was good to see that the team had identified innovation needs for the inverter technology.

Reviewer 3

John Deere is using an excellent approach to downsizing the engine, providing modest electrification, and pushing inverter/converter technology to improve the efficiency of multiple types of vehicles/devices. This approach is likely to be effective in multiple market segments. The project team has a fallback plan if the SiC technology is not ready by the required time and the overall project goals are highly likely to be accomplished. The reviewer said the future work looks very promising.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports the overall VTO goals for reducing GHG emissions in off-road vehicles.

Reviewer 2

Electrification of the ADT will lead to significant decarbonization since this application has significant energy recovery opportunities under its prevalent duty cycles.

Reviewer 3

This work leverages known benefits of downsizing engines and adding electrification to improve overall vehicle efficiency. This project is very relevant to DOE goals to improve GHG emissions in the off-road sector. The project is using the correct approach and technology suite to help DOE achieve these goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources for this project seem to be sufficient, though additional DOE investment could help accelerate the timeline of deliverables and the number of pieces of equipment that the novel hybrid system could be applied to.

Reviewer 2

The significant delay in BP1 makes it hard to evaluate the resources but the reviewer assumed that it was not due to lack of funding (Federal or cost share).

Reviewer 3

The resources appear to be sufficient for the project to accomplish the intended goals.

Presentation Number: DORMA027
Presentation Title: Control of aldehyde emissions from alcohol-fueled non-road engines
Principal Investigator: Sreshtha Majumdar, Oak Ridge National Laboratory

Presenter

Sreshtha Majumdar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

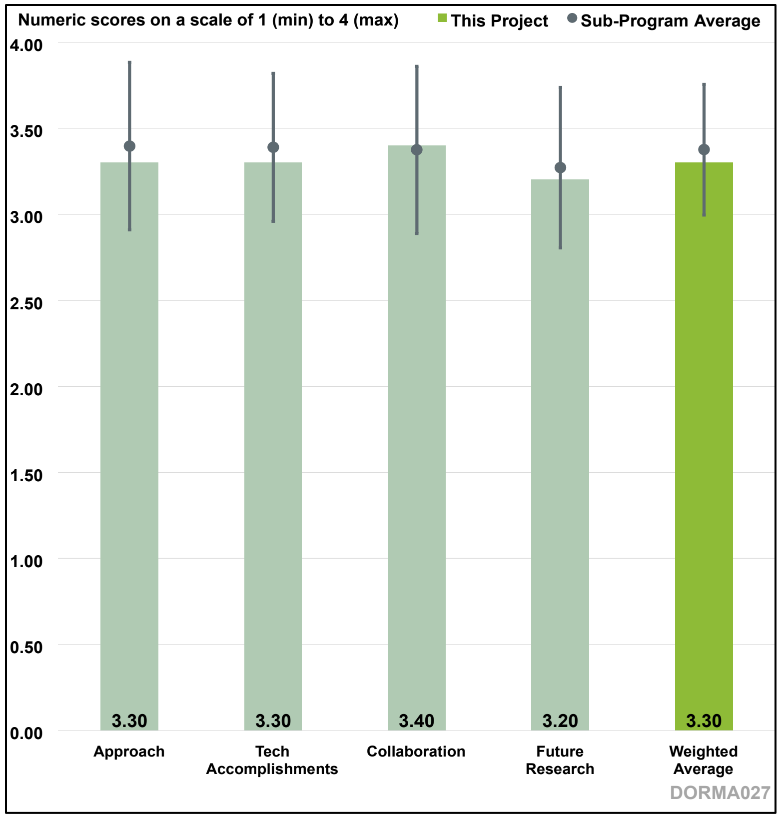

Figure 3-20. Presentation Number: DORMA027 Presentation Title: Control of aldehyde emissions from alcohol-fueled non-road engines Principal Investigator: Sreshtha Majumdar, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project clearly addresses obtaining insights into technical barriers associated with partial alcohol oxidation in engines for off-road applications. The need to evaluate aldehyde emissions in particular is made clear from the presentation. Fundamental insight into the nature of these intermediates is key to developing ways to mitigate their formation. In general, the system design to monitor reactivity using advanced infrared methods (diffuse reflectance infrared Fourier transform spectroscopy [DRIFTS]) is appropriate. The reviewer said it was also gratifying to see close interaction with industrial partners to ensure the types of catalysts and conditions used mimic as closely as possible conditions in the real systems.

Reviewer 2

The findings and detailed data on formaldehyde formation from methanol and acetaldehyde formation from ethanol are necessary to look further in how to improve the system. The range of tools used, including DRIFTS, is a very wise plan. The reviewer is hopeful to see the DRIFTS data in a future presentation.

Reviewer 3

The reviewer said that a good range of fuels are being tested and there was a good use of Clean Energy Emission Reduction protocols. The reviewer also said there was a good combination of DRIFTS, flame ionization detection, and Fourier transform infrared (FTIR) spectroscopy for gas analysis and that the development of the aldehyde introduction system was impressive.

Reviewer 4

The project goals include further understanding of LLCF, with a specific interest in MeOH and ethanol (EtOH), reactivity over emissions control catalysts and identification of catalyst formulation to mitigate aldehyde emissions. Upon reviewing the presentations from 2022, 2023, and 2024, the reviewer noted that the technical work appeared exploratory in nature. Clear and measurable goals and therefore the metrics that should help to achieve these goals were not obvious to the reviewer. Going forward, defining success criteria of what it means by “further understanding” and “identification of a catalyst” should be attempted. Specific strategies for identifying alcohol and aldehyde mitigation were not obvious to the reviewer. The reviewer suggested examples including identifying commercial formulations, working with suppliers to develop formulations based on the insights generated, identifying conditions for optimal performance to enable engine-based controls to mitigate the pollutants, or generating quantifiable insights (kinetics) to select right design for the catalyst package/formulation (PGM contents/ratio) etc.

Reviewer 5

This project addresses aldehyde emissions issues from alcohol-fueled engines. Aldehyde emissions is not a new topic as it has been discussed for decades when alcohol research was conducted before 2000. This project is not well-designed. The reviewer noted the research should focus on the methodology mitigating aldehyde emissions other than aldehyde formation in the DOC. The project milestone was also not well-designed. The reviewer stated the milestone should be technical achievement rather than submitting a publication.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Progress has been significant towards the goals. The equipment and data have been well done to advance for great results in the coming year. The reviewer commented that it will be great to see the paper that will be submitted soon.

Reviewer 2

Commercial DOC technologies were used and oxidation of alcohols and aldehydes were carried out. The reviewer recognized the challenge of handling aldehydes in the lab and how ORNL overcame this hardware challenge. However, from the technical studies that addresses the intent of the project, the presentation did not highlight what was the unique or impactful technical insights that were not already known. From conversion and selectivity data such inhibition signature was not obvious. The reviewer was unclear on what specific data led to the statement “Highly stable acetates or formates on the catalyst during alcohol oxidation can inhibit aldehyde and alcohol oxidation.” The reviewer also noted that this is limited research work to theorize the underpinnings of inhibition. Potential constraints and feasibility of specific solutions derived from this project in overcoming the barriers were not obvious.

Reviewer 3

The project team found that oxygenated fuels unfortunately form stable aldehyde intermediates on the conventional oxidation catalyst formulations which are difficult to get rid of and can block catalyst sites and disrupt activity.

Reviewer 4

The reviewer said milestones appeared to be on track though it would have been good to see metrics from other FYs for reference. The general setup appears well designed, with a flow reactor system that allows testing of a range of catalysts that have been varied in their aging conditions and composition. The reviewer also said it was clear care was taken with replication of experiments and the data presented was top notch. The systems are clearly well characterized and provide reproducible platforms to study these intermediates. The reviewer stated DRIFTS seems like the perfect tool to interrogate surface functionalized organics in the course of the reaction. The reviewer also noted the development of a high part per million formaldehyde delivery system is not a trivial technical accomplishment given the difficulty in handling of the reagent. Examination of the surface species and understanding of their stability under operating conditions will certainly help in the design of next generation catalysts. While the current capabilities are good, there is also a heavy reliance on DRIFTS. The reviewer suggested expanding to other techniques to provide additional information on intermediates or how the catalyst changes over time. In particular, the reviewer noted that imaging of catalysts before and after might be beneficial to understand the impact of the surface intermediates seen by DRIFTS on the catalyst structure (migration of sites in the formulation, etc.). Several presentations on the work were good, though the reviewer questioned listing internal quarterly DOE program updates in this section. The reviewer noted that providing more details on the progress and status of the publication was a missed opportunity.

Reviewer 5

Some progress has been made in characterizing the impact of the current DOC in producing aldehyde and aldehyde oxidation in the DOC at different temperatures. Progress was well aligned with the milestone but the milestone was not well developed. The submission of one paper should not be a milestone assessing the progress of this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The collaboration has been mainly limited to discussion, guidance, and assistance. Caterpillar provided the catalyst sample. The new catalyst provided by Johnson Matthey is the key to the success of this project. The reviewer suggested ORNL has further discussions on aldehyde emissions control especially the new catalyst which can oxidize aldehyde at lower temperature.

Reviewer 2

Caterpillar and Johnson Matthey appear to have been excellent partners in that Johnson Matthey provided a catalyst to test and Caterpillar provided focus on the aldehyde formation from alcohols.

Reviewer 3

Collaborations with Caterpillar and Johnson Matthey are good, but the reviewer would have liked to have seen involvement of a university partner or at least summer interns.

Reviewer 4

Overall, the team is comprised of a small but diverse set of entities that bring singular skill sets to the project. ORNL supplies the catalysts and characterization expertise while the two companies provide key insights on aging conditions and catalyst composition to provide the most “real” conditions possible that mimic industrial catalysts. The partners from the various companies and the national lab group bring these needed skills and appear to be working together well to complete the various milestones in a timely manner, given the amount and quality of data provided.

Reviewer 5

The reviewer commented that the partners were relevant. More partners may not be required, however, the reviewer could not tease out their active contributions from the generic statement of “Discussions, guidance and catalyst sample.” Listing specific and concise contributions of collaborators will help in better assessing the effectiveness. The reviewer suggested examples such as: Collaborator 1 helped in defining and shaping up specific technical barriers and defined real-world operating conditions based on which relevant evaluation protocols were developed; Collaborator 2 designed the catalysts for the targeted reactions and conditions as defined by Collaborator 1; and all collaborators reviewed the progress on periodic basis and collectively decided on the metrics for success of this project, etc.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Future research should focus on the technology/catalyst improving the oxidation of aldehyde. The research of biodiesel fuel seems not necessary with the future market in consideration. The resources and time are limited. The mitigation of aldehyde should be the focus of this project.

Reviewer 2

The reviewer stated future plans look excellent. One of the main variables so far has been comparing catalyst formulations and finding the platinum (Pt) + Pd catalyst had the lowest temperature light-off for alcohol oxidation and aldehyde formation, but the Johnson Matthey methane oxidation catalyst was better for aldehyde conversion at lower temperatures. The reviewer noted that it would have been nice to know why, possibly from the DRIFTS studies. The other variable that does not appear to have been tried, which is easier, would have been to change the gas feed of some species. In 2012, this ORNL group published a paper where NO concentration was varied and it appeared to affect the temperature of aldehyde formation and conversion. NO and other species could be increased or decreased in a few experiments to see if they have any impact in future studies.

Reviewer 3

The plan to evaluate alternative catalyst formulations is good, but based on the presentation, the reviewer did not see any evidence for rational design of these materials. Right now, it seems as if this project lacks a clear end goal.

Reviewer 4

In general, the provided plans were adequate. The team plans to examine other catalysts and a range of other organics that would likely be part of fuel formulations and study in analogous fashion how they degrade and the surface intermediates involved. Given the prior success outlined in the presentation, the reviewer has no doubt of the success of these studies. The reviewer would have liked to seen a little more detail and insight on the rationale of new catalyst formulations that might be pursued. Even if only broad strokes are provided, some idea of how the catalysts might be changed would be valuable.

Reviewer 5

Using alcohols as fuels is a pertinent project under LLCF. However future work must define specific research activity, not a generic high-level description. The reviewer suggested identifying the pragmatic fuel (for example, MeOH or EtOH) and developing an approach, activities, and project success metrics and deliver the outcomes in support of such plans.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is relevant to advanced engine and fuel technology. The research will help industry to solve the aldehydes emissions issues from alcohol-fueled engines.

Reviewer 2

As stated in the slides and talk, LLCFs like those studied here will be useful and important in powering off-road, marine, and rail applications and are relevant to this project's goals. This is especially true towards the end of project that is getting excellent data from the new directions seen in the project.

Reviewer 3

The reviewer said the project is relevant to supporting low carbon fuels.

Reviewer 4

The project goals and approach are well aligned with VTO interests in understanding emission profiles from engines that run non-standard fuels derived from biodiesel or other sources. Understanding the emissions will be critical to eventually gaining certification for use of such systems broadly. The focus on the catalytic intermediates and evolution of the catalyst will also be helpful in the design of next generation formulations.

Reviewer 5

The project is relevant to overall VTO subprogram objectives. Projects such as this present a great opportunity for enabling reduced emissions, energy security and transition to renewable energy sources, and play a significant role in achieving a more sustainable transportation solution.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This team has sufficient resources needed to complete the research work proposed.

Reviewer 2

This group at ORNL has sufficient access to the tools it needs.

Reviewer 3

The reviewer stated that the resources appear sufficient.

Reviewer 4

Given the diverse skill sets of the partners and that they cover all the areas needed to probe relevant catalysts, along with having the necessary instrumentation in place to study key catalytic intermediates, all required resources were present.

Reviewer 5

The performance evaluation hardware developed at ORNL, the advanced characterizations tools that exists at ORNL, and catalyst development capabilities from suppliers and research expertise from all the participating collaborators are more than sufficient to define and achieve the milestones in a timely fashion, especially that are needed to identify practical solutions with solid underpinnings.

Presentation Number: DORMA028
Presentation Title: Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles
Principal Investigator: Andrea Strzelec, University of Wisconsin-Madison

Presenter

Andrea Strzelec, University of Wisconsin-Madison

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

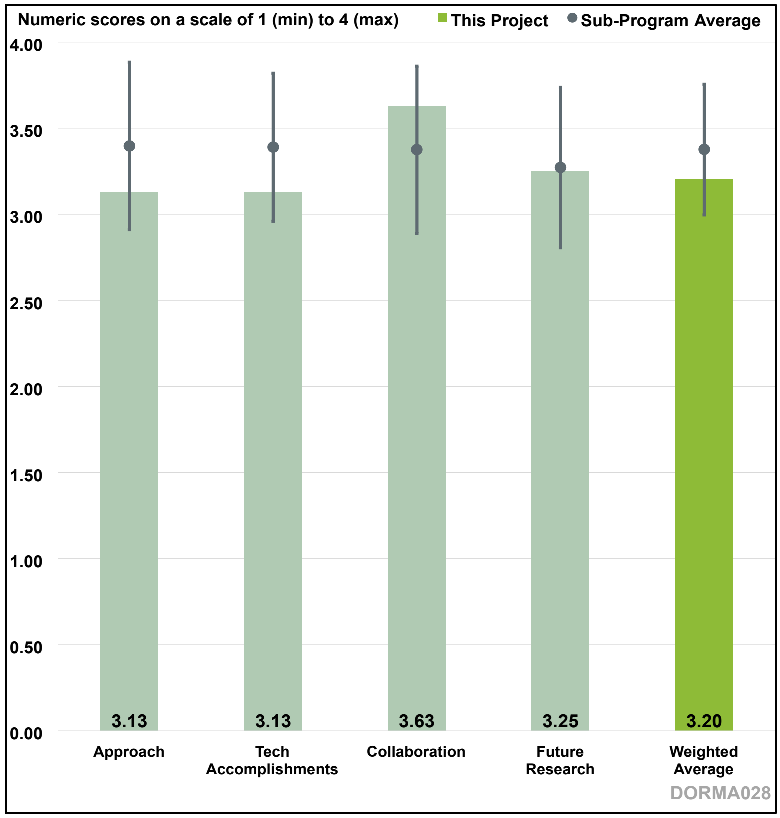

Figure 3-21. Presentation Number: DORMA028 Presentation Title: Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles Principal Investigator: Andrea Strzelec, University of Wisconsin-Madison

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

One of three key innovations (“Introduction of VoFLE methodology to provide unprecedented levels of validation to reduced-dimensional aftertreatment models”) was dropped due to computational cost.

Reviewer 2

The reviewer said it appeared that the urea spray modeling was being done at a much higher fidelity than the rest of the aftertreatment system model. The reviewer also said it was hard to tell from the presentation that this effort is indeed producing a better result. “Objective of this work is to determine the concentration of ammonia at the SCR inlet plane for different engine exhaust conditions.” The reviewer questioned if that was presented at a previous Annual Merit Review. “Unprecedented levels of validation” are claimed, but that was unclear to the reviewer.

Reviewer 3

This is a great project to have an integrated simulation tool in GT-POWER. In the presentation, it was stated the SCR model was a single Cu-zeolite formulation. The reviewer commented that it may be an improvement to add other formulations such as vanadium and was not sure if these models are available to import into package.

Reviewer 4

The project is well designed with clear plans laid out on tasks by the partners. The PI is an excellent integrator and communicator for tasks.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Actual/planned completion dates are not fully populated in the tables so the reviewer could not tell if the project is on time or behind. Large eddy simulations replaced Volume of Fluid and Lagrangian Eulerian (VoFLE) due to computational cost. The SCR model has been validated and shows good experimental agreement. The integrated GT-POWER model (aftertreatment + engine) is completed. There were limited comparison results presented between GT-POWER and experiment due to availability of data at the time of presentation submission. The reviewer noted that load vs. speed vs. error plots should have been shown as well as space velocity vs. temperature vs. error plots. Error (of unknown magnitude) should have also been shown between the model and experiment for hydrocarbon (HC), CO, and NOx conversion efficiency. Further calibration work is planned that may address conversion error but could also over-calibrate the model to one engine. It was not clear to the reviewer how the model will stay architecture general in nature.

Reviewer 2

The reviewer was happy to see the aftertreatment model in GT-SUITE working and is looking forward to the validation of the optimized models.

Reviewer 3

The reviewer commented that there was good progress on meeting targets and plans.

Reviewer 4

The reviewer said good progress has been made on all fronts. Computational work complements experimental work well. In situations where experimental data is unavailable, higher fidelity computations are being used to train the 1D approach in GT-POWER.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project work is well dispersed across industry and academic laboratories. Isuzu is providing the engine and aftertreatment hardware, FEV is conducting engine testing, and Marathon is providing the fuel. ORNL is providing bench testing for SCR aging.

Reviewer 2

This is an impressive team organization for this sized project. The reviewer commented that there was great coordination.

Reviewer 3

All project team members seem to work together to create a simulation tool package and meet project targets.

Reviewer 4

The reviewer said the project team was excellent. The roles and responsibilities of each team member were clearly laid out.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Model calibration form engine testing will no doubt help improve the model. The reviewer questioned how the model will stay general to all architectures and which architectures were in consideration. The reviewer assumed that SCR will be needed for all of them but there are different types of SCR catalysts, DPFs, and DOCs. The reviewer also questioned if the DPFs would be catalyzed to oxidize HC or if DOCs would be left out in some architectures. It was unclear to the reviewer if the large available library of architecture allows for this project to be completed by the end of the year or what metric is needed to meet near-zero emissions.

Reviewer 2

The reviewer said the project looks to be on track to finish out in the next few months and that future work is on target.

Reviewer 3

The reviewer stated there was a clear list of future research tasks. The low NOx concept demonstration will be a great test on the usefulness of the simulation tool. The reviewer also stated additional SCR models would be a good goal to target.

Reviewer 4

The future work is well laid out. The general applicability of the model for different fuels and engine platforms was also addressed. Follow-on Coordinating Research Council (CRC) funded work is also encouraging to see.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project supports VTO subprogram objectives to minimize the formation of emissions.

Reviewer 2

Improvement in aftertreatment optimization supports VTO DORMA subprogram goals through better, more predictive modeling.

Reviewer 3

The project clearly supports VTO DORMA subprogram targets and objectives.

Reviewer 4

The project supports the deep decarbonization objectives of the DORMA subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that there seemed to be only one student at UW-Madison providing engineering support. Putting models and data together from the collaborators is a very large task. The reviewer suggested that more students be added to the project to support calibration and check the model architecture.

Reviewer 2

The project has been on target the entire time with the current resources.

Reviewer 3

The reviewer stated the project seemed to have sufficient resources to meet project targets and timeline.

Reviewer 4

The reviewer said resources were sufficient and there was good leveraging of cost-share as well.

Presentation Number: DORMA029
Presentation Title: Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System
Principal Investigator: Hailin Li, West Virginia University

Presenter

Hailin Li, West Virginia University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

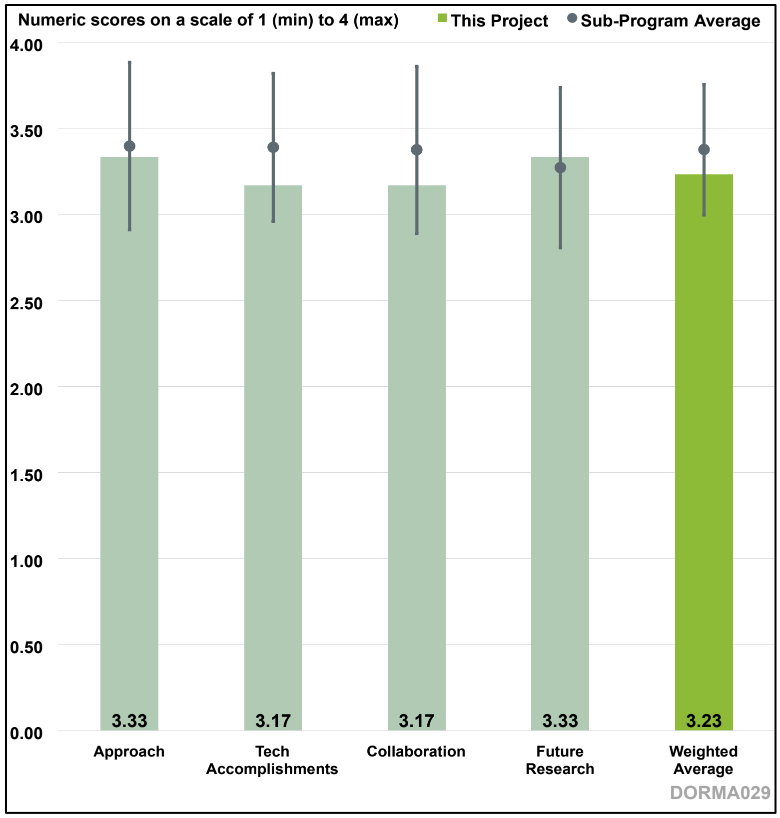

Figure 3-22. Presentation Number: DORMA029 Presentation Title: Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System Principal Investigator: Hailin Li, West Virginia University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The research plan encompasses both experimental and modeling accomplishments on a complicated system. The reviewer said that it appeared to be well laid out with about a year to go on a project that is two years in.

Reviewer 2

The overall approach to the project is sound, but the specifics of the implementation seem to be fighting against some of the project goals. For example, the reviewer noted that if the eventual model platform is GT-SUITE, which does pair with CONVERGE, it seemed like extra work to develop a high-fidelity 3D CONVERGE CFD model, only to have to reduce it to a reduced order model in the simulation platform to avoid excessive computational times. The reviewer also noted that it seemed that just developing a 1D model in GT-SUITE would have moved the project along more quickly. Certainly, there is value in the CONVERGE model (for student learning if nothing else) but it did not make sense to the reviewer as part of a 3-year project that will end with a 1D system simulation. It was unclear to the reviewer what SCR catalyst formulation was being used. Quasi-steady circuit splitter appears in both system simulations projects that GT-SUITE is part of. The reviewer was curious about how GT-SUITE is able to leverage both projects. The reviewer thought there was a lack of planning on aftertreatment system aging. Hydrothermal aging can be done in a relatively short period of time by a number of suppliers. The reviewer questioned if the project would get to a demonstration of near-zero NOx.

Reviewer 3

The project focus is on combined simulation of a heavy-duty diesel engine (15 L from Navistar) with exhaust aftertreatment system (EAS). This is a legacy project (ACE172) that primarily addresses on-road applications.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

A great range of results are already in that show many areas are well covered. The aftertreatment modeling and results seem to match well, especially for the transient response. Having detailed mixer ammonia uniformity studies developed is harder to find, but it could be improved.

Reviewer 2

Overall, a lot of work has been done, but it was hard for the reviewer to correlate that to achieving the overall project goals. The project is behind schedule, mostly related to negotiations being delayed. However, there is also work going on (i.e. CFD) that seems to be a bit of a side stream rather than contributing to achieving the project goals.

Reviewer 3

The project team was finally able to generate data from the Navistar engine and EAS in the test cell. Data was collected spanning the full speed and load range for the engine and tabulated steady-state engine-out results. The ANL team has validated the combustion CFD model for the engine, including NOx formation, and are fitting the model to the experimental data. The technical progress for the current budget period seemed good to the reviewer, especially given the disruption in the test facility availability.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The partners are very supportive given the many results. The relationships with modeling partners are strong and captured in the results. The reviewer commented that it was hard to evaluate the contributions of equipment and approaches to experimental systems, but that it appeared to be working well also.

Reviewer 2

The reviewer said there was good collaboration with Gamma Technologies and ORNL, but it was not clear to the reviewer how much the other partners were involved.

Reviewer 3

The ANL team did engine CFD. Gamma Technologies supported development of the EAS model, including SCR system models at varying levels of detail (i.e., 1D, two-dimensional [2D], 3D) and the urea injection model. West Virginia University (WVU) is primarily working with ANL and Gamma Technologies. Convergent Science is in more of a vendor role. Navistar provided the engine, dyno harness, and controller and has been consulting/providing technical support as the team works with the engine.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

All of the items appear responsive to indicators from previous results, so future plans look reasonable. The reviewer noted that completing them in about one year will be a challenge.

Reviewer 2

Future work does not include demonstration of project goals being achieved. Machine learning for adaptive aftertreatment system simulation (and control) seems to be computationally expensive and as the PIs note, have significant barriers remaining.

Reviewer 3

The team wants to understand the uniformity index for the urea distribution over the front face of the SCR catalyst. To that end, the team has removed and scanned the static mixer to be able to use CFD to evaluate its performance in radial mixing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The relevance strongly supports VTO’s and DOE’s interest in improving fuel economy and reducing greenhouse gases.

Reviewer 2

The reviewer said the project was relevant to VTO goals.

Reviewer 3

The reviewer stated the project was relevant, especially considering when the project started.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

This group of partners is well provided with the equipment to carry out this project.

Reviewer 2

Based on the project resources expended to date (40% of total project after two budget periods), the reviewer questioned if perhaps the project estimates were incorrect or if the project team could not access the resources and testing that they originally planned.

Reviewer 3

The reviewer commented that it was a major setback for WVU to offload their engine laboratories from the university to an external organization. The overall budget seems sufficient otherwise, though. The team has sourced used EAS hardware from a vendor that works with Navistar trucks.

Presentation Number: DORMA030
Presentation Title: Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System
Principal Investigator: Ming Huo, Achates Power

Presenter

Ming Huo, Achates Power

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

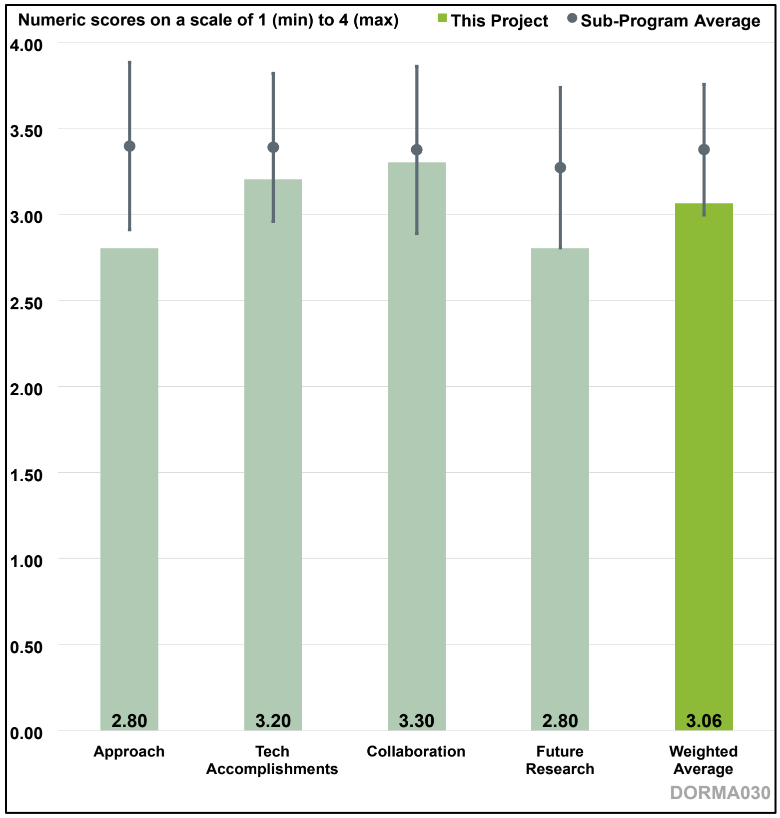

Figure 3-23. Presentation Number: DORMA030 Presentation Title: Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System Principal Investigator: Ming Huo, Achates Power

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is confusing and is difficult to rate because there are really two separate efforts. The original project scope seemed to be centered around developing a hybrid electric strategy for the opposed 2-stroke engine, including all of the milestones, but there is a substantial amount of unrelated hydrogen work. On the hybridization work, the project team is developing a hybrid strategy from the ground up. It was not clear to the reviewer how much of this is unique to the opposed piston 2-stroke engine (OP2S) architecture and how much could be ported over from existing hybrid trucks. Further, the motivation for using reinforcement learning seemed to be lacking. On the hydrogen engine work, the team has done a lot of work and got an experimental engine working on hydrogen direct injection with a diffusion combustion system. The reviewer commented that is a big deal and did not want to understate it. However, the team's approach did not seem to be sufficiently focused on emissions, as no emissions results from the OP2S engine were shown.

Reviewer 2

The approach to the work is technically sound and the use of modeling capabilities to achieve the objective is a cost-effective approach to develop a hybrid powertrain. The reviewer questioned if there was there any other metric like brake specific fuel consumption, boost response, etc., used as a validation of GT-POWER and experiments in addition to fuel economy or if there were any special considerations for modeling an opposed piston using GT-POWER. The reviewer also commented that hydrogen combustion in an opposed piston engine is an excellent approach.

Reviewer 3

Achieving the dual goal of meeting ultra-low NO_x ($ULNO_x$) and demonstrating hydrogen combustion on this relatively new platform provides significant complexity. This project will provide confidence and insight into the maturity of this specific approach to opposed piston 2-stroke engines. The demonstration of emissions over key legislation cycles appears to show compliance though the effect of hybridization requires more repetition than shown to allow the storage at cycle-initiation to be understood. Also, the reviewer noted that the condition of the aftertreatment at the start of cycles may not be consistent due to the hybrid system and should be shown as well. The steady performance of hydrogen operation is an excellent accomplishment.

Reviewer 4

The approach to hybridize a truck has some merit to create the lowest possible fuel consumption. However, hybrid trucks are most effective in the medium-duty (MD) space, not HD. The closer the vehicle operates to an automobile, the more likely hybridization is to help. However, MD vehicles are extremely cost sensitive and paying for both a high voltage electrical system (batteries, motors, inverters, etc.) and an expensive engine system with aftertreatment (even if it is a slightly reduced cost engine and aftertreatment system) is a major challenge for commercial vehicle OEMs. Potentially a spark-ignition engine (natural gas, in particular) could have a use case in hybrid, but compression ignition (CI) engines almost all need some form of $ULNO_x$ aftertreatment. The reviewer questioned what a hybrid MD truck has that a battery electric truck does not. Range and payload are not major concerns on MD trucks. Battery electric MD trucks can operate in zero emission vehicle zones and provide carbon credits. Hybrid electric MD trucks are significantly more expensive. The fuel savings will not likely overcome the substantial initial cost differential compared to a conventional powertrain and offer no real advantage compared to a battery electric truck. The OP2S engine is likely better applied to Class 8 and vocational trucks where conventional powertrains are used. Electrical hybrid systems on trucks tend to be very unattractive due to cost, complexity, and modest return on investment. The reviewer noted that perhaps the off-road market may be a better application of this approach. The hydrogen work is novel, if only for the use of CI. If successful, it could pave the way to more extensive use of CI hydrogen in the future. There are significant challenges, however, and this project has only begun to address them. NO_x and transient performance are likely to be very difficult to get control of in this combustion system.

Reviewer 5

The reviewer stated that progress was being made to achieve the project goals. There has been some slips in the timeline but the plan for getting on track was noted by the reviewer. The coordinated approach is good on a high-level but the lack of details of how the work was performed made it difficult to link the approach to the barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project team has done a great deal of work with the opposed piston 2-stroke hybrid architecture development. The team compared simulated cycles to experimental cycles with engine-in-the-loop testing. It was not clear to the reviewer if there were any unique battery or power electronics requirements for this system, as the team viewed their hardware role to be exclusively limited to the engine. On the hydrogen engine development side, getting the engine to operate on direct injection hydrogen is a big deal. The reviewer would have liked to have seen some emissions plots, as there is a great deal of concern with NO_x emissions with hydrogen and a stratified charge.

Reviewer 2

The technical accomplishments to a large extent depend on the accuracy of the engine model. The reviewer would have liked to known what specific steps were taken to model the opposed piston accurately in the vehicle model. The results show only a fuel consumption comparison and not a comparison of other parameters such as boost pressure, IMT, etc., to assess the engine performance with a different hybrid strategy. The reviewer questioned if there were any critical changes to the airpath to deliver the required air flow for hydrogen combustion, especially during transients, or if the project team expects any pre-ignition in the opposed piston design.

Reviewer 3

A sound plan and goals were put forth to address the barriers. At completion, insight into the applicability of this approach to internal combustion propulsion will be better understood. The challenges of packaging, durability, and the operational implications to aftertreatment from both approaches will still need to be investigated. The reviewer stated this is solely due to the departure from traditional engine arrangements for the opposed piston and departure from conventional operating characteristics driven by the hybrid system and not a comment on the architecture.

Reviewer 4

With the stated goals provided, the technical progress has been quite good. The engine has demonstrated significant progress toward the project goals. The hybrid work appears to show some potential for fuel consumption improvement. The hydrogen engine also shows some promise in a CI combustion system.

Reviewer 5

The technical progress supports the project plan, objectives, and milestones. The reviewer noted there was a lot of detail missing in how the accomplishments were actually performed. Questions about the calibration starting up in a catalyst heating mode instead of hot mode were not addressed. Questions about the measurements made during the engine-in-the-loop testing were also not answered. The link of the Markov training to the more targeted speed and load points was also not clear to the reviewer. No information about the hybrid setup, the size of the engine, details of powertrain or energy storage were provided. The quick coverage of the CFD accomplishments made it hard for the reviewer to link to the project plan objectives.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project team consists of an OEM (Isuzu) and two universities working with Achates Power. This project has all of the required participants. And although they are not officially a partner on the project, Argonne National Laboratory is a contributor. While it was clear what Clemson University and UW-Madison contributed, as well as Argonne National Laboratory, the reviewer would have liked to have seen Isuzu have a bigger role in the project as it appears they are mainly consultants. The reviewer questioned if Isuzu had any plans to put either the hybrid system or the hydrogen engine into a vehicle.

Reviewer 2

The reviewer stated the project had excellent collaboration between industry and academia.

Reviewer 3

The use of the team has provided a satisfactory range of input but perhaps not comprehensive from a commercial vehicle application (starting point) and the shift to off-road applications was not addressed. Input from an off-road OEM would be useful as a reaction to the shift in focus of the VTO's advanced engine area. The public entity contributors and academic institution seem to be providing excellent service.

Reviewer 4

Several collaborators were listed (Clemson University, UW-Madison, ANL) and it appears that each organization supplied valuable input to the work as a whole. The project appears to be well-coordinated, with each partner providing results that build upon the others. For the vehicle portion, the reviewer noted it would have been beneficial to have a commercial vehicle OEM on the team, particularly for any hybrid drive work.

Reviewer 5

The reviewer said it seemed like there was good coordination with existing collaborators. The nature of collaboration with ANL was not clear in the presentation or even noted in Slide 18 on collaborations. The actual collaboration on each task was not clear in the presentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The next steps listed are logical given where the team is with the project and the fact that this project will wrap up later this year.

Reviewer 2

The work planned for the future does address many of the questions that the reviewer put forward. Overall, the work yet to be completed is interesting and much needed for the success of the project.

Reviewer 3

For future work, addressing the barriers to implementation is needed. The reviewer questioned what that looks like in agricultural or construction equipment applications and what the operating cycles for those applications emphasizes. The reviewer also wanted to know if those applications result in any new hurdles. Continued investigations as to the enablers of efficiency for hydrogen combustion in the OP2S engine are called out and extremely important. Simulation-led development of combustion systems leveraging current work will be very interesting.

Reviewer 4

Investigating hydrogen CI parameters and performance will be critical to enabling this type of combustion system. The reviewer was uncertain that the hybrid portion of the project will deliver on the promise of improved fuel consumption, particularly since no HD OEM is involved.

Reviewer 5

The proposed future research is inline with meeting project milestones but the link to achieving project targets and overcoming the barriers was not clear to the reviewer and seemed more focused on the hydrogen portion of the project. The expected gains from the reinforcement learning-trained control strategies for meeting the challenges were also noted by the reviewer. The discussion of NO_x

mitigation strategies included hydrogen SCR as a potential path forward but it was not clear to the reviewer if there is even the ability to source a prototype system for use in the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project, and the hydrogen piece in particular, directly contributes to the decarbonization goals. This application is somewhat smaller than most of the other goals for the DORMA subprogram, but hydrogen combustion is of keen interest.

Reviewer 2

The project is highly relevant for the decarbonization goals of DOE as well as accelerating new powertrain technology for hydrogen engines.

Reviewer 3

New approaches that promise increases in efficiency though prediction or initial demonstration are important to investigate all the way through the expected lifecycle. The approach that is being taken will build confidence in the direction of the selected approach but will still leave questions about many aspects of applying this approach in the field.

Reviewer 4

The reviewer noted that this work may be a bit more applicable to off-road vehicles that may benefit more from hybridization than on-road trucks. Hydrogen engine improvement certainly supports DOE’s goals of decarbonization. The quality of the work appears to be quite good, just perhaps a bit misapplied in terms of market segment.

Reviewer 5

There is general relevancy to increase efficiency, reduce NO_x emissions, and utilize a low-carbon fuel like hydrogen. However, the reviewer said there were no clear links to the subprogram objectives from when the project started.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources would have been excessive if the project was solely a hybrid effort. With the hydrogen piece added, the reviewer said the resources seemed about right.

Reviewer 2

The industry and university partners have all the testing and simulation capabilities for the project. For the future hydrogen work, it was unclear to the reviewer if testing capability has been identified for hydrogen engine testing.

Reviewer 3

The reviewer commented that more investigations into the in-vehicle performance of this OP2S approach are needed and would be very interesting. The reviewer also said that it appeared as if the engine alone with appropriate aftertreatment was viable. The hybrid approach was novel and brings the questions from light-duty applications to heavy-duty applications relying on aftertreatment in different ways and different operating regimes.

Reviewer 4

The reviewer said the resources appear to be sufficient to accomplish the goals of the project.

Reviewer 5

The reviewer stated the resources seem sufficient for the project and did not impact the milestones.

Presentation Number: DORMA032
Presentation Title: High Efficiency Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project
Principal Investigator: Tim Lutz, Cummins

Presenter

Tim Lutz, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

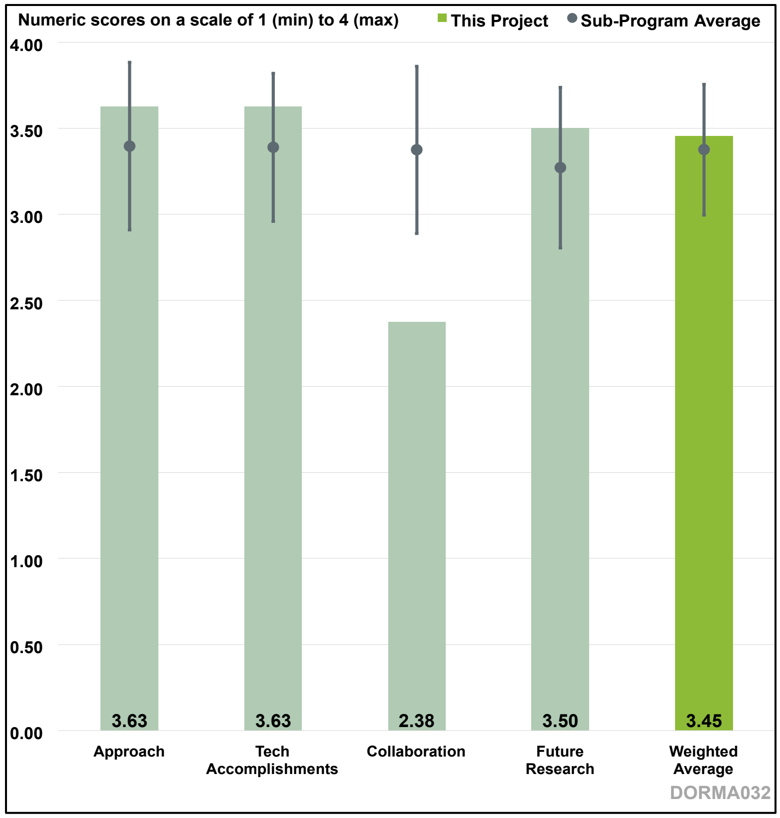

Figure 3-24. Presentation Number: DORMA032 Presentation Title: High Efficiency Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project Principal Investigator: Tim Lutz, Cummins

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer approved of the approach to design an engine specifically for natural gas combustion rather than just adapting a diesel (CI) engine for SI natural gas use. The reviewer assumed the previous years' reports spoke to the details of what was done. Given that the project is running on schedule, the timeline was definitely reasonable.

Reviewer 2

The barriers are well-defined, and Cummins has a well-planned approach to resolving them.

Reviewer 3

This project does an effective job at addressing some of the previous challenges with compressed natural gas (CNG) engines, an engine designed from the start to be SI and gaseous fueled. Proper cylinder head geometry, the elimination of EGR, and other design choices make this project rather innovative in approach. There is likely still some work to be done in cylinder-to-cylinder lambda control to take full advantage of these opportunities, particularly for low NO_x. The reviewer said it was an intelligent decision to keep the NO_x target at 0.02, even in light of recent regulatory changes.

Reviewer 4

The project has a complete and comprehensive development and testing plan and includes aggressive application of CNG with cost savings and industry satisfying brake thermal efficiency (BTE). The reviewer also commented that the project was on track.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project seems to be running ahead of schedule and the team has started work on Budget Period 3 tasks. The reviewer said that the results to date seem very promising, although some important gaps remain between what has been demonstrated and what remains to be delivered. The team is using intake cam phasers to implement variable valve timing (VVT) for Miller cycle late intake valve closing to reduce the effective compression ratio at high load to mitigate knock and improve overall efficiency. The team has demonstrated 41% BTE with fixed cams, so reaching 42% BTE with VVT seems achievable. The engine needs premium exhaust system materials because natural gas combustion exhaust is hotter than diesel exhaust. The intent is to use a combined close-coupled and underfloor three-way catalyst (ccTWC + ufTWC) for criteria pollutant control. Cummins does not want an EGR loop in parallel with a high-temperature nickel-alloy exhaust manifold. Thus, no EGR is a better solution for the targeted power density. Cummins will evaluate a stainless steel exhaust manifold option to mitigate costs.

Reviewer 2

This team has made excellent progress with first engine firing 18 months from the project start. It was unclear to the reviewer how far along this new engine was in its development prior to the start of this project, but the efficiency “out of the box” was very impressive.

Reviewer 3

Building a new engine is a costly undertaking. The progress made thus far is excellent. The engine has already fired and has demonstrated excellent efficiency numbers right out of the gate. The modeling was even close, which probably was a bit surprising to all involved. This bodes well for the ability to hit the target in the future. The reviewer also said the preliminary performance results were very encouraging.

Reviewer 4

The project team has made good progress with a low-cost, single injection point method while still meeting NO_x requirements. Though CNG combustion has CO_2 as by-product, it is lower than diesel and the GHG production is far less. There is a fuel sourcing issue with renewable CNG, but this work helps to solve the vehicle side factors. The initial engine test results indicate that the team should be able to meet BTE targets when additional hardware testing allows for optimization of combustion (new cam phasing, etc.).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Cummins is apparently the only funded partner on this project. The reviewer was disappointed, especially since their cost share is under 50%, and are not a national laboratory.

Reviewer 2

The reviewer would have liked to have seen some other entities brought into this project. The reviewer suggested some modeling expertise at a university or national lab that could help with the poor knock prediction by using a higher fidelity simulation. DOE had a consortium with the national laboratories (Partnership for Advanced Combustion Engines) that had a focus area on knock modeling.

Reviewer 3

Cummins is a big and very capable company with lots of experience in CNG engines and development. The reviewer suggested that a university or national lab could have investigated some of the knock issues given their improved tools and work purpose for this type of research.

Reviewer 4

Predictions from modeling seem to match well with early test results but the reviewer would have liked to seen some materials development to help with any issues that may arise from high temperature combustion or possibly any aftertreatment concerns that arise after lengthy durability testing.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

No results were presented that showed current engine-out NO_x values, so it was difficult for the reviewer to gauge how challenging the brake specific NO_x target would be. The knock control seems like it will be especially challenging for this engine given the non-linear onset of knock. The team needs to “upfit” the engine with cam phasers for VVT and the EAS (three-way catalysts) for Budget Period 3 tasks. To mitigate damage from knock, the reviewer noted that Cummins could perform modal analysis of the vibrations caused by knock if using an accelerometer to detect knock, although challenging. Ideally, the reviewer suggested having a cylinder pressure sensor to measure the knock more directly. Cummins will also look to change the piston material from aluminum to steel. The aluminum piston transfers heat well, so the face stays cooler until knock starts. Thus, the onset of knock is quick. Steel pistons will be hotter in the bowl, but cooler around the perimeter because of the piston cooling jets. In addition, the steel piston crown will be more robust to knock pressure spikes than aluminum is. Excellent air-fuel ratio (AFR, or λ) control is key to achieving low engine-out NO_x levels and high BTE. However, the reviewer noted it was tricky to mitigate cylinder-to-cylinder variation in AFR given the air flow and fuel variability. Additional challenges for a natural gas-fueled engine are that three-way catalysts require relatively high PGM loading to oxidize methane and that the natural gas fuel system is very expensive. The reviewer questioned if the Cummins team could evaluate other ignition systems (e.g., pre-chamber, plasma) that might help mitigate knock conditions better than spark plugs. The reviewer recommended conducting CFD studies first to evaluate potential benefits.

Reviewer 2

The work proposed in the final budget period will produce the milestone deliverables of 42% BTE and 0.02 g/hp-hr brake specific NO_x over the Federal Test Procedure and ramped mode cycle Supplemental Emissions Test cycles.

Reviewer 3

Lambda control and NO_x prediction/mitigation are the heavy hitters that potentially limit the impact of this project. The reviewer was happy to see them both explicitly addressed as the next steps to come. Again, the right partner here may have been useful.

Reviewer 4

As the project enters Budget Period 3, the team has a running engine with solid initial results. As discussed with the PI, there do exist other applications for this powerplant once the research effort is converted to commercial products. Port injection variations may also be investigated in the future to understand the sensitivities to load balancing and to combat predictive detonation but would drive project cost.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

Natural gas is one part of a decarbonization strategy, especially if there are renewable, non-fossil sources for methane available at scale.

Reviewer 2

A high-efficiency, alternative-fueled internal combustion engine meets the VTO DORMA subprogram objectives. The reviewer was glad to see the planning for hydrogen fueling for future decarbonization work.

Reviewer 3

This project definitely addresses DOE goals for CO_2 reduction. The reviewer said there was an opportunity to use CNG, renewable natural gas, and even hydrogen as the project progresses.

Reviewer 4

The project is extremely relevant to decarbonizing efforts in difficult to electrify sectors. The results of this work may have multiple applications as natural gas strengthens the options to decarbonize without going full electric.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the project definitely seemed to be running on budget. Given that Cummins has a line of natural gas-fueled engines in production, the reviewer would have expected this project to have had a 50% cost share requirement.

Reviewer 2

The reviewer commented that the resources seemed reasonable with the costs of prototype hardware for an engine demonstration project.

Reviewer 3

The reviewer stated that the resources allocated appeared to be sufficient for this project to accomplish the goals.

Reviewer 4

The project has progressed well against the planned timelines, and the funding available should allow the team to complete engine upgrades and future testing.

Presentation Number: DORMA033
Presentation Title: High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines
Principal Investigator: William de Ojeda, WM International Engineering

Presenter

William de Ojeda, WM International Engineering

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

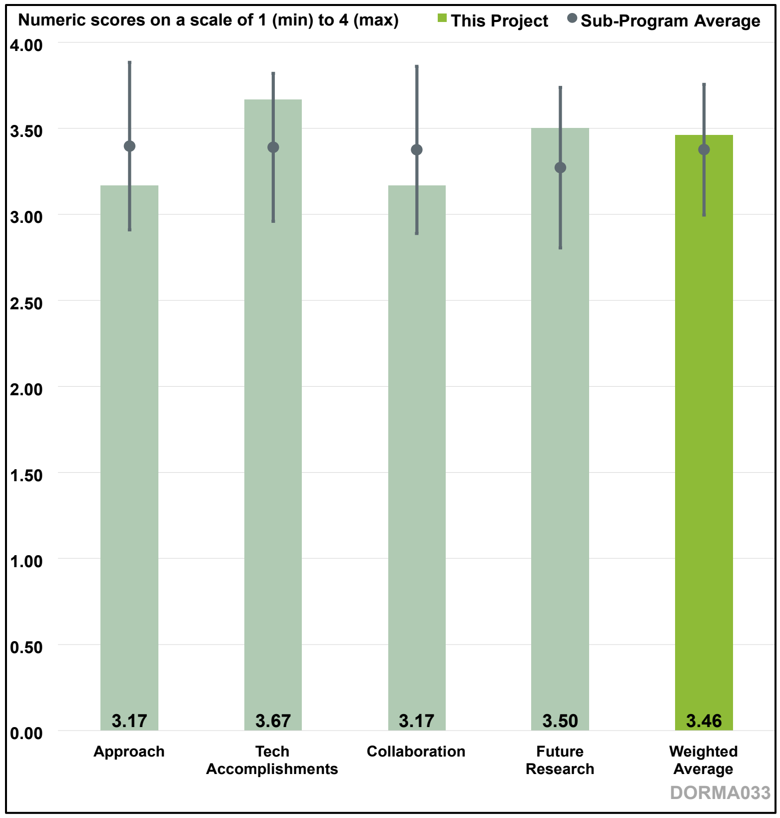

Figure 3-25. Presentation Number: DORMA033 Presentation Title: High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines Principal Investigator: William de Ojeda, WM International Engineering

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is well-executed to develop a DME and propane capable light-duty engine. However, while propane/DME have technical possibilities to reduce GHG emissions, as demonstrated in the project, their practical impact on GHG emissions reductions is minimal, and the project does not significantly contribute to technical barriers identified by DOE to the commercial utilization of lower carbon intensity fuels.

Reviewer 2

This project team took a sound approach to identify the difficulties with fuel handling equipment (pumps and injectors), which is one of the main difficulties with DME and propane, and focused on solving the associated technical challenges. In the case of the pump in particular, the project team made major modifications to the state-of-the-art and proved it was durable. The reviewer also applauded using a multi-cylinder engine for the engine testing and brake efficiency measurements.

Reviewer 3

The approach of the project clearly addresses the main challenges associated with developing a high-pressure fuel system for liquified gas fuels. The project has adopted the necessary steps to design a fuel system, demonstrate the durability, and then conduct engine optimization to deliver GHG reduction.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project has made outstanding progress, achieving all technical milestones on time.

Reviewer 2

The project team has designed, fabricated, and tested new fuel component hardware for proof of concept and durability. The team has also performed engine testing in a way that allows potential engine calibration (e.g., mapping out the EGR and emissions space). The reviewer noted that the team has done a lot.

Reviewer 3

The reviewer stated that comparison of a high flow injector with baseline flows and the benefits of the new design was a good accomplishment for combustion stability. The reviewer also stated that nozzle design for quicker injector closing was an excellent design change.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The team has identified technical partnerships, however it seemed to the reviewer that the partnerships did not have major impacts on the project.

Reviewer 2

The project team consists of WM International to do the majority of the development work, as well as Argonne National Laboratory to do the spray imaging and durability testing. Diversified CPC was providing the fuel. It was not immediately clear to the reviewer what role Illinois Tech was playing. Regardless, the team appeared to be well integrated and was making progress towards their goals.

Reviewer 3

The task of the university partner was unclear to the reviewer. It was also unclear to reviewer if any tasks were delivered by Illinois Tech or if they were part of future work.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The project’s proposed future research aligns with project goals and has a clearly defined purpose to deliver on remaining project commitments.

Reviewer 2

The project is roughly 67% complete, and the team is well poised to be able to successfully conclude the project goals with the remaining planned work.

Reviewer 3

The reviewer said future work related to engine testing and project demonstration will be an important part of this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

Use of low carbon domestic fuels is critical for energy security and this project directly focuses on increasing the use of propane-DME mixture for transportation applications.

Reviewer 2

The project was relevant when it was initially funded. However, since this project has shifted to decarbonization the off-road, rail, marine, and aviation sectors, the project goals of using mixtures of propane and DME in a 2.2 L engine seem less relevant than when the project was initially awarded.

Reviewer 3

The project does not substantially support overall DOE VTO subprogram objectives, and therefore is not relevant. Combustion of DME/propane in an automotive-type engine does not advance DOE objectives of increasing utilization of lower carbon intensity fuels in off-road/marine/rail (“hard to abate”) sectors.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project’s budget was sufficient for the scope of the planned work.

Reviewer 2

The project team has made good progress on their project goals and seems poised to successfully conclude the project. At the same time, the team has done a lot of work and achieved a lot. The project resources seem about right.

Reviewer 3

WM International is highly experienced in fuel system development and their collaboration with ANL and Illinois Tech provides them visualization and modeling capabilities.

Presentation Number: DORMA037
Presentation Title: Sustainable Aviation Fuel Characterization
Principal Investigator: Gina Fioroni, National Renewable Energy Laboratory

Presenter

Gina Fioroni, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

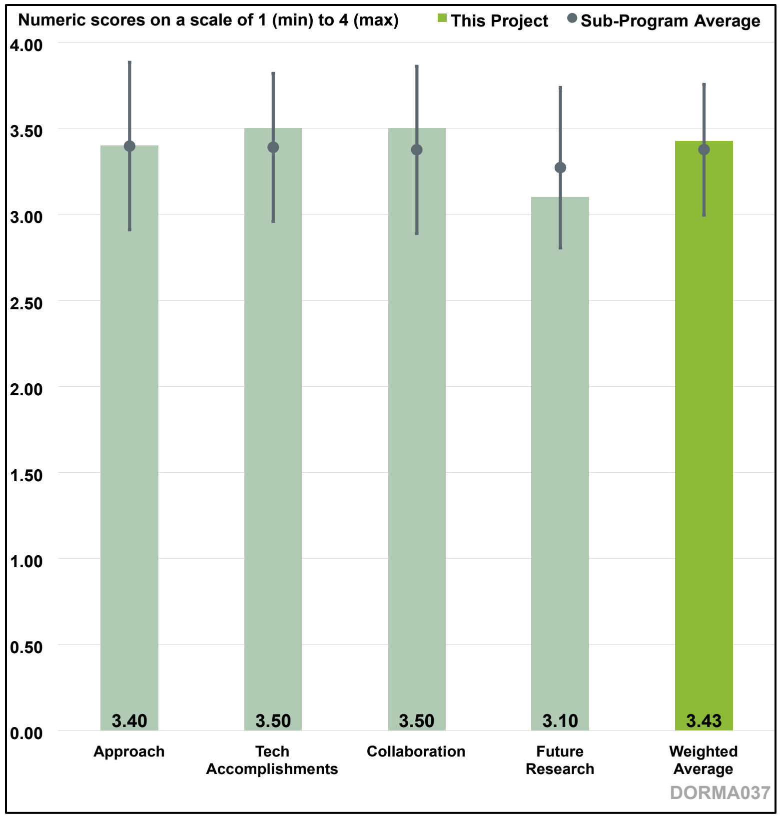

Figure 3-26. Presentation Number: DORMA037 Presentation Title: Sustainable Aviation Fuel Characterization Principal Investigator: Gina Fioroni, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project's approach to reducing barriers to the utilization of SAF through a data-driven program is providing high-quality data to industry and industry committees, speeding the process to further SAF approvals.

Reviewer 2

Four barriers are listed, all pertinent, and the team has a good project plan to address them. However, one of the barriers listed is just a start. To address this barrier, specific further identification of the "remaining barriers that constrain current fuel property requirements" are required. Engagement of OEMs or ASTM committee members should help. Although it is clear the team is generally aware of some of the issues (and is addressing them), the reviewer said it would have been good to call these out clearly and talk about which of these the team is addressing, and which are beyond the teams control. Regarding the property measurements of fuels at a range of engine conditions, the reviewer suggested the team might engage OEMs to define the key property needs at what conditions, and to what accuracies. This will help ensure the team does not miss a critical need by the aero-engine community.

Reviewer 3

The project is well designed to address the noted technical barriers with proper goals set across a reasonable timeline. The project tasks include key fuel property measurements needed to address the stated technical barriers.

Reviewer 4

The approach presented was confusing to the reviewer because it included a wide range of focus areas. The approach makes connection of work in this area to the bigger picture, but it really does not seem to connect to the technical accomplishments. The reviewer commented that it would have been beneficial to streamline the language so that reviewers can connect approach to technical accomplishments and future work.

Reviewer 5

This is a large project with a comparatively large budget that includes PIs from national laboratories and academia. The subjects covered are among the most important that can be envisioned for selecting alternative fuels and simulating their performance in combustion engines. The properties selected for measurement are relevant and the methodology and data appear outstanding. There are also a lot of data on surface tension using other methods. The presentation could do a better job of comparing their pendant drop data in the context of alternatives, though the Wilhelmy plate method is mentioned that shows “good agreement.” It was not clear to the reviewer what that meant or what liquid was being referred to. The reviewer thought the pressure effect on surface tension was interesting. Corresponding states correlations do not consider it. The reviewer questioned if there was an effect for incompressible liquids. The reviewer suggested the team scrutinize their data to try to develop a correlation that includes a pressure effect. There is an opportunity here for the team to make a useful contribution to bring in the pressure effect in a correlation of surface tension. It was not clear to the reviewer why the PIs selected cryogenic temperatures for their measurement conditions in some cases. Distillation data for POSF# 10325 show temperatures ranging between 177°C (T10) to about 245°C and average boiling points of about 270°C. An oxidation mechanism is being developed for a SAF which will be validated by RCM data, which is very important. The broader applicability of the validated mechanism to the engine environment should be considered. Transport can affect a kinetic mechanism by its influence on distributing the gaseous species throughout the combustion zone in different ways for different combustion configurations with different transport. Since data for validation obtained from laboratory scale configurations include transport conditions that are very different than in an engine (e.g., 1D for laboratory scale vs. 3D transport in the combustor environment), the reviewer suggested some thought should be given to the broader question of what “validation” means. The reviewer said it was best to try and use data from three or four configurations to develop a sort of averaged mechanism that provides the best fit to several configurations. The configurations that are modeled the greater chance of a broader applicability. The reviewer noted that the surrogate for hydroprocessed esters and fatty acids-synthetic paraffinic kerosene (HEFA-SPK) and how it was determined was not specified in the presentation. The reviewer recommended that a review be undertaken of the governing transport equations for simulating combustion in engines to identify the properties of greatest importance in simulation engine combustion. The reviewer noted that measurements of binary diffusion coefficients for species ‘i’ and ‘j’, thermal diffusion coefficients for species ‘i’, specific heat at constant pressure, gas and liquid thermal conductivities among others were not included in the research. For some of these properties, data do not exist at temperatures relevant to combustion and significant extrapolations to operational conditions are required which can create inaccuracies. The reviewer also noted that some discussion of mixing rules in property correlations would have been useful.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project is delivering a number of technical accomplishments that directly support the increased utilization of SAF, furthering DOE goals. Providing high-quality data on physical properties of jet fuel and SAF samples across a range of temperatures and pressures allows for a direct comparison of where SAF is indistinguishable from today’s jet fuel, and where measurable differences occur. One key watchpoint for this work is to recognize that jet fuel varies substantially from producer to producer, and therefore a range of jet fuel samples must be obtained and measured in order for comparisons with SAF to be meaningful.

Reviewer 2

The team started nearly three years ago, has made good progress, and even has started sharing results with the pertinent ASTM committee on fuels. Further, the team has successfully acquired or fabricated experimental equipment to make measurements of a variety of hydrocarbons over a range of conditions, much of which was not available before. Extensions of these studies to more SAFs and a range of different jet fuels would be a big contribution to the literature. Much of the data were lacking uncertainty bars, although the numerical data for density suggests five decimal points of accuracy, yet no accuracy level is claimed. The reviewer commented that such information should have been reported.

Reviewer 3

The project is making good progress according to the document project plan. The four top level milestones are all complete or on target. It was unclear to the reviewer what milestones are projected beyond FY 2024 given that the project end is set for FY 2027.

Reviewer 4

Critical fuel properties for simulations to accelerate fuel qualification is a unique area that DOE is having a large impact. The results of this accomplishment were well presented and interesting. There should continue to be investment and technical work in this area. All technical accomplishments are well presented and are impactful to the community. The reviewer noted that it would have been helpful to connect the approach language to the technical accomplishment language to know where each of these tasks/working areas fit.

Reviewer 5

The PIs have reported a lot of data which have the potential to be very useful. The data reported appear to be quite accurate for surface tension, liquid density, and kinematic viscosity. Given that it will be a POSF# 10325 surrogate that would be simulated, the reviewer noted that measurement of mixture component properties may need to be carried out. Mixing rules will be necessary which is especially true for development of an equation of state. Many such rules exist, and the reviewer suggested that the team should try to identify those that will yield the most accurate mixture “rules” from measurements of component mixture properties.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project leverages a range of collaborations with DOE laboratories (Lawrence Livermore National Laboratory and Argonne National Laboratory), universities, and industry committees in order to increase the value derived from this project.

Reviewer 2

The reviewer said collaborations and coordination amongst groups appears to be working very well. The team is engaging WSU in one area. Given that there is substantial overlap with the group at WSU headed by Prof. J Heyne with funding by the FAA, the reviewer encouraged increased collaboration and sharing of information.

Reviewer 3

The project clearly identifies project team partners alongside roles and responsibilities. The project notes the contributions made by industry partners (General Electric), national laboratories (LLNL, and ANL), federal partners (U.S. Navy), and academia (WSU, Princeton, and Georgia Tech).

Reviewer 4

Collaboration was presented as working with Georgia Tech, WSU, and ANL but the actual work within these collaborations was not clear to the reviewer. The reviewer understands that the presentations are short and it is hard to highlight all of the areas, but this is an area that is important for understanding how the DOE work integrates into the general community and has impact. Several questions were based on this topic. The reviewer noted that it was great to see engagement with ASTM and CRC.

Reviewer 5

The collaborative team is excellent for the properties being investigated in this project. The team has significant expertise from their past work for making accurate measurements of the properties selected. The effort to obtain data at elevated pressures is particularly challenging and the team has done a good job to obtain data at the pressures considered in the project. Development of the kinetic mechanism and equation of state for POSF# 10325 is highly relevant though the broader applicability of the mechanism being developed may be a concern.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The project's plans to leverage ongoing work to support ASTM ballot measures, increase experimental capabilities, and support contrail work being developed at other DOE laboratories clearly identifies technical barriers and proposes effective measures to overcome these barriers.

Reviewer 2

Regarding the 2D gas chromatography (GC) method for SAF analysis, the reviewer encourages comparing/contrasting this work with that of WSU (J. Heyne) and Purdue (G. Kilaz), who have been doing similar research for several years. The reviewer noted that pressure-enthalpy curves for the different fuels would be useful as well as collecting and reporting data on critical points for the different fuels. The reviewer also noted that limited details were provided about the jet stirred reactor to examine the impact of different fuels on sooting characteristics, but if the research is done well, it will be well-received by the community. Given the demonstrated ability to measure physical properties of liquid hydrocarbons over a range of conditions, a major contribution by this team could be made by studying and documenting properties of binary and tertiary mixtures. Subsequent studies on theoretical simulations of such fluids could result in significant advancement in the science of mixtures and intermolecular forces amongst dissimilar molecules. Given the immense number of possible combinations, some thought into targeting certain mixtures will be required. Tahe reviewer stated that coordination with members of the ASTM approval committees and OEMs would be very useful to target certain properties at selected conditions and for which fuels. The reviewer also noted that it would be useful to characterize liquid properties of the “worst” and “best” jet fuels as defined in the NJFCP studies for comparison to the SAFs (existing and future).

Reviewer 3

The project has clearly defined future research tasks with noted purpose for tasks outlined in FY 2024 and FY 2025. The reviewer said that it would have been helpful to have the proposed tasks more clearly linked to overarching research targets but noted that it is very likely that the project will achieve the targets for proposed future research.

Reviewer 4

Proposed future research in enthalpy and GC seem in line with relevant and impactful work. The reviewer was not sure what the jet-stirred reactor soot generation-characterization for contrail formation was, but that it did not seem to align with other future research areas.

Reviewer 5

The reviewer said the focus on reactor design, model validation of burner experiments, and kinetic mechanism development for future work was good. The PIs also want to “broaden collaborations” for model development which was also good. For the continuing work, some consideration should be given to such properties as diffusion coefficients, gas thermal conductivity, and mixing rules for combining mixture component properties in a way that results in accurate data for the mixtures which will be relevant to the equation of state that is planned for development. Surface tension and liquid density are important to processes relevant to liquid jet and spray injection, but liquid phase properties will not factor into the burning of fuel vapors once the liquid has completely vaporized and transport dynamics take over to control and maintain the fuel burning process. The reviewer noted consideration should be given to developing correlations for some of the properties developed such as a pressure (and temperature) effect for surface tension. Adding new properties may mean scaling back other properties but can be worth the effect if the property being added is especially useful to modelers. In the process of validation of a kinetic mechanism, for example the reviewer commented that the plan for dealing with discrepancies between measurements and simulation was not discussed for future work. With the kinetics, there are many rate constants to consider and not all of them will be known with unquestioned accuracy. The reviewer stated that a strategy should be developed for closing the gap between measured and predicted data used for validation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project directly supports DOE’s goal of increasing SAF utilization to reduce the carbon intensity of commercial aviation. The project’s results will aid in the adoption of SAF by reducing concerns over SAF variability, refining of SAF specifications over time, and the eventual elimination of the SAF blendwall.

Reviewer 2

The embedded links appear outdated, but the work is fully consistent with the SAF Grand Challenge Roadmap.

Reviewer 3

The project is relevant and clearly set its tasks against identified research needs under the SAF Grand Challenge Roadmap. The reviewer noted that the linkage to a specific VTO subprogram objective was not clear given the linked VTO subprograms.

Reviewer 4

Work presented in the package centered around fuel characterization is incredibly relevant to the community and helps fill in a gap that is critical for future fuel qualification.

Reviewer 5

This project touches on many of the most important problems that will limit simulation of SAFs in engines: property database development; equation of states of a SAF (POSF# 10325 being chosen here); oxidation kinetic mechanisms; surrogates for POSF# 10325; validation of the simulation, data and oxidation mechanism, etc.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The project's resources are excessive compared to other DOE VTO projects, program goals and technical accomplishments.

Reviewer 2

Resources appear to be healthy, although the reviewer recognized that developing and running such experiments are costly. The reviewer noted that it would be a shame to create these capabilities and not get the required data sets for a few extra dollars. The reviewer also commented that it was important to note that the cost of further development of the jet reactor, assembling its diagnostics, characterizing its performance, and running a variety of pertinent conditions and fuels will be costly.

Reviewer 3

The resources are well suited to achieve the project's stated milestones in a timely manner. The project has a diverse research team to support the tasks and deliver the research objectives.

Reviewer 4

A budget of $4.05 million across three years seems like a significant amount of funding for the tasks laid out in this project.

Reviewer 5

The project is large, incorporates many collaborators and organizations, and covers an important topic. It is envisioned that additional topics as noted in the review could have been incorporated which would require more resources (e.g., additional property characterization and data processing, other burning designs for validation, etc.) although some could be scaled back to incorporate new properties.

Presentation Number: DORMA038
Presentation Title: Towards Accurate Combustion and Emissions Modeling of Sustainable Aviation Fuels
Principal Investigator: Debolina Dasgupta, Argonne National Laboratory

Presenter

Debolina Dasgupta, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

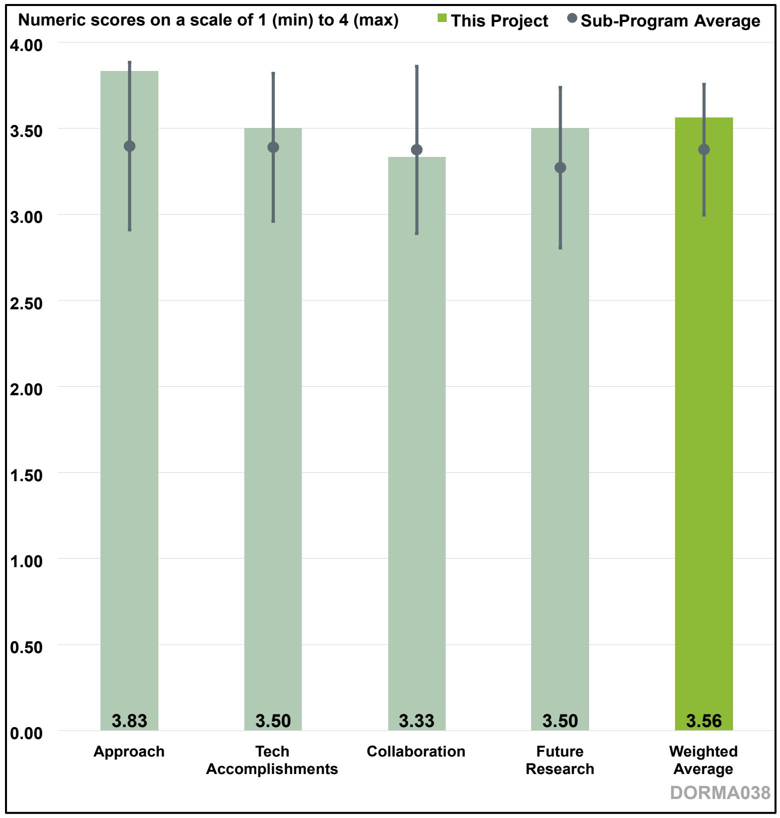

Figure 3-27. Presentation Number: DORMA038 Presentation Title: Towards Accurate Combustion and Emissions Modeling of Sustainable Aviation Fuels Principal Investigator: Debolina Dasgupta, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is performing simulations that address fuel impacts on combustor operability (lean blowout and ignition) and is performing modeling work (wall-resolved LES) to improve the wall-modeled LES simulation of combustor operability. The project has also started work in two challenging areas that are important to quantifying and reducing aviation’s impact on climate: soot modeling and contrail modeling.

Reviewer 2

This project aims to address two major SAF technical barriers: a lack of 100% SAF blends that meet conventional fuel performance and safety standards, and a lack of understanding of fuel formulation effects on engine performance and emissions. The project aims to do this with a three-pronged approach. First, high-fidelity combustion simulations will be developed, validated using optical diagnostics, and used to create sub-models that describe relevant flows. Second, these sub-models will be implemented in engine performance simulations which will be used to investigate the stability and sensitivity of SAF-burning engines, with comparison to a Jet A baseline. Third, the simulated engine performance will inform a computational investigation of soot behavior and contrail formation.

The proposed approach is sound, and the three focus areas create a logical division of interrelated tasks. The timeline is well-planned, with all milestones either complete or on track for completion.

Reviewer 3

This work focuses on development and use of simulations for assessment of SAF at realistic engine conditions. The PIs aim to develop reliable tools for predicting ignition, heat transfer, combustion instabilities (including LBO), and emissions/contrails over the range of operating conditions to be expected on a gas turbine engine. The duration for the proposed scope of activities (2022-2027) appears to be sufficient. Milestones for the current year's work are well laid out and the PIs seem well on their way to achieving them. Tasks dealing with LBO, cold-start ignition with plasma discharge modeling, and contrail formation are well delineated. The use of two combustors (Army Research Combustor [ARC] and referee rig) was a bit confusing to the reviewer. The reviewer questioned if it was because soot emissions were only available from the ARC combustor. In any case, validation of results for two combustor rigs is certainly a commendable effort. The collaborations with entities who can provide experimental data and validation support are well established. Overall, the project and proposed goals have the potential to make a significant contribution to the combustion and aerospace community as well as related industry partners. The focus on extending knowledge to engine performance on 100% SAF is also noteworthy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

For improved LES modeling of LBO and ignition, the project is performing a limited set of wall-resolved LES (WRLES) for the ARC-M1 combustor. Non-reacting WRLES have been completed and compared to particle image velocimetry (PIV) velocity measurement in the ARC-M1 combustor and reacting simulations are underway. The details of what wall models will be developed based on these WRLES simulations was not presented other than noting these will address combustion and heat transfer modeling near the walls. There are challenges in having an efficient GPU-based spray solver and less stiff chemistry mechanisms for these WRLES (or near DNS) simulations. The progress is reasonable, but the reviewer believes it was uncertain whether improved wall models for wall-modeled LES (WMLES) will be available in time to impact to WMLES simulations for LBO or ignition. WMLES simulations of LBO in the Air Force Research Laboratory (AFRL)/University of Dayton Research Institute (UDRI) referee rig for individual and combined fuel property variations relative to the average Jet-A baseline have been completed for a limited set of property variations (density, viscosity, heat of combustion) and there are plans to extend such LBO studies to HEFA fuel and the ARC-M1 combustor (which is similar in combustor design to the AFRL/UDRI referee rig). The method for approaching LBO in the simulations appears similar to that followed in NJFCP (a set of step reductions in global equivalence ratio, sufficient flow through time simulated at each new global equivalence ratio [GER] and monitor time variation of global heat release rate at each new GER). It was not clear to the reviewer if GER was reduced in a constant step wise fashion after GER of 0.096 and 0.090. The reviewer was expecting GER values of 0.085, 0.080, 0.075, etc., for each property combination until LBO was reached. The reviewer was also surprised at the 10-12% difference in LBO GER predicted with only changes in heat of combustion and one or two other properties (density and/or viscosity) but using a fixed chemistry mechanism and spray injection conditions since the NJFCP experiments with average Jet-A (A-2) and Gevo alcohol-to-jet (C-1) had only a 8% change in LBO GER (0.0806 for A-1 versus 0.0869 for C-1 at the same starting conditions as these simulations).The project made some progress on the soot modeling goals by developing a

Jet-A mechanism with polycyclic aromatic hydrocarbon (PAH) chemistry using HyChem for A-2 and King Abdullah University of Science and Technology for PAH chemistry and comparing the large molecules from this 126 species mechanism with the more detailed LLNL mechanism for Jet-A with PAH. The project also completed some evaluation of existing soot models and performed some validation of core and bypass flow mixing typical of a jet-engine exit for a simple experimental geometry. These activities provide a reasonable start to efforts on soot and contrail modeling.

Reviewer 2

Two out of five and a half years of this project are complete, and the technical progress made so far is excellent. LES compares well to non-reacting PIV measurements of an optically accessible combustor. Initial engine performance simulations demonstrate significant sensitivity to fuel properties, as demonstrated by changes in flame shape, droplet distribution, and LBO equivalence ratio. The investigators have developed a soot mechanism and are building the computational framework needed for the third focus area of the study.

Reviewer 3

The PIs have presented results from reactive and non-reactive LES calculations conducted on a GPU-ported code for the ARC combustor from the University of Illinois. The influence of perturbing fuel physical properties (within ASTM spec limits) was investigated individually and in a combined fashion. Downstream effects on flame shape and symmetry (or lack thereof) was investigated. Correlations between observed flame shape/asymmetry were made with regard to perturbed fuel properties and are consistent with what would be expected intuitively from changes induced in atomization and combustion processes. Droplet size distributions and their effect on flame stabilization are presented. The reviewer said it would be very worthwhile to compare droplet size distributions to measurements if available. The reviewer also noted that some more effort to understand the reasons for flame asymmetry would be good and any possible comparison to experimental results through imaging/planar laser-induced fluorescence/etc. LBO was investigated for the various cases using a set simulation approach. The reviewer commented that comparison of LBO phi to those from experiments would have been good to have. Attempts to further correlate LBO phi to cetane number which has been recognized as a marker for fuel sensitivity to LBO is recommended. A soot and contrail modeling framework has been established. The reviewer said it was good to see the PIs leveraging efforts at LLNL and Sandia National Laboratories on this aspect. A key question would be pressure and temperature effects on the soot modeling and fuel chemical kinetics and to what extent validated kinetics models for SAF in particular are available as needed to conduct the LES calculations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project has good collaboration and access to test data for previous referee rig experiments conducted under NJFCP and experiments using the ARC-M1. Soot modeling is an area that would greatly benefit from increased collaboration among the DORMA projects especially for simulations of soot evolution using Jet-A and/or SAF fuels. The work on contrail formation near the jet engine exit and contrail evolution in the far field are both challenging areas for LES simulations. It was not clear to the reviewer how much experience the team has to start this effort so any collaboration within DOE or with other research groups actively engaged in LES simulations of contrails would greatly benefit this project. Validating such simulations is also challenging. The reviewer commented that comparisons to previous LES simulations for a particular aircraft and flight conditions may be beneficial or at least provide a longer-term target of some final set of simulations.

Reviewer 2

A very large number of groups collaborated on this project. Argonne National Laboratory leads a group of several national laboratories performing computational fluid dynamics tasks. Experimental results are provided by AFRL and The University of Illinois Urbana-Champaign. There is coordination with another DORMA project (019) that is providing experimental and simulated multiphase flow results. It is to be commended that this project brings together many different groups to tackle an incredibly difficult and multifaceted problem. However, the reviewer commented that the specific responsibilities of each group were left somewhat unclear. Computational fluid dynamics efforts are billed as a coordinated effort between five different laboratories. It was unclear to the reviewer, for example, what exactly ORNL will contribute to, as they are not mentioned elsewhere.

Reviewer 3

The PIs are collaborating with industry, a university, and other government laboratories. The reviewer noted that there does not appear to be a need for more collaborations. The collaboration with experimental groups to get data for validation and geometry/boundary conditions/etc., is key to this effort. The collaboration with other groups working on soot and contrail models is also very strategic and will help the project move faster to achieve their goals.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed research is addressing important simulation capabilities: fuel impacts on LBO and ignition; soot modeling for jet fuels; and contrail formation and evolution. The reviewer said the proposed work on contrail modeling appears very broad and with the resources available may need to narrow its focus to achieve meaningful results in the next few years.

Reviewer 2

The proposed future work for this project is well-defined, likely to succeed, and fits well with the work that has already been accomplished. Direct numerical simulations will be developed to model combustion with improved resolution and fidelity over current large eddy simulations. Combustor simulations will move to HEFA fuels with a comparison to experimental rigs. Advanced soot models will enable high-accuracy contrail and cirrus formation simulations. This research contributes directly to the goals of the project and is achievable in the stated timeframe.

Reviewer 3

The project has identified key tasks related to high fidelity simulations, fuel and combustor performance simulations, and contrails modeling for future research. These activities are in line with the technical barriers that the project seeks to address. In particular, the DNS simulations and their ability to inform and improve the LES modeling efforts will be very useful. The PIs could also refer to ongoing DNS work from Souza-Soriano and Chen and their findings in this project. Evaluating SAF like HEFA and others will be of very high interest to the combustion community. While sensitivity to LBO to perturbing fuel physical properties is interesting, the PIs could potentially also generate a lot of interesting information about near-blowout dynamics through their simulations. The impact of droplet size distributions (which other investigations in DORMA have shown to be asymmetric and/or influenced by nozzle internal geometry), turbulence-chemistry interaction, multi-modal flame propagation phenomena, turbulence backscatter, etc., are very interesting and these simulations are ideal for examining such effects. Plans for contrail modeling in the near and far field are discussed and also in line with overall project goals. Potentially other emissions, particularly NO_x, could be incorporated within the framework of this effort.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is developing capabilities that address combustor operability fuel sensitivity, soot modeling, and contrail modeling. These are all important simulations capabilities for understanding and minimizing aviation's impact on climate.

Reviewer 2

This project directly supports VTO objectives. It aims to create predictive simulations that can screen SAF candidates, enable SAF adoption, and analyze SAF combustor performance and emission effects. Achieving these goals will decrease the cost of SAF adoption, mitigate aviation environmental impacts, and enhance aircraft engine performance.

Reviewer 3

The relevance of this project to DORMA is supported through the stated goals of this work to develop predictive modeling capabilities that can provide a pathway for 100% SAF adoption. Further, through the efforts of this work to model emissions including soot and examining contrail development, metrics other than safety relevant ones (LBO, cold start) will be evaluated which have received less attention in past work. Development of improved heat transfer and combustion modeling techniques through the overlapping DNS and LES portions of this work will be beneficial to the community as a whole.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

For the milestones to be completed in FY 2024, the resources are sufficient. And for future work on wall-resolved LES, wall model development, and further LBO simulations, the resources are sufficient. The reviewer was concerned that the current resources may be insufficient to complete future plans to develop a simulation framework for high altitude relight predictions and predicting contrail formation and evolution for Jet-A and SAF. Those are very challenging efforts that likely require more than a few people working the effort.

Reviewer 2

The investigators have sufficient resources to carry out the project and the budget is reasonable. Collaborators have demonstrated that they have the experimental and diagnostics framework to produce high-quality validation data for simulations. Investigators at Argonne have demonstrated that they have the computing infrastructure and expertise necessary to perform the proposed simulations.

Reviewer 3

The reviewer said resources, personnel and financial, appear to be sufficient for this work.

Presentation Number: DORMA040
Presentation Title: Optimized Low Carbon Fuel Range Extender (HyREX)
Principal Investigator: Jon Dickson, Cummins

Presenter

Jon A. Dickson, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

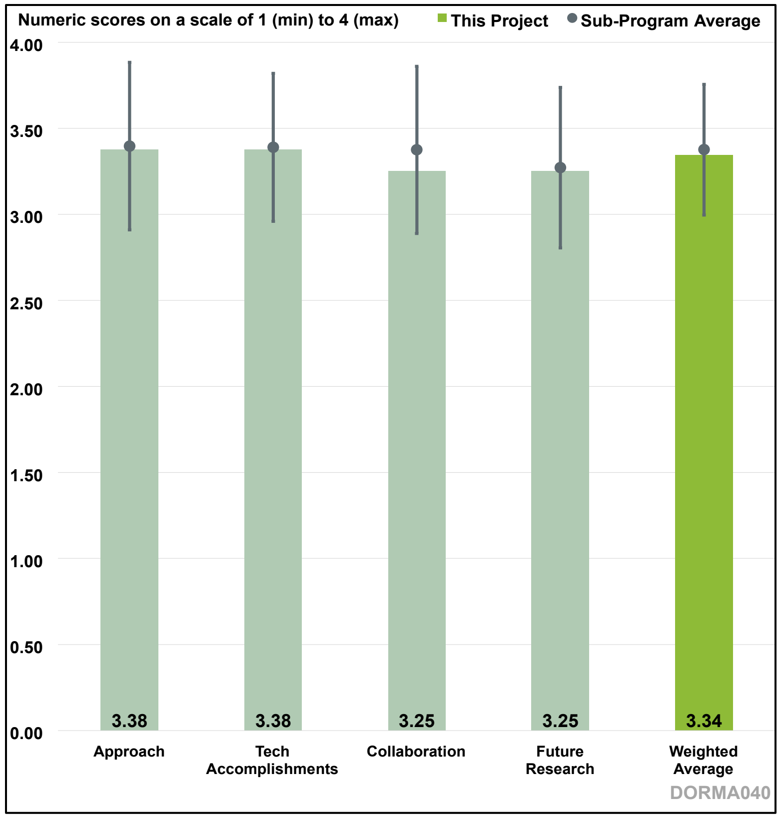

Figure 3-28. Presentation Number: DORMA040 Presentation Title: Optimized Low Carbon Fuel Range Extender (HyREX) Principal Investigator: Jon Dickson, Cummins

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project has just begun (15% complete) and is in its first budget period. The overall approach is good, but details will be defined as the data is collected. In BP1, the team plans to 1) define the simulation approach for technology evaluation, by defining the model requirements, architecture, interfaces, tools, machine types, power range, duty cycles and design space; 2) identify the low carbon liquid fuel (LCLF) pathways for techno-economic analysis by providing data on current market LCLF volumes, planned expansions and potential future volumes; 3) determine the layout of the motor-generator (MG) and inverter components, and finalize the MG topology and coolant strategies; and 4) define the base range-extended electric vehicle architecture and power-generating unit size for the range-extender and power-generating unit. The reviewer said this was an appropriate approach to defining the overall project.

Reviewer 2

The reviewer commented that the project plan seems reasonable for the scope of work. The project is still in an early phase, so there have not been many opportunities for setbacks or similar that would affect the schedule. The reviewer had some concerns about the schedule for the design, build, and demonstration phases, given that the design has hardly been started. If successful, the project will definitely address the barrier of decarbonizing non-road applications.

Reviewer 3

A range extender hybridized powertrain provides a very flexible approach to adapting to multiple offroad applications, particularly those with hydraulic power needs that can be electrified. Identifying the hydraulic power partner soon will be important to the success of the project.

Reviewer 4

The project relies on a lot of factors to fall into place and be defined during the final year of the project. Ther reviewer said this approach seems to have high risk associated with it. If successful, the approach would address the technical barriers that the team strives to overcome which is increased low carbon fuel adoption and demonstration of a 50% reduction in GHG. The reviewer noted that the lack of specifics in the presentation made it difficult to assess the likelihood of success.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project is at 15% completion so at this point only the first milestone has been achieved. The reviewer commented that the timeline appeared reasonable, development of the optimization pathway was in process, and analysis on closed cycle, open cycle and mechanical efficiencies were ongoing. The reviewer also noted that the powertrain roadmap workflow was well-defined. Evaluation of range options, selection of machines, and duty cycle gathering is complete. Model development and cost input gathering are in progress and on-schedule. The TCO ranking approach has also been identified.

Reviewer 2

The reviewer questioned how a series hybrid configuration was different from a typical non-road equipment diesel-electric powertrain. For example, it was unclear to the reviewer what the opportunities for energy recovery were. The reviewer noted that energy recovery options were limited, and very application specific. The main benefit comes from aggressive powertrain optimization and from the use of lower-carbon fuels. The team is using an EAS solution from Cummins Emission Solutions to meet CARB Tier 5 non-road emissions requirements ($NMOG+NO_x$) that also accounts for the effects of fatty acid methyl ester biodiesel on the EAS. The goal is to narrow the operating range of the engine in the series hybrid configuration, hence the redesign of some engine components (Slide 9 in the presentation). The Cummins team is building a series hybrid system for demonstration, but they are evaluating other options as well in its modeling work.

Reviewer 3

The reviewer commented that it was very early in the start of this project, so most tasks were just getting underway. The reviewer would have liked to have seen more information on the machines and duty cycles that have been selected. The reviewer noted that the maps on Slide 21 did not provide enough information about the energy recover opportunities.

Reviewer 4

The project is effectively just getting started and is thus far meeting the proposed milestones.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Collaborations with a university (Ohio State University), a national lab (NREL), and other partners seems well aligned, though the team is still working on selecting a hydraulic system partner which will have strong impact on the energy efficiency of the overall system.

Reviewer 2

The reviewer said that it looked like the overall collaboration was good among the team. The reviewer did not see a lot of engagement from Manitowoc yet but assumed that will come in later phases of the project. The reviewer was concerned that the team did not yet have a hydraulics supplier engaged on this project yet.

Reviewer 3

The reviewer commented that a hydraulic systems partner was needed.

Reviewer 4

The reviewer noted there were good partners and collaborations which seemed to be engaged at this point.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Results from the first budget period will help to further define the follow-on work with the MG and inverter designs being the key portion of the work. From there, the remaining tasks will be able to be more fully defined.

Reviewer 2

Building a demonstrator is going to be one of the more challenging tasks of this project with lots of risk to the budget and schedule. The reviewer questioned what the team's stretch target for GHG reduction was. The key innovation from this work is the high-temperature motor-generator and high-temperature inverter that will work well at 105°C, a typical temperature for engine coolant.

Reviewer 3

The reviewer said that the project plan looked good.

Reviewer 4

The stated that the proposed future work was too open-ended to fully evaluate for appropriateness. With further questioning, it was determined the project is focused on one or two fuels.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that a 50% reduction of lifecycle analysis-GHG was an incredibly aggressive target. Additionally, there are a number of technological advancements proposed in this project that are definitely benefiting from DOE funding.

Reviewer 2

The project does support the VTO objectives since it is focused on decarbonizing non-road machines, both for agriculture and construction. Cummins is a reasonable lead for getting this series hybrid powertrain into production.

Reviewer 3

A 50% reduction in GHG emissions in addition to meeting CARB Tier 5 NO_x limits meets the DOE VTO subprogram objectives.

Reviewer 4

This effort supports decarbonization technologies and is thus relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

At this time, the resources seem sufficient, but the project is only 15% in. The reviewer imagines that as the project progresses, there may be a need for additional funding.

Reviewer 2

The project has a budget of nearly $9 million, but it does involve building a demonstrator system and testing it. The reviewer was more concerned about the schedule than the budget.

Reviewer 3

The reviewer said the resources seemed appropriate, but most of the expense would be in building the demonstration machine.

Reviewer 4

The reviewer commented that the funding level from both DOE and Cummins was adequate for this project.

Presentation Number: DORMA041
Presentation Title: Low greenhouse gas NO_x control
Principal Investigator: Dhruba Deka, Pacific Northwest National Laboratory

Presenter

Dhruba Deka, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 40% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

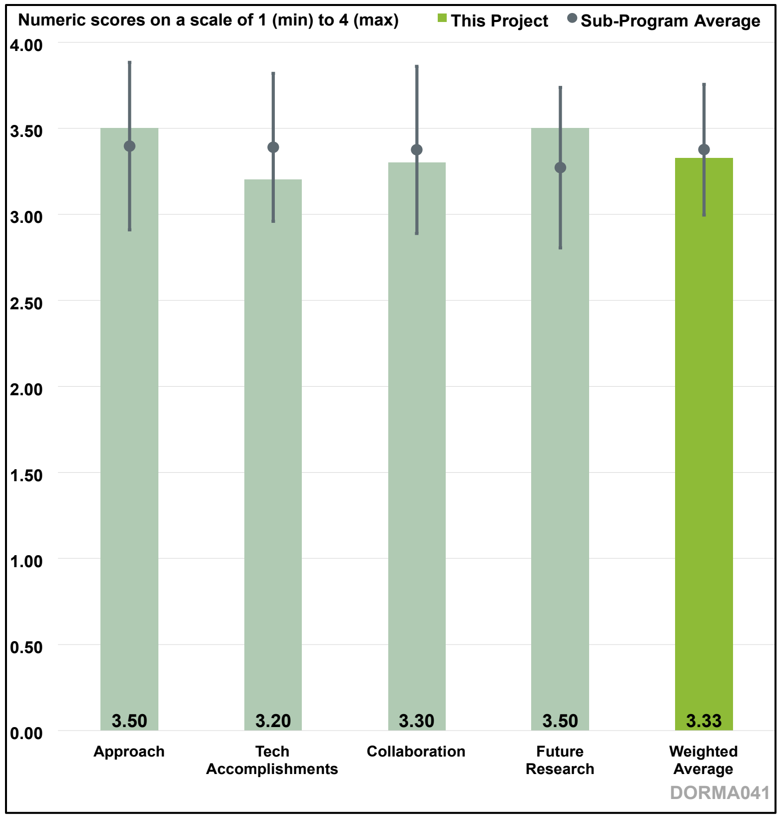

Figure 3-29. Presentation Number: DORMA041
Presentation Title: Low greenhouse gas NO_x control
Principal Investigator: Dhruba Deka, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project clearly addresses the fundamental science that underpins technology barriers related to development of active exhaust catalysts that operate at low temperature, minimize GHG emissions, while minimizing N_2O formation. The mechanistic focus and emphasis on exploring a broad range of catalysts to interrogate effects of various structural and electronic motifs seems like a logical way to develop design overarching principles to help guide future catalyst development.

Reviewer 2

The reviewer commented that the project focus is solidly on reducing both criteria pollutants and GHG emissions from diesel exhaust aftertreatment systems.

Reviewer 3

The reviewer noted that this project address the N_2O formation mechanism in SCR and mitigation methodology, which addresses the GHG topic of diesel engines in both on-road and off-road applications. This project is well designed, and the timeline is well planned. The project team has completed the work as scheduled; however, research on nitrogen dioxide (NO_2) mitigation technology could be very challenging, so the team will need more efforts in next budget period.

Reviewer 4

The reviewer articulated the project technical goals as understanding the mechanism behind N_2O formation and identifying opportunities to reduce GHG emissions. Considering the approach to performing the work and progress, it appears that the two goals cannot be completed. This is understandable as the challenge is technically complex. However, the approach has to be revisited on a periodic basis and adjusted accordingly to increase the success chances of reaching the goals. Setting up specific quantifiable key performance indicators might help in achieving impactful outcomes. The feedback in other fields should provide a few relevant details.

Reviewer 5

The reviewer commented that the approach seems to be “cook and look” rather than following a hypothesis driven rational design (or at least this was not explained). Despite the amazing resources available at PNNL, the project team really is not set up for high throughput screening of materials; that seems to be better done at the supplier. Additionally, it was not clear that the experimental conditions represent real exhaust; zeolites can be particularly sensitive to those conditions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that this team has made excellent progress in characterizing the NO_2 formation mechanism, and confirmed the sensitivity of N_2O formation to temperature, NO_2 pool, and the formation of N_2O through ammonium nitrate, which helps industry to develop the technology mitigating N_2O emissions from SCR.

Reviewer 2

The reviewer appreciated the work that has gone into developing the dual-bed SCR system, an iron-chabazite (CHA) SCR catalyst brick followed by a composite of a selective catalytic oxidation (SCO) catalyst blended with a copper (Cu)-CHA SCR catalyst, and noted good work with the accomplishments in this fiscal year (FY). A focus is on lower-temperature N_2O formation, in the 180° to 300°C range, since high-temperature N_2O formation greater than 450°C) comes from ammonia oxidation. It appears that there is not one single mechanism for N_2O formation on all catalysts. The project focus is then on Cu-CHA catalysts, since that is a common commercial SCR catalyst. Catalyst cost and complexity, especially the mixed SCO and Cu-CHA, will be a barrier to adoption.

Reviewer 3

The reviewer stated that the focus on mitigating N_2O formation seems appropriate, given industry identifying this driver for further investigation. Milestones have been completed or appear on track, including the specific goals of understanding the catalyst active site, the role of the zeolite support, and identifying opportunities to mitigate N_2O selectively which seem like key areas to study to make impacts in catalyst design. The approach generally seems rational with studying a range of Cu-exchanged small pore zeolite catalysts, and allowing various parameters such as metal loading, acid site density, and aging protocols to be tuned. The work has clearly demonstrated that multiple mechanistic pathways are operative and intermediates are less stable than the ammonium precursor result in N_2O formation, insight that can be used in future catalyst design. Using the knowledge gained from the mechanistic studies to move toward a multi-component system demonstrates the power of the approach. The resulting hybrid catalysts appear promising to break down NO_x with low levels of N_2O production.

In general, the reviewer appreciated the amount and depth of results presented. Despite this wealth of data, a slide focused more on the overall discrete mechanistic picture of what is going on in the systems would be very instructive; some elements of this appear in places (Slide 13), but a complete picture that covers the full catalytic cycle is not presented and would further enhance the work. While a multitude of techniques were mentioned such as transmission electron microscopy, electron paramagnetic resonance (EPR), X-ray, and nuclear magnetic resonance spectroscopy, these did not really appear as significant components of the data presented. This seemed like a missed opportunity and could be exploited more heavily in future studies.

Reviewer 4

The reviewer commended the really impressive number of samples screened, and some good insights that were able to come from this work regarding the stability of the intermediates that can lead to N_2O formation. However, there appears to be no mechanistic insight possible from this array of samples which do not appear to follow a single pathway. Perhaps it is too early in the project to evaluate the usefulness of the data and accomplishments.

Reviewer 5

The reviewer questioned information presented on Slide 6. How much variability or noise should be expected in the activation energy (AE) for N_2O, given the fact that they are very small numbers and that also measured in the regime is either high NO_x conversion, is limited by reactant availability, or in the measurement noise ratio? Regarding the Y axis for N_2O, is it rate of N_2O formation or converted parts per million (ppm) into logarithmic scale? If it is ppm converted to log scale, is it expected it to show a different AEs? SCR and N_2O formation do not share the same intermediate, therefore how is this conclusion derived? If they share the same intermediate, is the same AE expected? The project team does not have to form ammonium nitrate (AN) for N_2O; it is AN-like species on the catalyst surface that decomposes to N_2O. Were there any tests to confirm whether it is surface species or bulk-like AN; did the project team do any low levels of AN deposited on the catalyst followed by its decomposition and calculate the AEs?

Regarding Slide 7, the project team's technical objective is to understand the mechanism behind N_2O formation. If a single mechanism does not explain the N_2O formation, what is the path forward to resolve it, especially given there is almost no time left in this project? Without such understanding how can the formulation be optimized or the N_2O emissions quantified?

Regarding Slides 8-12, NO_2-containing feed gas reactions at low temperatures for example below 150°C certainly form bulk ammonium nitrate deposits and interfere with various reactions and decomposition processes. An overarching question is were such scenarios considered during the analysis and interpretation of the data in coming up with proposed reaction schematics? These are going to be important to create kinetics for quantifying in the application space.

Regarding Slide 14, the reviewer suggests the primary focus of solutions should be decreasing N_2O formation on copper (Cu) SCRs. Hybrid systems are not preferred due to application robustness challenges. Also, it will not solve the fundamental challenge of N_2O formation on CuSCR, a most widely used technology.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team is comprised of a diverse set of individuals and institutions who generally bring unique expertise to the project. A project of this type clearly needs expertise in zeolite synthesis, active site modelling, characterization, catalysis, and reactor engineering. The roles of each institution were described sufficiently.

Reviewer 2

The reviewer identified a diverse collaborative team including OEMs, two catalyst suppliers, and two universities.

Reviewer 3

The reviewer remarked that PNNL has the state-of-art facility for the project team to complete this project. The support from BASF is critical for the project team to succeed. The reviewer is not sure of the role that John Deere and Cummins have played in this project. Overall, the project team has enough support in PNNL and from industry. There should be more funding made available to this project as N_2O is so important in this area, especially when a hydrogen engine is to be deployed as N_2O will be the key GHG emitted from hydrogen engines.

Reviewer 4

The reviewer commented that the project team is PNNL only, although the PNNL team is informally consulting with external partners on this project. Collaborations to date have been informal, involving soliciting information from commercial partners about what the key needs are. This feedback focused the project team on mitigating N_2O formation from SCR catalysts. The reviewer recommends collaboration with partners who could commercialize the SCR catalysts evaluated on this program.

Reviewer 5

The reviewer noted relevant partners and indicated that more partners may not be required. However, the reviewer could not tease out collaborators' contributions from the generic description on Slide 15.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the N_2O formation mechanism has been well understood in literature and the research in this project. The key issue is how to mitigate N_2O emissions from SCR. The future work proposed in this project is well aligned with the critical problems needs be mitigated. The reviewer is sure the project team can and will make significant progress in this area.

Reviewer 2

The reviewer commented that the proposed future work is a logical continuation of the work to date. The goal is to set up a formal CRADA with external partners to help foster commercialization of the SCR catalyst concepts evaluated here.

Reviewer 3

The reviewer noted that the future work clearly builds on the technical achievements described in the presentation. Remaining challenges/barriers are adequately identified. However, some degree of defined metrics on the future slides, even if more qualitative, would be desired and is a bit lacking. Even for a more exploratory project of this nature, attempting to align with some semi-quantitative goals could be productive.

Reviewer 4

The reviewer stated that the proposed future work items are open-ended, in that the success criteria for generated knowledge use is not obvious. For example, generated knowledge will be codified into a model and the model will be validated, or the generated knowledge will be used to generate recommendations to address the low carbon fuel strategies to minimize or avoid excess N_2O formation and other metrics.

Reviewer 5

The reviewer commented that it was not clear, based on the earlier data showing that there are multiple mechanisms in the mix, which of them this work will focus on. Based on the work so far, will there be a down selection of materials?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project goals and approach align with VTO interests in developing improved catalysts or formulations for exhaust systems while reducing GHG emissions in the process. In this reviewer's view, the connection between performance and understanding at the atomic level of composition and dynamic behavior is an important aspect of the research.

Reviewer 2

The reviewer stated that this project is well aligned with the advanced engine and fuels area. There should be more funding made available in this project so that the project team can develop the methodology mitigating the N_2O issues from future carbon-free engines such as hydrogen engines and ammonia engines.

Reviewer 3

The reviewer commented that the project is relevant to overall VTO subprogram objectives. Projects such as this presents great opportunity for enabling reduced GHG emissions, and a smoother transition to renewable energy sources.

Reviewer 4

The reviewer remarked that one of the challenges of urea-SCR is that it forms N_2O from the NO_x in the exhaust. N_2O is a potent GHG, with a warming potential of about 300 times that of CO_2. Thus, finding copper zeolite SCR catalysts that have a very low selectivity for N_2O is necessary to make sure that a criteria pollutant problem does not become a GHG problem.

Reviewer 5

The reviewer commented that the project is relevant to VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that given the diverse skill sets of the partners and that they cover all the areas needed to prepare a range of catalysts, assay them in catalytic reactions, model active site behavior, and adequately characterize them, the appropriate amount of resources appear to be allocated across the partners.

Reviewer 2

The reviewer noted that the performance evaluation and other advanced characterizations tools exist at PNNL and catalyst development capabilities from suppliers and research expertise from all the participating collaborators are more than sufficient to define and achieve the milestones in timely fashion especially that are needed to identify practical solutions with solid underpinnings.

Reviewer 3

The reviewer commented that this team has an extensive research facility in PNNL to conduct the research work proposed in this project.

Reviewer 4

The reviewer commented that a FY 2024 budget of $300,000 seems sufficient for the bench-scale testing and associated analysis that the project team looks to do. This project is part of a series of single-year projects.

Reviewer 5

The reviewer stated that the resources appear more than sufficient.

Presentation Number: DORMA042
Presentation Title: Unforeseen challenges with renewable fuels
Principal Investigator: Konstantin Khivantsev, Pacific Northwest National Laboratory

Presenter

Kenneth G. Rappe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

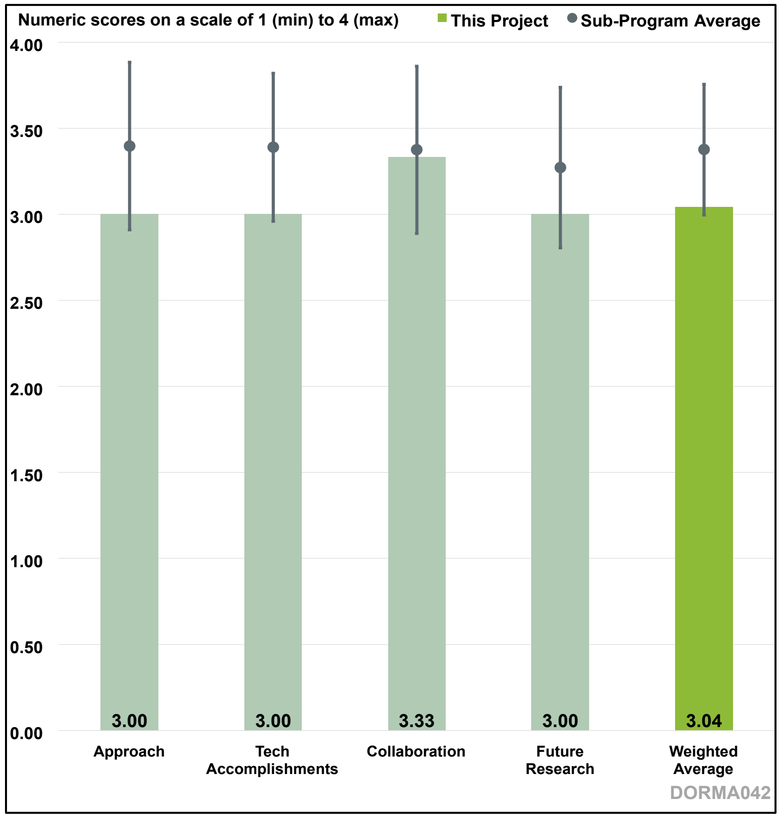

Figure 3-30. Presentation Number: DORMA042 Presentation Title: Unforeseen challenges with renewable fuels Principal Investigator: Konstantin Khivantsev, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the study focuses on impact of renewable fuels on aftertreatment systems, specifically biodiesel. Has a survey of biodiesels across the country been conducted? Phosphrous has been identified as a target species to study; is there any background on the levels of phosphorus in market fuel?

Reviewer 2

The reviewer commented that the project clearly addresses core research and development guided toward technology barriers related to challenges associated with H_2 ICE emissions and improving durability of ammonia (NH_3) SCR catalysts. It is less clear from the presentation the connection of the studies to the on track goal related to aldehyde oxidation. Even if dealt with in another presentation, more explicit mention of the connection should be provided in the slides. The lower-end TRL work is needed to clarify challenges in these areas and look for general principles to guide potential solutions in next generation catalyst design, striving for low temperature, durable catalysts that remain effective in their role. Understanding the fundamental issues that arise in emissions streams from various contaminants (phosphorus, water, and certain organics) is certainly a topic of value, given that it was also mentioned in the presentation as being suggested from industry feedback.

Reviewer 3

The reviewer identified the project technical goals in support of a hard to electrify sector and in using next generation renewable biodiesel and hydrogen fuels to be identifying or clarifying the challenges and removing the barriers such as minimizing the detrimental effect of poisons derived from renewable fuels.

The approach to performing the work selected phosphorus contaminant for studying biodiesel-derived contaminants; the rationale for the selection of this contaminant for the study are not obvious. Major challenges using biodiesel are trace level of contaminants like potassium and quantifying its impact and potential mitigation strategies based on sound science. Similarly, the fuel properties like sharp but high boiling point will bring additional new, unique or difficult engineering issues and how these species interact with catalyst components in a quantified (kinetics) way are still a gap. Such important aspects were not considered in the approach. The approach did not indicate plans for removing the barriers. The approach must focus on specific fuel; without such consideration the studies will be superficial and incomplete.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that given the nature of the catalyst systems involved, which are complex multi-atom alloys, the need for molecular level insight into how these catalysts operate and change during reaction is very important to guide future catalyst design. General milestones seem completed or are stated as on track. Valuable results have been obtained in the view of this reviewer. For one, the effects of water and phosphorus have been explored and given the differences in catalyst behavior from commercial and in house versions with phosphorus contaminants, it is clear great care is needed when baselining and drawing conclusions from batch to batch. This further demonstrates the need to work out and understand these discrepancies in a controlled environment.

The advanced tools brought forward by the project team to characterize the systems is a clear strength. The advanced microscopy and elemental mapping are critical to the effort, along with X-ray methods very useful to see changes in the NH_3-SCR catalysts and the role of hydrogen (H_2) as a partial reductant. A potentially promising H_2-SCR catalyst has been developed that reduces Pt loading, while the multi-stage concept also seems interesting with shunting of NO_x to a low temperature reactor bed allowing high temperature NH_3-SCR to still occur. It was a little difficult for the reviewer to see how the economics of this type of system might work in practice, but it is still critical to develop lower TRL concepts like this if they indeed accomplish the goal of negligible N_2O emission so they are ready if the time is ever right for scaling. The reviewer was surprised at no mention of publications. For a lower TRL research and development effort, this is pretty disappointing not to have a discrete plan for some dissemination of the very carefully performed studies. The reviewer would hope some part of the in house/commercial material story behaving differently in the presence of phosphorus could be of great value to the community. This seemed like a missed opportunity not to have some degree of focus on broader distribution of the work.

Reviewer 2

The reviewer stated that the impact of water on N_2O formation is a very interesting result, specifically 0% water exhaust where the N_2O formation window is shifted. The implications for a hydrogen engine is significant at the low temperature window. Should engine calibrations target a higher engine out temperature to around 300° C SCR temperature to get higher NO_x conversion as well as lower N_2O formation? N_2O formation in H_2-SCR appears to be a significant problem; are there mitigation strategies being researched? The combination of H_2-SCR and NH_3-SCR is an interesting approach, complexity of system could be a barrier for packaging reasons for off-road applications.

Reviewer 3

The reviewer commented that for the DOC study, it was not obvious what the technical outcome means to the path forward. Were the commercial DOC technologies studied under this project representative of next generation DOCs, in other words state of the art DOCs? If not, it is strongly suggested to work with catalyst companies to procure the latest technologies which could be advanced designs whose chemistry and physics of interactions are expected to be different. The underpinnings of contaminant impact on such technologies are critical for identifying advanced solutions.

On slide 9, what does the ratio of N_2O rate to NO_x conversion rate convey? In addition, there were no insights into the important observation of N_2O increase with increase in H_2O concentration through the studies.

Regarding Slide 10, the impact of H_2 on long term NO_x conversion is an important nuance. However, the technical rationale provided to explain the nuance is substantiated with limited characterization information, if any. Such impactful findings are expected to be followed upon with solid experimental evidence such as operando copper species characterization or other specific probing techniques. It is also expected for the project to provide technical insights under long term exposure to H_2-containing feed gas, under practically relevant conditions but such attempts were not made.

Slide 11 reiterates known technical challenges and no major nuanced insights and solutions. What would be the recommendation from these studies on the H_2-SCR TRL?

Regarding Slide 12, the question is what the expectations from this study were, given the practical application of the proposed technical approach as a solution and the intricacy associated with it (requiring H_2 fuel, safety, sensors, valves etc.) makes it difficult if not impossible.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer appreciates the breadth of industrial collaborations. This is an absolute necessity in a lower TRL, more research and development environment to be able to identify the key issues and bottlenecks various parts of industry encounter and need help solving. Access to the expertise across catalyst formulation, engine, and system design is critical to the effort focusing on the types of issues that advanced characterization methods can shed the most insight on and to ultimately maximize impact of the research.

Reviewer 2

The reviewer noted relevant partners. More partners may not be required, however, the reviewer could not tease out current collaborators' active contributions from the generic statements on Slide

13. Listing specific and concise contributions of collaborators will help in better assessing the effectiveness.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that there are solutions such as Clearflame technologies that are developing E98 fueling for compression ignition engines. The reviewer thinks the impact of E98 type fuels on current SCR formulations would be interesting to focus.

Reviewer 2

The reviewer remarked that in general, the future areas seems reasonable and binned in ways that can provide impact and insight from additional characterization of the systems, explore further designs of systems involving H_2 SCR and NH_3 SCR improvements, as well as examining oxygenates further. It was a missed opportunity to at least have a slide on the final topic, as there was little or no reference to this milestone in the deck.

Reviewer 3

The reviewer commented that the breadth of proposed future work will not allow focused identification of specific critical challenges, technical underpinnings and solutions. The project teams needs to select a specific fuel for the hard to electrify sector and address challenges and identify solutions. Oxygenated fuels are also studied at ORNL for a couple of years; what different and additional technical aspects will be addressed by PNNL? The project team needs to identify synergy between PNNL's proposed work and ORNL's current project work and must avoid redundancy. For H_2 ICE work, without understanding the technical underpinnings, for example N_2O increase mechanism, how is it possible to identify solutions as indicated by future plan? The reviewer suggests revisiting such proposal and comprehensively address scientific reason behind the increase in N_2O with increase in water (H_2O) and similarly other nuances.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project goals and approach are well aligned with VTO interests in understanding the challenges with use of biodiesel streams in engines and exhaust catalyst systems. The work here can give key insight into the issues that arise with various contaminants and the ways they can be mitigated, either through separations on the front end or use of new catalyst designs. By understanding the change in catalyst structure over time, it should be possible to identify when major problems will arise and potentially impact catalyst durability and provide a path to potentially circumvent such issues by innovative reactor design or reformulation of catalyst.

Reviewer 2

The reviewer remarked that the impact of renewable and low-carbon fuel on engine and aftertreatment is highly important understand to develop mitigation strategies for pre-mature component failure. This will directly help in adoption of renewable fuels into current powertrains with minimal modifications.

Reviewer 3

The reviewer commented that project is relevant to overall VTO subprogram objectives. Projects such as this present great opportunities for enabling reduced emissions, energy security and transition to renewable energy sources and play a significant role in achieving more sustainable transportation solution.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the performance evaluation and other advanced characterizations tools exist at PNNL; catalyst development capabilities from suppliers and research expertise from all the participating collaborators are more than sufficient to define and achieve the milestones in a timely fashion especially that are needed to identify practical solutions with solid underpinnings.

Reviewer 2

The reviewer stated that given the diverse skill sets of the partners and that they cover all the areas needed to identify the types of contaminants that need to be studied and the characterization tools required to understand the systems of interest, all required resources were present.

Presentation Number: DORMA043
Presentation Title: Low-load cycle emission control
Principal Investigator: Yong Wang, Pacific Northwest National Laboratory

Presenter

Yong Wang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 40% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

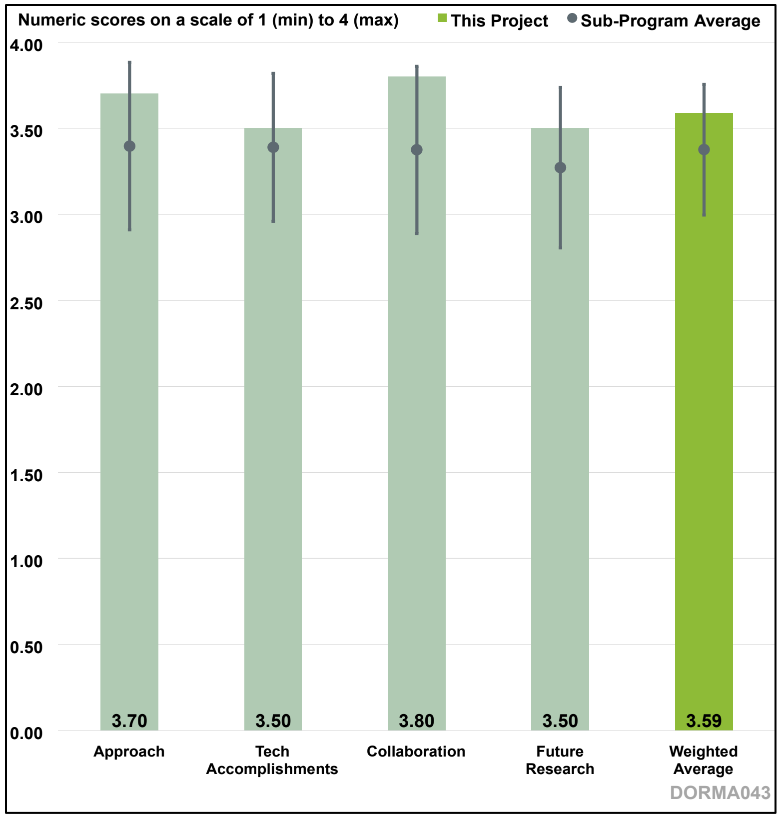

Figure 3-31. Presentation Number: DORMA043 Presentation Title: Low-load cycle emission control Principal Investigator: Yong Wang, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project clearly addresses fundamental science issues related to technology barriers involved in development of next generation, emissions exhaust systems. The goal of accessing more durable, cost effective, and still highly active at low temperature catalysts is a valuable one. The mechanistic focus seems like a reasonable approach to understand general design parameters for next generation catalyst formulation.

Reviewer 2

The reviewer remarked that the low efficiency of SCR in reducing NO_x at low temperature is one of the critical issues for the diesel industry to meet the new NO_x regulations. This project is well designed which is supported by the experimental research work about catalyst composition examined, the range of temperature tested and the effort in examining the reduction half cycle (RHC) kinetic modeling. The time line is well planned as the project team has completed all proposed work as planned; the data presented in this review meeting provided evidence of work completed.

Reviewer 3

The reviewer noted a very detailed fundamental experimental project that addresses low temperature SCR activity for off-road applications. Catalyst durability is an important parameter to be characterized accurately.

Reviewer 4

The reviewer stated that for the issues to address in this project, the plan was well laid out. Adding the use of operando EPR was critical in the reviewer's view.

Reviewer 5

The reviewer remarked that the project goal is to identify opportunities to improve low temperature activity, extend useful life, and/or reduce cost associated with emission control from low carbon fuels for hard-to-electrify applications that are aligned with industrial priorities The approach to performing the work was generic in description. Specific details of strategy process in defining the opportunities and challenges are missing; it was difficult to assess the end goal and timelines for meeting end goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the results for the NH_3 SCR catalysts certainly appear promising with the studied Cu zeolite systems. Theory has played a key role to understand conversion of a redox resistant form of the Cu sites to something more likely to undergo reduction while also helping to understand why the process favors one type of zeolite support over the other. It is good to see the direct value of the experiment-theory interplay here as well as treatment of the full reaction mechanism in the backup slides. Kinetic modeling, though very different than reaction modelling, also plays an important role in the project and highlights the need for a team with varying expertise. Use of EPR to study copper sites is well chosen and a sound technique to assist in understanding of oxidation states present in the various catalysts. The studies provided on understanding NH_3 inhibition are very important, given the field aged catalysts exhibit similar profiles. The probe of NH_3/NO ratios is also valuable to tease out the distinct impacts on RHC versus oxidation half-cycle. The six publications and three presentations are impressive productivity, with many of the reports appearing in high impact factor forums. This ensures dissemination of the fundamental knowledge gained in these studies is available for the broader catalysis community and could demonstrate impact well beyond the field of emission control catalysis. Project milestones seem on track. The team has performed the fundamental studies into SCR catalysts and the project will culminate in use of these insights to develop next generation catalysts.

Reviewer 2

The reviewer stated that this team has completed the tasks proposed. The data presented in this review meeting demonstrated the progress in this project.

Reviewer 3

The reviewer remarked that the characterization of the role of ammonia inhibition is a important finding. Are there preventive measures? Was any transient emissions tests performed?

Reviewer 4

The reviewer identified a variety of nuanced technical insights; however, how this information was used to improve the technologies or applications should be attempted with the help of industrial partners/collaborators.

Reviewer 5

The reviewer observed that the number of technical accomplishments was impressive in the time so far for the project. They were well presented and put in the order needed to make the case for what was and was not limiting the active sites. Still there is little time left to get to important remaining issues on the best way to proceed for the hard to electrify applications.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that this project has collaboration with OEMs such as John Deere and Cummins and suppliers such as BASF and Zeolyst. The input from industry and aged SCR systems are critical for this project to succeed. There is no need to have other external entities.

Reviewer 2

The reviewer commented that overall, the team is comprised of a diverse set of entities that bring singular skill sets to the project. Of particular note in this project are the collaborations with theory and characterization, given these two areas were critical to studying the reaction mechanism of the systems. At the same time, it is also important to have industry partners involved that provide key knowledge of how these systems need to bridge to technology. Reliable access to field samples and aging protocols consistent with real-world aged catalysts is also important to ensure catalysts studies in the lab generally mimic field performance.

Reviewer 3

The reviewer noted that there were excellent partners in this project, familiar with the issues and in the tools needed to study them.

Reviewer 4

The reviewer affirmed excellent industry, academia and national lab collaboration.

Reviewer 5

The reviewer noted relevant partners. More partners may not be required, however, the reviewer could not tease out their active contributions from the generic statements.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the proposed future research challenges in this project will be met by the proposed approach, especially for off-road applications.

Reviewer 2

The reviewer stated that this team has a very clear picture of the future research work. The research work proposed are typical but not new to this research community. The engine-out emissions from off-road engines should be well-known information, so it is not necessary to have it listed as a major work. The degradation factors, including thermal and chemical factors, are two well-known factors many researchers have evaluated. It may be a good idea for the research team to evaluate the changes in catalyst coated and also if there are any other chemicals that have covered the catalyst. The principal investigator may have had this included in their research in chemical factors, which should be the focus for research to aged SCR system. The testing and aging protocols simulating real world off-road challenges is important in SCR development, but it should be much easier than on-road operations, which can be completed by OEMs other than this team, so it may be a good idea to have this item removed from future work, so this team can focus on SCR catalyst and its aging research.

Reviewer 3

The reviewer stated that the proposed work description is at a high level and should attempt to provide details in backup slides. The proposed future work appear to extend and complete the identification of barriers in the context of off road applications.

Reviewer 4

The reviewer commented that the slide on future barriers and work seems to address major overarching issues, though a few statements are generic and could be further expanded on to some degree with a next level of detail (thoughts on improving durability as one example). Regardless, the key stumbling blocks, such as durability, are identified and the reviewer has no doubt the team will make progress in this and other areas. The reviewer cannot reiterate enough the key advantage of having access to field aged and “real” catalyst systems to examine in these studies. The collaboration across the National Lab group and industry makes this possible and is a strength of the effort.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project is directly relevant to advanced engine and fuel technologies. The aging of SCR catalyst has been one issue bothering the diesel engine industry for years. The low efficiency of SCR in reducing NO_x at low temperature is the major barrier in reducing NO_x emissions as low load operation is very popular in many operation scenarios. The reviewer trusts this project is an excellent example that DOE funding can play in the future.

Reviewer 2

The reviewer commented that the project is relevant to overall VTO subprogram objectives. Projects such as this present great opportunity for enabling reduced emissions, energy security and transition to renewable energy sources and play a significant role in achieving more sustainable transportation solutions.

Reviewer 3

The reviewer remarked that the project goals and approach are well aligned with VTO interests in developing improved SCR catalysts for advanced emission control systems. The fundamental understanding of the reaction mechanism is also valuable for the broader research community and provides unique insight into Cu zeolite chemistry.

Reviewer 4

The reviewer stated that aftertreatment for NO_x will be needed for LLCF that are being studied along with other alternative fuels that make NO_x. This project is very relevant to the goals of these projects.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that given the diverse skill sets of the partners and that they cover all the areas needed to probe the mechanism of the Cu catalysts, all required resources were present. In closing, the reviewer would just highlight again the key contribution of the computational and kinetic modelling effort plays in the work. The project exemplifies the potential of bringing together a team well-versed in experimental and computational catalysis and the impact these interactions can have.

Reviewer 2

The reviewer noted that performance evaluation and other advanced characterizations tools exist at PNNL and catalyst development capabilities from suppliers and research expertise from all the participating collaborators are more than sufficient to define and achieve the milestones in timely fashion. However the reviewer strongly suggests to align with industry partners on the remaining milestones.

Reviewer 3

The reviewer remarked that as stated in slides and the talk, this project makes very good use of the experimental tools available at PNNL.

Reviewer 4

The reviewer commented that national laboratories such as PNNL always have excessive resources for them to conduct the state-of-art research. The support from industry partners is also critical for the success of this project. The resources are sufficient for this team to achieve the stated milestones on time.

Presentation Number: DORMA045
Presentation Title: Biodiesel poisoning of close-coupled SCR catalysts for off-road engines
Principal Investigator: Todd Toops, Oak Ridge National Laboratory

Presenter

Todd Toops, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

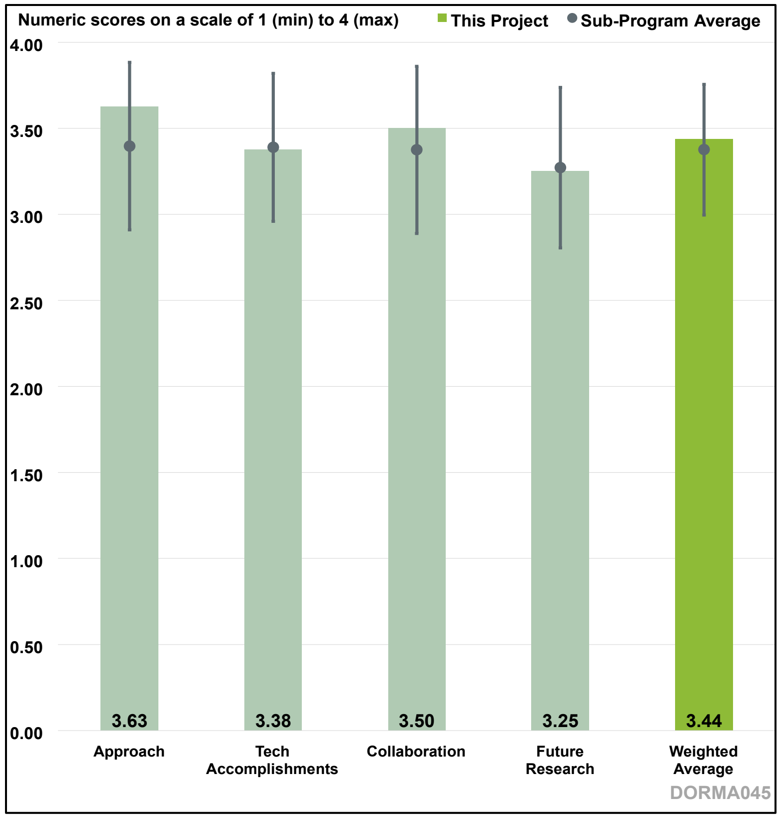

Figure 3-32. Presentation Number: DORMA045 Presentation Title: Biodiesel poisoning of close-coupled SCR catalysts for off-road engines Principal Investigator: Todd Toops, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the approach to this project is impressive, representing a very systematic approach to determine the impact of metals on SCR aging and determine methods for minimizing the acceleration factor. The investigators will identify where the metals are interacting with the catalyst and correlate the locations to changes in function in order to create better predictive models. They will achieve this by engine aging the samples with doped fuels, then use spatially resolved capillary inlet mass spectrometry (SpaciMS) to determine the local performance data. The reviewer cannot think of anything that is left out of the approach.

Reviewer 2

The reviewer remarked that the project clearly addresses technology barriers related to catalyst poisoning by contaminants in biodiesel-derived fuels within associated emission control exhaust systems. The work will also have implications for ultimately reducing carbon intensity of fuels/engine systems given the knowledge imparted about effects on catalyst from impurities in biodiesel streams. This could affect the types of purifications needed prior to engine/exhaust system exposure (as one example). There is a clear need to improve understanding of how these contaminants impact exhaust catalysts; “baselining” these effects with standard biodiesel and SCR catalysts is critical for the field as a whole.

Reviewer 3

The reviewer commented that the project appears to be on track.

Reviewer 4

The reviewer noted a great project to determine aging of vanadia-based selective catalytic reduction (V-SCR) with 100% biodiesel (B100), which is very applicable to current on-road HD engines and future Tier 5 engines. The project has a good overall design, testing methodology and measurement technique. The reviewer suggested maybe allowing some time for another iteration with higher doping levels if results are not very aged.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted great progress in setting up test equipment and measurement technique.

Reviewer 2

The reviewer commented that the project has just started and the progress is on target, getting things quoted and purchased.

Reviewer 3

The reviewer stated that support hardware and protocols are in place, and the project team is ready to execute the aging study. For the table on Slide 4, please verify the Tier 3 emission limits of 9.2 g/kWh instead of 4.0 g/kWh. Please also pay attention to the fine print of 0.4 g/kWh vs 0.40 g/kWh due to rounding number allowance, and for 0.040 g/kWh for CARB Tier 5. For good bookkeeping, the reviewer recommends the project team gets an estimate of engine oil consumption from an OEM and predict the sulfur exposure from both oil and B100 for the intended durability test duration. Even V-SCR is known not to be sensitive to sulfur poisoning. In addition, the project team should characterize the engine out emissions, flow and temperature of the Type D2 ramped modal cycle test with B100 and ultra-low sulfur diesel (ULSD). Finally, a DEF) sample should be analyzed for impurities as a good engineering practice.

Reviewer 4

The reviewer remarked that the presented vision for the work is clear in that moving to close-coupled SCR systems leaves a greater susceptibility to chemical poisoning. The summary of challenges with biodiesel containing higher metal content is well presented. A better fundamental understanding of metal impact on catalyst durability and effect on structure is key to maximize efficiency and longevity of the exhaust systems. In general, the conceptual plan in place seems logical and the established protocols in Slide 6 seem systematic and thorough. The reviewer was curious why phosphorus did not really seem to be a focus of doping in the B100 fuels relative to the other metals? The reviewer may have misread the slide, but it seemed like phosphorus content was not an emphasis and the reviewer did not recall this being expanded on further in the verbal presentation.

The SpaciMS seems like a unique and valuable technique to help correlate changes in activity to metal distribution. However, the presentation was a bit superficial in correlating results from the systems studied to insights on potential effects on the exhaust catalyst. Especially considering the scaled setup is not yet in place, spending some additional time on the results that have been obtained here and their potential significance for the future studies was desirable. Other products beyond milestones such as two presentations and a publication are also worth note. The publication is in a high-profile catalysis journal and provides a valuable impact of the work beyond just the specific study. The scoring here is in part due to lack of any discrete milestones in line with most of the other projects evaluated. Some idea of explicit timeline for the next series of activities would be helpful and seems like an omission to this reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that all teams seem to be working together to meet project targets. ORNL is coordinating very effectively.

Reviewer 2

The reviewer noted a good team with both formal and informal collaborators and a good plan for communication.

Reviewer 3

The reviewer recognized that cross-functional collaboration with suppliers and OEM is apparent.

Reviewer 4

The reviewer commented that the team represents a diversity of expertise one would expect for this type of project. Each member plays an important role, from the Clean Fuels Alliance America supplying the biodiesel to getting necessary catalysts samples or standard aging protocols for testing from industry partners. Clear investment from industry partners is seen with the matching funds and help with needed equipment purchase and setup. The large capital investment to set up the various system components is recognized. Lots of moving pieces still seem like they are coming together for testing in Year 2 in a reasonable fashion. However, not providing some more discrete timelines for Year 2 seems like a missed opportunity.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future directions are to carry out the thoughtful approach.

Reviewer 2

The reviewer noted that as mentioned above, the conceptual framework is strong; it just seems like a chance to provide a better understanding for the full system setup and the stages of data analysis was missed. The project team seems poised to execute, but the fluid nature of the milestones and activities in Year 2 is a bit surprising for an applied project.

Reviewer 3

The reviewer suggested that as stated in response to Question One, maybe add some future test time for increased doping.

Reviewer 4

The reviewer requested that in a future report, please include engine out emissions of D2 cycle (B100 and ULSD) and indicate if the engine has EGR. The researchers could define what is the size of close-coupled SCR (relative space velocity), expected NO_x conversion efficiency in order to judge the severity of degradation and tolerance from impurities from B100 exposure.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the use of renewable, low carbon fuels like biodiesel is likely to be limited by the ability to meet regulatory limits for emissions. In particular, biodiesel which does not have an ASTM International standard for its neat use, can therefore have contaminants that do not bother the engine/combustion but can wreak havoc on the aftertreatment system, which has been seen for years with respect to DPFs. In order to meet the coming Tier 5 regulatory limits for NO_x, aftertreatment will become even more important, and particularly, industry will need to be certain that the SCR is compatible with higher levels of biodiesel blends to achieve both low (net) carbon fuel targets along with the regulatory targets for NO_x. Therefore this project is not only relevant, it is essential; the reviewer thinks that the industry funding that was volunteered is an excellent indication of that.

Reviewer 2

The reviewer remarked that the project goals and approach are well aligned with VTO interests in understanding contaminant effects on use of biodiesel in engines and catalyst exhaust systems. This will be critical to understand as industry moves to incorporating larger percentages of bio-derived fuels into the supply chain. In this reviewer's opinion, the connection between performance and understanding at the atomic level of composition and how the catalyst changes based on exposure to these elements is essential to moving the field forward.

Reviewer 3

The reviewer noted that this project addresses one important aspect of the B100 impact to one potential aftertreatment system (system with a close coupled V-SCR). B100 induces other changes of engine out characteristics, exhaust temperature and NO_x, etc.; the sensitivity of catalyst degradation depends on engine out NO_x, NO_x conversion efficiency target and size, etc.

Reviewer 4

The reviewer stated that the project is extremely relevant to today's U.S. Environmental Protection Agency vehicles and future Tier 5 off-road engines.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that every indication is that the team has the needed resources to complete the proposed work. It is clear the partners are vested in the project moving forward. This applies to both the industry and trade association groups associated with the project.

Reviewer 2

The reviewer observed a very effective use of resources with simplified test equipment and test procedure.

Reviewer 3

The reviewer noted that the project team appears to have the right tools and knowledge base to execute the project. The project team might want to think ahead what key questions will be addressed through this study and what will not.

Reviewer 4

The reviewer commented that at this point, resources seem sufficient; however, as the project moves forward, the reviewer can see where additional experiments or diagnostics may be needed.

Presentation Number: DORMA046
Presentation Title: Ammonia for 4-stroke Marine Dual Fuel and Gas Engines (Retrofits and New)
Principal Investigator: Scott Curran, Oak Ridge National Laboratory

Presenter

Scott Curran, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

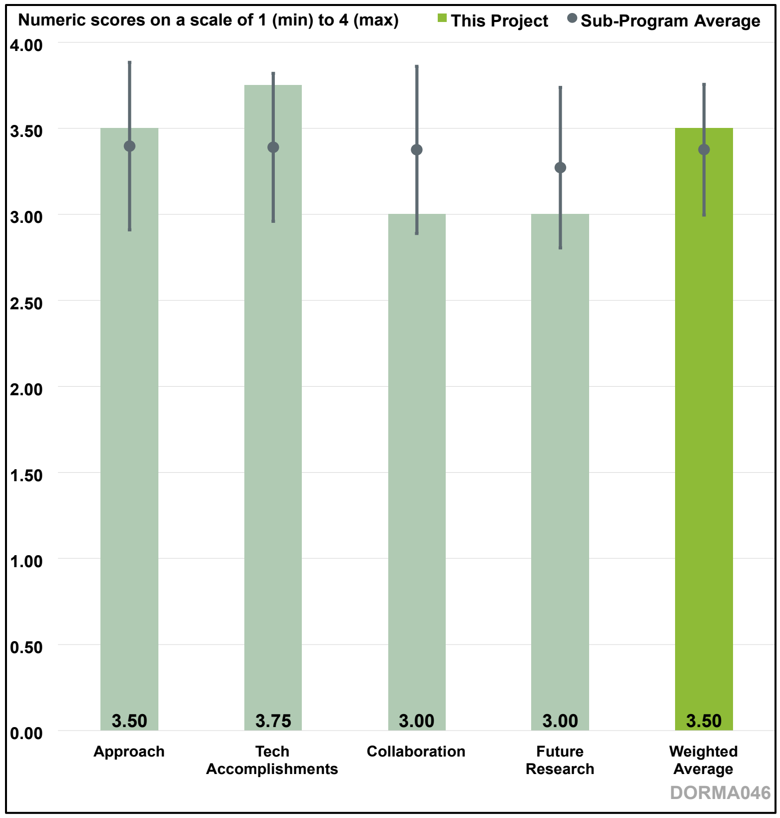

Figure 3-33. Presentation Number: DORMA046 Presentation Title: Ammonia for 4-stroke Marine Dual Fuel and Gas Engines (Retrofits and New) Principal Investigator: Scott Curran, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked the overall program is a nice mix of applied internal combustion engine development coupled with flow reactor and aftertreatment studies that address multiple facets of research on ammonia-fueled engines for marine applications. The focus on retrofit narrows the overall scope somewhat and aligns with the direction for auxiliary engines being used on large marine vessels as well as prime movers for medium-size commercial vessels. The reviewer noted the overall timeline is relatively short, but given the progress made thus far, and a clear program path, the timeline seems achievable.

Reviewer 2

The reviewer said this project is an interesting study to assess the viability of ammonia as a fuel in 4-stroke marine engines. Included are ammonia as a fuel in its own right and hydrogen-assisted combustion of ammonia. The project incorporates a team to investigate the feasibility for ammonia as a fuel in diesel 4-stroke, dual-fuel 4-stroke+hydrogen, as well as spark ignition 4-stroke and emissions control strategies. The PIs are using a single cylinder engine modified for dual fuel ammonia operation to assess performance. The reviewer noted the project also included a medium-duty multi-cylinder diesel engine. The emphasis of past work appears to be on 2 stroke engines. This project has intended to fill this gap with an emphasis on marine engines in particular. The reviewer said that here, the concern of N_2O emissions is noted with its greater impact as a GHG by a factor of 300 compared to CO_2. The dual fuel approach is quite interesting.

The reviewer said that a consideration for the use of ammonia as a fuel that was not clear from the presentation concerns its low vapor pressure. Ammonia is a gas in the standard atmosphere. This would impact its storage, transport and injection. The reviewer recommended the PIs should have a slide in their presentation which summarizes this potential concern. Also, some consideration on the production/supply of ammonia to meet the needs of the targeted transportation sector should be given. The reviewer noted that collaborations with DOE's Bioenergy Technologies Office can be useful in this matter.

The reviewer said the project incorporates reaching objectives that "…inform the next generation of ammonia-capable marine engines" by using "flow reactor experiments" and "thermodynamic analysis." The reviewer was not clear what was involved with the flow reactor and thermodynamic analysis that was related to "limitations of ammonia consumption…". The experiments and analyses noted should be clarified.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said it is important to highlight the publication on safety considerations for using ammonia fuel in a test facility; this is an area of high interest for the industry as others look to install ammonia systems in their own facilities. Publishing this brings great value to the work conducted in the lab, which for setups usually does not deliver intrinsic value to the industry. The reviewer noted the project demonstrated a range of results using ammonia dual-fuel combustion, indicating good progress towards milestones. In addition, it is also worth highlighting that that this work appears to have leveraged learnings from prior DOE-funded research into dual-fuel combustion. Building off this prior DOE investment to accelerate this program is notable. Further, the emissions focus on not only CO_2 emissions, but relevant GHG emissions as well is recognized. The clear tradeoffs of N_2O, a GHG, emission versus the decarbonization that would be provided by low-carbon ammonia is important to understand and nicely dovetails with the combined combustion and emissions capabilities and focus of the program.

Reviewer 2

The reviewer said a lot seems to have been accomplished in the past year. However, the presentation suffered from a lack of details that would have enabled a more detailed assessment of the accomplishments. This is likely due to the limited time the PIs had to present their work. The reviewer cited as an example, it was noted that "formation pathways are under investigation through additional experiments…", but from this statement alone it was not clear how these "pathways" were to be determined and what the "additional experiments" were. Color coded figures were presented (e.g., Slides 10 and 13) showing interesting information on NH_3 and a large (93% reduction) of CO_2 though it was not evident if these figures were from simulations or processed experimental data. The reviewer said more information on these points would have been preferred. The reviewer provided as additional comments: A single cylinder diesel engine facility was modified for duel-fuel injection and made operational to carry out experiments to measure emissions including N_2O, NO_x, CO_2, and other gases with several injection approaches. Safety protocols were incorporated into the dual-fuel engine laboratory. A demonstration of an injection strategy enabling duel NH_3/hydrogen injection was shown. Formation pathways were noted to be under investigation by collaborators, which is interesting, but no details were provided. Generally large reductions of CO_2 emissions were found in the experiments, which is impressive. The flow reactor experimental configuration is intended for studying ammonia decomposition. However, the presentation did not make clear what was being measured here. Is the flow reactor intended to determine the decomposition rate of a one-step decomposition reaction?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said this project has clear, numerous, collaborations across different industry and university partners.

Reviewer 2

The reviewer remarked collaboration is good and seems generally effective. Monthly meetings are held with industrial partners and DOE personnel. However, the deliverables of some of the collaborators were not described so it was not evident in some cases how their contributions would contribute to the overall project objectives. For example, three university partners are incorporated into the project. It was not clear what they brought to the project. One university partner (Oakland) provides a "…deeper understanding of the chemical kinetics of NH_3 combustion." How this "deeper understanding" was developed, what metrology is involved with it, and where it fit into the project was not discussed. Similarly for the other collaborations. For the ExxonMobil collaborations, the reviewer remarked it was not clear how they are providing an "…understanding NH_3 impacts to engine oil by supplying test oil and input analysis…". What this means should be clarified.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked the plan for future work seems good. In the main it will involve more testing to address various barriers that include trying to reduce N_2O emissions, assessment of commercial decomposition catalysts to produce hydrogen, more hydrogen enhanced dual-fuel experiments from the flow reactor, and others. The reviewer also recommended that the PIs address the question expressed previously regarding ammonia supply to meet national needs for marine engines, and the infrastructure to provide it to the marine sector.

Reviewer 2

The reviewer said the project has a clear scope and plan for future work, and connects. It would be useful to see a GHG comparison against a diesel baseline using low-carbon diesel fuels like renewable diesel and/or biodiesel. For larger marine applications with a dual-fuel ammonia main engine, it seems like the diesel consumption of an auxiliary engine would be small relative to the diesel use on the main engine, which may well be renewable diesel or biodiesel in future applications. Given this, it is unclear whether a dual-fuel ammonia engine would make sense for the auxiliary. The reviewer said as such, it would be useful to understand the decarbonization opportunity from ammonia relative to an engine operating on low carbon diesel rather than a petroleum diesel baseline. Additionally, understanding the effects of exhaust gas recirculation (EGR) on ammonia-fueled engines is an opportunity space that should be explored in more detail. This is acknowledged as part of the proposed work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project is highly relevant to VTO program objectives of new fuels for efficient combustion, here being to the marine sector and the emissions it generates as related to global climate change. Alternative fuels that are ammonia-based have significant promise for clean combustion. This project fits well into a program constructed to provide foundational information on ammonia's potential to this end for the marine sector.

Reviewer 2

The reviewer remarked clear connection to VTO's focus on decarbonization of off-road applications, including marine.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said the project's budget is low relative to the work scope and progress, and in comparison to other projects.

Reviewer 2

The reviewer commented the resources seem adequate for this project. However, because details were not provided regarding budget breakdown for specific tasks a more thorough assessment of the financial resources for the project could not be provided.

Presentation Number: DORMA047
Presentation Title: High-Efficiency Mixing Controlled Compression Ignition Combustion of Propane Dimethyl Ether Blends
Principal Investigator: Sage Kokjohn, University of Wisconsin

Presenter

Sage Kokjohn, University of Wisconsin

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

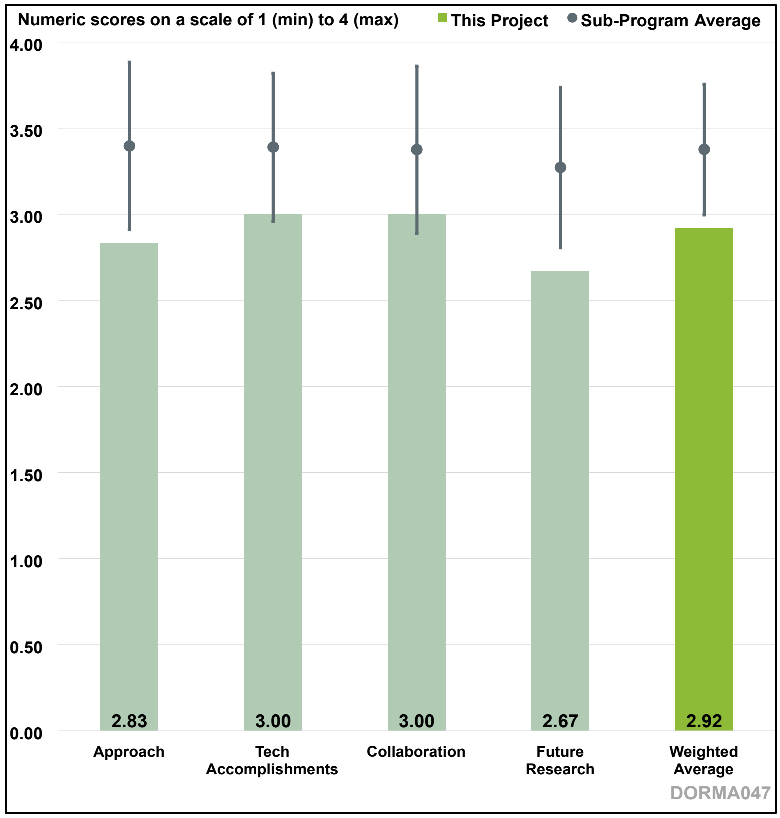

Figure 3-34. Presentation Number: DORMA047 Presentation Title: High-Efficiency Mixing Controlled Compression Ignition Combustion of Propane Dimethyl Ether Blends Principal Investigator: Sage Kokjohn, University of Wisconsin

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project is well designed to address some of the key barriers for propane and DME/propane MCCI combustion. The project team is encouraged to utilize 1D system-level tools more extensively in combination with three-dimensional (3D) CFD to drive the development a full-range operating strategy.

Reviewer 2

The reviewer remarked the approach to devise a method for compression ignition (mixing controlled) for propane is rather innovative. It is a clean, low-carbon fuel that is relatively easy to produce, with lower carbon intensity than diesel. The project is investigating the necessary aspects of how to get an engine to even have a chance to CI combustion with propane, since the chemistry of propane is not easily conducive to CI. The efficiency benefits, if successful, could be significant. The reviewer said the challenge is marketplace—(MD trucks as opposed to off-road or other, where propane is more easily accepted and found. MD trucks will be offering significant competition with battery electric vehicles (BEVs), and well-to-wheels CO_2 for electrical power for BEVs is likely to continually drop over the development life of this project. However, this combustion system should have value in a variety of applications, if successful, and it is well-worth the effort to explore.

Reviewer 3

The reviewer said that for the amount of funding in this project, the approach lacks ambition. The project team is using an existing and installed single cylinder engine, and is using correlations to get to a brake efficiency number. The team is using a fuel pump/injector system that seems like it was primarily developed in a different project. The GT Power and CFD simulations, while useful, are not overly complex. The planned testing to conclude the project seems like it will only be installing a new cam shaft for the exhaust re-breathing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the project team made good progress on developing the fuel injection system, generating initial engine test results, conducting 3D CFD and 1D engine cycle analysis. The gross indicated thermal efficiency/BTE results need to be compared with the base diesel engine performance to drive identification of areas for improvement. The reviewer remarked it will benefit the team to conduct a thorough assessment on a full range valve strategy along with geometric compression ratio (CR) evaluation in the 1D analysis.

Reviewer 2

The reviewer remarked the engine has been operated at high fuel pressure and has produced insightful results. The exhaust rebreathe concept looks to be effective at raising the compression temperature without raising the compression ratio of the engine. The backpressure penalty might reduce the optimum BTE a bit but it appears to provide significant leverage for consistent compression ignition of propane. The reviewer said CFD models appear to do a decent job of capturing the correct trends and comparisons, so the project can move through the test space with some confidence. The only concern the reviewer had is with the injectors and the lack of lubricity/cooling of propane and DME. The reviewer realized the injectors are part of a different project, but they have significant influence here.

Reviewer 3

The reviewer remarked the project team has identified the in-cylinder engine conditions that need to be achieved to operate on their chosen DME/propane blends and devised a method using exhaust re-breathing to achieve this. However, the solutions that are being developed seem very much like a lab-based solution and they lack direct applicability to the real world. The reviewer said it is not clear that the team will be able to operate over the full engine map with a single set of hardware (cam). And, while the team can point to existing advanced valvetrain hardware that could help them achieve these goals, the reviewer would expect more to be implemented for the amount of resources in this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said collaboration is well organized with activities at each partner complement each other.

Reviewer 2

The reviewer commented that the project partners appear to have most of the bases covered—universities to perform the scoping and simulation work, a small, specialty company to work on the injectors and support from fuels organization. The project could potentially benefit from an engine OEM involvement to ensure technology transfer, if the project is successful.

Reviewer 3

The reviewer said the project team consists of two universities, an engine consultant closely linked to the project lead (Wisconsin Engine Research Consultant), a start-up company that aims to develop fuel pumping and injection equipment (WM International), and a company that produces DME. The reviewer noted there is no major OEM or Tier 1 supplier in this project team that can steer the project to more ambitious efforts and get them closer to implementation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said plans to conclude the project consist of running some additional single cylinder engine experiments with a modified camshaft to prove that exhaust re-breathing can achieve the in-cylinder conditions necessary to reach autoignition with high propane blends. While technically this can meet the project goals, it seems underwhelming for the amount of resources that DOE is putting into this project. The reviewer said it would be nice to see a custom solution—perhaps hardware that can achieve full-map operation. Or operation in a multi-cylinder engine that includes fuel pumping so that brake efficiency correlations do not have to be used.

Reviewer 2

The reviewer said that considering the lean burn nature, future research should involve performance comparison with the base diesel engine. The analysis should place an emphasis on how to close the performance gap including CR, piston bowl geometry, spray pattern, and valve strategy. Laser ignition may not bear strong practical significance. Diesel/DME pilot ignition may be a more feasible approach.

Reviewer 3

The reviewer commented that the future work should be able to address most of the barriers to this technology being demonstrated, if successful. Much more thorough engine testing, over a variety of conditions, is a good plan to ensure that the predicted CO_2 reductions are realized. The reviewer said it is a bit unclear how laser ignition would enable much in terms of barrier elimination, in the sense that the cost will increase, and it is not clear that the performance will increase in a similar way. It will be important to stay on top of the latest information on CO_2 well-to-wheels for BEVs, because that is the genuine competitor in this space. The reviewer said under the current regulations, the BEV also has the zero-emission vehicle advantage from a regulatory point of view, and it may be reasonable to account for that in the analysis.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project definitely supports DOE goals in CO_2 reduction. Propane and DME are also potentially renewable, but even in fossil form, propane has some CO_2 benefit compared to diesel. The project goal to utilize CI is quite worthwhile and should be pursued.

Reviewer 2

The reviewer said the project is well aligned with the future GHG reduction requirements. The project team is encouraged to clearly define the engine-out NO_x targets with appropriate description of drive cycles and the lean aftertreatment system to be used.

Reviewer 3

The reviewer said that while answering this question “yes”, the project goals of using mixtures of propane and DME in MD engines seem less relevant to this project then when it was initially awarded. The project has more recently shifted to heavier, hard to decarbonize applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are adequate to support the project milestones and the timeline.

Reviewer 2

The reviewer commented that resources available appear to be sufficient to accomplish the goals of the project.

Reviewer 3

The reviewer noted there are a lot of financial resources going into this project. For this amount of funds, the reviewer would expect a lot more work than to use an existing single-cylinder research engine with a modified fuel injection system. The effort seems underwhelming for the amount of resources being put into it.

Presentation Number: DORMA051
Presentation Title: Fuel effects on aviation engine emissions–a modeling tool for SAF screening
Principal Investigator: Dario Lopez-Pintor, Sandia National Laboratories

Presenter

Dario Lopez-Pintor, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

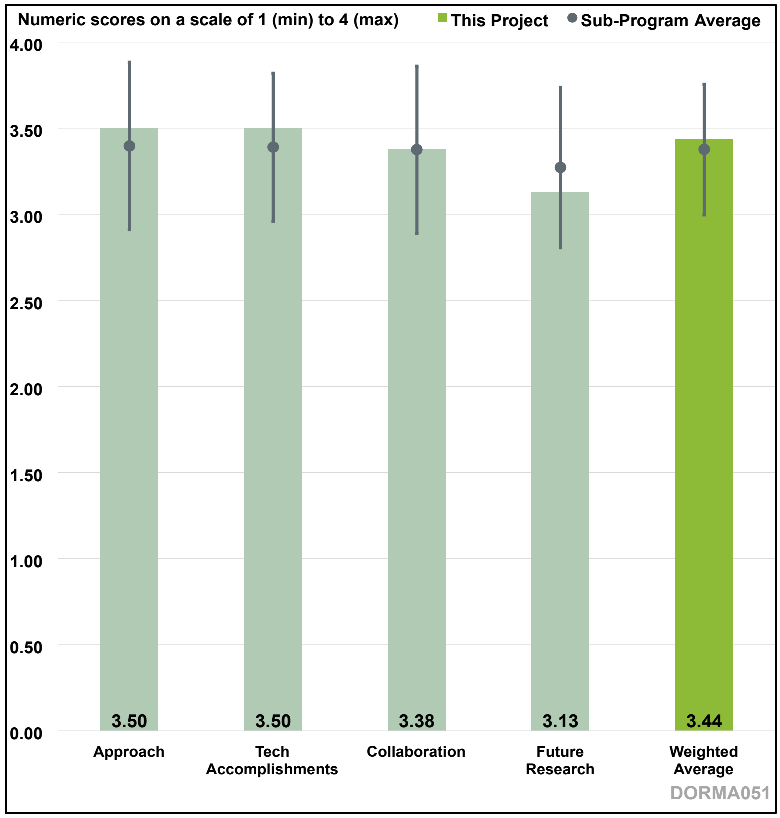

Figure 3-35. Presentation Number: DORMA051 Presentation Title: Fuel effects on aviation engine emissions–a modeling tool for SAF screening Principal Investigator: Dario Lopez-Pintor, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the team is targeting creation of modeling tools for the simulation of particulate emissions preceding plume/contrail generation, as well as understanding the source of such emissions, specifically the impact of soot particles and sulfur oxides. The timeline is aggressive, although the project plans have been developed well to make contributions to reducing the barriers.

Reviewer 2

The reviewer remarked the project uses a combustion model to simulate soot particle mass, number, and size distributions as well as trace gas emissions for a combustor burning conventional and alternative fuels. The work allows for simulation and understanding of the fuel effects associated with different sustainable aviation fuel (SAF) formulations in a conventional, CFM56-7 engine. Future work will connect the simulated emissions to contrails, although the contrail piece of the project is not clearly described. Overall, the work is important and leverages DOE’s expertise in fuel chemistry and combustion simulation.

Reviewer 3

According to the reviewer, the approach is very well thought out and presented in the review process. The use of a rapid low-cost screening for soot is very attractive and the steps are reasonable to meet the objectives.

Reviewer 4

The reviewer said the project identifies the importance of a simplified computational tool to evaluate fuel effects on aircraft engine emissions and contrail formation. The timeline only outlines two milestones; however, the two milestones may be appropriate given the limited budget allocated for this work. The reviewer was not clear what work will be done in the interim between the second milestone completion on 6/30/2024 and the project end date of 9/30/2024.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said progress made by the team in terms of successfully simulating particulate emissions from a gas turbine engine is significant and represent a remarkable achievement. This work represents a significant advancement to the existing state of the art. There are a lot of details embedded in this work, and they need to be shared with the community and published in the archived literature. The reviewer said based on the supporting but limited details provided, the work has been competently performed. Given that the “soot community” feels that experimental measurements (of soot mass) within a factor of two are considered good, the capturing of trends of soot mass over a range of operating conditions is remarkable. The larger uncertainties in number density are recognized, indicating that there is more work needed, but should not distract from the encouraging results. The reviewer said one minor issue needs to be addressed. The chart on Slide 5 showing the predicted and experimental soot particulate matter, is inconsistent with the similar plot on Slide 14. Also, the PAH data is missing on Slide 14.

Reviewer 2

The reviewer said the project highlights technical progress for model agreement with International Civil Aviation Organization (ICAO) data for engine emissions at varying operating conditions. This was achieved with a very low computational cost, showing significant improvement over more complex modeling approaches. The project also notes significant progress on evaluating various fuel sooting properties across multiple fuel types. The reviewer remarked the project makes valuable contributions in understanding the relationship between fuel chemical classes and sooting propensity.

Reviewer 3

The reviewer commented it seems that the results indicate that there are only large reductions in soot for Φ greater than3.5 with a change in fuel. Experimental results on the ground indicate high reductions in soot particle number across conditions with iso-paraffinic kerosene (IPK). The reviewer was unsure why the model is showing reductions with IPK at climb and take off. Discussions with NASA on past ground tests with low sooting fuels may provide data beyond the ICAO Databank.

Reviewer 4

The reviewer said the project has made considerable technical progress related to setting up the simplified simulation environment, obtaining results, and comparing these results to ground-based measurements. It is clear that the model adequately captures the trace gas and particle mass emissions, but the microphysical simulation of particle number, growth, and size yields unrealistic results. Some of this discrepancy may be due to model assumptions, while other sources of error relate to the interpretation of the measurement data (e.g., a sharp 10 nm cutoff for the measurement condensation particle counters). The reviewer remarked the project also mentions connecting the simulation results to contrails, although it is not clear how the model will be adapted to simulate engine operation at cruise conditions and what the next steps would be for the contrails piece.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented project collaboration is outstanding with strong external partners. The addition of Aerodyne Research (while technically not industry) as an atmospheric and engine emissions modeling subject matter expert is particularly valuable.

Reviewer 2

The reviewer remarked much of the work has been performed by the PI, but he has engaged team members well. In particular, key to the success are the CFD simulations (from Sandia) of the flow conditions in the combustor and their dependence on operating conditions as well as the detailed chemical kinetic models from LLNL, and the input from Aerodyne on the role of sulfur in water condensation. Clearly, results from other groups have contributed in addition.

Reviewer 3

The reviewer said the project clearly outlines the project team contributors and their roles. It would be helpful to more clearly see which team members contributed across the various technical accomplishments and progress. The project team includes a diverse set of collaborators: industry (Aerodyne), national laboratories (Sandia National Laboratories, LLNL, and ANL), and academia (Polytechnic Valencia, University of Illinois Urbana-Champaign, and Ecole Polytechnique Fédérale de Lausanne).

Reviewer 4

The reviewer assumed the simulations are for the design cycle points for the CFM56 engine developed and optimized under the reactor network model, but this was not explicitly mentioned. The SAF End Use Program Review Meeting is a good opportunity to engage industry and academia. The reviewer said this presentation could highlight the connections to other DORMA projects better.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked proposed future research focuses on key needs for the aviation community regarding the impact of cycloalkanes in comparison to aromatics regarding sooting and contrails. The purpose for the research is clearly stated, and the work is likely to achieve its objectives given the technical accomplishments of the team thus far.

Reviewer 2

The reviewer said there is great potential for this model for connecting changes in future SAF chemistry to emissions. The early results are very promising for bulk mass particle and trace species, although the modeled particle microphysics remains inconsistent with observations. Capturing accurate particle size and number is a very challenging problem!

The reviewer noted the initial finding that mono-aromatics strongly affect soot is an interesting conclusion that should be explored more in the future as the results of this work could serve to guide efforts to tailor the fuel aromatic and polycyclic aromatic composition. The plan for how the plume model will be refined and connected to contrail propensity is not clear and would benefit from more thought on how this will be carried out. The reviewer said the contrail modeling is particularly challenging, and may be a step too far for the present project. Last, while the reviewer understands the desire to simulate the particle microphysics from first principles and not “cheat” by imposing a prescribed particle size distribution, we do know from observations that the soot mode is considerably larger than uncovered by these simulations. Future efforts to improve the soot growth rate would be one approach to resolving this discrepancy. In the meantime, however, it would be interesting to explore how using a prescribed two-mode lognormal size distribution might improve closure between the measurements and models. Finally, it would be useful to incorporate volatile sulfate and nitrate aerosol species into the model to explore the interplay between soot particle coatings and new particle formation.

Reviewer 3

The reviewer said proposed future work is clearly presented and seems reasonable. The reviewer liked the approach to look at improvements in the current model in addition to new areas to explore. It would be interesting to compare to NREL’s reduced chemistry model when the HEFA model is complete.

Reviewer 4

The reviewer said future results are hindered by the apparent near-term termination of the project. There are only two bullets for proposed work. One is a surrogate for iso-paraffinic SAF. The creation of a single surrogate for multiple iso-paraffinic SAFs seems improbable given that the range of iso-paraffinic SAFs are yet to be defined. The second is the implementation of a 1D plume model to capture fuel effects. The reviewer said this objective may be difficult to achieve in the existing timeframe given that the characterization of soot particle emissions and how they change with fuel changes is, as yet, poorly defined. The reviewer said even specific data on (particulate) emissions from engines operating under cruise conditions are limited, for jet-A, let alone SAF fuels.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the embedded links appear outdated, but the work is fully consistent for the SAF Grand Challenge Roadmap.

Reviewer 2

The reviewer said the project is highly relevant to VTO and relates to future SAFs and understanding how changes in fuel chemistry impact emissions.

Reviewer 3

The reviewer remarked the project is very relevant for the aviation fuels community in answering research questions regarding fuel composition impacts on sooting and contrail formation. The work is timely and focused.

Reviewer 4

The reviewer commented soot modeling is of great interest to industry and the reviewer understands why a CFM56 was chosen to do these simulations; however, technology has advanced significantly from the CFM56. Applying the model to current state of the art technology that has emissions/soot data available would increase the relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer was not sure how to respond to this question, as the resources seem to have been zeroed out in fiscal year 2023, and it is uncertain how the recent work was completed. Nevertheless, the team has proven productive, and there is plenty of (appropriate) proposed research to perform. So, the resources are not sufficient.

Reviewer 2

The reviewer said the charts indicate that this project was funded with $150,000 in fiscal year 2022 and $0 in fiscal year 2023. It seems like these simulations would cost something and $150,000 would be approximately the cost of a post-doctoral researcher. The reviewer was not sure if this is a typo or if this is accurate, but it does not seem to be reasonable if this is an accurate funding profile.

Reviewer 3

The reviewer said the project resources appear to be commensurate with the proposed research effort.

Reviewer 4

The reviewer remarked resources are sufficient and appropriate for the project to achieve the milestones on schedule.

Presentation Number: DORMA052
Presentation Title: Simulation of Jet Engine Performance using SAF Blends
Principal Investigator: Shashank Yellapantula, National Renewable Energy Laboratory

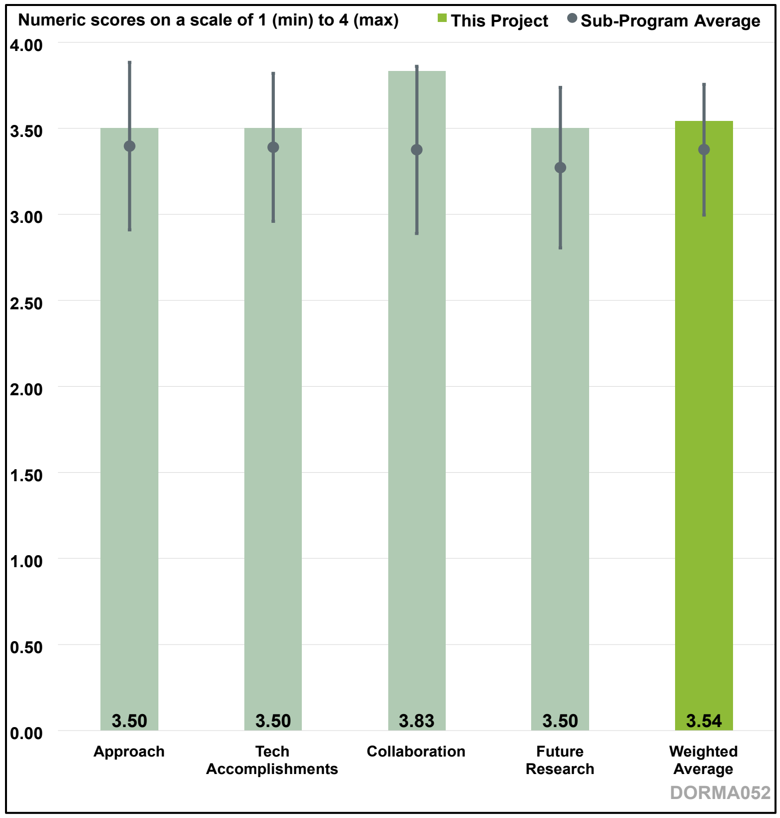

Figure 3-36. Presentation Number: DORMA052 Presentation Title: Simulation of Jet Engine Performance using SAF Blends Principal Investigator: Shashank Yellapantula, National Renewable Energy Laboratory

Presenter

Shashank Yellapantula, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted this work is focused on overcoming SAF Grand Challenge barriers, namely developing 100% SAF formulations that meet fuel property requirements, characterizing the performance benefits of those fuels, and improving methods of testing those fuels. The project aims to address these challenges by developing chemical kinetic mechanisms for the simulation of high-SAF fuels and performing numerical simulations of the combustion of these SAF blends. The reviewer said the end goal is to validate the simulation outputs using optical diagnostics data from experiments. The project is well-designed. The proposed work will enable predictive simulations that lead to quicker fuel development and certification, directly addressing the Grand Challenge barriers. The timeline is reasonable, and all milestones are complete or on target for completion.

Reviewer 2

The reviewer remarked this project tackles some very important technical barriers relating to adoption of SAF at blended and 100% replacement levels in aviation gas turbine engines. Specifically, there are many unknowns relating to approval for use of 100% SAF as well as potential performance and emissions benefits that can be gained from use of SAF at any level in existing gas turbine engines. The approach used by the PIs is that of using numerical simulations with predictive capabilities utilizing detailed chemical kinetics specifically targeting SAF (HEFA) as well as fuel thermophysical property data expressly generated for conditions relevant to aviation gas turbine engine operation. This is a very well-designed project that leverages experimental data from two combustor rigs for validation as well as pertinent simulation data from GE Aerospace.

The reviewer said the project timeline (2021-2027) is adequate for this effort and the milestones presented for this year appear to be keeping the PIs on schedule to complete the targeted project goals. The reviewer suggested clearly defining what metrics are of interest while talking about "combustor performance." Clarifying specific metrics would help design the simulations and the conditions and manner in which they are carried out. Another comment is can this work (in combination with simulation efforts on SAF from other DOE laboratories) be used to modify ASTM certification procedures themselves? The reviewer said to the extent that predictive simulations can be a supplementary step particularly in the pre-screening process to reduce cost/time of certifying new SAF. A DOE led effort (with support of the FAA) might be able to achieve progress on this. Actually, after continuing on to the end of the presentation, it appears that such outcomes are part of the intended goals for this project and that is definitely commendable.

Reviewer 3

The reviewer said the team has excellent tools and capabilities to perform reacting spray combustion simulations with Jet-A and SAF including developing the chemistry mechanism for HEFA-SPK. And for the work planned, the project is well designed with a reasonable timeline, but the simulations are not addressing relevant combustor concepts nor the operating conditions that would impact the ASTM synthetic fuel pathway approvals and blend limits. The reviewer said the lean premixed prevaporized (LPP) injector certainly has potential for low NO_x and very low soot emissions but LPP is not a concept that is currently flying on any aircraft nor likely to fly on a next generation subsonic aircraft or first-generation supersonic aircraft (if a commercial market is established). The combustor operations of most importance to the ASTM fuel approval process are lean blowout and ignition, but simulations in this project are mostly focused on stable operating conditions. The reviewer said there may be some simulations of combustion dynamics from the Aviation Sustainability Center (ASCENT) 74 LPP experiments.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that development of the chemistry mechanism for HEFA-SPK appears to be nearly complete. A 2-component surrogate model has been validated against ignition delay time (IDT) and laminar flame speed measurements and is being used for CFD simulations. For the ASCENT 74 LPP experiments, non-reacting simulations have been validated against PIV measurements of air velocity with good comparisons and the reacting spray simulations for the ASCENT 74 LPP are underway. Simulations of the NASA University Leadership Initiative (ULI) LPP injector section upstream of the combustion chamber predicting the degree of fuel vaporization and mixing have been performed ahead of testing. The reviewer said in general, there is evidence of steady progress in working towards validation of reacting spray simulations with Jet-A and HEFA-SPK against the ASCENT and NASA ULI LPP experiments.

Reviewer 2

The reviewer said these researchers have made excellent technical progress. A comprehensive set of optical diagnostic data enables these researchers to establish simulation boundary conditions and validate simulation outputs. The researchers have developed a surrogate model for fuel blends of interest that demonstrates strong fidelity to experiments. Initial nonreacting flow comparisons between simulated and experimental combustors show that their simulation approach is able to reproduce flow features observed in experiments. The reviewer remarked all of these milestones show strong work towards overcoming technical barriers.

Reviewer 3

The reviewer said the PIs have made significant progress on technical objectives. Development of predictive simulations with detailed chemical kinetics of SAF as well as well-characterized thermophysical properties at conditions relevant to GT engines is the main overarching deliverable of this work. To this extent, the PIs have shown progress on several fronts.

The reviewer noted a two-component surrogate model for HEFA has been developed (of reasonable size) showing consistency with ignition delay and flame speed measurements for HEFA-SPK. Flame speed agreement is not as good as that of ignition delay. Per this reviewer, one recommendation would be to ensure comparison of both metrics with measurements (as available) for HEFA over the range of pressures and temperatures that the simulations will be pursued for. Another comment is that the fuel property set for comparison to the surrogate should be expanded to include things like flash point, viscosity, distillation, etc., since they have been identified in previous National Jet Fuel Combustion Program work as having critical influence on various aspects of the combustion process including lean blowout (LBO). It is unclear if emissions are a target metric for this work but in that case there may be additional items to consider for the surrogate fuel. That said, the mechanism itself is a valuable contribution to the combustion community.

The reviewer said the PeLeLMeX solver appears to have the required capabilities to carry out the predictive simulations including graphics processing unit performance, multiphase capabilities in combination with the dispersed phase solver, tabulated chemistry for flamelets, and support for multi-component fuels. The reviewer provided as input direct numerical simulations from the Sandia group (Chen) appear to have shown some advanced flamelet techniques for capturing multi-modal combustion and these could be leveraged in the present work. Air-only simulations and ongoing spray simulations of the LPP rig and vaporization simulations of the ULI rig seem to demonstrate good progress towards the reacting flow simulations and will provide useful feedback to the experimental teams for fine-tuning operating conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer was very impressed by the collaboration set up by this project, and how well it was described in the presentation. Georgia Tech operates two optically accessible combustors, producing experimental data for simulation validation. One of the combustors involves a proprietary fuel nozzle from GE Aerospace; GE provides the project with boundary conditions for this nozzle from their own simulations. NREL performs chemical kinetic modeling and flow simulation, while subcontracting for combustor testing to Georgia Tech and transferring developed models to GE

Aerospace. The reviewer said this collaboration between government, industry, and academia has distinct roles for each group and seems to be producing excellent results.

Reviewer 2

The reviewer said there are strong collaboration efforts with FAA, GE, Georgia Tech, and NASA that use experimental data from LPP injectors testing under the FAA ASCENT 74 project and NASA ULI grant. Providing the NASA ULI grant additional funding to perform testing with HEFA-SPK is a notable component of the collaboration.

The reviewer said the collaborations of NREL with LLNL on chemical kinetics development for Jet-A and HEFA-SPK are not clear. The reviewer asked if they are comparing mechanism results for prediction of IDT and laminar flame speed, are the surrogate species or fundamental chemistry for lower carbon number species (such as C1 to C4) similar or the same, and what is the nature of the collaboration?

Reviewer 3

The reviewer remarked the PIs are very well aligned with several key collaborators from industry, university, and other DOE national laboratories. The collaborations, particularly with the experimental groups at Georgia Tech are key to validating simulations and providing boundary conditions/geometry/etc. The reviewer said some collaboration with the group from Sandia performing direct numerical simulation of swirl combustors could be helpful to leverage newly developed flamelet based approaches for multi-modal combustion, and the same applies to the ANL group developing tools for heat transfer and ignition relevant phenomena.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

According to the reviewer, proposed research tasks for the future are spot on with the overall project goals. This includes reacting flow simulations of the LPP and ULI combustors, correlating fuel properties to combustor metrics (appears that emissions are indeed part of the intended metrics as well as dynamics, this reviewer would still recommend identifying key performance metrics), studying other SAF (besides HEFA), and incorporating tools developed through this effort into the pre-screening workflow. Given the progress of the PIs so far, it appears that the future work will achieve proposed targets and address the technical barriers motivating this study.

Reviewer 2

The reviewer commented the proposed future research for this project logically builds off what has already been accomplished and contributes directly to achieving project goals. The researchers plan to move to reacting flow simulations, explore correlations between fuel properties and combustor performance, and implement neural networks to prescreen new fuel formulations. The prior accomplishments of these researchers makes it very likely that the proposed work will be successfully accomplished.

Reviewer 3

The reviewer said the project is currently focused on completing the reacting simulations for ASCENT 74 LPP and some initial configuration of the NASA ULI LPP with Jet-A and HEFA, and comparing against available test data. The project is planning further LPP simulations with SAF other than HEFA but there may not be experimental data available for comparison so the simulations would only show possible impacts of fuels on the LPP performance (presumably at the same stable operating conditions as current Jet-A and HEFA experiments). The reviewer remarked this work is clear in terms of objectives and has a high likelihood of meeting its timeline and targets. There was also a note about developing a SAF pre-screening tool. The reviewer was not sure how much of that work occurs under DORMA 052 versus 037, or perhaps it is a combination of both projects 052 and 037. It will be interesting to see how this pre-screening work compares with pre-screening low fuel volume approaches being developed under FAA ASCENT projects 25 and 65A where 25 is using a detailed FTIR spectral analysis approach and 65A is further developing the previously developed “tier α- and β-test methods” to further reduce fuel volumes and improve potential for ASTM fuel pathway approval.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this project is relevant and directly in support of VTO program objectives. This work contributes to new aviation fuels that will increase efficiency and decrease pollutant emissions, leading to economic and environmental benefits.

Reviewer 2

The reviewer said proposed work targeting SAF implementation in aero GT engines and developing correlations between SAF properties and combustor metrics through development of predictive simulation capabilities validated by experiments is completely in line with the objectives of the DORMA program. The project will support DOE and agency-wide efforts to achieve objectives of the SAF Grand Challenge as well as develop a solid framework of simulation approaches, kinetic mechanisms, and fuel properties which will be highly beneficial to the combustion and aviation community as a whole.

Reviewer 3

The reviewer said the project is expanding capabilities in simulating the impact of SAF and higher SAF blends on combustor performance. But to reduce the large fuel volumes and time spent in testing of synthetic fuels in the ASTM fuel pathway approval process, simulations of lean blowout and ignition for more combustor designs more representative of those currently in-service and likely to enter into service in the coming decade are needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked the project has the codes and high-end computing facilities required to complete the proposed tasks. The project has made significant progress towards the reacting spray simulations with Jet-A and HEFA currently underway.

Reviewer 2

The reviewer said resources for the project are sufficient. The budget is very reasonable. The presentation established that the investigators have the necessary experimental infrastructure, computational framework, and technical expertise to carry out the plan they have established.

Reviewer 3

The reviewer said personnel and financial resources appear to be satisfactory for the level of work.

Acronyms and Abbreviations - DORMA

Abbreviation	Definition
0D/1D/2D/3D	Dimension - zero, one, two, three
L	Liter
ADT	Articulated dump truck
AE	Activation energy
AFR	Air-fuel ratio
AFRL	Air Force Research Laboratory
Al_2O_3	Aluminum oxide
AN	Ammonium nitrate
ANL	Argonne National Laboratory
APS	Advanced Photon Source
ARC	Army Research Combustor
ASCENT	Aviation Sustainability Center
ASTM	ASTM International, formerly known as American Society for Testing and Materials
AT	Aftertreatment
atm	Standard atmospheric pressure unit
B100	100% biodiesel
BEV	Battery electric vehicle
BTE	Brake thermal efficiency
CARB	California Air Resources Board
CAT	Caterpillar
CCV	Closed crankcase ventilation
CFD	Computational fluid dynamics
CH_4	Methane
CHA	Chabazite
CI	Compression ignition
CNG	Compressed natural gas
CO	Carbon monoxide

Abbreviation	Definition
CO_2	Carbon dioxide
CR	Compression ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CRF	Sandia National Laboratories' Combustion Research Facility
Cu	Copper
DC	Direct current
DEF	Diesel exhaust fluid
DFI	Ducted fuel injection
DI	Direct injection
DME	Dimethyl ether
DNN	Deep neural network
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DOE	U.S. Department of Energy
DORMA	VTO Decarbonization of Off-Road, Rail, Marine, and Aviation subprogram
DPF	Diesel particulate filter
DRIFTS	Diffuse reflectance infrared Fourier transform spectroscopy
E98	98% ethanol/2% gasoline
EAS	Exhaust aftertreatment system
ECU	Engine control unit
EGR	Exhaust gas recirculation
EPR	Electron paramagnetic resonance
EtOH	Ethanol
FAA	Federal Aviation Administration
FPT	Fiat Powertrain
FTIR	Fourier transform infrared
FY	Fiscal Year

Abbreviation	Definition
g/kWh	grams per kilowatt-hour
GC	Gas chromatography
GDI	Gasoline direct injection
GE	General Electric, Inc.
GER	Global equivalence ratio
GHG	Greenhouse gas
GM	General Motors
GPU	Graphic processing units
H_2	Hydrogen
HC	Hydrocarbon
HD	Heavy-duty
HEFA	Hydroprocessed esters and fatty acids
HyREX	Optimized Low Carbon Fuel Range Extender
ICAO	International Civil Aviation Organization
ICE	Internal combustion engine
ID	Identification
IDT	Ignition delay time
IMEP	Indicated mean effective pressure
IMT	Intake manifold temperature
IPK	Iso-paraffinic kerosene
kWh	Kilowatt-hour
LBO	Lean blow-out
LCLF	Low carbon liquid fuel
LES	Large eddy simulation
LLCF	Low-lifecycle-carbon-fuels
LLNL	Lawrence Livermore National Laboratory
LPP	Lean premixed prevaporized
MCCI	Mixing-controlled compression ignition

Abbreviation	Definition
MD	Medium-duty
MeOH	Methanol
MG	Motor-generator
MIT	Main injection timing
N_2O	Nitrous oxide
NASA	National Aeronautics and Space Administration
NH_3	Ammonia
NJFCP	National Jet Fuel Combustion Program
NMC	Nickel manganese cobalt
NMOG	Non-methane organic gas
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
PC-MCC	Prechambered enabled mixing-controlled combustion
Pd	Palladium
PeleLMeX	PeleLMeX is the non-subcycling version of PeleLM, an adaptive-mesh low Mach number hydrodynamics code for reacting flows
PFI	Port fuel injection
PGM	Platinum group metals
PI	Principal investigator
PIV	Particle image velocimetry
PM	Particulate matter
PNNL	Pacific Northwest National Laboratory
POSF#	Fuel designation
Pt	Platinum

Abbreviation	Definition
RANS	Reynolds-averaged Navier-Stokes
RCM	Rapid compression machine
RDD&D	Research, development, demonstration, and deployment
RHC	Reduction half cycle
SAF	Sustainable aviation fuel
SCO	Selective catalytic oxidation
SCR	Selective catalytic reduction
SI	Spark ignition
SiC	Silicon carbide
SOA	State of the art
SpaciMS	Spatially resolved capillary inlet mass spectrometer
SPK	Synthetic paraffinic kerosene
SVF	Soot volume fraction
SwRI	Southwest Research Institute
TCO	Total cost of ownership
TMB	Trimethylbenzene
TRL	Technology readiness level
TWC	Three-way catalyst
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability DOE partnership
UDRI	University of Dayton Research Institute
ULI	NASA University Leadership Initiative
ULSD	Ultra-low sulfur diesel
UW	University of Wisconsin
V	Volts
VoFLE	Volume of Fluid and Lagrangian Eulerian
V-SCR	Vanadia-based selective catalytic reduction
VTO	Vehicle Technologies Office
VVT	Variable valve timing

Abbreviation	Definition
WMLES	Wall-modeled LES
WRLES	Wall-resolved LES
WSU	Washington State University
WVU	West Virginia University

4. Energy Efficient Mobility Systems

The Vehicle Technologies Office (VTO) supports research, development, deployment, and demonstration (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency and improvement); combustion engines to reduce greenhouse gas (GHG) emissions; and technology deployment and integration at the local and state level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), the Vehicle Technologies Office advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Energy Efficient Mobility Systems (EEMS) subprogram supports research, development, and demonstration of innovative mobility solutions that improve the affordability, accessibility, and energy productivity of the overall transportation system. EEMS leverages emerging disruptive technologies such as connected and automated vehicles, information-based mobility-as-a-service platforms, and artificial intelligence (AI) based transportation control systems to accelerate the transition to a zero carbon-emission transportation future. The EEMS subprogram also develops and utilizes large-scale transportation modeling and simulation capabilities to evaluate the impacts of new mobility solutions across multiple geographies and populations, ensuring that all Americans, especially underserved and energy communities, benefit from the development and deployment of clean transportation technologies.

The EEMS subprogram consists of two primary activities: Computational Modeling and Simulation, and Connectivity and Automation Technology. The subprogram's overall goal is to identify feasible system-level pathways and develop innovative technologies and systems that can dramatically improve mobility energy productivity (MEP) for individuals and businesses when adopted at scale. The EEMS subprogram has developed a quantitative metric for MEP, which measures the affordability, energy efficiency, convenience, and economic opportunity derived from the mobility system. The metric, while encompassing multiple vehicle classes and modes for passenger and goods movement, is used by the subprogram to evaluate success and by the transportation community to inform planning decisions. The EEMS subprogram's target is a 20% improvement in MEP by 2040 relative to a 2020 baseline.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 4-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS013	ANL Core Tools-Simulation	Phil Sharer (Argonne National Laboratory)	4-8	3.63	3.75	3.63	3.38	3.66
EEMS037	Big Data Solutions for Mobility 2.0	Jane Macfarlane (Lawrence Berkeley National Laboratory)	4-12	3.38	3.50	3.00	3.50	3.38
EEMS041	ANL Everything-in-the-loop (XIL) Capabilities	Kevin Stutenberg (Argonne National Laboratory)	4-15	3.80	3.70	3.80	3.50	3.71
EEMS066	Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing	Lauren Spath-Luhring (National Renewable Energy Laboratory)	4-19	3.40	3.40	3.40	3.25	3.38
EEMS090	Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway	Hong Wang (Oak Ridge National Laboratory)	4-23	3.38	3.38	3.50	3.00	3.36

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS092	BEAM CORE	Anna Spurlock (Lawrence Berkley National Laboratory)	4-27	3.60	3.80	3.60	3.38	3.69
EEMS093	Transportation System Impact POLARIS Workflow Development Implementation and Deployment	Joshua Auld (Argonne National Laboratory)	4-32	3.70	3.70	3.90	3.50	3.70
EEMS094	Development and Validation of Intelligent CAV Controls for Energy-Efficiency and ENACTED	Dominik Karbowski (Argonne National Laboratory)	4-37	3.63	3.50	3.50	3.25	3.50
EEMS095	Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use	Jinghui Yuan (Oak Ridge National Laboratory)	4-41	3.60	3.70	3.80	3.30	3.64
EEMS097	Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE)	Andrew Duvall (National Renewable Energy Laboratory)	4-45	3.17	3.33	3.50	3.00	3.27
EEMS098	Optimizing Drone Deployment for More Effective Movement of Goods	Victor Walker (Idaho National Laboratory)	4-49	3.50	3.50	3.50	3.17	3.47
EEMS099	Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems	Venu Garikapati (National Renewable Energy Laboratory)	4-53	3.25	3.13	3.13	2.50	3.14
EEMS100	Dynamic Curb Allocation	Nawaf Mohammed (Pacific Northwest National Laboratory)	4-57	3.50	3.63	3.50	3.13	3.52

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS101	RealSim, An Anything-in-the-loop Platform for Mobility Technologies	Max Chen (Oak Ridge National Laboratory)	4-61	3.63	3.63	3.50	3.75	3.63
EEMS105	Energy Optimization of Light- and Heavy-Duty Vehicle Cohorts of Mixed Connectivity Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing	Darrell Robinette (Michigan Technological University)	4-64	3.50	3.67	3.33	3.00	3.57
EEMS106	Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments	Mina Sartipi (University of Tennessee Chattanooga)	4-67	3.40	3.30	3.80	3.17	3.40
EEMS107	Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity	Joshua Bittle (University of Alabama)	4-72	3.17	3.17	3.33	3.00	3.19
EEMS108	Co-Optimization of Vehicles and Routes	Nick Hertlein (PACCAR)	4-76	2.67	3.00	3.17	N/A	2.93
EEMS109	Connected and Learning Based Optimal Freight Management for Efficiency	Ali Borhan (Cummins)	4-79	3.67	3.33	3.33	3.50	3.44

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS110	Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency	Yunyi Jia (Clemson University)	4-82	3.50	3.75	3.38	3.50	3.61
EEMS112	NREL Core Modeling & Decision Support Capabilities (RouteE FASTSim OpenPATH T3CO)	Jeff Gonder (National Renewable Energy Laboratory)	4-86	3.50	3.50	3.50	3.30	3.48
EEMS113	Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles	Lauren Harper (Los Angeles Cleantech Incubator)	4-91	3.40	3.40	3.40	3.30	3.39
EEMS114	Real Twin	Ross Wang (Oak Ridge National Laboratory)	4-95	3.63	3.88	3.75	3.63	3.77
EEMS115	Modeling Connected and Automated (CAV) Compute Power	Ben Feinberg (Sandia National Laboratories)	4-99	3.25	3.50	3.13	2.75	3.36
EEMS116	High-Quality Perception Data	Zach Asher (Western Michigan)	4-102	3.00	3.17	3.17	2.83	3.08
EEMS117	Visual-Enhanced Cooperative Traffic Operations (VECTOR) System	Achilleas Kourtellis (University of South Florida)	4-107	2.13	2.25	2.38	2.50	2.27

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS118	AI-Based Mobility Monitoring System and Analytics Demonstration Pilot	Scott Samuelson (University of California Irvine)	4-111	3.50	3.50	3.67	3.67	3.54
EEMS119	Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios	Xiao-Yun Lu (Lawrence Berkeley National Laboratory)	4-115	3.38	3.38	3.25	3.13	3.33
EEMS120	A Cooperative Driving Automation (CDA) Framework for Communications	Adian Cook (Oak Ridge National Laboratory)	4-119	3.50	3.83	3.50	3.33	3.65
EEMS121	Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency Safety Sustainability and Public Health	Michael Lim (Xtelligent)	4-122	3.00	3.13	2.88	3.25	3.08
EEMS122	Pathways to Net Zero Mobility	Joshua Auld (Argonne National Laboratory)	4-126	3.50	3.75	3.50	3.63	3.64
EEMS123	Freight in the Loop	Kevin Stutenberg (Argonne National Laboratory)	4-131	3.67	3.50	3.33	3.67	3.54

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS124	Deployment of Real-Sim/Real-Twin Scenario Library Generation and Benchmark of Energy Centric CAV Controls	Ross Wang (Oak Ridge National Laboratory)	4-134	3.33	3.17	3.17	3.33	3.23
EEMS125	Energy Metrics in Traffic Signal Performance Measures	Joseph Fish (National Renewable Energy Laboratory)	4-137	3.00	3.00	3.00	3.00	3.00
EEMS126	Arena Mobility Hubs for an Equitable Low-Carbon Future	Jeff Baer (The EV Button)	4-140	1.67	1.50	2.33	1.83	1.69
EEMS127	Deploying Autonomous On-Demand Energy Efficient Mobility Solutions in Tulsa's Underserved Communities	Samitha Samaranayake (Cornell University)	4-143	3.17	3.00	3.50	3.00	3.10
EEMS128	National Impacts of Community-Level Strategies to Decarbonize and Improve Convenience of Mobility	Christopher Hoehne (National Renewable Energy Laboratory)	4-146	2.50	2.75	3.50	2.75	2.78
EEMS129	Using Artificial Intelligence to Predict Ridership and Optimize Shared Mobility	Josh Rands (Terracity)	4-149	2.83	2.50	3.17	3.25	2.71
Overall Average				3.29	3.33	3.36	3.19	3.31

Presentation Number: EEMS013
Presentation Title: ANL Core Tools-Simulation
Principal Investigator: Phil Sharer, Argonne National Laboratory

Presenter

Phil Sharer, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

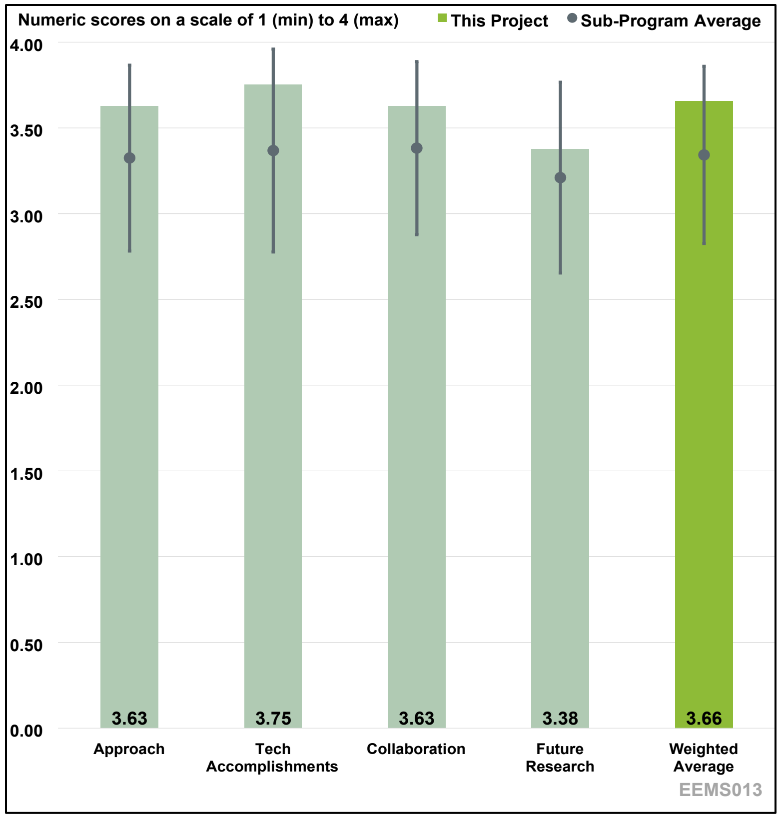

Figure 4-1. Presentation Number: EEMS013 Presentation Title: ANL Core Tools-Simulation Principal Investigator: Phil Sharer, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project approach is excellent and has resulted in successful execution of this project that is 80% complete.

Reviewer 2

The reviewer commented that the continued expansion of the user base will be important in establishing the core Autonomie suite as a consensus tool for developing and analyzing decarbonization strategies, in a manner similar to how, Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) is now widely accepted.

Reviewer 3

The reviewer liked the approach of reusing and building new tools from the strong existing foundation and highlighted how the presenter mentioned in his presentation “Rinse and Repeat”. The reviewer liked how it was discussed on who and how the tools where used. The reviewer said that a little more detail on some of the results and findings that came directly from these tools being available would be good to see. The reviewer encouraged a bit of a victory lap or pat on the team’s back in addition to Slide 27 in the material.

Reviewer 4

The reviewer noted that lots of scenarios are baked in and available to explore in the software runs. The reviewer added that no barriers seem to be in evidence there. The reviewer continued by saying that one of the chief challenges of modeling tools like this is remaining up to date when the vehicle technologies themselves are dynamically evolving. The reviewer stated that having gone out to the free versions available to inspect, it is impressive that the scenarios offered include virtually every configuration available for different vehicle types, fuel types, etc. The reviewer continued by stating that a kind of content maintenance and integration is critical to the ongoing relevance of the tool.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the progress especially with regard to both Aeronomie and advanced model-based engineering resource (AMBER) is outstanding, and sustained efforts at validation will be critical.

Reviewer 2

The reviewer noted that the project has done an outstanding job at integrating the suite of tools that are developed and maintained by Argonne National Laboratory (ANL).

Reviewer 3

The reviewer stated that a little more description of Autonomie AI and Express would be helpful. They added that it was hard to see exactly how they differ, why each is needed, and who would use them.

Reviewer 4

The reviewer commented that with the materials presented, it is not possible to draw clear comparisons between the nuances of the project plan and what has been executed against it. They added that the team does an impressive job of horizon-scanning about vehicle technologies and building tools that keep pace with and perhaps, such as in the case of electric aviation, may even be a little ahead of the game. The reviewer also stated that this seems to reflect a high degree of progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that establishing and expanding collaborative partners in the non-road segment, principally in agriculture and construction but also including Aeronomie, will also be important to future decarbonization scenarios.

Reviewer 2

The reviewer noted that the project team appears to have done an excellent job at collaborating and coordinating with tool users and government industry groups.

Reviewer 3

The reviewer asked whether the use and license of these tools should be restricted to U.S. stakeholders.

Reviewer 4

The reviewer commented that presented information does not provide a very deep look into the project team within the laboratory. Collaboration and coordination with users and stakeholders, however, was featured in both the oral and written presentations. The reviewer focused on this specifically because the sophistication in the approach described is worth noting and, given that the team has this capacity, there is some potential not fully realized in this project that could add substantial additional impact and relevance. Attentiveness and responsiveness to the needs of industry stakeholders in tool design and functionality was portrayed as a priority, and convincingly so. Besides several testimonials to that effect, the presenter gave a good description of their approach.

The reviewer added that the project's online presence contains pretty good instructional videos on how to use these tools. The style of engagement with these stakeholders, at least on the surface, seems to represent a form of co-design, which is a sophisticated method that, in theory, would be expected to produce better results and higher use rates. To the extent that these CORE tools are widely used by industry, that is some indication of the success of their stakeholder and analytical expertise. Although it does not presently seem to be part of the project plan, the reviewer wondered about the impact of taking that same approach to municipal governments, as a different kind of stakeholder.

The reviewer suspected that the value of the underlying analytics would transfer seamlessly, but it would likely require differently designed user interfaces, more accessible terminology in the drop-down menus, and maybe some additional scenarios. The tool controls are not user-friendly for non-technical users, but they could be. The reviewer would like to see these tools become more accessible, through co-design, by public entities such as cities, counties and regions. This could provide an easier pathway for planning as well as for aggregating scenario assessment, emission metrics, etc., which is currently a challenge.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the suite of tools has appropriately focused on on-road transportation modes. However, continuing to expand Aeronomie to allow analysis of mesh-based rather than hub-and-spoke based freight mobility, enabled by short-range aerial modes, possibly based on MEP considerations, may be useful.

Reviewer 2

The reviewer noted that the proposed next steps appear to be a logical and systematic expansion of the ANL tool integration and workflow process and support environment.

Reviewer 3

The reviewer noted that the tools should be maintained as there will always be new questions that if the product became static it would not be able answer.

Reviewer 4

The reviewer commented the there is little doubt that this team can remain current with the kinds of tools they are building and that these tools are valued by current stakeholders. Wondering if there are additional users and stakeholders to be served with these tools, leading to broader impacts of the public investments in them.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the work on ANL Core Tools is systematically breaking down the individual components of freight and personal mobility to allow assessment of decarbonization strategies, leading to optimization.

Reviewer 2

The reviewer noted that the project supports the EEMS and Analysis subprograms by improving individual ANL analysis and simulation tools and by improving the integration and interoperability of the overall set of tools that are being maintained by ANL.

Reviewer 3

The reviewer stated that the core tools presented are the backbone of the simulation and virtual design space for many energy reducing and carbon dioxide (CO_2) reducing project concepts considered by DOE.

Reviewer 4

The reviewer stated that due to the inclusion of so many different vehicle and fuel types in these tools, they touch virtually every part of the VTO portfolio. It may be worth brainstorming about whether there are additional applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient for the scope defined. However, if expanding the user base is a key part of the business strategy, then more resources will be needed to support the effort.

Reviewer 2

The reviewer commented that the presentation material indicated that the tool suite can be maintained at current funding levels. Without more specific upgrade needs listed funding appears to be sufficient.

Reviewer 3

The reviewer stated that the resources are sufficient for the scope defined. However, if expanding the user base is a key part of the business strategy, then more resources will be needed to support the effort.

Reviewer 4

The reviewer felt that this hard to review based on available information. It would require a much deeper dive to make this determination. If, however, there would be some consideration to expand attention and design of these tools to more diverse and discrete stakeholders, the reviewer commented that additional resources might be required.

Presentation Number: EEMS037
Presentation Title: Big Data Solutions for Mobility 2.0
Principal Investigator: Jane Macfarlane, Lawrence Berkeley National Laboratory

Presenter

Jane Macfarlane, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

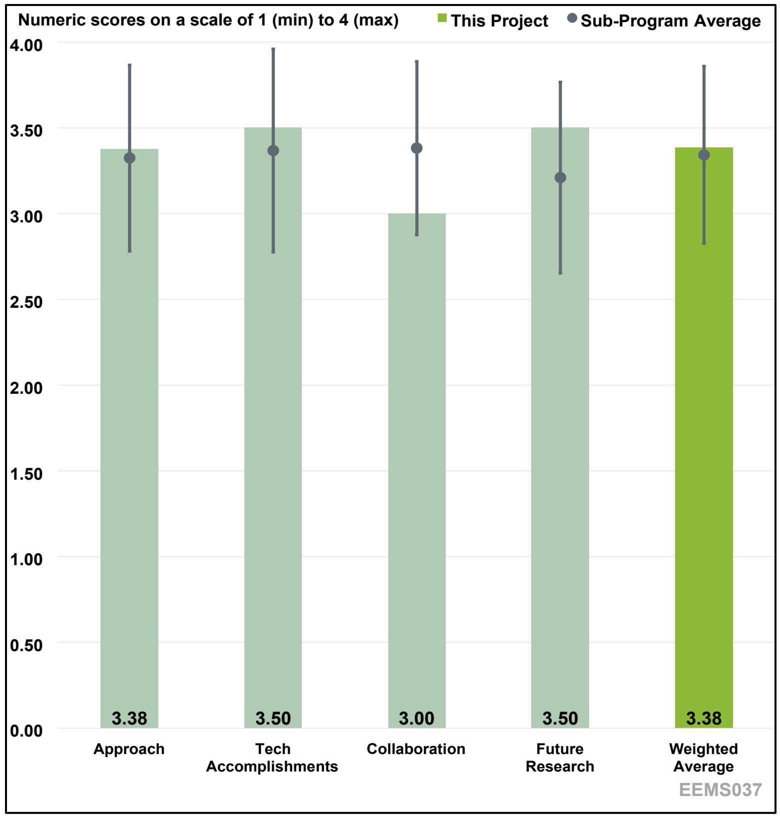

Figure 4-2. Presentation Number: EEMS037 Presentation Title: Big Data Solutions for Mobility 2.0 Principal Investigator: Jane Macfarlane, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the plan sounds reasonable, and it was successfully completed.

Reviewer 2

The reviewer commented that although the project is completed, it would appear that it has met the barriers and challenges which it had hoped to answer.

Reviewer 3

The reviewer noted that the approach presented seems technically sound and covers a multitude of factors to consider for modeling. The use of high performance computing in the cloud allows for quick and cost-effective use of resources.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that it was well done based on the project plan.

Reviewer 2

The reviewer stated that the City of San Jose, California, the primary stakeholder, appears well pleased with the outcome of the project and its ability to run time sensitive transportation studies.

Reviewer 3

The reviewer noted that the results shared are very impressive and show great validity in the project itself. The reviewer stated they were very excited to see the continuation of this research.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer felt that the collaboration could have been described more. Though the time was very limited and did not see it as a pitfall of the presenter.

Reviewer 2

The reviewer commented that the partners in the project give a broad perspective and provided what appear to be useful data. There are immediate use cases for the work that has been done. The reviewer would have liked for considerations of how this research could support other areas. An example would be: “can this work be tied to other data sets such as mobile emission sources to support air quality modeling?” There is a lot of potential to this work’s applications, especially given how quickly multiple scenarios can be run. Of course, setting up data for other regions is time consuming and complex.

Reviewer 3

The reviewer felt that the objective for current period included energy estimates for battery electric vehicles. Electric vehicle (EV) original equipment manufacturer (OEM) collaboration and contribution could be a strong value add.

Reviewer 4

The reviewer stated that in this final presentation, there was little discussion about the partners final contributions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that the ongoing research into the areas presented will lend itself to additional discovery of use cases for this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said that the project and its achievements can support the EEMS and Analysis objectives in the VTO programs.

Reviewer 2

The reviewer commented that yes, the project did clearly define a purpose for future work.

Reviewer 3

The reviewer noted that the modeling provided in this project would seem very much in line with the objectives of EEMS.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted the project is now completed.

Reviewer 2

The reviewer stated that the project is complete.

Reviewer 3

The reviewer commented that large-scale modeling can often use any and all resources available and it is difficult to discern where resources are flowing but this topic did not raise concerns one way or another from the information presented.

Presentation Number: EEMS041
Presentation Title: ANL Everything-in-the-loop (XIL) Capabilities
Principal Investigator: Kevin Stutenberg, Argonne National Laboratory

Presenter

Kevin Stutenberg, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

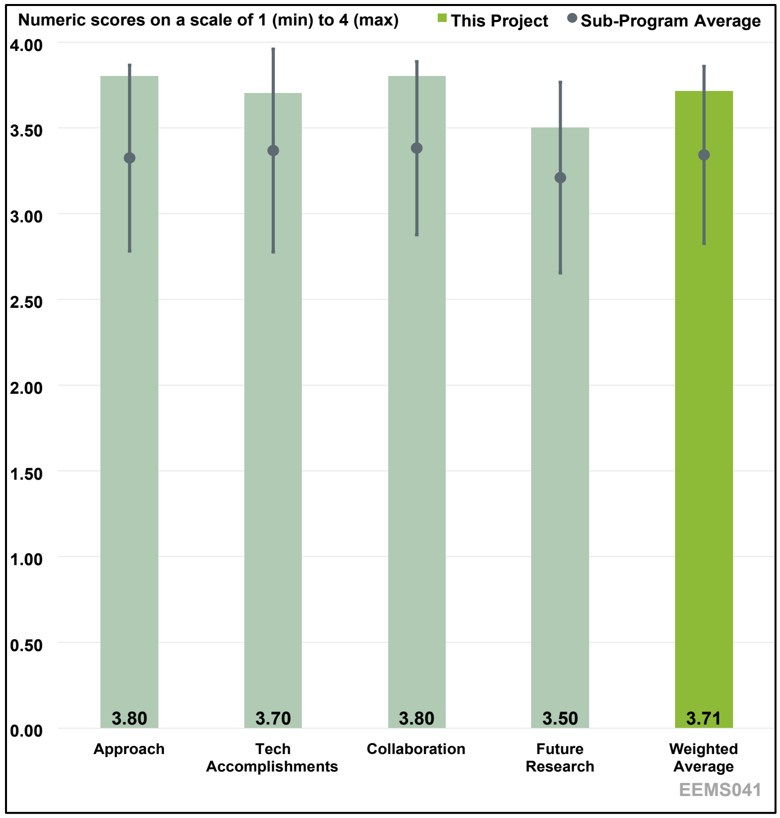

Figure 4-3. Presentation Number: EEMS041 Presentation Title: ANL Everything-in-the-loop (XIL) Capabilities Principal Investigator: Kevin Stutenberg, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the project has developed methods that address the described technical barriers very well. The ability to interface real and virtual vehicles in a test setting is impressive. The real-time tools allow for maximum flexibility in what can be measured.

Reviewer 2

The reviewer noted that the project is addressing barriers including working to include real-world energy impacts.

Reviewer 3

The reviewer stated that the everything in the loop (XIL) project is well-designed and meticulously planned. The developed technical approach is an efficient method for evaluating connectivity and automation. Additionally, the EEMS program barriers have been well addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the technical progress has been excellent. The tasks are on track or completed. It is nice to see that the team now has some of the latest vehicle technology to work with and the Virtual Open Innovation Collaborative Environment for Safety (VOICES) demo was an impressive use of the methods developed to date.

Reviewer 2

The reviewer said that the presenter has achieved various accomplishments, such as integrating new validated vehicle platforms, streamline, improve and expand XIL workflow including to support EEMS/Systems and Modeling for Accelerated Research in Transportation (SMART) projects. The presenter also demonstrated a successful peer review publication and two conference talks.

Reviewer 3

The reviewer said that it was good to see impact of grade included as this has been noted as an important factor in energy consumption. Working on incorporating impact of lateral movement and uncertainty. Suggest further understanding of uncertainties associated with on-road testing.

Reviewer 4

The reviewer stated that the virtual environment and actual field conditions are well-synchronized. Critical components of the system were integrated. The workflow of XIL simulation is well designed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the project tasks support and are spread across various programs and a significant number of researchers. The collaboration amongst these folks appears to be smooth and is achieving the desired results.

Reviewer 2

The reviewer commented that the proposer has described successful collaboration with other national laboratories Oak Ridge National Laboratory (ORNL) and Lawrence Berkeley National Laboratory (LBNL), U.S. Department of Transportation (DOT), Illinois Institute of Technology, and University of California, Irvine (UCI). One example is the Department of Transportation (DOT)/VOICES review and collaboration Pilot 2 program.

Reviewer 3

The reviewer said that this project collaborated with DOT’s VOICES project to advance distributed testing.

Reviewer 4

The reviewer stated that there is excellent collaboration all around.

Reviewer 5

The reviewer said the vehicle OEM and or a dynamometer test organization collaboration and partnership could further benefit the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that the proposed work continues and extends the capabilities already developed. These are reasonable next steps.

Reviewer 2

The reviewer stated that the proposed future research is solid.

Reviewer 3

The reviewer commented that the proposed future work is relevant. This reviewer questions the proposed necessity of acquiring new vehicle models without explanation of the new technology being deployed.

Reviewer 4

The reviewer stated that the aerodynamic load emulation is likely overly optimistic in energy reductions. Impact of cross flow, adjacent vehicles all have a negative impact.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project methods allow assessment of vehicle technologies in a mobility system environment, allowing the study of vehicle to everything (V2X) implications.

Reviewer 2

The reviewer stated that yes, the overall project is able to demonstrate ANL anything in the loop's XIL workflow with aero load emulation, integration of uncertainty analysis for energy characterization, safety implementation and real time distributed XIL architecture update.

Reviewer 3

The reviewer stated that the project is closely tied to the EEMS objectives and workflow.

Reviewer 4

The reviewer stated that yes, this project meets the VTO EEMS and Analysis objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the resources appear sufficient. The team has been able to achieve success in addressing vehicle testing barriers with the funding provided.

Reviewer 2

The reviewer commented that yes, the allocated resource is sufficient.

Reviewer 3

The reviewer stated that the resources are appropriate for the project.

Reviewer 4

The reviewer commented that the presenter highlights the difficulty of acquiring new research vehicles through General Services Administration (GSA), which has resulted in long lead times (more than 12 months) for desired advance technology vehicles that are new or uncommon in the current market. VTO needs to take note of this inconvenience and coordinate with GSA to reduce the long lead time from 12 months to three months.

Presentation Number: EEMS066
Presentation Title: Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing
Principal Investigator: Lauren Spath-Luhring, National Renewable Energy Laboratory

Presenter

Lauren Spath-Luhring, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

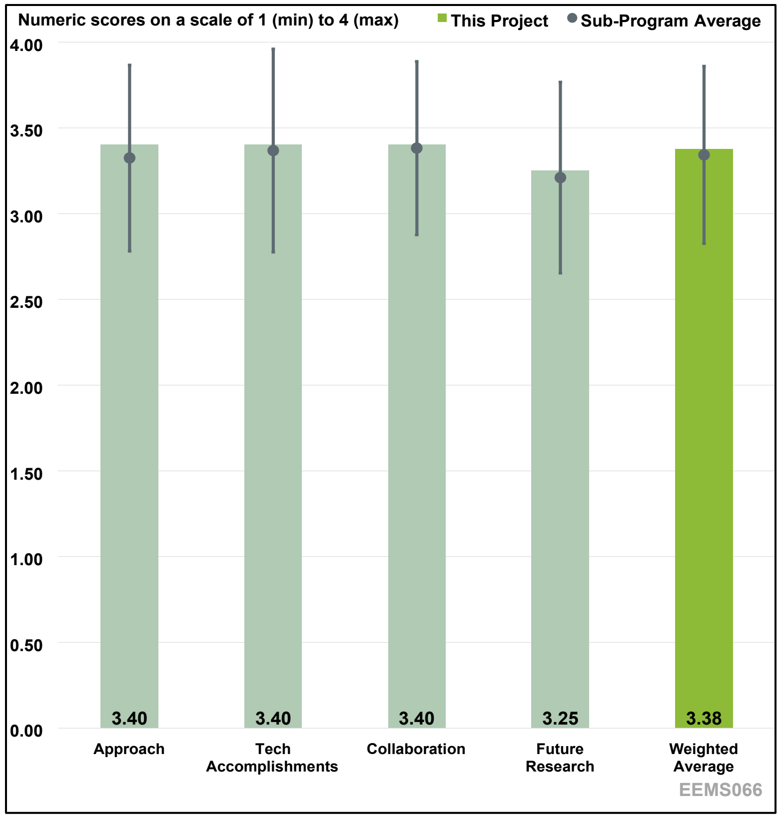

Figure 4-4. Presentation Number: EEMS066 Presentation Title: Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing Principal Investigator: Lauren Spath-Luhring, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the work was performed well, and technical barriers are adequately addressed.

Reviewer 2

The reviewer commented the Livewire data platform is a collaboration among Pacific Northwest National Laboratory (PNNL), National Renewable Energy Laboratory (NREL), and Idaho National Laboratory (INL) to make EEMS data open and easily accessible. The project team worked to address technical and cultural challenges with the data and provide three levels of data access. The project was a large undertaking, and the 392 datasets are only as of March 2024.

Reviewer 3

The reviewer said that the project, and associated tool effectively addressed many of the technical barriers. The tool offered cross-federation of datasets with data.transportation.gov, it provided varying levels of access based on user needs.

Reviewer 4

The reviewer stated that the purpose of Livewire is to help advance research on new mobility technologies by bringing data on those technologies together onto one secure, organized, well-managed platform. The platform should be used to share findings and enable collaboration to expedite and improve knowledge generation.

Reviewer 5

The reviewer noted that concerning barriers, e.g., expansive community of relevant stakeholders and difficulty in sourcing empirical real-world data applicable to new mobility technologies such as connectivity and automation, the project is addressing both, but quantitative assessment of users and potential users would be beneficial.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the technical progress is good.

Reviewer 2

The reviewer commented that the Livewire team has made great progress on getting several hundred datasets onto the platform, with a focus on reference document management and "low-level" metadata. There is cross-federation between Livewire and data.transportation.gov, which is an important connection that increases access and visibility for DOE and DOT stakeholders.

Reviewer 3

For reviewer commented that the technical accomplishments and progress, key metrics would be helpful to present in the main deck it notes: Saw an increase in usage metrics in FY 2023 quarter one. There is a back-up slide which is helpful but additional assessment of current and potential users would be very helpful.

Reviewer 4

The reviewer said that the project has made expected progress compared to the project plan.

Reviewer 5

The reviewer stated that the platform provides free data storage, quality characterization, data discovery, and multiple upload and download methods. It provides user support and has a forum for user feedback. A significant accomplishment in the previous year has been the use of generative AI along with detailed metadata to provide a chatbot feature for users. The team has recently also focused on outreach to increase contributors and users, presenting on the platform at numerous conferences. It appears that the team is constantly improving this platform and increasing the number of contributors and users, thus enhancing its value.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the collaboration across teams is good.

Reviewer 2

The reviewer stated that this project involved collaboration across three national laboratories and many data owners and data managers at DOE, as well as the DOT data program. No additional collaboration needs were noted.

Reviewer 3

The reviewer commented that the project relies on collaboration of contributors and users. Noting and assessing feedback from both groups would be beneficial.

Reviewer 4

The reviewer noted that there were positive and significant collaborations within the project team, including from PNNL, INL and from mobility researchers at large. NREL built and managed the application program interface. PNNL provided built the underlying platform and provides quality assurance (QA)/quality control for ongoing development.

Reviewer 5

The reviewer commented that the project relies on collaboration. The platform is run by 3 national laboratories and contains data from more than 60 organizations. The latter, especially, requires an impressive amount of communication, coordination, and trust-building among a large, diverse group of researchers. They are also expanding the value of the platform by opening up its data to other similar catalogs, like the DOT data catalog. More can be done to get data from state energy offices and receive and incorporate feedback from data working group.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project is complete and well done.

Reviewer 2

The reviewer said that the project has clearly defined future work streams and a path to achieve those goals. Future work includes identifying and incorporating other datasets, providing better data quality characterization, increasing analysis capabilities, and using generative AI to establish chatbot support.

Reviewer 3

The reviewer stated that there are plans to get more datasets onto Livewire. It would be helpful to better understand the end uses and potential analysis capabilities on the platform.

Reviewer 4

The reviewer stated that using user feedback in assessing needs for future development would be helpful.

Reviewer 5

The reviewer commented that some future work is clearly vital to the success of the platform, e.g., adding GSA and U.S. Environmental Protection Agency data. However, it is unclear what the value of the interactive data map is. Similarly, it is unclear what additional progress the team plans to make on generative AI methods.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said that this project facilitates access to diverse sets of use case data and is a good resource for the EV research community.

Reviewer 2

The reviewer commented that Livewire includes a range of transportation and EEMS datasets. The project supports multiple VTO objectives.

Reviewer 3

A reviewer said that a data sharing tool like this is very valuable to the community.

Reviewer 4

The reviewer commented that the project provides useful support to public and private mobility researchers to enable discovery and storage of transportation data.

Reviewer 5

Data sharing and effective data management across research teams is vital for effective knowledge generation on advanced vehicle technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources were adequate.

Reviewer 2

Reviewer stated that there were no concerns noted regarding resource availability.

Reviewer 3

The reviewer said that the resources are sufficient to achieve the milestones within the remaining project timeframe.

Reviewer 4

The reviewer commented that the platform seems to be fully functional, as envisioned, and even incorporating advanced search, download, and upload functions to improve user-experience. The biggest challenge is finding and convincing relevant researchers to provide the necessary data and make use of the available data.

Presentation Number: EEMS090
Presentation Title: Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway
Principal Investigator: Hong Wang, Oak Ridge National Laboratory

Presenter

Hong Wang, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

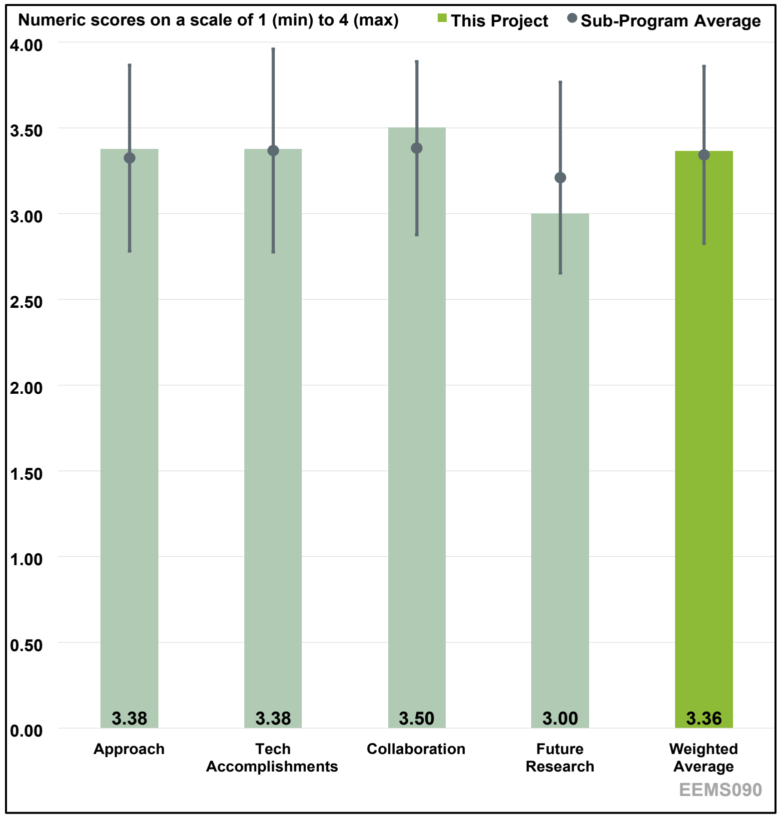

Figure 4-5. Presentation Number: EEMS090 Presentation Title: Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway Principal Investigator: Hong Wang, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said there was a good plan and that the barriers are addressed.

Reviewer 2

The reviewer noted that given that the project is 100% complete there is basis to judge the timeline. Given that, according to the presentation, the system has been deployed in the field and has been working during the last three months with no issue the reviewer calls it a success.

Reviewer 3

The reviewer stated that the researchers proposed and executed a well-designed project to address the technical barriers listed. Most notably, their contribution to advancing a use of a neural network and real-time AI control implementation on an arterial road is a significant accomplishment to our understanding of the potential for use of these technologies to optimize mobility in high-traffic conditions.

Reviewer 4

The reviewer commented that this seemed like a project that was created to get data, but did not have a focus on deliverables for the work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that all the milestones were achieved.

Reviewer 2

The reviewer commented that all project tasks have been completed. There is a report of some delays in the project implementation but given that all work has completed successfully all issues have been resolved.

Reviewer 3

The reviewer stated that the researchers have completed the work and made important technical contributions in both developing the neural network and executing real-time application of AI, with data and analysis on results under different conditions and time-periods. There was limited focus on the energy elements of the technology use. Though the project is completed, it would be useful if any future research could do more assessment of the energy and emissions implications of the use of the AI system. For example, the researchers note energy savings demonstrated so far at 9% but there are many research questions that could delve further into this context, such as variations in energy savings under different conditions, improvement to how energy efficiency is estimated, and how this compares to energy use involved in use of the AI in real-time.

Reviewer 4

The reviewer was unclear as to the accomplishments. The reviewer appreciated the 8-10% productivity gains, but the presenter did not explain, even after a question or two by the reviewers how this was actually measured, giving me concerns over validation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer believed that the collaboration details could have been described further, although, presentation time was limited in general.

Reviewer 2

The reviewer said that project team collaboration seems ok.

Reviewer 3

The reviewer stated that the presentation gave the impression that the collaboration between ORNL and University of Hawaii at Manoa was smooth and fruitful. More importantly, the reviewer saw the adoption of the system by Hawaii DOT, as well as the seamless collaboration with Econolite, one of the biggest suppliers of traffic control systems in the country, as a great success.

Reviewer 4

The reviewer noted that the researchers worked successfully with a cross-institution team. Most notably, it is helpful to see the integration of state DOT officials and private sector involvement. This collaboration and coordination undoubtedly led to successful completion of the project and the reviewer hoped that the collaboration also paves the way for continued implementation of the technologies, even though the research project as concluded. It is great to see that patent applications have been filed and steps towards commercialization are being taken.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the presentation documents did not describe any future research beyond this completed project. There is a mention of a patent application, and it was verbally discussed that the industrial partner Econolite has expressed interest in adopting the system.

Reviewer 2

The reviewer noted that the project is at 100%. The PI requested carry on projects, but the reviewer would be reluctant.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer identified the project as related to EEMS and Analysis.

Reviewer 2

The reviewer stated this was a very interesting and realistic project and that the use of new technologies like AI and machine learning (ML) was practical and it allowed for the development of an actual, immediately feasible traffic control system that showed benefits as soon as it was implemented.

Reviewer 3

The reviewer commented that the project is relevant and responsive to the objectives of the EEMS Program; however, future projects in this area could benefit from additional and more expansive scope and analysis directly connected to the energy and emissions impacts of technology applications. Here it is understandable that the focus was on development of the algorithm and real-time application of it, given the novelty of these technologies. It would be great for future work to shed additional light on the potential this work to improve energy efficiency of transportation networks.

Reviewer 4

The reviewer said that the project is relevant in that traffic management and is a great solution to work on but was unclear as to the success of this project.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources were sufficient, and the project is complete.

Reviewer 2

The reviewer was unsure.

Reviewer 3

The reviewer said that that given that the effort involved deployment in the real world, the reviewer believed the budget was reasonable.

Reviewer 4

The reviewer stated that the researchers did an impressive amount of work on a $2 million budget.

Presentation Number: EEMS092
Presentation Title: BEAM CORE
Principal Investigator: Anna Spurlock, Lawrence Berkeley National Laboratory

Presenter

Anna Spurlock, Lawrence Berkley National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

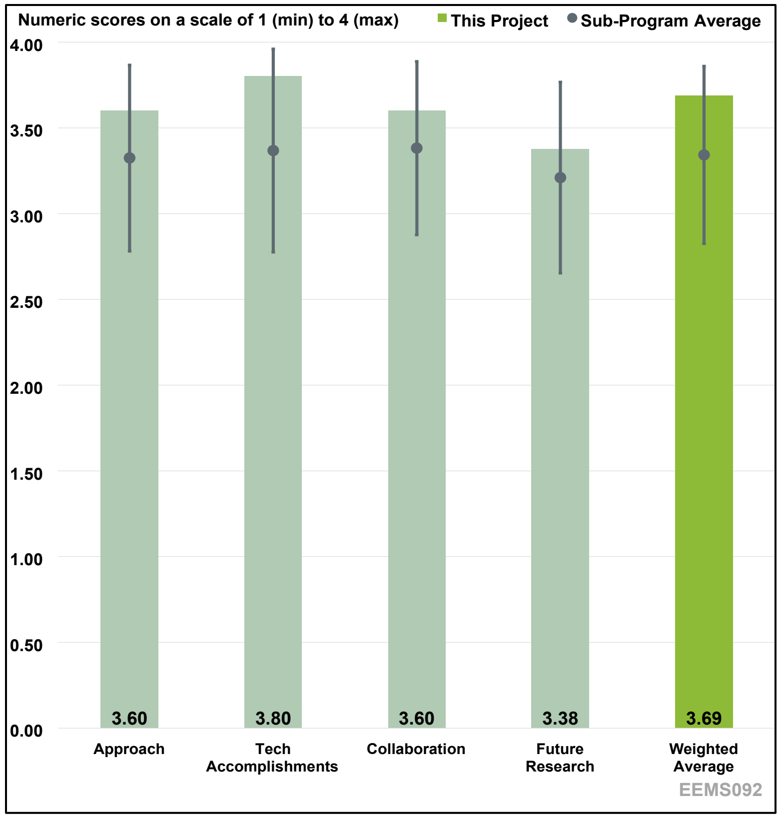

Figure 4-6. Presentation Number: EEMS092 Presentation Title: BEAM CORE Principal Investigator: Anna Spurlock, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that particularly given the scale, variety of project partners, and tools used and developed, all was well-coordinated. Starting with substantial stakeholder engagement with 20+ listening sessions guided work and was in good agreement with initial plans. Continued dissemination of work to stakeholders ensured continued alignment. Modular tools that are mixed/matched and swapped made a flexible tool to study a variety of scenarios.

Reviewer 2

The reviewer stated that Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE) is an impressive package of integrated software tools and methods attempting to answer very difficult questions. It does an impressive job of capturing the details of the moving parts of a very complex system of systems (SoS). The team has been able to do some impressive what-if studies that can be utilized by city and transport system planners.

Reviewer 3

The reviewer commented that this project involves agent-based and behavioral modelling related to passenger and freight mode choice. The BEAM CORE approach includes various technology adoption considerations and “what if” mode choice scenarios. The project appears to be very well designed and managed, especially given the complexity and number of modules and case studies that have been completed. No concerns noted regarding the methodology or timeline.

Reviewer 4

The review said that the approach was excellent on all aspects except for vehicles. The team did not have a subject matter expert on EV deployment, maintenance and predictive component replacement. The approach of working with stakeholders to provide insights on feasible actions they may take to improve mobility, energy, environmental and equity outcomes in their regions is solid and relevant.

Reviewer 5

The reviewer commented that three-year timeline is reasonable. Comprehensive due to its use of multiple tools specializing in a different segment of the transit system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that there was a substantial tool development with several new modules developed to expand the initial model, including stakeholder input (e.g., freight). Several interesting and timely scenarios were developed and analyzed, including telecommuting, ride-hailing, and congestion pricing.

Reviewer 2

The reviewer said that the technical progress has been outstanding. All tasks have been completed, on time. The original BEAM tool has been greatly extended in capability.

Reviewer 3

The reviewer commented that the presentation included overviews of the Automobile and Technology Lifecycle-Based Assignment (ATLAS) and Freight Activity Mobility Simulator (FAMOS) modules and several case studies, including the Austin Freight medium-duty (MD)/heavy-duty (HD) and San Francisco Bay teleworking scenario. Future considerations include ZEV freight and more detailed evaluations of air quality and health impacts as a result of implementing a scenario. Validation has been conducted on the baseline so far. It would be interesting to see additional verification and validation of the scenario outputs, including the telework and pricing programs.

Reviewer 4

The reviewer noted that the workflow established and implemented to process and transform scenario outputs for users to interact with model results in web-based data visualization dashboard. Scenario comparison feature supports understanding the direction and magnitude of change across scenarios. Continuing to integrate equity focused sociodemographic variables to enable nuanced filtering of travel by individual and household features such as race, age, income, gender, vehicle availability and employment.

Reviewer 5

The reviewer commented that the technical approach was excellent and did overcome most barriers. The lack of having a commercial transportation stakeholder on the team or as advisors leaves a gap in the true technical requirements.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said that the large number of collaborators spread out across the country, dealing with integrating their portions of the software project, requires very good communication and collaboration. The national laboratories, particularly NREL have provided outstanding contributions to the project.

Reviewer 2

The reviewer commented that the project team has conducted extensive outreach as part of BEAM CORE development and for specific case studies, including coordination with San Francisco Bay Area agencies and community groups and MD/HD stakeholders in Austin. The project is led by LBNL with contributions from other national laboratories and federal and state agencies, such as the California Air Resources Board (CARB). The team may consider future collaboration with these same groups to validate scenario outputs with real-world outcomes.

Reviewer 3

The reviewer said that this a very good team was assembled, the lack of a professional commercial transportation stakeholder leaves a significant gap. The academia, government and laboratory partners are all very good.

Reviewer 4

The reviewer said that the variety of national laboratories and two mobility simulation technology companies, and one university are part of the team. Particularly tight teamwork with NREL, even working on the same modules together. Only negative is that some additional end user engagement would support development and ensure end product(s) is(are) in alignment with up-to-date needs.

Reviewer 5

The reviewer noted that the project did well bringing various laboratories together based on their differing expertise. Appreciate the listening sessions completed, to incorporate stakeholder feedback throughout the project. Recommend further engagement with private sector for feedback, demonstrations, and pilots.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that working with metropolitan planning organizations to do additional studies, and also discussion options with other agencies. Current topics such as vehicle to grid are proposed and would support EEMS goals. Additional focus on freight and addition of air quality and health impact for environmental justice impacts are positive. It would be good to have more details on the plan to get the open-source model/modules used by others, especially considering how complex the full model is.

Reviewer 2

The reviewer commented that the additional capabilities planned are logical follow-ups to the current work. The emissions modeling work sounds intriguing.

Reviewer 3

The reviewer said that yes, the project clearly defined future work and goals. The project team plans to follow up with stakeholders and conduct data updates. BEAM CORE development will continue with additional modules or updates to existing modules.

Reviewer 4

The reviewer noted that the future research is relevant to develop emission modeling that couples with simulated traffic activities and emission factors. Quantify the air quality and health impacts from the spatially resolved emission changes.

Reviewer 5

The reviewer suggested that instead of continuing to add new tools, the project focus should be on piloting existing tool, like with CARB, Metropolitan Transit Commission and the Puget Sound Regional Council.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer described the project as highly flexible and adaptive tool was used to study currently relevant scenarios and additions to the model were developed to do so. All aspects meet EEMS goals on mobility, accessibility, efficiency, and community engagement.

Reviewer 2

The reviewer commented that this project ties all of the EEMS pillars together to allow long-term what-if assessments of mobility system impacts. It can provide useful insights as to possible impacts of EEMS programs.

Reviewer 3

The reviewer stated that the project supports several VTO objectives, including EEMS, Electrification, and advanced technologies. The modeling and scenario analysis approach includes many modes and technologies (micromobility, zero emission vehicles EV, etc.).

Reviewer 4

The reviewer commented that this research must be completed to fully understand the impacts of EV adoption. Establish incentives and dedicated spaces to increase commercial EV adoption and safe and compliant curb behavior. This project develops a roadmap to support cities with policy structure, curb user data and identify improved management opportunities.

Reviewer 5

The reviewer said the project is mostly relevant to EEMS, Electrification, and Analysis.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said that it is a highly capable and diverse team. National laboratories, companies, and universities involved have the needed expertise and tools.

Reviewer 2

The reviewer noted that the project was completed successfully with resources provided. The presenter did not mention any missed opportunities due to lack of resources.

Reviewer 3

The reviewers stated that the project resources appear to be sufficient. No concerns noted about funding levels. The part of the project in the presentation is considered complete. The reviewer did not comment on availability of future funding.

Reviewer 4

The reviewer noted that the project had many resources with great contributions. The stakeholders need to include strong business acumen. The current resources do not include this acumen, laboratories and government agencies do not provide this accurate data input.

Presentation Number: EEMS093
Presentation Title: Transportation System Impact POLARIS Workflow Development Implementation and Deployment
Principal Investigator: Joshua Auld, Argonne National Laboratory

Presenter

Joshua Auld, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

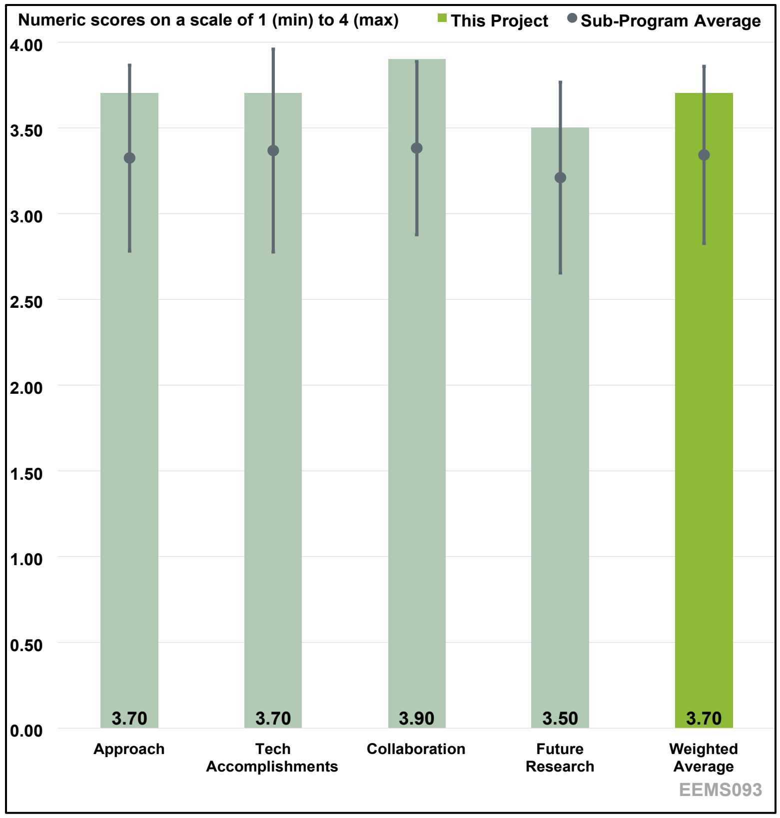

Figure 4-7. Presentation Number: EEMS093 Presentation Title: Transportation System Impact POLARIS Workflow Development Implementation and Deployment Principal Investigator: Joshua Auld, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that POLARIS's capability has been significantly enhanced over the life of the project. New capabilities are effectively addressing the questions posed by EEMS. The project is effective in addressing various uncertainties associated with the EEMS-related technology and policy options.

Reviewer 2

The reviewer stated that the approach for this project was very extensive and tackled everything from new feature development to incorporation of new studies and data sets and stakeholder engagement. This was extremely thorough and far-reaching.

Reviewer 3

The reviewer commented that POLARIS is an advanced freight and passenger travel demand model that can help evaluate goods and people movement in a transportation system. Recent work has focused on validation and calibration and increasing the scope and scale of studies, including a large 192-scenario study in Chicago. The project seems to be well designed and managed and cover a very wide range of strategies and stakeholders. Discussion around the stickiness of auto mode and impacts to disadvantaged communities was particularly interesting and addresses some of the barriers facing local communities and decision makers.

Reviewer 4

The reviewer noted that the project approach is very clear, and the project team was able to accomplish a lot in the roughly three-year timeline. The project team worked through a number of technical barriers, including developing workflow automation capabilities and increased accessibility for end-users through development of desktop and cloud-based processing. It seems that the capabilities of POLARIS to evaluate the impact of changes to transportation system technologies and policies have come a long way, but that there is still a significant opportunity to improve and increase functionality of the model. Throughout this project timeline, the team added many interesting and relevant features to the model and identified several others that can be added in the future to enhance the tool. It seems the project made great strides in addressing gaps in the POLARIS workflow. All milestones for the project have been met, and the project has been completed.

Reviewer 5

The reviewer's perception of this presentation was predominately focused on results, not methodology. However, the reviewer was impressed with the way the project team coordinated the Chicago study. Part of what makes transportation so challenging is that there are too many "cooks in the kitchen" so to speak (i.e., there are so many agencies that have jurisdiction over a small part of the network). The reviewer hopes that the project team is going to document all of its challenges and lessons learned in coordinating Chicago Department of Transportation, Chicago Metropolitan Agency for Planning, Chicago Transit Agency, and the Regional Transportation Authority. The reviewer is interested in how the project are documenting how they came to consensus across different priorities to identify a path forward as part of this process. The reviewer thought that the consensus piece (or getting everyone steering the ship in the same direction) is one of the biggest challenges we face. The reviewer was really excited to see the different deployment paths that you are exploring (e.g., the working directly with agencies, cultivating agency/university connections, and the hands-on support from ANL like with the Chicago example) – The reviewer hoped the project team will keep exploring these opportunities to get POLARIS into the right hands.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project has achieved its technical objectives and has been effectively deployed to help address policy questions posed by local governments, with study results which will provide input for their planning.

Reviewer 2

The reviewer commented that the technical accomplishments of this project were extremely far reaching and impressive. The vast expansion of capabilities of this model will enable so many new and different studies.

Reviewer 3

The reviewer noted that the project team has pulled together an impressive case study on Chicago area transportation. As part of this case study, they coordinated with stakeholders (Chicago Metropolitan Agency for Planning, Chicago DOT, and transit authorities) and considered strategies and systems such as congestion pricing, off hours delivery, connected traffic signals, and shared scooters. By pulling various levels, the team used POLARIS to demonstrate increased efficiency even though without a decrease in vehicle miles traveled or vehicle hours traveled.

Reviewer 4

The reviewer said that the team does seem to have been successful at addressing gaps to the POLARIS workflow, and made significant technical progress in developing the tool, by automating the workflow, adding functionality on different platforms, increasing the scope and scale of studies over the course of the project, and adding many new features to the tool. There does seem to be an opportunity to expand on the project even more, continuing to refine the workflow, expand functionality and accessibility for end-users, refine and add features, and run additional studies. The reviewer found it interesting that the transit levers did not result in MEP improvements—the reviewer expected transit improvements to also improve mobility metrics. This makes me wonder, are the transit levers (speed and frequency) sufficient? Should there have been additional levers, such as increased routes, easier payment systems, enhanced multi-modal connection?

Reviewer 5

The reviewer noted that according to Slide 8, all milestones on the project plan were met prior to the completion of the project. (CONGRATS!)

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said that the project has a large team of contributors that need to collaborate effectively to achieve the project goals. The national laboratory, academic and industry partners are working well together.

Reviewer 2

The reviewer commented that the collaboration between teams, participants, and stakeholders is at another level for this project due to its sheer scope and size. Only suggestion is to continue finding ways to provide resources for additional users and agencies to make use of.

Reviewer 3

The reviewer noted that the project team includes software development (open-source studio tool, etc.) and stakeholder outreach with local agencies, vendors, and community groups. No additional collaborate needs noted.

Reviewer 4

The reviewer commented that the coordination among partners appears to have been strong throughout the project period. Stakeholder engagement informed features to include, and coordination with partners in the Chicago area for the main study seemed to have been strong. Coordination activities with partners was woven throughout presentation and workplan.

Reviewer 5

The reviewer was really excited to see the work the project put in to build connections with metropolitan planning organizations and look for opportunities to bring them to the table. The more we can understand where the planning workforce is (from a technical perspective) and how we meet them where they are (e.g., Slide 29), the more POLARIS will be utilized. Great work!

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the proposed future work includes enabling wider deployment of Polaris to encourage greater use by interested parties. Additional features proposed are logical follow ups to the existing work.

Reviewer 2

The reviewer commented that future research proposed looks excellent, the reviewer was excited about the efforts to make this tool set available and accessible to additional stakeholders for their own purposes.

Reviewer 3

The reviewer said that the project team will continue stakeholder engagement to set priorities and accelerate deployment of POLARIS. There was also mention of incorporating new regulations and technologies (e.g., cooperative adaptive cruise control (ACC) case studies).

Reviewer 4

The reviewer commented that the presentation clearly outlined remaining challenges and barriers, along with a proposed future research plan to build on this project and expand the capabilities and relevance of the POLARIS model on measuring impact of transportation system changes. The findings from this project demonstrate the potential for future impact - they were very interesting and showed a lot of promise to be relevant for a variety of organizations and use-cases. The reviewer wondered about the potential to study the impact of a major increase in transit ridership on the various energy, mobility, and efficiency metrics. Additionally, the reviewer was curious what barriers might exist for integrating new mobility modes and options, such as microtransit, dockless shared micromobility, and multimodal travel.

Reviewer 5

The reviewer was a little confused because according to Slide 2, this project is complete as of January 2024, however, Slide 32 provides future research. There is carryover provided on slide 2, but it was not clear to the reviewer what the carryover was being used for. The reviewer thought the presenter said that future research is tied to a different project (EEMS122), so for the purposes of reviewing EEMS093, the reviewer scored this question as not applicable, as the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the software developed in the project is a critical component in measuring the benefits of EEMS policies and technologies which are not yet in place. The tool provides insights into the potential impacts of the EEMS program over time.

Reviewer 2

The reviewer stated that the work conducted under this project is certainly in line with the mission under EEMS.

Reviewer 3

The reviewer stated that the project supports several VTO objectives, including advanced technologies, Electrification, and EEMS. For example, the case study for Chicago included a scooter share component and consideration of connected vehicles and connected signals.

Reviewer 4

The reviewer commented that the project is highly relevant to the objectives of the EEMS Program. The POLARIS tool enables the quantification of the impact of changes to the transportation system on mobility, energy, and efficiency.

Reviewer 5

The reviewer stated that the EEMS Program envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption. However, before different technologies and strategies can be deployed in the real world, they must be evaluated using modeling techniques. This project creates a robust modeling tool that is capable of quantifying the impact of new mobility trends requires to better understand how these technologies will influence vehicle usage, energy consumption and cost.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the project objectives were achieved with the funding available. There is no indication of missed goals/opportunities due to a lack of funding.

Reviewer 2

The reviewer commented that the POLARIS research seems to be sufficiently funded. More funding would still likely lead to worthwhile additional results.

Reviewer 3

The reviewer had no concerns noted related to resource availability.

Reviewer 4

The reviewer said that the project team was able to complete their project and all milestones within the timeline with the provided resources, with little funding leftover.

Reviewer 5

The reviewer said that the project was able to achieve its objectives with the financial resources made available; the reviewer saw this as sufficient.

Presentation Number: EEMS094
Presentation Title: Development and Validation of Intelligent CAV Controls for Energy-Efficiency and ENACTED
Principal Investigator: Dominik Karbowski, Argonne National Laboratory

Presenter

Dominik Karbowski, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

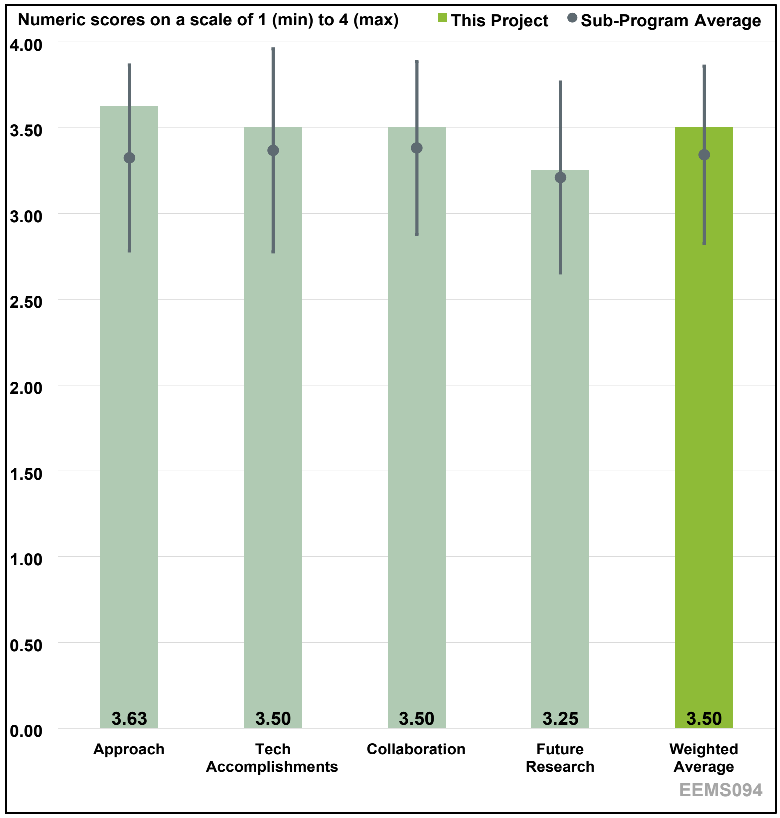

Figure 4-8. Presentation Number: EEMS094 Presentation Title: Development and Validation of Intelligent CAV Controls for Energy-Efficiency and ENACTED Principal Investigator: Dominik Karbowski, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the approach of using real world data and planning to conduct real world model calibration and validation will make it more realistic. The distribution of customers is varied and depending on vehicle class is a major variable as well.

Reviewer 2

The reviewer stated that in characterizing the importance of the ACC work, a fuel consumption penalty for ACC is described. The penalty is based on data from one manufacturer (General Motors), so it is not clear if this is manufacturer specific or more general. Also, it was not clear what the error bars on Slide 9 represented, but it is also possible that there is no statistically significant difference for ACC engagement vs. disengagement. The reviewer recommend that the researchers look at a data from multiple vehicle manufacturers and multiple vehicle types.

Reviewer 3

The reviewer commented that the overall approach to the project is well designed to address the barriers identified.

The reviewer made suggestions on potential additions to the methodology for traffic simulation approach that could be useful, including the use of representative trip data from the OEM trip data set.

The reviewer noted that a key feature the work is capturing is vehicle interactions through automation/connectivity, however the dataset does not appear to include driving behavior simulation calibrated against real world leader/follower pairs.

The reviewer believed that the captive fleet source of data is unlikely to have many clear instances where one vehicle is following another. The "dummy" preceding/leader vehicle behavior will directly impact the behavior of the human driven or automated vehicle. The reviewer does not anticipate that this suggestion would significantly change the conclusions of the project but rather just an additional element of robustness on which to develop and validate the energy saving approaches.

The reviewer added that the use of the next generation simulation data (highway domain) to represent realistic traffic flow in a signalized corridor is understandable given available data but would be a spot that could further enhance the work in the future. Capturing realistic traffic volumes is okay, but validating against real-world dynamics would be desirable.

Reviewer 4

The reviewer said that the presenter did a good job of explaining the importance of this project. The reviewer liked the approach of moving from real-world data to simulation to XIL to real-world deployment (side 5, 34). The reviewer appreciated the team's approach to making sure their simulations are well calibrated before applying the model in simulation and XIL. The reviewer was very excited to see the team building off of Federal Highway Administration (FHWA) projects, such as those with the University of Wisconsin (UW) and University of Illinois Urbana-Champaign (UIUC). The reviewer does not have any concerns with the approach used by the project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that integrating EV vehicle into the program and expanding the scope is a complex process. Methodology development is very different, and the team has been able to adapt.

Reviewer 2

The reviewer stated that the project appears to be on track.

Reviewer 3

The reviewer commented that the overall progress is commendable, and they do not have significant concerns.

Reviewer 4

The reviewer commented that the SMART Mobility Consortium 2.0 portion of the project appears to be on-track for completion by its targeted date. The ENACTED project is just getting started, so there is not enough information available to pass judgement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the team has been able to coordinate very well with industry, academia and other national laboratory partners. Having an industry partner provides direct input into the project.

Reviewer 2

The reviewer believes it would be helpful to engage with more than one vehicle manufacturer. If that is not possible, the reviewer recommends engagement with large corporate or institutional vehicle fleets that may have vehicle telemetry data (GSA, state governments, rental car companies, and other companies with large, late model passenger car fleets).

Reviewer 3

The reviewer commented that the project includes eight partners including U.S. DOE laboratories, universities, industry, and city department of transportations. Each members role and contributions are clearly defined and relevant to the stated project goals. The level of collaboration is high but seems to be well organized which is not always easy.

Reviewer 4

The reviewer stated that this is a diverse team that is well coordinated by ANL. The reviewer was very excited to see General Motors (GM) with such an active role on this project. It is hard to get OEMs to come to the table.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that Collaboration with ORNL to provide lateral control inputs using the dyno.

Reviewer 2

The reviewer stated that the future planned work is within scope for the project.

Reviewer 3

The reviewers aid that the future work is a clear follow on to the prior works and represent necessary steps to fully realize/demonstrate the benefits of the technologies being developed.

Reviewer 4

The reviewer commented that in the Q&A portion of the presentation, a lot of time was spent talking about developing SAE International standards (and how this is key for getting OEMs to consider changing their ACC algorithms). However, this is not at all mentioned in the future work (or in the slides at all). The reviewer would have loved to hear more about this at the next Annual Merit Review (AMR), because it sounds like it is the key to getting this work deployed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that automation in traffic is a much needed push to optimize the energy utilization during commute.

Reviewer 2

The reviewer commented that ACC is an increasingly used technology, so understanding its impacts and improving vehicle efficiency is certainly relevant and supportive of VTO's mission.

Reviewer 3

The reviewer stated that the broad range of simulation tools and development and testing of connectivity and automation technologies clearly aligns with the EEMS Program objectives.

Reviewer 4

The reviewer said that the EEMS Program envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption. This work has identified that production ACC algorithms penalize fuel economy and that new control algorithms are necessary to make Level 1 (L1), and Level 2 (L2) automation features more eco-friendly.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the team is well supported.

Reviewer 2

The reviewer said that no information was provided to indicate that funding was insufficient.

Reviewer 3

The reviewer said that the large group and broad scope of the work require an extensive set of resources from all partners. The scope of work, requirements for the integration of the partner efforts, and overall availability of resources appear to be well aligned.

Reviewer 4

The reviewer stated that this work is on schedule and budget.

Presentation Number: EEMS095
Presentation Title: Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use
Principal Investigator: Jinghui Yuan, Oak Ridge National Laboratory

Presenter

Jinghui Yuan, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

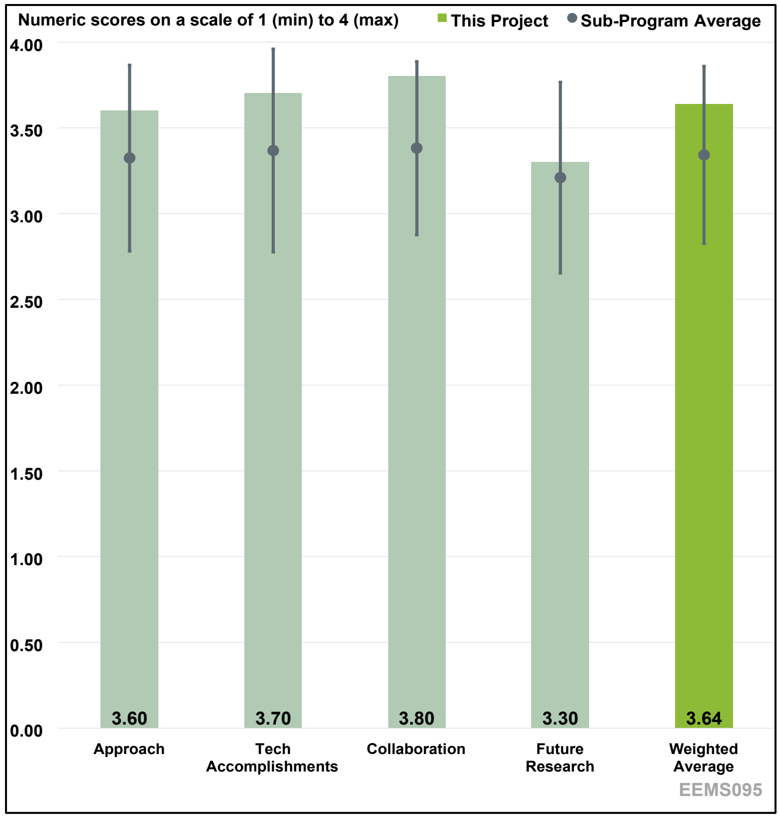

Figure 4-9. Presentation Number: EEMS095 Presentation Title: Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use Principal Investigator: Jinghui Yuan, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that there was a multi-level approach for the signal and vehicle controller developed and tested in simulation, dyno lab, and on-road. Additional detail on work done with vehicle OEM and city would be appreciated.

Reviewer 2

The reviewer commented that it was a well-planned project with a good mix of modeling and real-world testing, with help from car-manufacturer. The reviewer would have liked to hear how congestion level would impact the results. The assumption seemed to be that there would be reasonable traffic flow.

Reviewer 3

The reviewer said that the awardee is able to demonstrate that the integrated vehicle and signal control can provide up to 22% vehicle-level energy saving compared to non-controlled vehicles, which is significant. Additionally, other energy savings contributions are found in queue length prediction in congested and higher connected and automated vehicle (CAV) penetration scenarios.

Reviewer 4

The reviewer commented that the project aims to develop integrated control methods combining real-time traffic signal timing and CAV velocity profiles. The approach to the problem is well designed, with interconnected vehicle and signal control loops, simulation, and on-road demonstration.

Reviewer 5

The reviewer noted that the project approach was very good. The project team was able to answer many of the questions related to “connected vehicle” approaches to more efficient travel on traffic signalized roads. The approach to the real-world testing with the prototype vehicle had limitations with respect to generalizing the results. This was because the on-road testing was very limited and could not capture the variability of traffic volume and traffic signal status that would normally be encountered throughout the day. Any extrapolation of the on-road testing results cannot really be made. However, the on-road testing was a great validation of the feasibility of a connected vehicle approach for cooperative travel on traffic signalized intersections.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project demonstrated a 24-27% improvement in vehicle energy savings through the vehicle and signal controller compared to a baseline of actuated signal control. Variation of tests on no queue length prediction, implementable queue length prediction, and ideal (perfect) queue length prediction. Simulation (120k+ tests) is augmented with vehicles-in-the-loop (ViL) testing (148 tests) and week-long field experiment upon a corridor (35 tests). Substantial improvement in arrival on green and decreased wait times is demonstrated. Fusing of vehicle radar data with infrastructure data collection for queue length prediction is novel. Several publications have come from this work.

Reviewer 2

The reviewer said that the project has achieved its primary goals of demonstrating integration of Signal Phase and Timing (SPaT) and CAV technology to improve traffic flow. It is an impressive mix of hardware demonstration and modeling predictions.

Reviewer 3

The reviewer said that simulation, ORNL’s Connected and Automated Vehicle Environment (CAVE) laboratory testing, on-road demonstration (signal timing control and vehicle control and Traffic Technology Services (TTS) real-time SPaT data evaluation) are all demonstrated in this presentation. One feedback to the presenter: please substitute images of codes and Microsoft Excel files to more relevant graphs/information.

Reviewer 4

The reviewer commented that most of the critical milestones and timelines planned are met except the one planned for April. As the last two milestones are improvements, for the final report, the reviewer believes the team can accomplish it within the given timeline.

Reviewer 5

The reviewer noted that the project is mostly complete, and the team made great accomplishments in the three phases of: simulation analysis, laboratory testing, and on-road prototype testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the necessary partnerships have been established (traffic signal control, vehicle manufacturer, various national laboratories) to make the project successful. The work required significant contributions from different partners to make it all work.

Reviewer 2

The reviewer said that the project demonstrates clear collaboration and coordination with Toyota, City of Chattanooga and NREL.

Reviewer 3

The reviewer noted that the team consists of great partners supporting integration and implementations, not only for this project but also for other multiple EEMS projects.

Reviewer 4

The reviewer said that the team appears to have had outstanding collaboration among the key partners of ORNL, NREL, Toyota, and the City of Chattanooga. The reviewer stated that all partners had key aspects to the project, so collaboration and coordination was critical to the success of this project.

Reviewer 5

The reviewer stated that collaboration consisted of national laboratories, vehicle OEMs, and city team members, each with clearly defined roles according to strengths. The reviewer stated that more detail on the work done by vehicle OEMs and city team members would be helpful.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that additional on-road testing and ViL testing from real-world data, as noted, will strengthen project and enhance investment.

Reviewer 2

The reviewer stated that the next steps are logical and added that the reviewer is not able to judge how much of a challenge the proposed roads will be (busier?).

Reviewer 3

The reviewer commented that the project missed an opportunity to provide further details on how the future projects will help address the remaining challenges and barriers.

Reviewer 4

The reviewer commented that the proposed future research seems reasonable, with more on-road tests and its utilization for better energy benefit evaluation. It would be nice to see how the project results can be shared and interconnect with other EEMS projects from ORNL in the long term.

Reviewer 5

The reviewer said that the future work includes additional on-road testing and integration of the on-road test data into the laboratory environment for more valid laboratory results. A few other areas for the team to consider could be: 1) What could be the benefit of a lower latency SPaT data transmission (e.g., communicated via cellular-vehicle-to-everything (C-V2X) versus the “high” latency SPaT data provided by TTS? 2) What could be the benefit of implementing the assured Green Period that is being developed for CV applications at actuated traffic signals?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the novel signal and vehicle controller demonstrate substantial energy and traffic efficiency improvement.

Reviewer 2

The reviewer stated that the project is a good example of the kinds of beneficial technology synergies the EEMS team is trying to validate and doing it with real-world demonstrations.

Reviewer 3

The reviewer noted that the project was able to develop and demonstrate an integrated controls strategy that combines real-time traffic signal timing and vehicle speed controls for CAVs. This is relevant to the EEMS and Analysis VTO objectives.

Reviewer 4

The reviewer commented that the project aligns well with other EEMS projects and VTO’s goals of optimizing energy consumption through connectivity.

Reviewer 5

The reviewer commented that this project is very focused on EEMS related goals for using technologies (e.g., CV related) to improve vehicles’ energy efficiency on roads.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project team members bring expertise in controls, simulation and vehicle testing, and real-world deployment hardware. Each is used effectively at various stages in the project.

Reviewer 2

The reviewer said that the work is on time and on-budget. The presenter did not indicate constraints on progress due to lack of resources.

Reviewer 3

The reviewer said that the project is able to demonstrate that with the provided resources and collaborations, is able to achieve the stated milestones.

Reviewer 4

The reviewer said that the project has a great team with sufficient resources to perform all planned research.

Reviewer 5

The reviewer stated that the funding seems adequate to finish the current scope. However, more robust on-road testing could be performed in a variety of traffic conditions or with additional vehicles if additional resources were available.

Presentation Number: EEMS097
Presentation Title: Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE)
Principal Investigator: Andrew Duvall, National Renewable Energy Laboratory

Presenter

Andrew Duvall, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

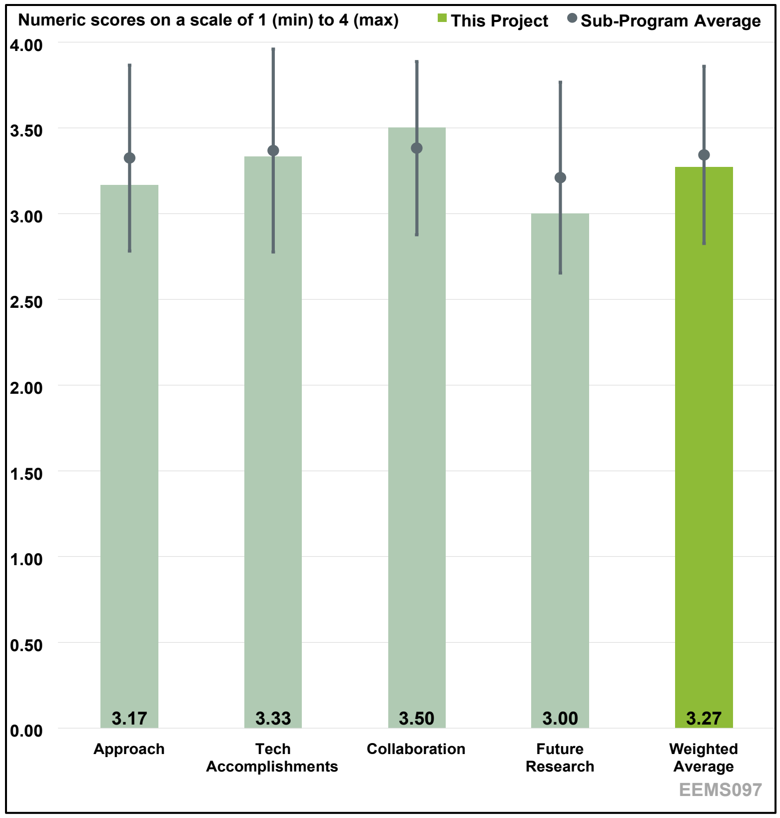

Figure 4-10. Presentation Number: EEMS097 Presentation Title: Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE) Principal Investigator: Andrew Duvall, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that based on the presentation, oral and written, the chief technical barrier is acquisition of micromobility data. It was striking to hear that this project has the largest dataset about e-bikes of any study, and its dataset is relatively modest in size. This project can, and probably should, be regarded as a proof of concept as to the value of scaling up the study and figuring out how to overcome the data barriers.

Reviewer 2

The reviewer commented that the project topic is of interest. However, not much technical approach was discussed during the presentation. With the limited technical information shared, it is difficult to evaluate viability of the methodology. However, the data used for the study, while is relevant, is not clear if it is representative enough and might have been needed to explore further or at least share the results on its viability for the purpose of the work.

Reviewer 3

The reviewer thinks that the research questions are on target, but even greater emphasis on equity for low-income/underrepresented groups in both urban and rural areas is important. Less impactful to energy considerations, perhaps, but more impactful to equity is the rural component of Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE) for both personal and freight mobility.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that on the surface, the analysis does indicate a benefit. Besides convenience and basic behavioral factors, to what extent do other factors (some controllable others not), such as weather, road safety and age/ overall health affect the viability of realizing the benefits?

Reviewer 2

The reviewer commented that this is a well-conceived and well-managed project that appears to be hitting all milestones comfortably. It lays out a thorough and well-rounded set of research questions that cover energy use, climate impacts, and behavioral patterns as well several different angles on quality of life, inclusiveness, markets, ownership/access, and real-life use cases and community scenarios for testing the benefits and barriers associated with e-bikes/micromobility vehicles. This is quite a multi-faceted agenda that takes full advantage of the funding, partnerships and opportunities available for conducting research.

The reviewer added the scope of the study is wide and thin, which is not a criticism as much as an acknowledgment that much more could be done. The questions for this research are really what more is needed, for what and by whom? How large should the evidence base be about micromobility to support what purposes? Based on this research, results could be useful for informing city policy, federal strategy, market developments to increase ridership/adoption, design of equity-oriented rideshare programs, and even for understanding EV adoption. In short, the project has illuminated many fruitful directions that further work on micromobility could go, with some winnowing based on input from its many stakeholders.

Reviewer 3

The reviewer said that lots of progress has made. However, the remaining Fiscal Year 2024 work (in progress) sounds more than 4% of the total. Though, due to lack of time for presentations, the presenter might have not got a chance to dig in further and explain.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaborations across laboratories and in particular with industry/city partners, makes this valuable. Expanding collaboration to a rural community to understand the opportunities for freight and personal mobility may uncover useful barriers and equity concerns.

Reviewer 2

The reviewer said that this project has, somehow, assembled an exceptionally large and varied set of partners and collaborators including four national laboratories, about a dozen cities nationwide, several universities, and state and federal agencies. If this set of partners meaningfully engages through the project, it is a huge asset and significant indicator of progress and potential for relevance. It is time-consuming to reach out to so many partners and not always easy to get their attention and agreement to participate in a research project. The research results and progress reporting do suggest meaningful engagement by stakeholders, which is all very impressive.

Reviewer 3

The reviewer said that collaboration could have been explained further and detailed of the roles of the partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that the plans are not described in detail. Main question is lack of credential and representative data. Until such data become available, further analysis will be very limited.

Reviewer 2

The reviewer said that the level of effort, the scope of the proposed research is appropriate. However, additional focus on micro-freight modes, perhaps beyond just e-bikes, may be a more productive area. What is unclear, perhaps, is the definition of the target, and what the collective impact on freight and personal mobility is of switching to micro-mobility modes, and its magnitude in relation to other energy reduction initiatives.

Reviewer 3

The reviewer stated that the project scope, progress toward the plan, relevance, and inclusion of stakeholders point to the solid foundation for future research laid by this current project, which is still in progress. Of the several promising next steps that could be taken, it could be valuable to construct a process for winnowing to priorities, possibly involving the stakeholders. A current theme across the project is evaluating how approaches to city planning and programs increase usage of owned or shared e-bikes/micromobility vehicles and how that relates to community goals for both emissions reduction and improving quality of life. It seems like a viable strategic direction to continue and scale, to the extent feasible given the challenges of data acquisition.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said that the project supports EEMS and Mobility programs.

Reviewer 2

The reviewer commented that the project's relevance to first-mile/last-mile, reducing congestion, and maximizing efficiency/optimizing MEP are all supportive of the subprogram objectives and worthy of research and analysis.

Reviewer 3

The reviewer noted that the focus on electric bikes and the general category of "emissions-free vehicles that are much smaller than cars" corrects for a lack of deep knowledge about this topic despite a substantial increase in e-bikes during the past several years and a need to explore all options for personal transportation flexibility as part of the energy transition. E-bikes have been regarded as niche, luxury goods and perhaps dismissed as a significant contribution to decarbonizing transportation. This study suggests otherwise, taking a much broader look at patterns of usage, and asking what it would take for them to become mainstream and what both decarbonization and quality of life implications might be. It is a thoughtful and sophisticated research project with room to grow.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the allocated budget sounds more than enough to get the milestones competed in a timely fashion.

Reviewer 2

The reviewers said that the resources of the project are modest, but sufficient for the scope defined.

Reviewer 3

The reviewer commented that the current budget is about right for a robust pilot or modest proof of concept. It is not sufficient to expand.

Presentation Number: EEMS098
Presentation Title: Optimizing Drone Deployment for More Effective Movement of Goods
Principal Investigator: Victor Walker, Idaho National Laboratory

Presenter

Victor Walker, Idaho National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

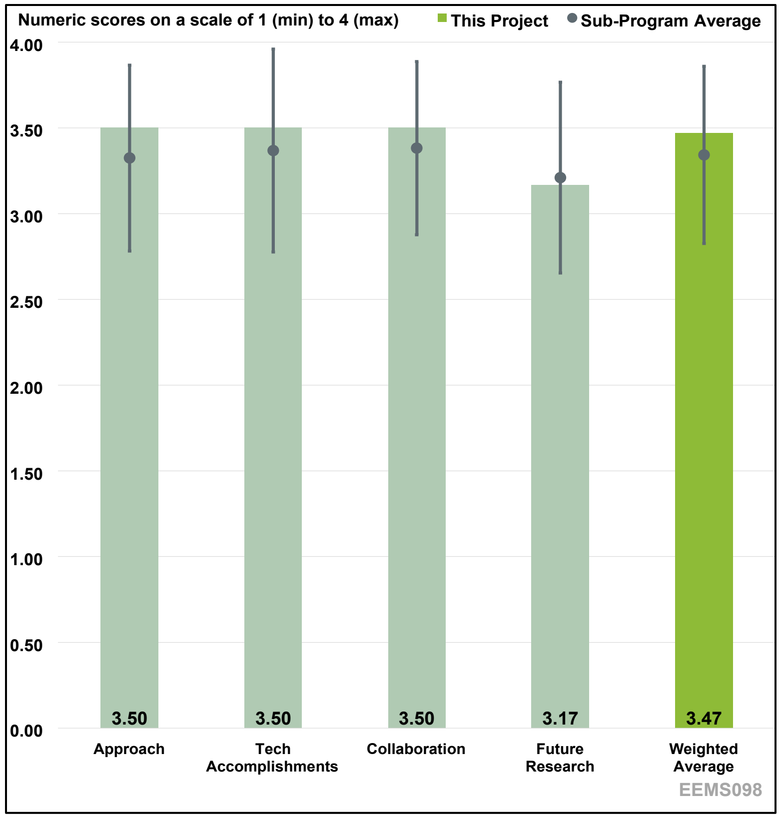

Figure 4-11. Presentation Number: EEMS098 Presentation Title: Optimizing Drone Deployment for More Effective Movement of Goods Principal Investigator: Victor Walker, Idaho National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the project focused on assessing two different types of drones (rotary and vertical take-off and landing (VTOL)) for efficiency in delivering goods to people. The project is well designed and considered key variables such as temperature, wind speed, and drone technology.

Reviewer 2

The review stated that this an outstanding area to focus effort. Drones have a reasonable potential for reducing energy consumption in freight and microfreight movement.

Reviewer 3

The reviewer commented that there was overall good progress, but it is difficult to assess energy impacts and performance of new technology. Technology impacts reviewed with respect to constrains on weather and delivery. Slide 13 discuss energy with respect to baseline, but baseline is not clear. Not sure what to do with the kilowatt-hour (kWh) numbers and what this means. What is the delta compared to existing delivery methods?

Reviewer 4

The reviewer noted that the project aims to manage and operate heterogeneous vehicles in delivery to increase energy efficiency. The analysis of the mixed-fleet scenarios and the results by including ground vehicles to handle the impacts of the weather were clearly shown. A public tool has been introduced to calculate energy and compare routes, energy, and fleet optimization, which is an excellent aspect of the project. Heuristic approaches were developed to have near-optimal solutions instead of putting in high computational efforts to achieve optimal results, which seems a proper approach.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that based on the planned timing and milestones, the project is right on track. The last two milestones are tough, and the reviewer looks forward to seeing the results next year.

Reviewer 2

The reviewer commented that the project is complete and met its primary goals of evaluating goods delivery by drone under different conditions. The team considered the effects of wind speed, temperature, delivery weight, and other variables on energy use. For example, VTOL drones could safely and efficiently deliver goods at temperatures above freezing and wind speeds up to 40 mph, while rotary models perform better at lower temperatures but cannot withstand higher wind speeds.

Reviewer 3

The reviewer commented that the focus on technical barriers may not necessarily be appropriate, as the real potential for the technology may not be manifested yet. As such, it may be useful to explore more speculative scenarios, which would perhaps present a different set of challenges than those identified. As an example, if the potential energy savings can be represented by (energy saved/drone)*(# of drones), then assuming that the energy benefit in relation to ground transport is around 100:1 (Slide 15), would a re-examination of the effect of utilizing numerous larger drones (which may be more weather resilient) on the hub-and-spoke paradigm for freight mobility be a worthwhile exercise?

Reviewer 4

The reviewer commented that it was not clear what the calculations for energy comparisons are being done. Are the calculations assessed on done type? What about new tech drones? Results in calculation window do not seem to be useful (e.g., total energy for flight is 259642.85714285713 Watthours). What decision is this supporting?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project team collaborated with drone manufacturers, delivery companies, and customers. No additional collaboration seems to be needed.

Reviewer 2

The reviewer stated that the collaborations are appropriate, but more acquiring more data quickly will be important, with a focus on greatest energy reduction opportunities in the 10-year timeframe (i.e., not the near-term).

Reviewer 3

The reviewer commented that additional information of activities/outcomes with collaborators would be beneficial.

Reviewer 4

The reviewer said that collaboration and coordination within the project team (with many partners and supporting collaborations) are listed as challenges, especially with scheduling meetings and robustness, but the results show that the team has managed the collaboration. It would be critical to meet the changing marketplace needs before releasing and maintaining public tools to be used in the field as expected.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project has ended, however the presenter noted potential to evaluate drone delivery for medical/trauma applications and considering launching drones from mobile vehicles as well as central locations. Launching drones from trucks could help serve more rural areas in particular.

Reviewer 2

The reviewer commented that the continued development and refinement of the tools is important, but greater focus on use cases that present most substantial energy opportunities (perhaps using MEP as a metric) may be needed. For example, food delivery may be a good validation case, but maybe not form a robust business solution resulting in substantial energy and productivity savings.

Reviewer 3

The reviewer said that the project is nearing its end at 85% complete.

Reviewer 4

The reviewer said it would be great to see how the tools will be maintained and updated based on the market needs to be utilized widely in the field. If the heuristics for near-optimal solutions could be shared with the public with open-sourced, it would be a great benefit to the society and would be happy to see the plan for it.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports VTO objectives, including EEMS and Electrification. The drones used in this study are electric and drones can help shift deliveries off of trucks and vans to more efficient devices.

Reviewer 2

The reviewer commented that drones are very much relevant to the EEMS subprogram objectives. The reviewer suggests that this program should also recognize and explore the potential equity aspects for both urban and rural communities.

Reviewer 3

The reviewer said that mixed mode delivery services is a key technology moving forward with the promise and challenges in robustness and energy consumption. Project is addressing some of these.

Reviewer 4

The reviewer stated that the project analyzed mixed-fleet systems with heterogeneous drones (and ground vehicles) and targeted to optimize energy consumption with given conditions. The public tools developed through this project will significantly benefit society by allowing them to analyze and plan for their system during the operations or planning for operations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the project is complete. No mention of resource or funding gaps was made in the presentation.

Reviewer 2

The reviewer said that the project has a great team with excellent partners and experts in the field to handle the problems.

Reviewer 3

The reviewer commented that as the project grows from being more exploratory in nature to addressing clearly defined transport problems. The reviewer believes the trajectory for the project funding should trend upward.

Presentation Number: EEMS099
Presentation Title: Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems
Principal Investigator: Venu Garikapati, National Renewable Energy Laboratory

Presenter

Venu Garikapati, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

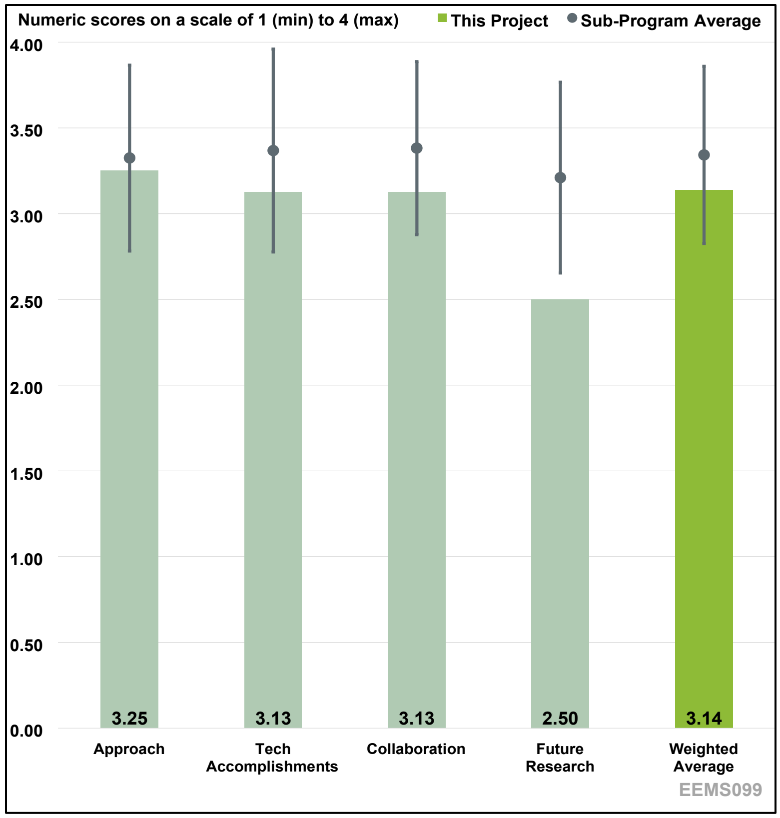

Figure 4-12. Presentation Number: EEMS099 Presentation Title: Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems Principal Investigator: Venu Garikapati, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that the MEP metric and the process for calculating it is quite worthwhile to DOE, DOT, and state agencies to analyze potential mobility projects.

Reviewer 2

The reviewer stated that the technical barriers were well-addressed by the project, and all project milestones were met. The project conducted studies using the metric for two state DOTs and evaluated source data for the metric by comparing two open data sources and was able to identify a superior dataset to use as an input for the metric. The project was well-designed to develop and refine the metric.

Reviewer 3

The reviewer commented that the project effectively addressed many of the technical barriers. The project defined the MEP metric, which provides a practical, common baseline to evaluate infrastructure investment projects using open-source datasets.

Reviewer 4

The reviewer said that one of the barriers is listed as the need for open and practical metrics to quantify energy productivity of mobility, but it is unclear what factors are used to calculate the MEP. The possible MEP value is not bound by a set or standardized range leading the MEP for the exact same location to change disproportionally, instead of relatively, based on different data sources, so it is difficult to compare the MEP beneficially across use cases. These factors also hinder meeting the barrier of accurately measuring the transportation system's energy impact (Second key barrier listed).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that the project is complete, and the successful examples of MEP analysis are listed.

Reviewer 2

The reviewer said that the project made expected progress compared to the project plan. Calculations were reduced from four hours to three minutes.

Reviewer 3

The reviewer commented that the project team made significant technical progress during the project timeline and have met project milestones and carried out studies to further refine the metric. The two state DOT collaboration projects mentioned in the presentation demonstrate the utility of the tool to measure impact of mobility improvements and transportation systems. It would be interesting to see collaborations with different types of organizations other than state DOTs - for example, regional planning commissions, cities, transit agencies - to demonstrate the utility and relevance of the metric among various groups. The presentation does highlight the success of the metric, and that it is being used in other DOE-funded projects, at other federal agencies, by industry groups, and non-profits.

Reviewer 4

The reviewer commented that the project plan seems to be comparing, OpenStreetMaps vs. Overture (complete) and applying MEP to various use cases. Although MEP was used with DOTs, the lack of standardization of the MEP questions its usefulness in its current state.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that since the project is complete, there was no need to explain the various partner relationships.

Reviewer 2

The reviewer said that the collaboration with project partners appears to be good, and partners are well-integrated into the presentation. It does seem like collaboration with a wider variety of organizations would be helpful, to assess accessibility of the metric and relevancy for different use cases and needs.

Reviewer 3

The reviewer commented that the project team achieved positive and useful collaboration, including with LBNL and ANL and from two state DOTs, with a third DOT collaboration underway. The collaborations are exploring scenarios of transit enhancements, pedestrian/bicycle enhancements.

Reviewer 4

The reviewer noted approximately 15 partners and collaboration across the U.S. However, besides the handful of early adopting organizations (Podaris, American Council for an Energy-Efficient Economy, the level of contribution by each collaborating organization is unclear. Getting direct potential customer feedback would improve the tool.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer hopes the Python tool can be funded so that this MEP analysis can be easily used by other U.S. DOE/DOT projects, as well as state agencies and universities. The reviewer would like to see the tech integration corridor projects use this type of analysis to evaluate corridors.

Reviewer 2

The reviewer notes that the project has concluded. However, the presentation does include ideas for future research activities, which primarily focus on lowering the barrier to adoption of the metric, which seems like a logical next step.

Reviewer 3

The reviewer stated that the project has defined a purpose for future work, including developing more rapid analysis capabilities, publishing MEP as an open-source library, and disseminating MEP as an evaluation tool more widely.

Reviewer 4

The reviewer commented that future plans focus on making MEP more accessible; however, the greatest needs are in the technical development and clearer value proposition of the tool.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer described the research as highly relevant.

Reviewer 2

The reviewer said that the project is highly relevant to the EEMS team, and the MEP metric is already being used by other EEMS projects.

Reviewer 3

The reviewer said that the project can provide a novel, dynamic and effective way to evaluate energy reduction capabilities of infrastructure projects. The project supports VTO subprogram objectives.

Reviewer 4

The reviewer commented that the focus is mostly on EEMS and Analysis.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the project is complete.

Reviewer 2

The reviewer stated that the project team successfully completed the project with the provided resources, and had some, but not a lot, of leftover funding.

Reviewer 3

The reviewer commented that the resources are sufficient to achieve the milestones within the remaining project timeframe.

Presentation Number: EEMS100
Presentation Title: Dynamic Curb Allocation
Principal Investigator: Nawaf Mohammed, Pacific Northwest National Laboratory

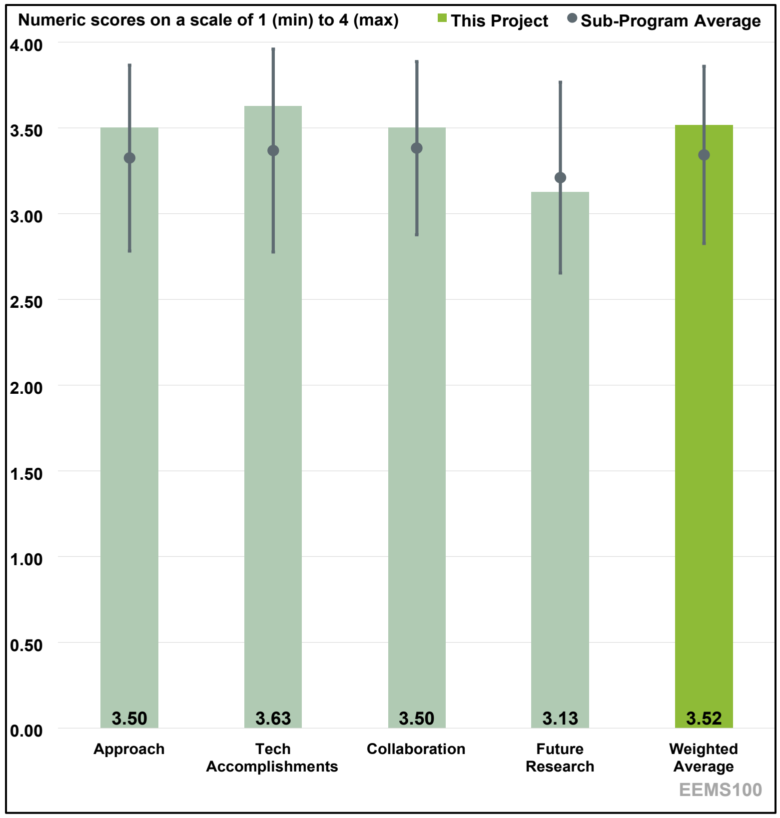

Figure 4-13. Presentation Number: EEMS100 Presentation Title: Dynamic Curb Allocation Principal Investigator: Nawaf Mohammed, Pacific Northwest National Laboratory

Presenter

Nawaf Mohammed, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the approach was excellent, and the project clearly defines problem statements and solutions to improving traffic patterns by reducing curb activity while supporting Electrical Vehicle charging opportunities. The reviewer recognized that the project addresses curb management and is an example of a transportation engineering problem municipalities are struggling with, roadway configuration features and environmental factors that impact travel speed vs. vehicle flow. The reviewer also comments that the project’s work on understanding factors like curb use will be critical for optimizing energy supply chains, including curbside charging for EVs.

Reviewer 2

The reviewer commented that the project is well-designed, and the timeline was reasonably planned. The reviewer commended the project for addressing research needed in the growing field of curb management. Specifically, the demand for the curb spaces in city cores is growing from an increase in goods delivery to homes and less access to short and long-term curb spaces at major transportation hubs. The reviewer also commented that as the EV becomes more prevalent, it will also lead to competition and a balancing act of access to the charging ports and parking spaces.

Reviewer 3

The reviewer expressed that the project is well-designed to address technical barriers, such as curb management and testing of curb management allocation policies. The reviewer commented that the only weakness of the project is the specific sensor technology the team used to measure curb use is very expensive. However, the reviewer noted that the presenter indicated other technologies, such as automated license plate reading, could be used to replace the sensor.

Reviewer 4

The reviewer had concerns that the barrier in the project listed as, "Curb allocation has impacts on congestion, greenhouse gas emissions, system energy efficiency, and productivity", was not resolved through the proposed curb management plan. The reviewer's concerns were that models did not seem to be able to assess all these matrices and the results do not show benefits for each of these matrices.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that one of the technical accomplishments in the project includes platform displays real-time parking status based on sensor data. The reviewer also commented that optimal curb allocation suggestions for future planning on curb-occupancy data available for access in the Livewire system brings full clarity to identify areas of concern. The reviewer also noted that the project has proof-of-concept in a cloud infrastructure hosting capability.

The technical accomplishments include platform displays real-time parking status based on sensor data. Optimal curb allocation suggestions for future planning on curb-occupancy data available for access in the Livewire system bringing full clarity to identify areas of concern. The also have proof-of-concept in a cloud infrastructure hosting capability.

Reviewer 2

The reviewer pointed out that the team was able to complete the project in the allotted time period. The reviewer specifically remarked that the team created Dynacurb to display real-time parking status based on sensor data. The reviewer also added that the team created an optimal curb allocation model to make suggestions for future planning. The reviewer commented that the team tested its tools in the real-world using variable message signs (VMS) to influence curb usage. The reviewer finalized that the test improved traffic conditions at the Seattle airport and reduced tailpipe emissions.

Reviewer 3

The reviewer commented on the success of the developed curb planning and management app being applied to an airport parking space. However, the reviewer also commented that the application to cities with the most opportunity to impact emissions and traffic is not demonstrated or discussed. The reviewer noted that the path to the market for public use where the curb parking areas are managed privately is not clear and recommended to further assess the path to market and the benefits to overall traffic and emissions in transportation and mobility systems.

Reviewer 4

The reviewer observed that the project has achieved the major objectives of the project. The reviewer expressed that the use of micro/macro simulators, Dynacurb platform, VMS, and the use of Amazon Web Services will further advance the research work in this area. The reviewer also noted that sensors needed to be installed in San Francisco and Seattle for technology deployment did not come to fruition. The reviewer suggested access to sensor data in Miami might help with technology deployment. The reviewer also expressed that some additional information on benefit-cost would have been helpful.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commended that the collaboration among the team members, including multiple national laboratories and universities, was presented well. The reviewer also commented that a path to the market requires further collaboration with industry and curb management software providers in the future.

Reviewer 2

The reviewer noted that all the collaborating partners contributed well and provided pieces of the project deliverables to make this project successful. The reviewer remarked that more partnerships with geographically diverse cities, airports/ports operators, logistics providers and ride-share companies would have been beneficial.

Reviewer 3

The reviewer stated that the project required collaboration with multiple different types of stakeholders, like Seattle city and multiple innovative private companies. Each team involved with the project made very specific and clear contributions.

Reviewer 4

The reviewer explained that the academic partners are all very good, but the project is missing municipalities and business partners. The reviewer recommended that the input from the business partners will add value as they are the biggest curb users, such as Uber, United States Postal Service, United Parcel Service, Federal Express, and Amazon.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project is complete, and that future use of the systems developed can be used to curb policy development and enforcement.

Reviewer 2

The reviewer remarked that more discussions of any barriers for technology deployment and how best to overcome these barriers, in particular, availability of sensors, VMS systems, and associated infrastructure needed for technology deployment would be beneficial.

Reviewer 3

The reviewer commented that the proposed future research is focused on practical extensions of the project aimed at identifying the specific conditions under which these curb management techniques are most valuable. However, future work should not just be focused on modeling and theoretically assessing the benefits and limitations of the curb management techniques but also validating those predictions with more real-world implementation.

Reviewer 4

The reviewer observed that while EV curbside charging and finding cost-effective ways to detect open spaces are listed as possible next steps, the other items listed in the next steps look to be mostly concluding remarks. For example, it is stated that “curb activity may only impact traffic flow in extreme cases, such as in ports, transit hubs, sporting events.” Three questions were proposed: 1) What would be the benefit of the developed application and simulation tool on the overall transportation, mobility, traffic, and emissions? 2) Is there any additional data and testing needed to confirm this conclusion? 3) What would be the impact when we have a mixed fleet of vehicles from EV and internal combustion engine where some curb spaces are dedicated to EV charging? The reviewer suggested that there are other important scenarios to be further assessed in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project is related to EEMS objectives to assess different software and digital technologies to improve traffic and emissions in transportation and mobility.

Reviewer 2

The reviewer stated that curb management will be a significant factor in EV charging as we transition increasingly to EV deployments nationwide.

Reviewer 3

The reviewer expressed that the project lines up nicely with the VTO subprogram objective for EEMS. As the demand for the curb spaces grows, management in a smarter manner would lead to smoother traffic flows and lower greenhouse gas (GHG) emissions.

Reviewer 4

The reviewer agreed that the project aims to reduce emissions and increase traffic flow using dynamic curb allocation techniques.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project budget was spent and looked sufficient to complete milestones.

Reviewer 2

The reviewer stated that the project completed its intended tasks in the allotted time and within budget.

Reviewer 3

The reviewer suggested that the project should have business input as well as municipality input for a more accurate assessment of the issue.

Reviewer 4

The reviewer stated that the resources seem to be sufficient. However, it was also suggested that it will be good to see how project dollars have or could have advanced the political leadership, city managers, private operators and entities’ willingness or desire to do benefit-cost analysis to install sensors and associated infrastructure for better management of curb spaces.

Presentation Number: EEMS101
Presentation Title: RealSim, An Anything-in-the-loop Platform for Mobility Technologies
Principal Investigator: Max Chen, Oak Ridge National Laboratory

Presenter

Max Chen, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

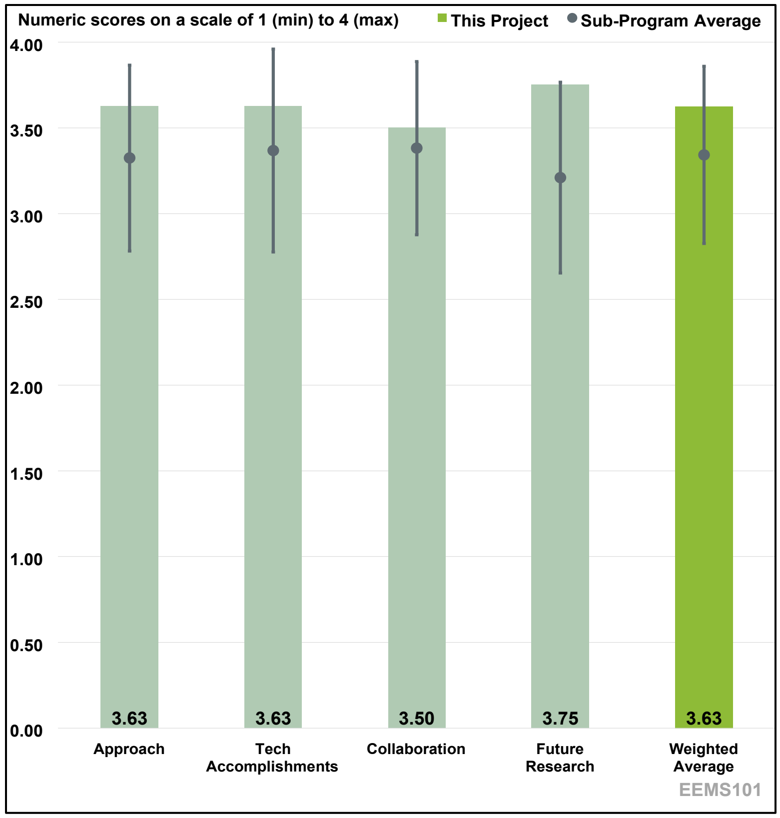

Figure 4-14. Presentation Number: EEMS101 Presentation Title: RealSim, An Anything-in-the-loop Platform for Mobility Technologies Principal Investigator: Max Chen, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project seeks to develop a flexible framework that can accommodate and integrate different models and data systems typically used in traffic simulations. The “gray box” concept is well-designed approach to achieve this.

Reviewer 2

This reviewer stated that the presentation indicates the deployment of FIXS on GitHub to be shared with the public, testing of Simulink vehicle dynamics models to replace CarMaker model, and refinement of the APaCK-V for future use cases along with data QA pipeline development and improved sensor validation.

Reviewer 3

The reviewer commented that this project well addressed barriers such as computational requirements of complex environmental simulation, and it is not easy to improve.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented the project for completing its milestones and goals, which is outstanding given the reduced staff and changing of project PI. The presentation indicates the deployment of FIXS on GitHub to be shared with the public, testing of Simulink vehicle dynamics models to replace CarMaker model, and refinement of the APACK-V for future use cases along with data QA pipeline development and improve sensor validation.

Reviewer 2

The reviewer stated that this project successfully integrated Carla-Simulink-Dynamometer simulation and also developed a prototype, as well as, provided two open-source data sets.

Reviewer 3

The reviewer stated that the project is complete and has accomplished the desired objectives to implement the framework.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer explained that the project involves collaboration between ORNL, ANL, an automotive OEM, and software developer IPG Automotive. The reviewer also added that the nature of the project requires close and precise cooperation between the partners to achieve a successful integration effort.

Reviewer 2

The reviewer stated that this project well-coordinated with ANL to efficiently work together to complete corresponding tasks.

Reviewer 3

The reviewer said that the awardee highlighted the collaborators of the project and their overall contributions. However, it was also commented that a weakness of the project was that the presenters did not provide specific details of their contribution. For example, there is no mention of how Ford provides critical feedback to the simulation and XIL testing and in which areas.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer agreed that the proposed future work is appropriate. The reviewer also asked if for the “gray box” concept to be more influential, would it need to be offered (included in software distributions) by the companies whose software is being integrated?

Reviewer 2

The reviewer confirmed that the proposed future research is solid.

Reviewer 3

The reviewer explained that the awardee has clear future reach and development goals. However, no estimated time of completion was provided.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project enables more sophisticated, realistic and flexible modeling of traffic situations, enabling demonstration of Energy Efficient Mobility System technologies to improve traffic flow in the transport system.

Reviewer 2

The reviewer confirmed that the project addresses VTO Analysis and EEMS program objectives.

Reviewer 3

The reviewer agreed that this project support the Analysis and EEMS objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project is complete, though some work has apparently been moved to a different project due to personnel shortages last year.

Reviewer 2

The reviewer stated that the proposer has finished his research in timely fashion and no financial roadblocks are mentioned.

Reviewer 3

The reviewer agreed that the resource for this project is sufficient.

Presentation Number: EEMS105
Presentation Title: Energy Optimization of Light- and Heavy-Duty Vehicle Cohorts of Mixed Connectivity Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing
Principal Investigator: Darrell Robinette, Michigan Technological University

Presenter

Jungyun Bae, Michigan Technological University

Reviewer Sample Size

A total of three reviewers evaluated this project.

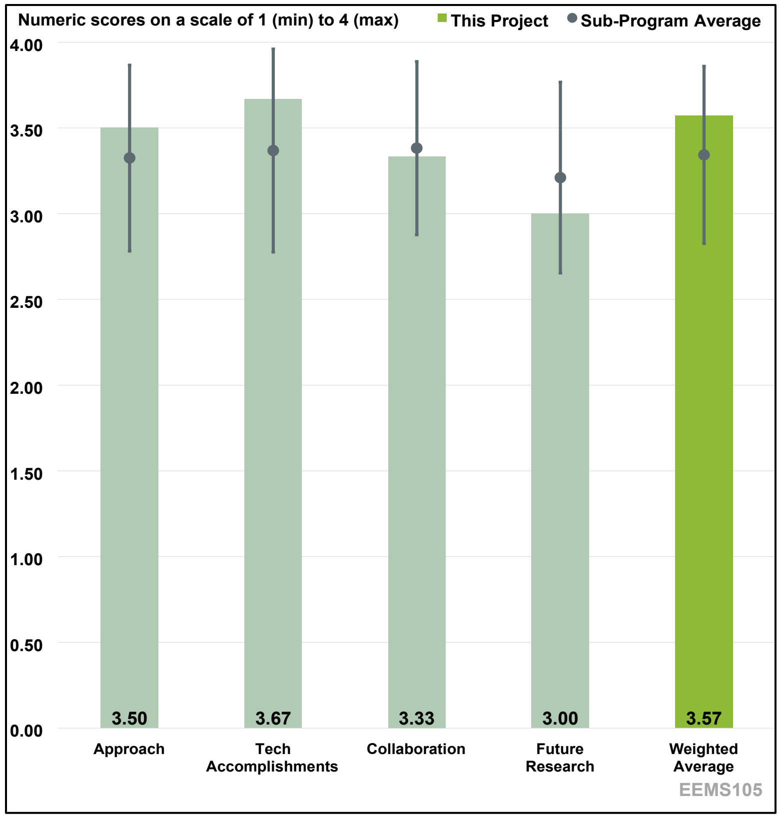

Figure 4-15. Presentation Number: EEMS105 Presentation Title: Energy Optimization of Light- and Heavy-Duty Vehicle Cohorts of Mixed Connectivity Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing Principal Investigator: Darrell Robinette, Michigan Technological University

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer expressed that the approach to investigating mixed vehicle swarms with connected and automated vehicle coordination in multiple infrastructure types was innovative and necessary to identify opportunities and boundaries of future cylinder deactivation systems. The mixing of the vehicles' order to consider drag effects across vehicle powertrains and body types was also innovative. Additionally, the timeline was appropriate for the phases of the project.

Reviewer 2

The reviewer noted that the approach of simulation to controlled testing and finally, on-road testing is effective and key assumptions are nicely detailed. The reviewer suggested that it would be helpful to have clear goals for each of these and better define how the design of experiment results led to a smaller subset of tests going ultimately to on-road testing.

Reviewer 3

The reviewer commented that the project and approach taken is complex. However, concern was expressed that although the presentation states that barriers were addressed, a number of project aspects that are declared completed are not mentioned at all in the results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer explained that the findings from simulation and test track identify optimal energy efficiency targets for mixed vehicle swarms. The combination of vehicle orders and types of infrastructure has provided target performance for future public road deployment. The demonstration of light-duty vehicle efficiency on public roads reinforced the strength of the approach, even though the HD truck powertrain and transmission did not adhere to the digital twin following performance. The reviewer concluded that the needs that have been identified by this project will inform future research with HD trucks and C-V2X communications.

Reviewer 2

The reviewer commented that while the upper end of the improvement range did not seem to be accomplished, the breadth and depth of the testing and analysis is impressive. The project demonstrated a substantial improvement in energy consumption (10-50%) in multiple important transportation scenarios. The reviewer also noted that several publications came from this work or are in progress.

Reviewer 3

The reviewer expressed concerns that the project was accomplished with marginal benefits. The project schedule mentions real public road testing. However, no mention of such testing was found. The reviewer also noted that all field results are from a closed track demonstration and experiments. The reviewer continued that given the ideal and control conditions, the marginal energy savings compared to the system complexity and requirements, questions whether this solution can have a realistic real-world implementation. A lot of knowledge was gained by this research exercise but if there is going to be any benefit it will be incremental.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted good coordination and allocation of skills and tasks across all partners.

Reviewer 2

The reviewer observed addresses collaboration within the project team with multiple businesses covering vehicles, simulation, and connectivity, along with a nonprofit for test track use. The reviewer commented that additional detail on the separation of tasks for light-duty powertrain modeling would be helpful as two teams share this.

Reviewer 3

The reviewer commented that this project included a lot of big names as partners, but it is not clear what was the contribution of most of the partners other than providing access to proprietary systems. Michigan Technological University seems to have made the largest part of the effort with AVL powertrain second. The reviewer could not find anywhere in the presentation any discussion that shows interest from entities like Navistar and BorgWarner in commercializing the developed technology.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project is 100% complete. The reviewer continued that there is a slide discussing further research but given the basic research nature of the project, there can always be more research.

Reviewer 2

The reviewer suggested that the study and improvement of connectivity latency would be welcomed. The reviewer also mentioned that future work for the digital twin effort such as gathering data from non-fleet vehicles was noted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that mixed fleet analysis and demonstration of cylinder deactivation is novel work needed in this field.

Reviewer 2

The reviewer said that the outcomes of the project support advancement and knowledge of process, equipment, powertrain, mobility management, and components.

Reviewer 3

The reviewer observed that the project has developed an overcomplicated system that depends on a lot of unstable factors to produce marginal energy savings. The research teams did not illustrate how the SoS approach can be scaled to real world scales.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that having diverse team members meets the needs of the project in terms of simulation and physical testing.

Reviewer 2

The reviewer commented that this project accomplished a lot with the given resources and although the results may be less than practical, the advancement of basic concepts was real.

Reviewer 3

The reviewer expressed the concern that it is not clear that additional resources would overcome the challenge of getting the physical HD truck to follow the requested speed profile or improve C-V2X connectivity.

Presentation Number: EEMS106
Presentation Title: Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments
Principal Investigator: Mina Sartipi, University of Tennessee Chattanooga

Presenter

Osama Osman, Leidos

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

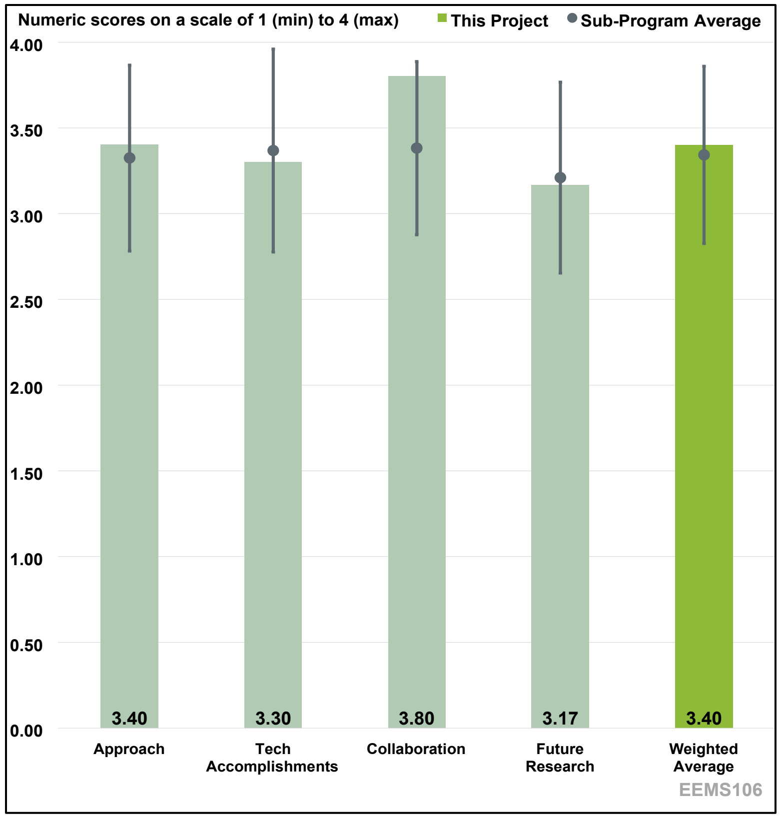

Figure 4-16. Presentation Number: EEMS106 Presentation Title: Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments Principal Investigator: Mina Sartipi, University of Tennessee Chattanooga

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that using a real-time digital twin, the project developed and implemented an adaptive signal control algorithm to reduce energy consumption and improve travel performance on a selected “smart corridor” in Chattanooga. This project was completed, included theoretical development, and proceeded to testing in the field.

Reviewer 2

The reviewer said the project execution was on schedule and addressed identified barriers.

Reviewer 3

The reviewer appreciated that the work was focused on the near term (i.e., it uses vehicle occupancy, vehicle count, speed, and signal state, which are all data that can be collected with technology available today). However, the reviewer suggested that it would be interesting in the future to see this work paired with automation and how much fuel and energy consumption could be saved. Slide 10 suggests that, in simulation, the team achieved their goal of reducing Eco_PI by 20% (reduced by 21.37%). The reviewer commented that it would have been helpful as part of the presentation to discuss intuitively what the Eco_PI performance metric is capturing to ensure it is capturing reductions in fuel consumption and GHG emissions and is the right performance metric. The reviewer further questioned if, for the hardware-in-the-loop integration, was the integration of the decentralized graph-based multi-agent reinforcement learning (DGMARL) algorithm into the traffic signal control algorithm the only test, or was it also tested to validate that the algorithm achieved the reduction in Eco_PI that was observed in the simulation? The reviewer asked for clarification about how the car-following behavior in the VISSIM simulation was calibrated. The reviewer advised that research efforts have shown that using default values and calibrating using speed and count data like recommended in the “Traffic Analysis Toolbox” can still result in wildly inaccurate trajectories. The reviewer suggested that if the car-following model has unrealistic acceleration/deceleration data, this will likely impact the Eco_PI and the goal of achieving field results within 5%of the simulation results.

Reviewer 4

The reviewer explained that the researchers met or are meeting the barriers identified, by coordinating single simulation across multiple research groups and sharing data and results. The research team demonstrated the potential for integration of Eco-ATCS in traffic controllers under real-world conditions. Given the technical challenges and barriers identified, it was necessary for the researchers to prioritize the work they did, including development of the digital twin and establishment of baseline data, however, to understand the full potential for Eco-ATCS in traffic controllers (and signalization in general) to contribute substantially to energy efficiency gains in real-world contexts, it will be necessary for future work to focus on different kinds of conditions, impacts of connectivity to other vehicles, signals, and vulnerable road-users (VRUs), and accounting for human factors in response (e.g. travel demand induced by shorter travel times, the degree of behavioral adherence to vehicle prompts, etc.).

Reviewer 5

The reviewer explained that there was some confusion between the information provided and the project title. The project description and plans did not show anything related to a connected vehicle environment. The reviewer continued that there are a few discussions regarding using cameras to track vehicles but, it is not clear if that is offered as an equivalent of receiving vehicle battery management system messages. The reviewer observed that in several slides, the traffic measurement is volume. The reviewer did compliment the handling of the barriers involving the integration of the optimization system and the field controllers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that according to Slide 2 and 4, the project is 90%complete and on-target to finish at the end of this month.

Reviewer 2

The reviewer commented that field-testing of adaptive control is actually very difficult. This project brought the work to a field test where a reduction in CO_2 emissions and an improvement in travel measures were both demonstrated.

Reviewer 3

The reviewer observed that the overall objectives are well-defined, and the project is working toward meeting the objectives. However, the reviewer was concerned that the project is not clear on addressing “Develop a multi-modal priority system” which has “A flexible priority system ready to accommodate transit priority and vulnerable road users (VRU).” Eco_PI is overly complex and therefore not clear and difficult to port to other applications and or consider other vehicle types. The reviewer suggested that a simpler energy and time optimization would seem to be sufficient. Slide 15 gives three energy/CO_2 metrics that seem to be the same savings at 3.54%. The reviewer questioned what different scenarios with different modal priorities look like.

Reviewer 4

The reviewer observed that the researchers have made substantial progress on the research plan. However, given the project end date in June 2024, it is critical that the researchers focus on ensuring that they complete the field-testing and demonstrate the fuel consumption/GHG emissions impacts, as this is the bottom line of the project. The reviewer continued that the contribution of this work to overcoming the barriers listed and meeting EEMS goals is dependent on the analysis of the energy and emissions consequences of the simulation. Thus, the success of the project requires completion of these critical steps. Similarly, the planned final report should elaborate on these results and articulate the conditions under which the simulations demonstrate the potential for Eco-ATCS technologies for reductions in energy consumption and GHG emissions.

Reviewer 5

The reviewer expressed concern that it is not clear how the full objectives of the project can be accomplished if the progress described in the presentation is by the end of April 2024. The presentation had only superficial information regarding how vehicle movements will be captured and how they are fed into the proposed system. The reviewer continued that the example photos provided on the subject show a variety of video surveillance methods, some of which are not realistic for a permanent field deployment. The above has clearly been accomplished in a simulation environment, so the proof of concept is accomplished. The reviewer agreed that it is conceivable that the technical details of integrating with the field hardware can be accomplished by June 2024.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the research demonstrated an impressive level of coordination and collaboration across several universities, research groups and a National Lab, all making significant technical contributions to the research. This work demonstrates the potential for researchers across institutions to work together on a unified project. The reviewer suggested that the unique contribution opens up opportunities for the research team to communicate some lessons learned and/or best practices for this kind of contribution in the final report or venues for communication about the project.

Reviewer 2

The reviewer complimented the leveraging the resources available at ORNL to perform “software-in-the-loop” and “hardware-in-the-loop” prior to testing this in the field. The collaboration with the City of Chattanooga was commended by the reviewer as it was observed that, it is critical to bring city and State Departments of Transportation and Metropolitan planning organizations to the table to address concerns about deployment that may not be initially acknowledged. Additionally, this gives opportunities to see and experience the technology, and hopefully encourages the implementation of other locations where this algorithm can be deployed.

Reviewer 3

The reviewer stated that the project successfully involved multiple research universities, ORNL, and a municipal government.

Reviewer 4

The reviewer agreed that the project was an overall great collaboration.

Reviewer 5

The reviewer agreed that the project teams seem to have very good collaboration going on. The reviewer commented that the project effort division takes into account each team's strengths and expertise. However, the reviewer expressed that the role of the ORNL is not clearly defined in the presentation. The reviewer understands that the PIs introduced a real vehicle on a dynamometer, but the measurement of the fuel consumption seems not to be accomplished with the current funding or under the current timeline.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the future work for this project could make important contributions, and most notably, help move this work closer to commercialization and use in the real world. To ensure that future work answers critical questions about the applicability and potential of this technology, it will be important for future work to test the Eco-ATCS use in the field and under a variety of conditions. Additional data and scenario testing will be critical, especially to inform further understanding of the degree of energy and emissions savings that occur from use of the technologies in real-world conditions (different vehicles, street designs, environmental conditions, traffic conditions, etc.).

Reviewer 2

The reviewer stated that the project was ending in June 2024.

Reviewer 3

The reviewer said that the project is nearing completion.

Reviewer 4

The reviewer pointed out that the project is ending very soon.

Reviewer 5

The reviewer observed that there was a lot of future work discussed in the presentation which covers almost the entire effort of field-testing the system. However, the reviewer also commented that given that the project ends in June 2024, it might be difficult to be accomplished without substantially more funds and time.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer articulated that the EEMS Program envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption. The reviewer continued that this project explored how a different signal control algorithm (DGMARL), which can be calibrated using technology available to deploy by infrastructure owners and operators

(IOO) today, can be utilized to reduce Eco-PI (a measure of fuel and energy consumption) expended by human drivers. The reviewer heartily agreed that this supports the EEMS program objectives.

Reviewer 2

The reviewer commented that many of the transportation system's performance problems are at traffic signals. The project demonstrated an operational improvement that can be further developed for commercialization.

Reviewer 3

The reviewer pointed out that the project addressed a key area of need and interest in urban corridor mobility and energy optimization.

Reviewer 4

The reviewer agreed that the approach taken in this project is realistic and practical. The reviewer noted that this is a solution with reasonable complexity, allowing it to evolve into a commercial application for traffic control.

Reviewer 5

The reviewer concurred that the project is relevant to EEMS scope. However, continued focus on the energy efficiency results will be critical for the remaining work and any future work to ensure the technologies and the research is informing EEMS focus.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project's resources were sufficient to bring the algorithm to a successful field demonstration.

Reviewer 2

The reviewer agreed that the project is appropriately resourced.

Reviewer 3

The reviewer commented that the project was completed on time and on budget.

Reviewer 4

The reviewer expressed that the resources appeared adequate. The reviewer also noted that there is a great distribution of resources across institutions involved. The reviewer was interested in the degree to which this distribution of resources helped make the project and collaboration successful.

Reviewer 5

The reviewer observed that the resources were sufficient to complete the project but expressed concern about the project's time and funding. Although it seems that the project is running out of time, it is not clear if it runs out of money also.

Presentation Number: EEMS107
Presentation Title: Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity
Principal Investigator: Joshua Bittle, University of Alabama

Presenter

Joshua Bittle, University of Alabama

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

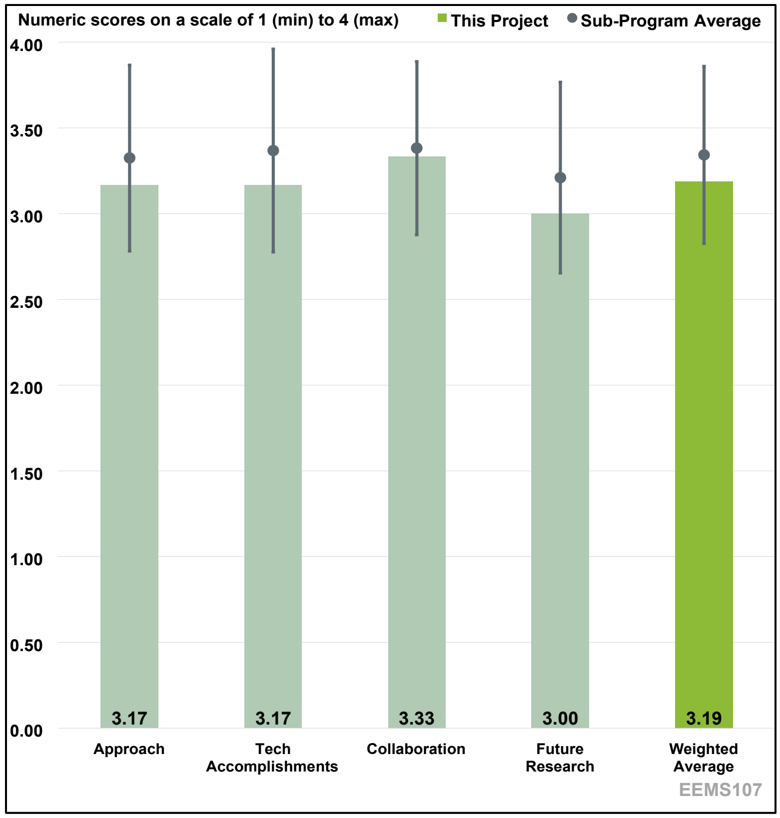

Figure 4-17. Presentation Number: EEMS107 Presentation Title: Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity Principal Investigator: Joshua Bittle, University of Alabama

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer praised the excellent job on the experiment design and the work done on data processing/sensor fusion and calibration over the last year. The insights into parameter sensitivity are extremely insightful. It absolutely makes the case to explore “truck signal priority” on arterial routes with high human-driven vehicle (HV) penetration rates (similar to transit signal priority) in the immediate term while we wait for IOOs to sufficiently deploy C-V2X and gain additional benefits. The reviewer expressed the hope that the work done to create well calibrated simulation models will pay off with the project team’s ability to achieve similar results in real world deployments.

Reviewer 2

The reviewer stated that overall, this was an excellent project specifically working to quantify the benefits of active traffic management with varying levels of CAVs.

Reviewer 3

The reviewer observed that the biggest barrier was the instrumentation of the three intersections and the processing of the data to produce vehicle trajectories. The reviewer then questioned why so much effort was put into this part of the project, since the rest of the project was conducted purely in a simulation environment. The reviewer suggested that calibrating a simple microsimulation like Simulation of Urban Mobility with high resolution vehicle trajectories is unnecessary. The reviewer did not consider this project well-designed, or the execution timeline reasonably planned. The reviewer noted a large part of the effort involved the interface of the hardware-in-the-loop part at ORNL, and did not see how the 95% of the project funds being expended on this part without results produced is justified.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project is on-budget and on-schedule for completion.

Reviewer 2

The reviewer explained that the project has made significant achievements in the implementation of in-field perception and data analysis of vehicle tracking applicable for input to the traffic controller optimization. Traffic optimization shows promise and the importance of priority of class eight truck energy consumption over other vehicles. However, the reviewer expressed concerns that the project was not clear about the connection to the individual vehicle optimization as part of this project and its contribution and what powertrain optimization is being done. The reviewer questioned if real-world scenarios with traffic and queuing constraints will be assessed?

Reviewer 3

The reviewer observed that marginal new knowledge was produced in this effort. The reviewer expressed concerns that for a project of this magnitude to just produce three simulation experiments with at least two of them using traditional traffic signal control methodologies, spending nearly $2 million is overkill for three intersections. At least from the material available for this review, the rest of the effort (sensor fusion, hardware-in-the-loop) was not essential or did not produce any actual results. The reviewer noted that, specifically in the results shown on Slide 20, the time space diagram contains some peculiar elements. The red intervals in the Federal Communications Commission (FCC) case indicate substantial cross traffic on these signals, yet the truck speed priority solution is allowed to substantially reduce these phases and the delays and fuel consumption from those vehicles stuck for several minutes on the side roads does not seem to affect the results. The reviewer suggested that the FCC control plan over constricted the mainline directions, basically making it a very easy baseline to improve from.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commended the project for bringing the Alabama Department of Transportation (ALDOT) in as part of the project team. The reviewer observed that the research team worked closely with them to understand the challenges with deploying the data collection technology in the field and worked with them to address implementation barriers at other future sites The Federal Motor Carrier Safety Administration may be interested in this type of project in the future, because they are interested in promoting connectivity to commercial vehicles through talking about safety benefits. Based on the modeling observations (that the best thing we can do for fuel efficiency is not stop heavy vehicles). The reviewer questions if this might be another way to promote connectivity to commercial trucking companies.

Reviewer 2

The reviewer comments that the work with the Alabama Department of Transportation and the City of Tuscaloosa was a great partnership.

Reviewer 3

The reviewer stated the project seems to have had good collaborations between teams although some of the efforts did not seem to be necessary.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented to be looking forward to seeing the results of the real-world demonstration.

Reviewer 2

The reviewer said that the project is wrapping up this month.

Reviewer 3

The reviewer is concerned that there seems to be a lot of things left over for the future unless the last two months of this project produced a lot of work. From Slide 23 it seems that real-world demonstration is unlikely to happen in the current project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer directly pointed out that Slide 2 states, "from USDRIVE Vehicle-Mobility Systems Analysis Roadmap, this project directly supports goals of: estimating fuel savings potential in future connected transportation scenarios and management, demonstrating the potential for real-time data collection and system modeling, and evaluating AI and ML approaches for traffic and vehicle control."

Reviewer 2

The reviewer stated that the project addressed the impact of mixed mode traffic including heavy trucks in urban corridors.

Reviewer 3

The reviewer did not see the progress in this project to be capable of advancing the Vehicle Transportation Office (VTO) objectives. The reviewer continues that the proposed solution does not involve the advanced connectivity technologies the VTO targeted for this research program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer confirmed that the project was able to achieve objectives with the budget provided.

Reviewer 2

The reviewer remarked that the resources are appropriate for the project with respect to signal optimization. However, it is not clear whether resources for single vehicle optimization were appropriate, as limited results were shown.

Reviewer 3

The reviewer commented that for the critical parts of this project accomplished, the budget was excessive. It was the reviewer's opinion that there was a lot of effort spent on parts not seen as necessary to reach the same conclusions.

Presentation Number: EEMS108
Presentation Title: Co-Optimization of Vehicles and Routes
Principal Investigator: Nick Hertlein, PACCAR

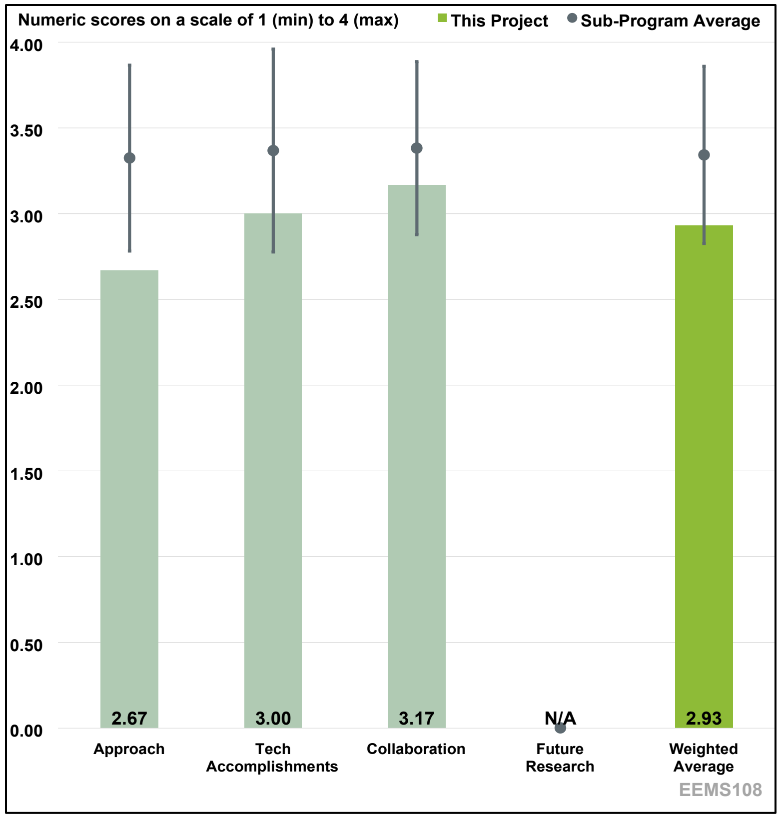

Figure 4-18. Presentation Number: EEMS108 Presentation Title: Co-Optimization of Vehicles and Routes Principal Investigator: Nick Hertlein, PACCAR

Presenter

Nick Hertlein, PACCAR

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the approach to performing the work is good.

Reviewer 2

The reviewer commented that the technical barriers appear to have been addressed. The project is well-designed for research and prototype. However, the project did not offer a business model to aid implementation.

Reviewer 3

The reviewer suggested that more time should have been planned for data analysis and organizing results. One quarter at the end of the project is currently labeled for data analysis and this is identified in the no-cost time extension period (annual quarter two, 2024). The reviewer further suggested that it would be more effective to start the analysis in annual quarter four of 2023 and cut the testing and validation period by one quarter.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the tech accomplishments are good.

Reviewer 2

The reviewer agreed that the technical accomplishments appear to be addressed. However, the project does not describe how powertrain adjustments are made or bandwidth limitations and mitigation.

Reviewer 3

The reviewer commented that the demonstration of the improvement of processes and tools to implement freight efficiency was well documented. However, results of the freight efficiency improvement metrics were unclear even though the briefing reported no remaining barriers, and the project is ending in annual quarter two (June 2024), which is the end of the extension period, not the original project period. The reviewer concluded that even if briefing time constraints were a concern with showing results or preliminary results, they could have been provided in the backup slides and were not.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer agreed that good coordination and allocation of skills and tasks between Kenworth, the NREL, Ohio State University, Kopas, and Esri.

Reviewer 2

The reviewer noted that collaboration between teams is good.

Reviewer 3

The reviewer observed that the partners have a significant role in the project's development success. The reviewer noted, however, that the partner's roles and products are critical to the entire system, which could be an issue moving forward. The reviewer stated that it would be nice to hear from them about their perspectives on adoption.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project is complete.

Reviewer 2

The reviewer said that the research is considered complete and technology transfer and business development are next.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer expressed that the project supports the VTO goals of promoting electrification and reducing emissions.

Reviewer 2

The reviewer suggested that the relevance would be demonstrated further with feedback from fleet owners with regard to cost viability and practicality.

Reviewer 3

The reviewer commented that the analysis of freight efficiency and results was light in the briefing, but the demonstration of the composite weight function on Slide 11 for energy cost and driver time for determining the optimal route is beneficial.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources were adequate.

Reviewer 2

The reviewer commented that yes, the resources are sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 3

The reviewer said that the funding, timeline, scope, and team appear sufficient.

Presentation Number: EEMS109
Presentation Title: Connected and Learning Based Optimal Freight Management for Efficiency
Principal Investigator: Ali Borhan, Cummins

Presenter

Ali Borhan, Cummins

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

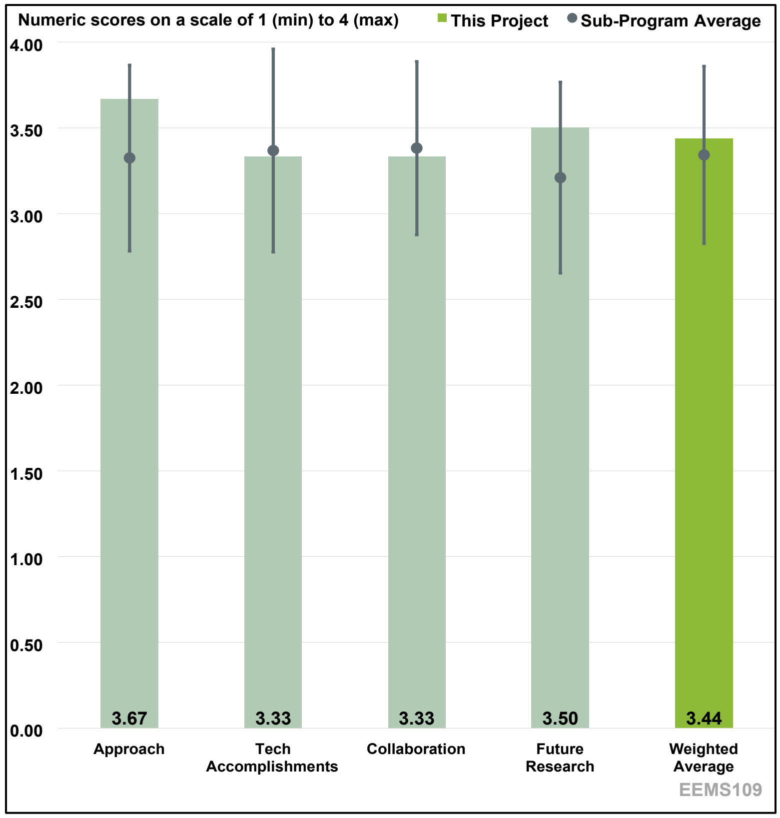

Figure 4-19. Presentation Number: EEMS109 Presentation Title: Connected and Learning Based Optimal Freight Management for Efficiency Principal Investigator: Ali Borhan, Cummins

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that this project created an evaluation tool for electrical vehicles versus diesels with the potential for use in other alternatives. The reviewer commended the approach that Cummins Inc. took to the problem using real data where possible and believed it could be the start of additional funding.

Reviewer 2

The reviewer agreed that the project was well executed and met its stated goals. The barriers of development of a software that demonstrated the target carbon emissions reductions, based on field and simulation data, were clearly met, using evidence-backed inputs with results presented clearly. Even though the project is completed, the reviewer expressed the hope that the researchers are able to get a few refereed papers out of the research, to ensure its findings are shared broadly and visible to the scientific community, as well as continue to share its findings broadly.

Reviewer 3

The reviewer articulated that the project is addressing barriers faced by the fleet owners to optimize their fleets to reduce GHG emissions, including both capital expenditure and operational expense decisions. The development of software to allow fleet owners to optimize the fleet is critical.

However, the reviewer commented that it is not clear how the rolling resistance characterization (RRC) work is integrated into the entire project. A better story of weaving that work would have been beneficial.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the researchers have made impressive progress in completing the project. The inclusion of real-world technical inputs, development of the software, tire characterization inputs, and AI applications make for a robust and important contribution to our understanding of the potential for battery EV deployment for freight truck fleet operations.

Reviewer 2

The reviewer commented that this is a big project to help the industry through a transformation. Transformations, by definition, are extremely hard and generally underestimated. This is an impressive start.

Reviewer 3

The reviewer confirmed that the project deliverables aligned well with the project plans. However, it was noted that it would have been beneficial to see more discussion about technology deployment barriers and how to address them. The reviewer suggested that it would make the project much richer by further connecting RRC work with this project. The project also lacks details on wider deployment of the technology.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the project was well executed in terms of the partnerships and collaboration across team members. The inclusion of Michelin for tire characterization, as well as National Lab expertise to ensure real-world relevance and leveraging of needed technical expertise, have made for a robust study with relevant findings for real-world deployment of battery EV technologies in HD freight operations.

Reviewer 2

The reviewer stated that there was not enough evidence of how the collaborations worked except for the ORNL piece, which was significant.

Reviewer 3

Although the reviewer agreed that the project had good collaboration and partnerships, it was also noted that the project missed out on laying out a path for how to deploy this technology more widely and with different manufacturers and fleet owners and operators.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer suggested that more funding from DOE with the intention of a commercially viable consulting solution would be good, although the project is now closed.

Reviewer 2

The reviewer did not have any comment regarding the proposed future research, but hoped, the researchers continue to share and apply the study findings.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the study is extremely relevant and responsive to EEMS objectives, as it evaluated and made important contributions to the understanding of the energy efficiency of battery electric vehicle technologies for the commercial freight trucking sector.

Reviewer 2

The reviewer observed that GHG emission reductions from freight or heavy goods vehicles is an area of concern, and this research is essential for advancing this mission’s goal of reducing GHG emissions from the trucking sector. The project has demonstrated quantitative CO_2 efficiencies.

Reviewer 3

The reviewer agreed that the project was very relevant in helping fleets and others navigate these new technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the researchers produced a robust study with the resources available. The work conducted is commensurate with the level of resources involved.

Reviewer 2

The reviewer stated that the resources of the project seemed sufficient.

Reviewer 3

The reviewer suggested that funds and discussions about technology deployment on a wider scale would be beneficial.

Presentation Number: EEMS110
Presentation Title: Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency
Principal Investigator: Yunyi Jia, Clemson University

Presenter

Yunyi Jia, Clemson University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

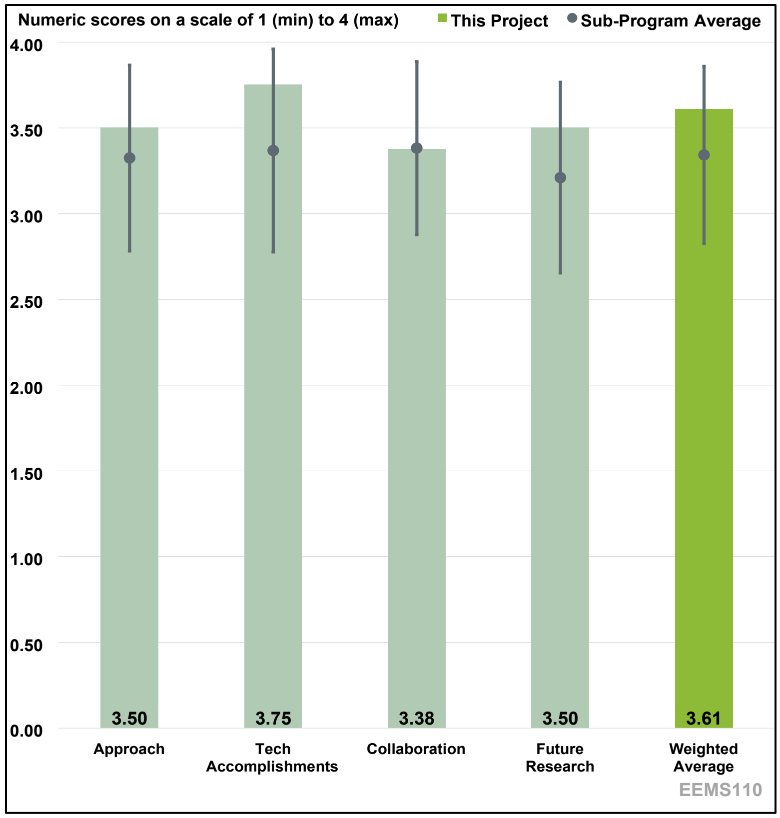

Figure 4-20. Presentation Number: EEMS110 Presentation Title: Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency Principal Investigator: Yunyi Jia, Clemson University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer evaluated the study as well-designed and expressed confidence that it will address the stated barriers. The reviewer continued that the research appears to be on track in terms of the timeline, especially given that the project team had been conducting evaluation and validation of the pooled rideshare (PR) use for the duration of the full study period. In Budget Period (BP) 3, it will be important for the researchers to focus on gathering adequate data to analyze the impact of the technology application on pooled-ride share use. This assessment of the impact of the optimization will be critical to fully understand the opportunity for energy efficiency presented by accounting for human factors in choosing rideshare.

Reviewer 2

The reviewer concluded that the purpose of the project is to improve the understanding of the circumstances under which individuals will accept PR. Then, based on that understanding, the project models PR use in different scenarios in order to guide technology design in such a way that encourages PR. The project results were presented to Uber, increasing the likelihood that they could influence the presence of PR, which is ultimately the goal. However, in order to assess the external validity of these human factor findings, a field test of the design innovations proposed by the survey and model was suggested.

Reviewer 3

The reviewer expressed that the approach is logical and the most significant factor variables are identified, though it is unclear how this data was obtained to feed the models.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer confirmed that the data gathered was effectively used to develop and partially validate the models. The reviewer also noted that system components were integrated for optimization.

Reviewer 2

The reviewer commented that the researchers have made significant progress in completing surveys, developing the tools and collecting data. The reviewer also added that to ensure the project team takes full advantage of this progress, it will be critical for the researchers to continue to collect and analyze data on the outcomes in this last budget year.

Reviewer 3

The reviewer observed that the team has achieved, at least in part, all of its goals; data was collected on PR through user studies, modeled PR usage, guided technology design, and the team has begun validating the technology design recommendations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer verified that the partnerships are adequate given the scope of the study and limited number of key stakeholders. The cooperation with Ford and J.D. Power is helpful for ensuring a strong technical backing. The reviewer commended that the Transportation Research Board (TRB) presentation yielded interest from Uber in the research. The reviewer noted that from the presentation, the PI noted that some of the work will not be able to be made public since private sector rideshare companies will not share their data and hoped that the researchers are at least able to share at a high-level useful and actionable information about the effectiveness of the interventions at increasing the proportion of users who choose PRs, where possible.

Reviewer 2

The reviewer stated that the roles of the partners were recognized and described. These partners contributions will be vital to technology demonstration and transfer to the public or private sectors.

Reviewer 3

The reviewer noted that the survey was conducted in collaboration with J.D. Power. The team also ensured that the behavioral results are being incorporated into other relevant EEMS projects to maximize the impact of the work. However, the reviewer also mentioned that it is unclear how the project team is collaborating among themselves.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed future work of a new national survey, new refinement of the model, and integration into POLARIS will be important contributions to ensuring the study is robust and maximally actionable for potential uses. The reviewer continued that given the reduction in PR being an option in many apps, an important opportunity for future research on this study will be to communicate the energy efficiency consequences of pooled share not being available to many rideshare users across the country. If the researchers are able to clearly convey the findings in an accessible way, linked to the energy or emissions impacts, and what opportunities or nudges might enable more PR availability and preferences, this would be an important contribution of this work to climate and transportation discourse. The reviewer suggested that one additional opportunity, considering the limited outlook for PR options in the near future in the U.S., is for the researchers to consider the extent to which the finding on human factors, preferences, and demographics, might be applicable to other kinds of trip choices. The reviewer explored the question, “do the moderators identified provide any insights about how decisions about transit, micromobility, and active transport infrastructure and design might make mode shift to more energy efficient modes more incentivized for users,” and commented that if the researchers are able to extrapolate any insights beyond PR, the results could be a useful contribution beyond the specific goals of the study.

Reviewer 2

The reviewer observed that the project shows the intent to further integrate the models in order to validate overall performance and energy savings improvements.

Reviewer 3

The reviewer agreed that the routing and repositioning algorithms make sense as a next step, as does evaluating the performance of the designs by incorporating them into the POLARIS. However, surveys are simply not sufficient to predict real-world behavior. The reviewer suggested that in order to truly understand whether the insights from this study will increase PR use, the researchers must conduct a more externally valid experiment, ideally in partnership with a company that offers a rideshare service.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this study is extremely relevant to EEMS, given the potential and documented impact of pooled ride share verses individual ride share trips on energy use. The reviewer continued that it will be important for the research to clearly convey the energy efficiency consequences of PR (and lack thereof) as well as insights from the surveys and modeling that informs what factors encourage or discourage PR preferences.

Reviewer 2

The reviewer stated that the project is relevant to EEMS, because it helps elucidate how rideshare (a commonly used mode of transportation) can be made more efficient.

Reviewer 3

The reviewer remarked there should be a maybe option, and said the project does not appear to be showing the energy advantage ratio that is perceived to be at an advantage to current rideshare or traditional taxi services and there could be more focus on energy.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that this is a highly complex project with reliance on the partners to provide development and data sourcing support and further resources are likely needed to fully accomplish the project goals.

Reviewer 2

The reviewer said the researchers appear to be conducting a significant amount of social science methods research for a fairly modest amount of resources. This is impressive, given the time intensity of the survey and the research design of this study. The reviewer said an impressive amount of work was done here.

Reviewer 3

The reviewer agreed that the project has made the intended progress in the allotted time frame.

Presentation Number: EEMS112
Presentation Title: NREL Core Modeling & Decision Support Capabilities (RouteE FASTSim OpenPATH T3CO)
Principal Investigator: Jeff Gonder, National Renewable Energy Laboratory

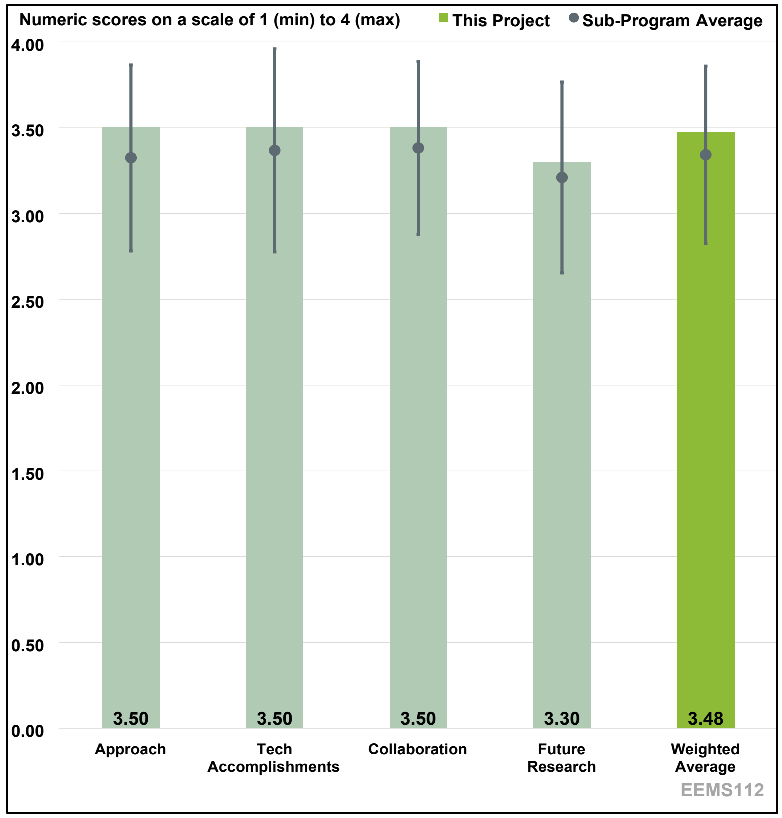

Figure 4-21. Presentation Number: EEMS112 Presentation Title: NREL Core Modeling & Decision Support Capabilities (RouteE FASTSim OpenPATH T3CO) Principal Investigator: Jeff Gonder, National Renewable Energy Laboratory

Presenter

Jeff Gonder, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the ability to expand the data sources with the understanding of the difficulties related to uncertainty and inconsistency with how it is generated is being addressed to the extent reasonable. The reviewer commented that identifying the most significant factors moving forward to aid in improving practicality will be a challenge.

Reviewer 2

The reviewer observed that adding greater complexity to the existing light-duty and HD capabilities versus adding new capabilities for analyzing other sectors (i.e., non-road), are both important. The reviewer added that from a timing perspective, prioritizing non-road development seems more important.

Reviewer 3

The reviewer agreed that the project design is good.

Reviewer 4

The reviewer commented that the maintenance, updating, and expansion of data analysis and software tools of this type is not flashy but, it is vital to help make lots of work useful to a much broader audience and drive impacts. The reviewer added that the approach to the work, getting regular input from stakeholders, expanding partnerships and awareness of the tools, and just updating the codes to run more efficiently and handle more and better data, is vital to keeping the tools relevant and increase the awareness of them. The project team's approach, which varies specifically for each tool and what that tool is intended to do, is very strong. The reviewer suggested that the project team thinks bigger, such as: what more could the project team do with more support, who would that impact, and who would be inclined to support this work because of that?

Reviewer 5

The reviewer noted that there is a widespread hypothesis that better dashboards and real-time, visually appealing metrics are both motivating and desirable for individuals and groups or cohorts for engaging in sustainability-oriented behaviors—both for making it easier to know what can be done to make a difference and to make it easier to see that they have made a difference individually and as part of the larger cohort. For transportation-oriented tools, intended to support real-time decision-making, a hand-held tool such as a smartphone app is ideal. The reviewer pointed out that one of the chief difficulties associated with testing this hypothesis is the cost and difficulty of developing such tools to test. The reviewer concluded that the project is delivering astonishing high-quality visuals in this regard, tied to very sophisticated underlying analytics.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commended the project team's list of technical accomplishments of the tools, in terms of capabilities added and use achieved is very strong and stated the team did excellent work.

Reviewer 2

The reviewer applauded the outstanding progress in the implementation of updates to transportation technology total cost of ownership (T3CO) and FASTSIM, and growing the user base across a critical cross-section of government, regulatory agencies and research.

Reviewer 3

The reviewer remarked that the effort of reducing the burden of users and therefore improving the likelihood of adoption is impressive, as is the quantification of many different data sources from collaborators. There is a reasonable effort to look forward as to how emerging technologies might influence the outcome of the research, which is hard given the limited time and budget and uncertainty as to how things will develop. The reviewer continued that effort in demonstrating and convincing collaboration from industry is key to project success and provides valuable insight into technical direction for the research.

Reviewer 4

The reviewer stated that the project seems to be making good progress and to be on track. However, the reviewer commented that the information as presented, makes it difficult to know how functional the app under development is at this time. There are three categories of progress needed for this project: develop meaningful analytics, develop a seamless and easy-to-use interface, and test it with users to refine it in a co-design process. As presented, there has been most progress on developing meaningful analytics and developing a seamless and easy-to-use interface, perhaps none yet on testing it with users to refine in a co-design process. Plans for how to test these tools are not clearly stated and are explicitly needed.

Reviewer 5

The reviewer commented that many barriers have been overcome or, at least, with some assumptions, are overcome. There are several moving pieces and so those assumptions are reasonable.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the list of partnerships and collaborations the team showed reads like an ideal wish list for any program of this type, in terms of length and diversity of collaborators. The reviewer was impressed with the level and breadth of interest and use these tools have generated. The reviewer suggested to continue work on this path, leveraging partnerships to get input on how to improve the tools and add useful data that can be added to the tools.

Reviewer 2

The reviewer commented that considering the wide range of tools that have been developed for various purposes by different people over the years, it is an impressive effort to integrate toward a larger goal and to have the foresight to use the attributes that are most influential toward the goal while leaving some behind. The reviewer noted that this demonstrated strong internal coordination. The partnerships with fleet operators operating in different conditions is a real strength for demonstrating the range of application of the research, while also creating greater exposure to the research effort and potential.

Reviewer 3

The reviewer remarked that the project showed excellent and appropriate collaboration, leading to a tangible impact on government and industry-wide decarbonization programs.

Reviewer 4

The reviewer said that several partners and players were involved, but the project was well-coordinated.

Reviewer 5

The reviewer commented that there is insufficient information provided to be able to review this component, which is a very important part of this project and needs more explanation going forward.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project is exciting and offers a rare opportunity to develop and test out a sophisticated smartphone app that could put some novel tools in people's hands. Plans for future research seem appropriate and well-aligned, and a high priority should be placed on carefully designing the following elements drawn directly from the slides; improve user engagement, implement additional gamification and personalized dashboard features, support more sophisticated automated analyses, integrate with MEP or other travel behavior analyzes tools, partnering critical to maximize impacts, build upon current successes by establishing new collaborative applications for the tools.

Reviewer 2

The reviewer stated that the project team provided a clear vision of how to build upon the accomplishments of the work so far with demonstrated understanding of the potential outcomes and benefits. The reviewer believed that the project will be more likely to succeed it the partnerships can be maintained and expanded.

Reviewer 3

The reviewer observed that the future work is clearly defined and achievable, but going forward, expanding non-road data and analytical capabilities will be an important area of growth.

Reviewer 4

The reviewer suggested that while improving the user dashboard is great, but investing more on finding additional use cases and reaching out even further would be better. The reviewer also said that adding new features based on potential new uses cases of the tool would be a plus.

Reviewer 5

The reviewer agreed that the proposed future research is in line with past and current success. Given the high quality and impact of success so far, the proposed future is likely to continue the great track record. However, the reviewer recommends the research team think larger about potential impacts, the work necessary to achieve that impact, and additional partners (including possible funders, in-kind contributors) that could be gained to accomplish that work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is relevant to EEMS and Analysis.

Reviewer 2

The reviewer agreed that the project supports the overall Vehicle Transportation Office's Energy Efficiency Mobility System objectives. The project supports the maintenance and improvement of tools that help interested entities (companies, city governments, interest groups, etc.) better understand new impacts on traffic and resource usage that new transportation technologies can have. This helps drive adoption and realize the great possibilities that new transportation technologies can enable.

Reviewer 3

The reviewer commented that the project is more likely to be adopted consistently by organizations and companies with fleets where there is some consistency and incentive for making the investment than individual citizens. However, the potential to meet the VTO objectives is high.

Reviewer 4

The collaboration with the U.S. Environmental Protection Agency (Slide 14) establishes an important milestone in the relevance and importance of T3CO.

Reviewer 5

The reviewer observed that the technological relevance of this project is high, even if just as proof of concept. The actual relevance will be determined by user feedback and whether users use it. Those results are not going to be obtained until a later stage in the project. The reviewer continued that it is tempting to consider whether this delivery system can be utilized to support other tools that are being developed by various VTO programs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer agreed that the project is sufficient.

Reviewer 2

The reviewer commented that, based on what has been presented, there seems to be good alignment between the project plan and the resources.

Reviewer 3

The reviewer said this is an issue less of whether the resources are sufficient, but what level and types of impacts you want to have. Fewer resources towards this project are still likely to have impacts, just fewer and slower. More resources seem very likely to increase and accelerate the positive impacts this project generates. So, it is more a question of “right sizing”.

Reviewer 4

The reviewer stated that considering the complexity of the project with regard to obtaining data in a manner that is consistent enough to feed the models and demonstrate reasonable outcomes in a short period of time, it seems that the resources are enough. However, this is only possible with the contributions of the collaborators.

Reviewer 5

The reviewer confirmed that the resources are substantial, and the success of the project suggests it is sufficient. The reviewer continued that the expansion of the user base and scope of the tools suggests that additional resources may be needed in subsequent fiscal years.

Presentation Number: EEMS113
Presentation Title: Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles
Principal Investigator: Lauren Harper, LACI

Presenter

Lauren Harper, LACI

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

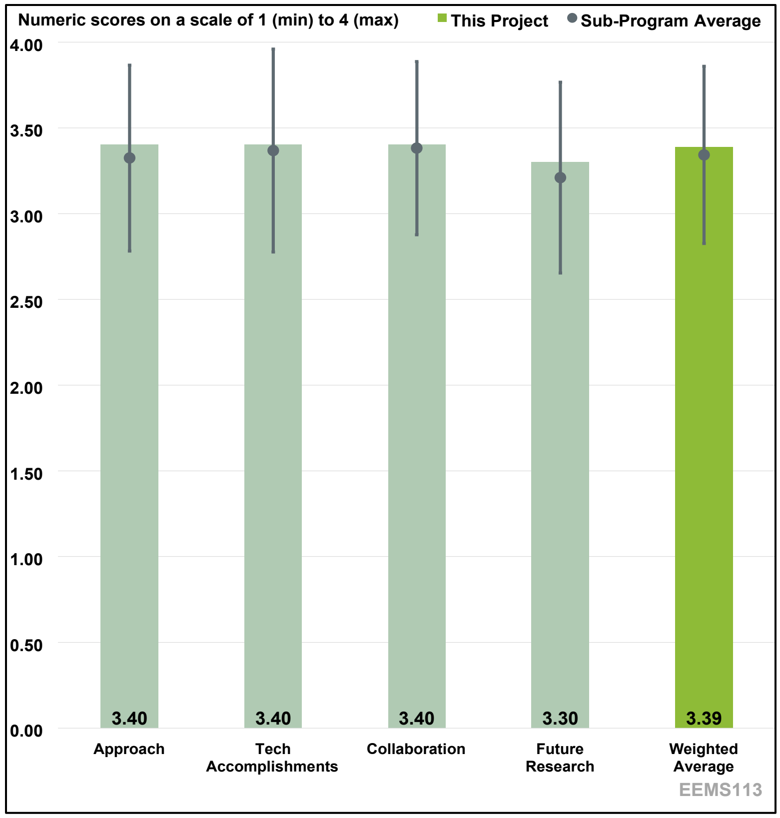

Figure 4-22. Presentation Number: EEMS113 Presentation Title: Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles Principal Investigator: Lauren Harper, LACI

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer explained that the project has an excellent approach with four main key points: to manage traffic congestion, build accurate models, compare the three cities modeling and best practices, and support policy change. To address the difficulty managing traffic congestion and enforcement in last mile and rideshare, the team has developed and is testing simulated and real-world intervention models to support EV adoption. To compare and evaluate strategies, the team is analyzing intervention implications and outcomes, incorporating feedback and new data, adjusting the models, and providing recommendations to cities. To support policy alignment on surveillance law related to data collection, enforcement, mail-based ticketing within cities, the project will inform the final roadmap for policymakers and other city governments.

Reviewer 2

The reviewer agreed that the project is well-designed, and the timeline is reasonably planned.

Reviewer 3

The reviewer expressed that the project team seems to have a good grasp of the barriers and have designed the project well. The timeline so far, had only minor adjustments, so for now it looks feasible.

Reviewer 4

The reviewer articulated that the project addresses curb congestion and related emissions and productivity losses by modeling and testing enforceable policy solutions. The design aims to leverage previous research and simulation modeling to understand how different policies would influence energy use and emissions (2023-2024). Finally, automated enforcement policies are being evaluated in several cities (2024-2025). There is evidence that the policy decreases double-parking and increases traffic flow.

Reviewer 5

The reviewer commented that this project seemed to lack focus and deliverables and was confused during the first review.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer agreed that the team has achieved all the milestones intended to be achieved by the 2024 review period, such as the model development and deployment and the beginning of the policy implementation in cities. The team has published six papers from their work so far.

Reviewer 2

The reviewer stated that the technical progress is good relative to the project plan.

Reviewer 3

The reviewer remarked that the target technical accomplishments had been made in all three locations. The Pittsburgh project has influenced policy changes in the city parking codes along with enforcement. The Santa Monica and Los Angeles projects have both moved, and it is likely that Santa Monica will follow Los Angeles in policy changes. Los Angeles also has increased to 11 sites, with 30 more considerations.

Reviewer 4

The reviewer affirmed that this is a multifaceted project that involves a lot of entities from the public sector. For now, it looks like the proposed approach is progressing in a satisfactory manner and it is accepted by the infrastructure owners.

Reviewer 5

The reviewer expressed concerns that the compliance seemed to be the goal and progress was confusing. The reviewer also noted the project team skipped around with examples in different geographies.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaboration across the team is excellent. However, the lack of a transportation stakeholder with current last mile delivery data, future plans on equipment and delivery methods are lacking. The reviewer suggested that the team needs a transportation stakeholder with delivery industrial engineering acumen.

Reviewer 2

The reviewer confirmed that the collaboration across teams is good.

Reviewer 3

This reviewer remarked that this is an extremely complex and challenging collaborative project, and it would not be possible without extremely effective coordination among researchers, policymakers, and technology providers.

Reviewer 4

The reviewer observed that it is difficult to keep public sector entities excited and delivering tasks, especially policy-related actions, reliably and on time. The project has encountered some difficulties, but for the most part, nothing yet that would put a doubt on the effectiveness of these partnerships.

Reviewer 5

The reviewer commented that the project seemed ok but was unsure of each companies' deliverables.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer expressed that the future work is clear and valuable, but it also seems to be quite extensive for the remaining time available in the project. In addition to conducting stakeholder data gathering and measuring the success of policy deployment, the team also proposes to develop resources to support EV adoption among delivery drivers, refine models and data frameworks, and implement the automated license plate reader technology in new contexts. The team has to address its ongoing implementation challenges, such as connecting with Technology Network Company drivers.

Reviewer 2

The reviewer stated that the proposed next steps are satisfactory.

Reviewer 3

The reviewer listed that the future research includes modeling for mesoscopic and microscopic scopes with the team laboratories, continuing to scale Smart and Zero Emission Loading Zones in Pittsburgh and Los Angeles, and hosting listening sessions with drivers and fleet managers and test interventions and scenarios in the models.

Reviewer 4

The reviewer explained that the plan is still unfolding, and no major or unsurmountable issues have been reported.

Reviewer 5

The reviewer commented that there was confusion about exactly what else was to be done.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project aims to increase efficiency in mobility systems by improving traffic flow, EV adoption, and equity.

Reviewer 2

The reviewer agreed that the project supports overall VTO objectives of clean, efficient transportation.

Reviewer 3

The reviewer confirmed that the research is very relevant to the adoption of EVs. With this research there can be an accurate model and plans to follow to reduce emissions and improve mobility.

Reviewer 4

The reviewer commented that the project generates real world progress. Only a few of such projects exist, so the work is needed and commendable.

Reviewer 5

The reviewer was not sure on the relevance of the project supporting overall VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer confirmed that resources appear to be sufficient for stated objectives.

Reviewer 2

The reviewer agreed that the resources are sufficient for the current team and stakeholders.

Reviewer 3

The reviewer said that the project is accomplishing its goals within budget and on time with a six-month extension.

Reviewer 4

The reviewer claimed that the project seemed sufficient but had a confusing scope and deliverables.

Reviewer 5

The reviewer noted that the project has a large budget. The reviewer observed that from the provided material it seems that a lot of city-wide systems are purchased, but how much are these costs to the project and how much are in-kind matching is unclear.

Presentation Number: EEMS114
Presentation Title: Real Twin
Principal Investigator: Ross Wang, Oak Ridge National Laboratory

Presenter

Ross Wang, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

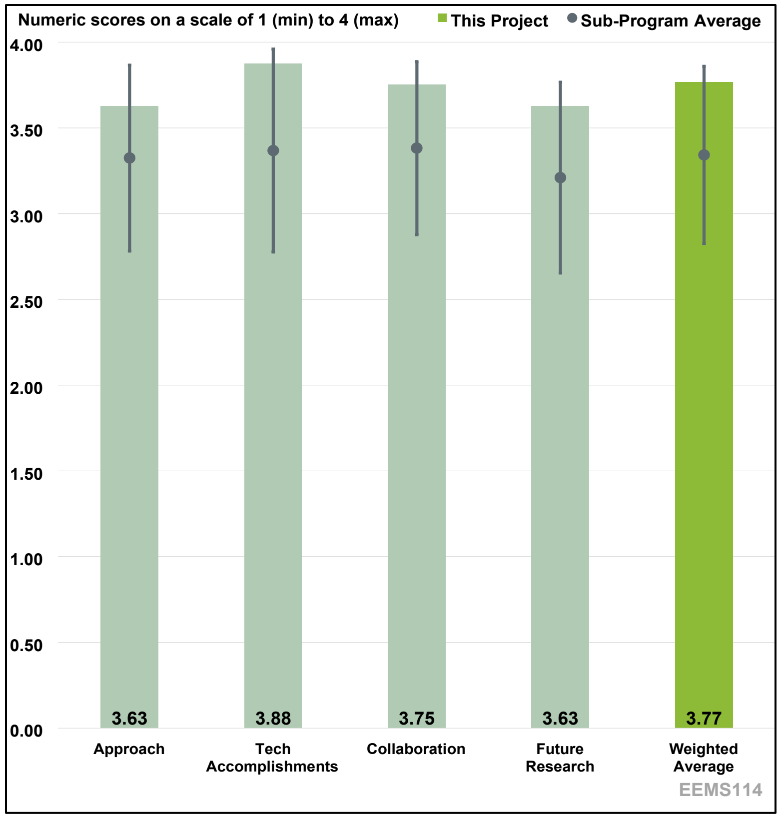

Figure 4-23. Presentation Number: EEMS114 Presentation Title: Real Twin Principal Investigator: Ross Wang, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the proposed approach to the problem looks great, in proper sequences to develop workflows, scenario generation tools and connecting them to exercise.

Reviewer 2

The reviewer agreed that the project proposed a unified, model agnostic scenario generation capability that is important to evaluate different energy and environment related strategies using the same and identical scenarios.

Reviewer 3

The reviewer noted that Slides 6-15 represented a well-thought-out approach to implementing the proposed project and did not have further suggestions of what to do differently.

Reviewer 4

The reviewer observed that the project approach is consistent with the overall goals and with overcoming the technical barriers identified. The challenge of creating consistent input files or “scenarios” across different software products with different internal models and algorithms is very difficult. However, it is noted that while an exact translation of scenarios is probably not feasible (for any approach) due to some underlying differences in the internal models and parameters embedded in the tools, the approach taken by the team seems to be sound.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that all proposed milestones are met based on the timeline as proposed and expressed excitement about the idea of Real-Twin with hopes seeing successful finalization.

Reviewer 2

The reviewer said that the project is well-designed and could support scenario generation and calibration (semi-automated) which streamline the testing process.

Reviewer 3

The reviewer agreed that the project is making great progress compared to the project plan and is on track to finish in December 2024.

Reviewer 4

The reviewer observed that the project team is making successful progress. The reviewer also noted that there may never be a perfect translation of scenarios from disparate tools, but the project team seems to be making strides in greatly reducing the level of effort required for researchers to develop “equivalent” scenarios across different tools.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project is interconnected with other EEMS projects and supports multiple projects in the field. Various stakeholders are supporting the project well, which seems very positive.

Reviewer 2

The reviewer said that the project is well collaborated with technical partners to complete target tasks.

Reviewer 3

The reviewer explained that the project is well coordinated across a diverse set of stakeholders, including universities, federal agencies, simulation tools developers, the DOE, OEMs, and local agencies.

Reviewer 4

The reviewer commented that although there are not really project partners, there are many project stakeholders that the team is coordinating and collaborating with. The stakeholders include representatives of other DOE projects, OEMs, and the DOT.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the plans for future research have been presented in detail, and how to connect with other EEMS projects. The reviewer looks forward to seeing the case study results in the future.

Reviewer 2

The reviewer said that the proposed future research is solid.

Reviewer 3

The reviewer stated that the project team has a strong approach to how they will wrap up the last six months of the project. Additionally, the reviewer expressed deep appreciation for the semi-automated calibration method chosen to be in alignment with the traffic analysis tool (TAT) and commented that this will help significantly with getting the method adopted by practice. The reviewer asked if the project team used the original method or the updated 2019 methodology, due to a lack of a citation to check in the slides. The reviewer continued that the FHWA has learned is that it makes a really big difference if you are using traditional data (e.g., counts, flow, travel time) or trajectory data for microsimulation model calibration. In work completed by FHWA, it was found that for a model calibrated using the TAT methodology, a model can be "well-calibrated" according to typical performance metrics. However, the trajectories are less accurate than if default parameter values had been used. The inverse was true if only trajectories were used for calibration (the more macroscopic performance measures suffered significantly in accuracy). FHWA found that a hybrid calibration method using both types of data resulted in the most accurate performance metrics, using holdout data for validation. The reviewer noted that given the DOE focus on emissions (which are extremely sensitive to acceleration/deceleration behavior), it might be worth using trajectory data as an additional calibration dataset in the future, such as from FHWA research on this topic.

Reviewer 4

The reviewer commented that the team will continue to work on the transferability of simulation scenarios across tools, such as extending the scope of the parameters and settings to include advanced simulation settings and agent behavior. The reviewer added that the plan for outreach for this scenario tool to make it available to all researchers, not just DOE sponsored researchers, is not totally clear.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project aligns perfectly with what the VTO and EEMS programs aim to achieve.

Reviewer 2

The reviewer stated that the project covers the VTO objectives: Analysis and EEMS.

Reviewer 3

The reviewer confirmed that the project is very supportive of EEMS goals by developing a tool that strives to create consistency in the evaluation of connected vehicle applications and also reduces the level of effort required to develop consistent scenarios across different analysis and simulation software packages.

Reviewer 4

The reviewer explained that simulation is one of the best ways to better understand what the impacts could be when there are significant uncertainties (e.g., automation). However, because the simulation is so sensitive to the assumptions in the underlying scenario, it makes it very challenging to compare across projects/simulations (e.g., apples to oranges... or drastically different results, so much so that there are limited insights that can be drawn). The reviewer agreed that the project keeps delivering a unified scenario generation capability that is model agnostic and ensures consistent scenario simulation across different microsimulation platforms, making it easier to various projects to work together and build on one another. This is a significant contribution to the field and seems EEMS program objectives (as simulation is necessary to understand what methods help to decouple carbon from increased mobility opportunities).

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project seems to have sufficient resources within the team and has solid support from stakeholders.

Reviewer 2

The reviewer said that the project has sufficient resources.

Reviewer 3

The reviewer agreed that the project is on-track to be completed on-time and on-budget, indicating that resources are appropriate.

Reviewer 4

The reviewer stated that the resources appear to be sufficient to complete the work.

Presentation Number: EEMS115
Presentation Title: Modeling Connected and Automated (CAV) Compute Power
Principal Investigator: Ben Feinberg, Sandia National Laboratories

Presenter

Ben Feinberg, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

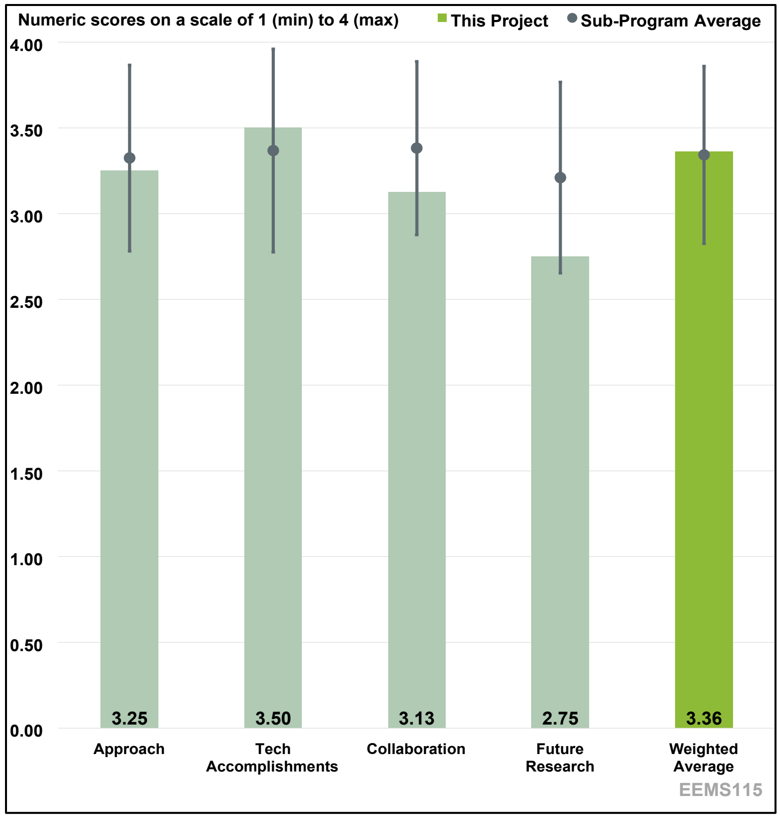

Figure 4-24. Presentation Number: EEMS115 Presentation Title: Modeling Connected and Automated (CAV) Compute Power Principal Investigator: Ben Feinberg, Sandia National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the approach to solving the problem seems properly planned, starting from defining workload, scheduling workloads, generating energy-consuming events from the schedules, and validating end-to-end processing latency.

Reviewer 2

The reviewer remarked that the project is complete, and the timeline is not relevant. However, it is also expressed that it is not exactly clear where or to whom this tool will be useful, but Sandia’s role in managing the project between key collaborators will be important in clarifying the problem statement and need for a tool.

Reviewer 3

The reviewer stated that there was no constructive feedback on the approach and congratulated the project team on successfully completing the project in March 2024.

Reviewer 4

The reviewer was not sure of the assessment of the second barrier “Revisit and expand the traditional systems engineering ‘V Diagram’ to consider vehicle operational environment,” and how this project is addressing this particular barrier.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer confirmed that the technical progress in developing the analysis is impressive, although limited in scope.

Reviewer 2

The reviewer said that the proposed all milestones were met within the given timeline.

Reviewer 3

The reviewer confirmed that according to the Slide 4, all milestones on the project plan were met prior to the completion of the project.

Reviewer 4

The reviewer commented that it is difficult to assess the provided results as vehicle energy consumption is complex compared to figures on Slide 3, which uses a constant 300Wh/mile. It would be very helpful to capture and categorize power and energy costs for sensing, perception, etc.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer agreed that the collaboration with The United States Council for Automotive Research is a good start, but broadening the collaboration in future efforts to include vehicle-to-infrastructure (V2I) providers, in addition to OEMs and Tier 1s, will be important to evaluate onboard versus offboard computational sensing and computational loads.

Reviewer 2

The reviewer observed that there is ample opportunity to collaborate across the EEMS community; the researcher should consider if this project would continue.

Reviewer 3

The reviewer stated that the team showed excellent collaboration through monthly meetings with the working group and continuing work.

Reviewer 4

The reviewer expressed that the collaboration seems limited.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that according to the Slide 4, all milestones on the project plan were met prior to the completion of the project.

Reviewer 2

The reviewer said that no further research is planned because it is the end of the project.

Reviewer 3

The reviewer observed that according to the Slide 4, all milestones on the project plan were met prior to the completion of the project.

Reviewer 4

The reviewer stated that the project has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project aligns well with the VTO and EEMS, focusing on computation power distribution to enable autonomy efficiently.

Reviewer 2

The reviewer noted that in various forms, CAVs are an important part of future decarbonization strategies. The reviewer suggested that the development of the tool may be helpful in assessing tradeoffs of onboard and V2I systems.

Reviewer 3

The reviewer commented that parasitic energy consumption of CAVs need to be understood against their benefits for potential energy savings. Building up information on the compute energy is an important part of the overall energy consumption but should consider what is needed for advanced driver assistance system, automated vehicles versus automated vehicles with energy optimization.

Reviewer 4

The reviewer comments that EEMS Program envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption. The reviewer suggested that the presenter did not do a great job of communicating the bigger picture of why the project is important.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project is complete.

Reviewer 2

The reviewer agreed that the resources are sufficient.

Reviewer 3

The reviewer stated that the project is accomplished successfully within the resources given to the team.

Reviewer 4

The reviewer commented that the project was able to achieve its objectives with the financial resources made available and is sufficient.

Presentation Number: EEMS116
Presentation Title: High-Quality Perception Data
Principal Investigator: Zach Asher, Western Michigan

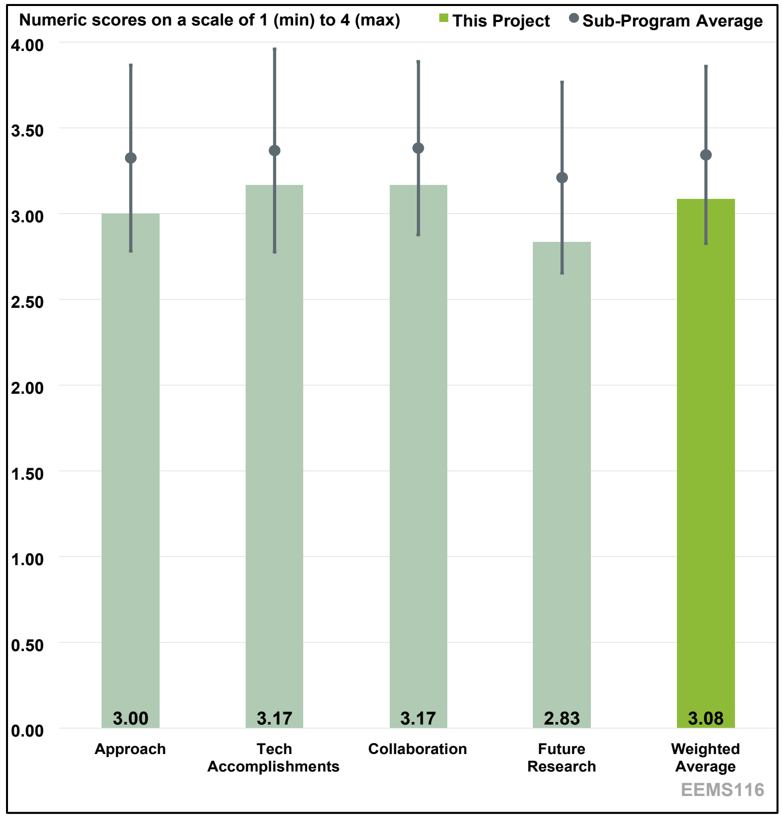

Figure 4-25. Presentation Number: EEMS116 Presentation Title: High-Quality Perception Data Principal Investigator: Zach Asher, Western Michigan

Presenter

Zach Asher, Western Michigan

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

83% of reviewers felt that the project was relevant to current DOE objectives, 17% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 17% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the work is excellent and provides interesting perspectives on sensing and perception factors in CAVs.

Reviewer 2

The reviewer commended the project for being well thought through and well-designed but cautioned that the timeline for the remaining work seems a bit ambitious. The reviewer commented that the project will help further the safety of the vehicles while reducing online computing and sensor loads. The reviewer said the future is heading in the direction of having intelligent/sensor embedded infrastructure and this project will help further the critical understanding. The reviewer concluded the per vehicle load savings might be modest, but collectively they will add up.

Reviewer 3

According to the reviewer, the project is well designed overall, and the timeline is reasonably planned. The reviewer added that results (energy impact) will be highly dependent on driving/environmental scenarios modeled. The reviewer finished by stating that greater detail on scenario definition, probability and energy impact would enable a better understanding of overall energy impact of technology implementation.

Reviewer 4

The reviewer summarized that the project is developing several early-stage infrastructure-based sensor technologies, and the project has a sound work plan to investigate and develop all technologies. The reviewer noted that most of the project milestones have been met, and the project is set to conclude at the end of the calendar year following on-road testing, engagement activities, and the completion of the final report. According to the reviewer, many technical barriers were addressed, and as the project was working to develop early-stage technology, more barriers were discovered. The reviewer noted that the project team does have plans to continue developing the most promising technologies studied; in particular, the Chip-Enabled Raised Pavement Markers (CERPMs) technology.

Reviewer 5

The reviewer acknowledged that the project encountered technical barriers that presented challenges for the team. The reviewer concluded by saying the team managed through some of the inherent limitations to detection in the on-road environment.

Reviewer 6

The reviewer stated barriers are presented as objectives without showing a link between them. The reviewer added if the goal is to reconfigure the existing technology within automated vehicles coupled with reliance on roadway infrastructure to achieve modest improvements in energy consumption, then the approach is reasonable; however, no experimental matrix is presented to assess overall success and draw statistically significant conclusions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that good progress has been made on evaluation of all proposed technologies. The reviewer suggested that consideration of reliance on existing sensors as a safety backup should be researched, and the possibility of incumbent sensors being removed or switched to a low power mode until needed and still fulfilling safety requirements should be evaluated and included in the overall energy impact.

Reviewer 2

The reviewer said the project is well executed and deliverables provided on planned dates but cautioned that the remainder of deliverables seem a bit ambitious in the timeline but doable. The reviewer stated the work further enhance use of CERPM, radar retro-reflectors (RRs), etc. and addresses the safety aspects. The reviewer concluded that this work is much needed as new and better on-board and infrastructure related sensor technologies continue to advance, and the results will increase awareness and quantification methodologies for estimating load savings.

Reviewer 3

The reviewer noted that the team made significant progress in developing the various sensor technologies included in the scope of this project. The reviewer listed key findings resulting from project work, including: 1) CERPMs shows great promise for lane line detection and can be affordable to implement. The project team is looking to commercialize this product through a Small Business Innovation Research (SBIR) funding opportunity. 2) Radar retroreflectors have been challenging to develop and require further study. 3) Existing weather sensors, for example, those at airports, work better than what could be purchased/implemented. 4) HD map data is promising when used in conjunction with other sensor types, but it seems that the quality of the data is crucial to its success. The reviewer concluded while not all tested technologies will reach the target technology readiness level increases, this project did make significant progress in developing and testing the infrastructure-based sensor technologies.

Reviewer 4

The reviewer described the project's approaches to infrastructure sensor developments (e.g., CERPMs) as interesting, and noted that its applications extend beyond energy to safety and other factors.

Reviewer 5

The reviewer said the project has made expected progress compared to the project plan and is on track to complete the intended scope.

Reviewer 6

The reviewer concluded that there is not a project plan presented, but rather a table of milestones, so it appears that they are on track. The reviewer advised that deeper and more frequent stakeholder communications would be appreciated.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented the project appears to be well-coordinated, and collaboration efforts support the project's objectives.

Reviewer 2

The reviewer noted the project's good level of collaboration with partners and suggested that an additional collaboration with an automotive industry company would be beneficial. The reviewer explained that this would enable further context refinement and understanding of implementation barriers.

Reviewer 3

The reviewer noted the project has a good set of collaborators and well-rounded list of stakeholders, and that it is good to see a couple of State Departments of Transportation (DOTs) and mention of Metropolitan Planning Organizations (MPOs). The reviewer concluded it will be beneficial to see collaboration or partnership with U.S. DOT/(National Highway Traffic Safety Administration (NHTSA)/FHWA/Turner-Fairbank Highway Research Center (TFHRC), etc.

Reviewer 4

The reviewer commented the project team appeared to achieve their goals to collaborate with partners from industry and the national laboratories.

Reviewer 5

The reviewer commented the project could seek additional collaborations with OEMS/suppliers.

Reviewer 6

The reviewer said that collaboration within the project team is not described or demonstrated. The reviewer added that the collaborators are presented along with their roles.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated future work is essential and absolutely needed, and the plan is well defined. However, this reviewer noted the timeline seems a bit ambitious, but manageable. The reviewer expressed excitement for future work and suggested connecting with NHTSA and other U.S. DOT administrations.

Reviewer 2

The reviewer expressed that opportunities to commercialize some of the technologies seem promising.

Reviewer 3

The reviewer suggested future work should focus on defining scenarios for technology evaluation and scenario-based energy impact determination; The selection of one static route for analysis will not be comprehensive of the spectrum of energy impacts from technology implementation.

Reviewer 4

The reviewer commented that proposed future research will take place this calendar year and complete all project milestones, including on-road demonstrations and engagement activities. The reviewer asked if at this stage, the project team has considered how different types or sizes of vehicles (e.g., transit vehicles vs. personal vehicles) might interact with the sensors?

Reviewer 5

The reviewer observed that future work appears to finish what should have been accomplished in this project without an explanation of what the potential significance is anticipated to be. The reviewer finished by stating the targets are not listed.

Reviewer 6

The reviewer commented the project has defined their goals for future work, however, given the known technical challenges, there is uncertainty as to whether the future work would achieve its targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted the program supports the overall VTO subprogram objectives and directly addresses an area of automated driving energy use. The reviewer added that the program is unique in that it addresses low-cost infrastructure technologies.

Reviewer 2

The reviewer commented the project supports understanding and minimizing energy consumption for sensors and perception. The reviewer mentioned that weather has a significant impact on vehicle energy consumption and taking this information into account could be used in vehicle optimization.

Reviewer 3

The reviewer commended this project because it will help develop better transportation systems and continued by noting that sensors are becoming ubiquitous; research is needed on how best to utilize and best place them. The reviewer concluded the research will help designers and planners to see the benefits of incorporating sensors in infrastructure and using less on-board sensors.

Reviewer 4

The reviewer commented the project supports EEMS goals to improve energy efficiency of mobility systems because it seeks to improve energy efficiency of electric and automated vehicles.

Reviewer 5

The reviewer stated the project supports EEMS subprogram objectives.

Reviewer 6

The reviewer highlighted out the project's demonstration of incremental improvements to existing technology, even modest if demonstrated, but pointed out there is no acknowledgment human factors, a significant barrier.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer asserted the project is well funded.

Reviewer 2

The reviewer stated resources for this project are sufficient.

Reviewer 3

The reviewer noted the project is on track with existing resources.

Reviewer 4

The reviewer commented the resources are sufficient to achieve the stated milestones within the remaining project timeframe (by end of calendar year 2024).

Reviewer 5

The reviewer remarked resources appear to be sufficient and the remaining budget is sufficient to complete the project in a timely fashion.

Reviewer 6

The reviewer asserted the resources provided may be enough to integrate and demonstrate some efficiencies in the system, although demonstrating through field trials and fitting the infrastructure with sensors will itself consume the whole bank of time and money if done properly.

Presentation Number: EEMS117
Presentation Title: Visual-Enhanced Cooperative Traffic Operations (VECTOR) System
Principal Investigator: Achilleas Kourtellis, University of South Florida

Presenter

Xiaopeng Li, University of Wisconsin Madison

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

50% of reviewers felt that the project was relevant to current DOE objectives, 50% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

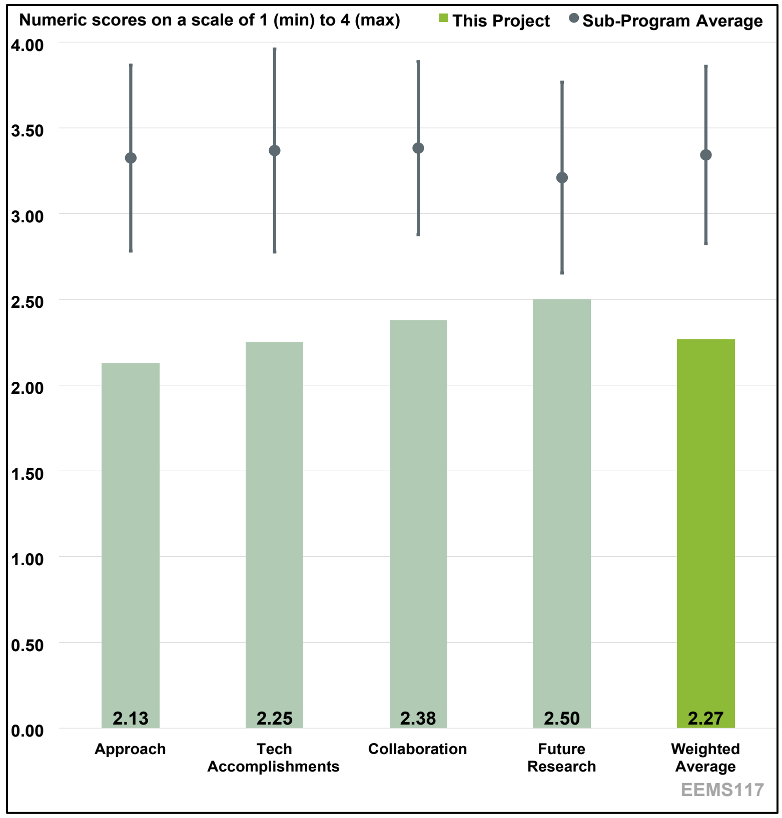

Figure 4-26. Presentation Number: EEMS117 Presentation Title: Visual-Enhanced Cooperative Traffic Operations (VECTOR) System Principal Investigator: Achilleas Kourtellis, University of South Florida

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted the project appears to be on the cusp of completing BP 1 tasks and beginning BP 2 (Slide 4 describes BP 1 go/no-go criteria, but did not clearly indicate if this had passed, though it appears to have done so). The reviewer continued by stating key modules in BP 1 appear to have progressed per the well-developed and detailed project plan. The reviewer added that this comment could also go into the Future Work session, but since the question asks to consider project design, the concerns will be raised here. Concerns for the project are noted: 1) The number of use cases five (5) is rather large, and much more detail needs to be given to assess the use cases. 2) In freeway corridors and urban arterials—the most straightforward of use cases, which scenarios will be tested? (lane changing, cut-offs, etc.). 3) “Multi-modal transportation” as a use case seems far too broad. 4) What are the specific aspects of rural corridors that make it unique compared to other use cases?

Reviewer 2

The reviewer stated the target of making improvements in cost and energy consumption of existing automated driving infrastructure is a low bar considering the larger barrier of human factors.

Reviewer 3

The reviewer asserted the project appears to have a number of modules/enablers that could each be project in isolation. The reviewer stated it is not clear how the modules interact and work together with a goal to achieving project objectives. The reviewer concluded the proposed impacts are very high, and it is unclear how the research corresponds to them.

Reviewer 4

The reviewer asserted that the decision to use light signals combined with cyclic redundancy check (CRC) encoders and decoders for vehicle-to-vehicle (V2V) communication must address the issues with significant attenuation by dirt on surfaces of the CRC encoders and decoders, inclement weather, dust storms, doppler effect, and other interferences, especially intervening vehicles and physical barriers (e.g., highway walls, tunnels, and bridges), as the reviewer thinks the reliability of the VECTOR system needs to be compared against wireless radio or microwave communication. The reviewer pointed out the use case of a rural scenario like Zion National Park, where there is no traffic congestion, and thus, no drastic need to improve energy efficiency could be justified further; another major shortfall is the lack of focus on safety.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented the project has made excellent progress. The reviewer noted the AI sensing module has achieved 99% accuracy but wondered if that will be good enough from a safety standpoint; although no standards have been established, and there is likely redundancy in the sensors, from a safety and regulatory perspective, 99% at first glance seems too low. The reviewer considered the significance of some of the improvements and explained reducing energy consumption of AI sensing is laudable, but when it is 100W system, at 8 hours of direct operation, that is still less than 1 kWhr, and the savings from the project get you to 0.64 Kahr. The reviewer concluded by asking if one assumes a 75 kWhr battery, how much does this really move the dial?

Reviewer 2

The reviewer commented the technical progress seems fair and suggested the project team might consider including the stakeholders much earlier, such as at the beginning of the project.

Reviewer 3

The reviewer asserted that, because it is not clear how the project plan will address the technical barriers, it does not appear that technical progress will actually deliver in solving these barriers. The reviewer added that the edge computing and control module appears to have the most critical role in delivering impact and addressing the technical barriers, but its development is lagging behind the other modules.

Reviewer 4

The reviewer commented the project plan provided neither target dates nor milestones and thus technical progress could not be determined.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the roles and responsibilities for each partner were not clearly communicated.

Reviewer 2

The reviewer observed there were no partners from the U.S DOT, especially from the Intelligent Transportation Systems Joint Program Office, which deals with CAVs or from the Volpe National Transportation Systems Center or from the FHWA.

Reviewer 3

The reviewer commented many partners are listed, but the contribution of each was unclear.

Reviewer 4

The reviewer stated that it's not clear what all of the partners are contributing to the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented from a broad perspective, the future work is aligned with project targets, but more specific deliverables and linking between tasks and the final objectives is necessary.

Reviewer 2

The reviewer asserted the proposed future research is satisfactory.

Reviewer 3

The reviewer expressed the cost of conducting the "use cases" does not appear to be realistic in comparison to the overall budget. The reviewer commented it is not yet determined how the other partners are expected to contribute to the effort, and finished by stating the extent of coordination, given uncertainties such as weather and other unforeseen events pose high risk of meeting goals in the given time frame.

Reviewer 4

The reviewer referred to prior comments.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commended the project, and expressed excitement for seeing more results, particularly as it moves to field testing. The reviewer continued by saying since the DOT is also doing a considerable amount of CDA research and testing, coordinating and communicating with DOT should be important.

Reviewer 2

The reviewer stated if this were implemented on a national scale and all the vehicles were electric, perhaps some slight energy savings might be achieved.

Reviewer 3

The reviewer commented at high level, the VECTOR system supports overall VTO subprogram objectives; however, it is difficult to see how the project will tangibly deliver results.

Reviewer 4

The reviewer criticized the use of light for V2V communication instead of radio or microwave wireless communication.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the allocated resources are sufficient.

Reviewer 2

The reviewer stated that while the project has a lot of use cases, it is also at 39% spent, so it appears to be sufficiently resourced.

Reviewer 3

The reviewer commented that the design, implementation, execution, analysis and validation of just the “use-cases” could easily consume the budget.

Reviewer 4

The reviewer asserted $4.8 million is too much for this kind of work.

Presentation Number: EEMS118
Presentation Title: AI-Based Mobility Monitoring System and Analytics Demonstration Pilot
Principal Investigator: Scott Samuelson, University of California Irvine

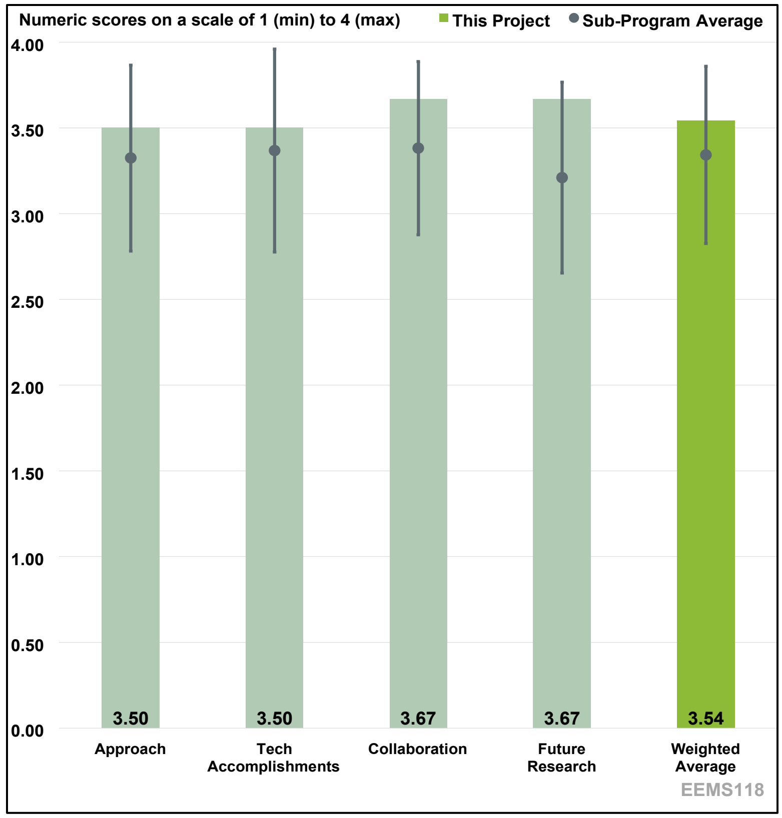

Figure 4-27. Presentation Number: EEMS118 Presentation Title: AI-Based Mobility Monitoring System and Analytics Demonstration Pilot Principal Investigator: Scott Samuelson, University of California Irvine

Presenter

Blake Lane, University of California Irvine

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that this is a great study scope and frame, and the fact that it allows for testing of different levels of CDA, and other scenarios is appreciated. The benefit of having a sample size of 25 intersections is noted, provided the overall traffic numbers and vulnerable road use numbers are substantial enough to provide adequate input for training the AI. The reviewer commented that in BP 3 and in communication of the results of this study, it will be important for the research to clarify the extent to which they are optimizing for energy efficiency vs. safety. The reviewer concluding by saying the proposal blends these objectives together in the presentation, but guiding the AI and driver assist recommendations toward safety or climate goals could yield different results—both could be interesting and useful, but the researchers should be clear about what is in scope.

Reviewer 2

The reviewer pointed out the project is not yet complete but has progressed to field testing. The reviewer commented the project has used an XIL-based approach to develop a connected-vehicle approach to improving travel on roads with low to moderate traffic densities. The reviewer finished by saying the project has addressed both theoretical and field operations challenges.

Reviewer 3

The reviewer asserted the timeline is reasonable for what is expected to be accomplished without scale-up and vehicle automation. The reviewer stated that the project's approach from controlled traffic event creation, to CDA Simulation, to CDA XIL Testing, to Full Scale CDA Deployment, and lastly, to scale up in area and vehicle operation type, was well designed and expansive; however, expecting to deliver both scales of deployment in and across conventional HV App behavioral intervention and fully automated driving system (ADS) vehicle intervention was bold. The reviewer stated that progress in one of each vehicle and location is a sufficient advancement. The reviewer added that safety was identified as a key factor and reinforced by the community outreach findings, the metrics to measure if not intervene/react to findings in deployment or future scale-up are unclear. Understanding that sensor detection distance is a critical factor may have been predicted in earlier stages of the program. The reviewer said it appears the simulation and XIL testing included important assumptions about market penetration which is understandable, but appears to have excluded Light Detection and Ranging (LiDAR) based data of traffic information from a small/early deployment which would have provided an important input to activities in Period 1 or 2. The reviewer added that these testing results may have led to modification of deployment breadth (i.e., less intersections) by concentrating more instruments at fewer intersections (e.g., mid-block). The reviewer finished by suggesting this may be a recommendation based on the benefit of hindsight, and it should be considered as a recommendation for future simulation and XIL testing approaches and go/no-go gates in other projects.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that excluding the stretch goals of increasing geographic scale and integration with ADS operated vehicles, the accomplishments of operating impacts to traffic and energy efficiency improvements, as well as identifying vehicle versus signal and combined impacts are excellent. The reviewer acknowledged that human behavioral modification and adherence are common confounds to CDA deployment, and the lack of clearly defined safety performance metrics for vehicle to vehicle and vehicle to pedestrian at intersections is an important gap to fill in the final months of the project.

Reviewer 2

The reviewer observed that the project has progressed to limited field testing for connected vehicles, and the project is now progressing to a metropolitan-scale analysis. The reviewer stated that, under the right conditions, the project is demonstrating emissions and travel condition improvements.

Reviewer 3

The reviewer commented that the researchers have made important progress in this study; however, it appears a lot of the work needed to address the barriers identified and there is less than a year left in Budget Year 3. The reviewer expressed it is important the researchers stay on track to address the barriers and get results by the end of the study period. The reviewer concluded by noting the data analysis, cost-benefit analysis, and agent-based model development are key outputs to address the barriers that are still to be complete.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer made note of good coordination and allocation of skills and tasks across partners. The reviewer made special note of recognizing the impacts to the community and seeking to educate and collect feedback on the planned traffic interventions.

Reviewer 2

The reviewer described collaboration on the technical elements as outstanding and highlighted good contributions and coordination between the academic researchers, municipalities, and regional decisionmakers. The reviewer did note, however, that it is less clear how the listening sessions and Saddleback Collage elements are playing a role in the research; in other words, it is unclear how this input is being incorporated into the research, if at all, or are these outreach events simply for educational purposes and not intended to feed into the research direct.

Reviewer 3

The reviewer summarized that the project effectively involves research universities, ANL, private firms, and two highway jurisdictions (a city and the university-UCI), but the project has also extended involvement to the larger metropolitan association of governments.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that if completed, the future research proposed will accomplish the stated purpose and contribute substantially to overcoming the EEMS barriers stated. The reviewer expressed confidence that the researchers' contributions will meet the stated purpose and shed light on important future potential for energy benefits from CDA and AI systems. The reviewer noted the importance for the researchers to be clear to include the parameters of the findings in their findings. The reviewer provided that it could be an important contribution for the research to analyze the potential for use of these technologies under different scenarios and conditions (e.g. to what extent does this inform the potential for use of the technologies to improve safety? To increase energy efficiency? How well does the technology handle VRUs and under what conditions?)

Reviewer 2

The reviewer observed that the future work for the current project is focused mostly on effectuating the suggested speeds through either driver encouragement or an automated process. The reviewer expressed the importance of this step, excitement for the results, and curiosity, for future projects, in an analytical context, how changes in roadway geometry would change the results. The reviewer elaborated by asking two questions: 1) How does this system work with a three-lane vs. four-lane roadway cross section with the same traffic volume (say $12,000–$15,000), appropriate for a three-lane cross section, but often four or five lanes)? 2) Some of the challenges of passing vehicles may be solved with a three-lane section, but would the higher traffic density make the connected vehicle system less efficient? The reviewer emphasized that these are interesting questions for us because we are pursuing three-lane cross section alternatives to improve traffic safety.

Reviewer 3

The reviewer said remaining challenges were clearly identified and insightful, however, communication of risk mitigation plans due to signal distance detection limitations, impacts to safety, driver behavioral adherence could be improved. The reviewer stated that there may be insufficient time to modify models due to signal detection and driver behavioral adherence and recommended defining the feedback loop for monitoring and safety management criteria where traffic intervention will be halted. The reviewer concluded by pointing out that causal relationships may be difficult to make with the traffic interventions, but the effort to identify safety management process would benefit this and future projects.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project does support the EEMS scope and has the potential to provide important insights on energy efficiency impacts of deploying CDA and AI technologies—with the caveat stated above, and added that the authors need to clarify to what extent they are optimizing for energy efficiency vs. safety (or clarify if there is not meaningful distinction between these goals in terms of how the AI and driver assist suggestions operate).

Reviewer 2

The reviewer commented the outcomes of the project support advancement and knowledge in process, equipment, powertrain, mobility management, and components.

Reviewer 3

The reviewer pointed out that delay at traffic signals is a major element of transportation system inefficiencies, energy consumption, and GHG emissions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that resources appear to be sufficient to complete the project.

Reviewer 2

The reviewer commented that the resources seem sufficient; however, the reviewer thought it will be important for the researchers to be efficient in their work for the (short) remainder of the project, given the number of tasks not yet completed in budget year three (3) that are key contributions to the purpose of the study and given the significant amount of resources in FY24 ($2 million).

Reviewer 3

The reviewer stated the stretch goals for larger scale deployment and both human and automation operations may have been unnecessary scope.

Presentation Number: EEMS119
Presentation Title: Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios
Principal Investigator: Xiao-Yun Lu, Lawrence Berkeley National Laboratory

Presenter

Hao Liu, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

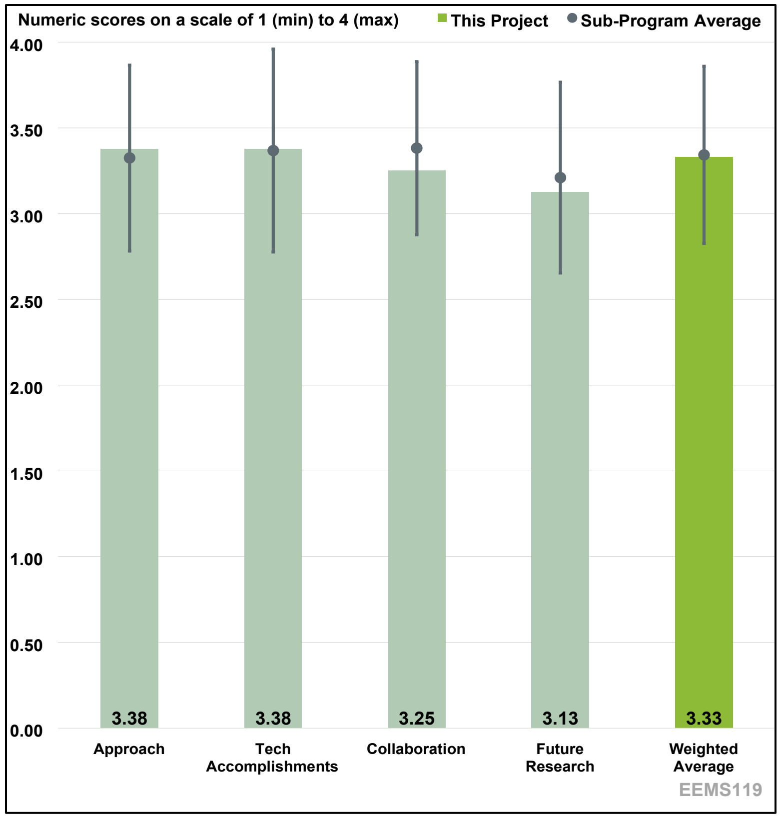

Figure 4-28. Presentation Number: EEMS119 Presentation Title: Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios Principal Investigator: Xiao-Yun Lu, Lawrence Berkeley National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the combination of different powertrains is commendable, and the detailed investigation into the factors and controls for CDA are well designed.

Reviewer 2

The reviewer observed that a multi-level signal optimization including both infrastructure (signal timing) and vehicle (speed) controls is demonstrated on public roads with vehicles of various powertrains following a thorough literature review, clear definition of V2X messaging framework, and lab testing. The reviewer concluded by stating that a sensitivity analysis using microscopic traffic simulation determines which parameters are of greatest importance.

Reviewer 3

The reviewer commented that when comparing fuel improvement or time improvement comparison for CAV interaction, the preference is to see some attempt to place the value in an overall improvement as well as in the single scenario improvement that is shown; for example, the 10% improvement on Slide 14 is for a specific scenario, what percent of driving does this represent?

Reviewer 4

The reviewer asserted that the approach was not well presented at high level in the presentation. The reviewer was able to stitch it together with detailed review of slides, but it was a challenge and not well conveyed in the actual presentation. The reviewer wondered how the multi-level signal optimization method presented on Slide 8 is different from traditional approaches from traffic engines and suggested it would be good to give this context. The reviewer said in the specific use case of high demand in all directions would not utilize a green wave, so that example is not so relevant. The reviewer described the description on Slide 9 as good, but mentioned a lack of clarity on how a typical approach would manage this situation. For further explanation, this reviewer said developing the methods with historical data, is of course, the best starting point, and asked: 1) How would the method adapt to real dynamics of traffic flows in real world? 2) Would this cause times when the method is worse than traditional traffic engineering approaches? The reviewer referenced prior comments.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that all reported progress is commendable and on target for the project milestones.

Reviewer 2

The reviewer said that controls look robust and complete. The reviewer said they would like to understand the constraints of the optimization better. The reviewer asked how the idea of inconveniencing a single driver for the benefit of the overall benefit of the mass of drivers could be limited.

Reviewer 3

The reviewer said it is hard to evaluate the accomplishments overall due to time limit on presentation. The reviewer commented that the topics discussed in depth seem reasonable. The reviewer asserted that on Slide 7, the range of cut-in/cut-out is not consistent, resulting in odd dynamics of driving behavior. The reviewer followed up by asking why is that and what are the broader implications of this variability?

Reviewer 4

The reviewer stated that real world operational challenges to implementation could be considered further.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that government and lab collaboration is well-developed, and interaction with SAE CDA Committee is commendable; however, vehicle and component manufacturer industry interactions could be improved.

Reviewer 2

The reviewer made note of clearly defined roles for the variety of project partners (national laboratories, academia, and industry) that play to each one's strengths.

Reviewer 3

The reviewer commented that the material shows all laboratories contributing and communicating as expected.

Reviewer 4

The reviewer noted that Slide 20 has description of collaborations, but the slide was not covered due to time during presentation. The reviewer notes that specific roles and coordination efforts across participants were not well conveyed in the presentation, so comments on its effectiveness cannot be made.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed work on additional heterogeneity of traffic in terms of weight class, connectivity and automation, and test cycles is appropriate. The reviewer finished by saying that further work on standards is also very appropriate.

Reviewer 2

The reviewer commented that the next steps proposed in introducing vehicles with hardware into over-the-road situations is needed to show the progress of theoretical and simulation math. A satisfactory combination with current SAE materials is good.

Reviewer 3

The reviewer noted that freeway portions of the future work were not clearly described in context of the rest of work during the presentation. It seems out of place though that may not be the case in reality. The reviewer expressed that future work slides are very general which makes it is difficult to commented on the likelihood of success.

Reviewer 4

The reviewer suggested that progress relative to percentage of time and milestones could be defined further, especially depending on accuracy of the 35% (appears to be typo upon comparison with 2023 slides) completion in the final year. The reviewer stated that future tasks had to be assumed based on milestones Slide 4 and tasks described in later slides and remaining challenges in Slide 21. The reviewer concluding by saying that future research defined in Slide 22 is "after this project" rather than describing how remaining tasks and challenges will be approached during this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that content is certainly relevant to the EEMS program.

Reviewer 2

The reviewer explained that improved Traffic flow will reduce Energy Consumption for the Fleet of vehicles over the road.

Reviewer 3

The reviewer noted that the study is comprehensive and includes simulation and on-road testing of heterogeneous traffic of CAVs along with needed standards work.

Reviewer 4

The reviewer asserted that outcomes of the project support advancement and knowledge in process, equipment, powertrain, mobility management, and components.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented the project has a good team, simulation hardware, vehicles, and infrastructure for testing important topics covered in the project.

Reviewer 2

The reviewer noted that the team includes many partners, each with extensive resources and seemingly adequate funding. The reviewer commented that specific roles and contributions of each partner are only loosely described on Slide 20 (this was not covered in presentation due to time).

Reviewer 3

The reviewer said that, as described by the presenters, all remaining tasks are within the budget allotted.

Reviewer 4

The reviewer commented that the resources are balanced. The reviewer concluded that even though task completion appears low for the final year, the remaining planned budget for FY25 appears balanced to the effort.

Presentation Number: EEMS120
Presentation Title: A Cooperative Driving Automation (CDA) Framework for Communications
Principal Investigator: Adian Cook, Oak Ridge National Laboratory

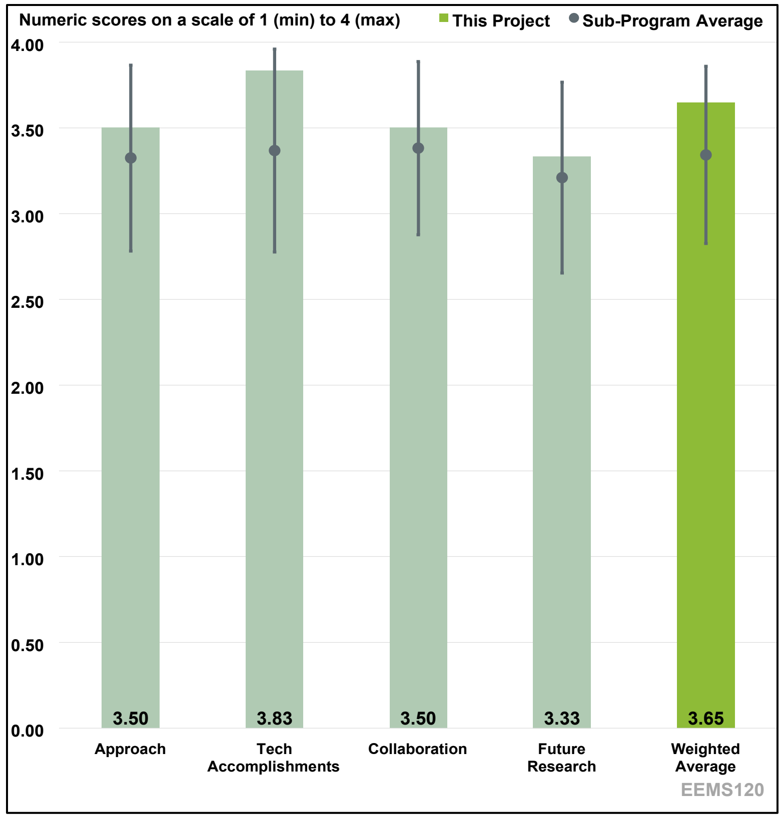

Figure 4-29. Presentation Number: EEMS120 Presentation Title: A Cooperative Driving Automation (CDA) Framework for Communications Principal Investigator: Adian Cook, Oak Ridge National Laboratory

Presenter

Adian Cook / Priyash Misra, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented there are clearly defined barriers with appropriate simulation, XIL, and (limited) on-road testing tasks outlined. The reviewer suggested tying the metrics to forthcoming or proposed standards would be a beneficial step to add.

Reviewer 2

Very complete. The reviewer expressed an appreciation for the analysis of communication speeds needed; a thorough explanation across the bandwidth of too little to too much is very good. The reviewer advised that most unconstrained optimization would end up with the more the better, but coming to a conclusion about what is needed has the best chance of success.

Reviewer 3

The reviewer commented that the timeline is appropriate for project objectives and phases, and the approach of integration and implementation with increasing levels of hardware and reality for validation is commendable. The importance of the metrics as factors in developing and improving future CDA vehicle operations is noted. The reviewer concluded by suggesting the measure of framework success in workflow step five (5) of on-road demonstration could be defined further.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

An introduction of new and key quantitative measures for CDA (e.g., time to agreement, cooperation ration, false cooperation ration) and the detailed study of them in two scenarios both in simulation and XIL testing is noted. The reviewer commended the project for executing an impressive multi-partner simulation and XIL testing demonstration that integrated many parts of the project in a novel experiment. Several publications coming from this work are noted.

Reviewer 2

The reviewer explained that the demonstration of metrics, criteria, and fault insertion is broadly supportive of future communication testing and development.

Reviewer 3

The reviewer commented that data shown in Slides 12,13,16,18 look complete.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that, of all presentations reviewed over the week, this was the best organized and prepared set of presenters for handing back and forth across the material during the review. The reviewer commented that the material shows all parties participating and communicating as expected.

Reviewer 2

The reviewer made note of the multiple national laboratories and DOT teams working together with clearly defined roles. The reviewer suggested that, given the focus on the framework and what might lead to standards, input from additional stakeholders in the regulation, an OEM, and standards areas could be beneficial.

Reviewer 3

The reviewer noted that government and lab collaboration is developed well, but industry interactions could be improved.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that there are clearly defined steps remaining for the current project; however, proposed future work was a bit vague and could be more directed at needs/gaps that arose during the current work.

Reviewer 2

The reviewer said that, as proposed on Slide 25, getting over-the-road data to demonstrate the theory is important. The reviewer pointed out that barriers for single user adoption of Autonomous Vehicles (AV) remain, and demonstrating CAV for multiple drivers is required to help remove those adoption barriers.

Reviewer 3

The reviewer suggested that the measure of framework success in workflow step five (5) of on-road demonstration could be defined further.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that improving traffic flow will reduce energy needed by the fleet.

Reviewer 2

The reviewer said outcomes of the project support advancement and knowledge in process, equipment, powertrain, mobility management, and components.

Reviewer 3

The reviewer noted the development of key novel quantitative measures (possibly on the way to standards) of CDA with tests done in simulation and XIL.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that team members fill needed roles well, and the simulation and XIL testing hardware is sufficient for the goals of the project.

Reviewer 2

The reviewer said that, as described by the presenters and their material all remaining work on Slide 25 fits with budget allotted.

Reviewer 3

The reviewer commented that resources are balanced for milestones, but more direct industry engagement in final stages of vehicle validation is recommended for this large investment.

Presentation Number: EEMS121
Presentation Title: Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency Safety Sustainability and Public Health
Principal Investigator: Michael Lim, Xtelligent

Presenter

Michael Lim, Xtelligent

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

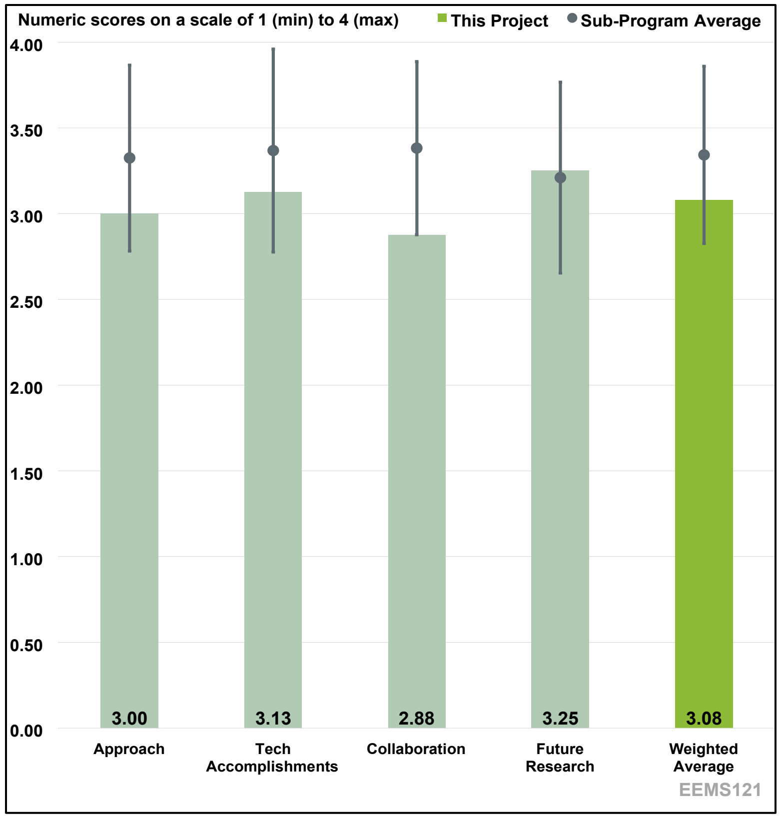

Figure 4-30. Presentation Number: EEMS121 Presentation Title: Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency Safety Sustainability and Public Health Principal Investigator: Michael Lim, Xtelligent

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that the project well addressed the barriers for implementing the developed solution into the field.

Reviewer 2

The reviewer said the approach seems good; however, it was not clear from the presentation materials or the presenter as to what data is being sent from the Connected Vehicle (CV) trucks to the traffic signal controller and what information (if any) is being sent back to the CV trucks. The reviewer added that, if information is being sent back to the CV trucks, it is not clear how that information is being used by the CV trucks.

Reviewer 3

The reviewer commented that the project's approach and team have mixed strengths and weaknesses. The reviewer stated that the focus on software solutions is strong because they do not need hardware to be installed in every vehicle, but the team admitted to being dependent on negotiations with different car companies for access to their proprietary systems. The reviewer also pointed out that the approach requires cooperation between traffic lights and the cars, which requires buy-in from local governments and car companies, which makes gaining widespread adoption difficult. The reviewer concluded that still, the team is doing a solid job of getting early agreements and proving out the technology.

Reviewer 4

The reviewer commented that the project's approach seemed scattered and not focused to the objectives of the program. The reviewer added that they struggled to understand what problem was being solved. The reviewer finished by saying the PI presented what the company was doing as a company and not enough on sharing what was being learned and why.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the project deployed the proposed systems in three cities of California and commented that this accomplishment is very impressive.

Reviewer 2

The reviewer noted the project has gathered some data, which is probably sufficient to show that the system provides benefits in terms of time and fuel efficiency. The reviewer added that many questions remain to be answered and many of them will impact willingness for adoption.

Reviewer 3

The reviewer commented that the Level 1 system of using infrastructure-based sensors to help optimize the traffic flow seems to be working, however, the accomplishments related to the Level 2 and Level 3 systems are not clear. The reviewer observed that Level 2 relates to data being sent from the CV trucks, and it is not clear what is being sent and how it is being used.

The reviewer noted that the presenter did comment that they are trying to collect more refined data from the CV trucks. The reviewer guessed that Level 3 relates to the CV truck not only sending data, but also receiving information from the traffic controller and acting on this information. The reviewer concludes by saying it is not clear what, if any, accomplishments have been made regarding Level 3.

Reviewer 4

The reviewer asserted that the team should be clearer on exactly what had been accomplished to date and why this is important to the objectives.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the project team coordinated well with other partners to complete the planned tasks.

Reviewer 2

The reviewer said that partners seem to have very good collaboration with the university, lab, and prime (Xtelligent), but it is not clear how good the collaboration is with the truck partners. The reviewer clarified that this comment is based on the fact that the team is continuing to try to get more refined data from the CV trucks. The reviewer finished by saying that they are not sure whether the CV truck providers are hesitant to provide this data or if there are technical issues to overcome.

Reviewer 3

The reviewer said the project team obtained cooperation from three (3) cities and multiple car companies, which has been sufficient to prove out the technology so far. The reviewer cautioned that the planned subscription business model does seem solid for getting partnerships with more cities.

Reviewer 4

The reviewer stated that a lot of collaborators were shown, but it is unclear what each were doing.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed future research direction is solid.

Reviewer 2

The reviewer commented that the project is 70% complete, but there seems to be significant work related to implementation of Level 2 and Level 3 for the system remaining. The reviewer emphasized the "Proposed Future Research" presentation slide because it mentions a possible extension of the traffic controller to "Multimodal signal control", and expressed interest at the possibility of investigating, in a simulation environment, assessing the ability of the control algorithm to accommodate modes such as transit and active transportation (e.g., biking, micromobility, pedestrians, etc.)

Reviewer 3

The reviewer said there are so many more questions still to be answered about this technical approach's value and likelihood of commercialization and adoption. The reviewer concluded by pointing out that the team has identified many of the key areas of unknowns and is pursuing getting the data and analysis to better understand them.

Reviewer 4

The reviewer asserted that at 70% completion of the project, this should be very clear, and it was not. The reviewer added that "We will keep working.", was the message here.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project covers the EEMS objective.

Reviewer 2

The reviewer stated that the project supports the EEMS goal by using CV technology to improve the energy and emissions for trucks along a freight heavy corridor.

Reviewer 3

The reviewer said the project seems relevant to EEMS and noted that it is testing a specific way to leverage the increased connectivity and automation capabilities to improve traffic efficiency.

Reviewer 4

The reviewer declared that the project is relevant, but did not understand what was being completed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer declared that the resources for this project are sufficient.

Reviewer 2

The reviewer stated that resources seem sufficient for the work done so far and will set a solid baseline. The reviewer expressed uncertainty if continued funding would be needed for this approach to gain sufficient private sector support and traction at this point.

Reviewer 3

The reviewer said the project should have sufficient funds to implement the Level 2 and Level 3 signal control; however, it appears that there could be a limited number of CV trucks willing to participate. The reviewer concluded by saying if the topic of "multimodal signal control" (as described in the Proposed Future Work) is considered, this would likely require additional funds as it may not be in the current approach/task assignments.

Reviewer 4

The reviewer commented that the resources seemed sufficient, but the project's scope was unclear so evaluating resources is tough.

Presentation Number: EEMS122
Presentation Title: Pathways to Net Zero Mobility
Principal Investigator: Joshua Auld, Argonne National Laboratory

Presenter

Joshua Auld, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

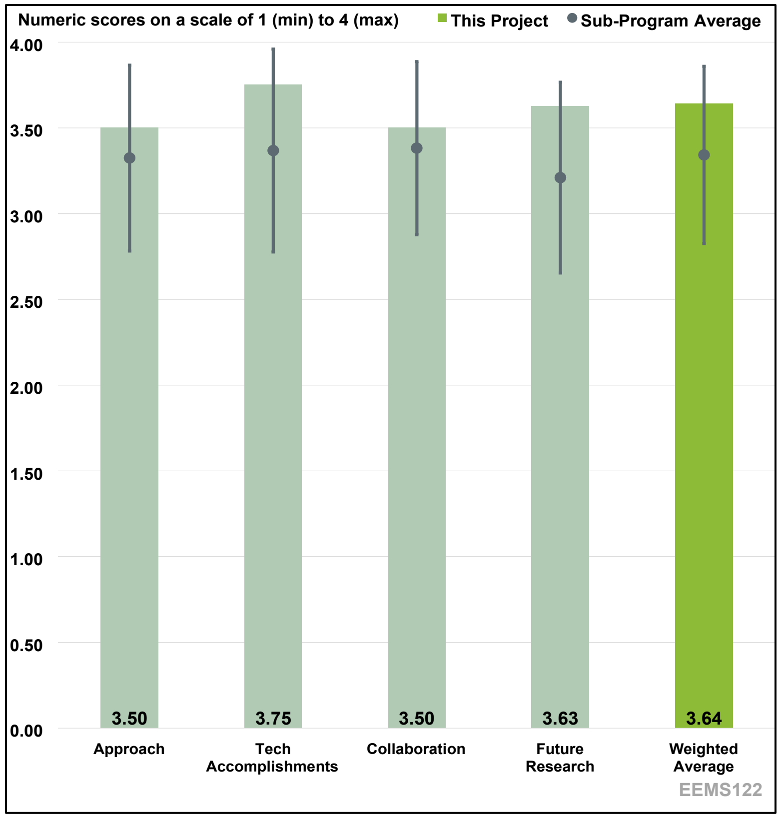

Figure 4-31. Presentation Number: EEMS122 Presentation Title: Pathways to Net Zero Mobility Principal Investigator: Joshua Auld, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project using such a rich model like POLARIS should provide transportation researchers with unique insights. The reviewer explained that the multi-faceted goals are rich, deep, and novel and are well worth investigating. The reviewer commended the project, saying the multi-team approach is extremely in-depth and will yield model improvements and findings well beyond this project’s scope.

Reviewer 2

The reviewer said this project works to answer important policy-relevant research questions about which strategies are effective at the regional level to meet GHG reduction goals. The reviewer expressed appreciation at the fact that the approach is inclusive in terms of consideration of a wide range of strategies—both technical and policy-based, and both established and emerging/potential strategies that require further study.

The reviewer described the modeling approach as sound and well-thought out in terms of scope and order of operations. The reviewer commented that, based on the slides and presentation, it is challenging to know what assumptions are being made about the strategies and their potential impact. The reviewer asked to what extent are the scenarios based on which strategies would have the greatest potential vs. which strategies are technically or politically feasible for a given area? The reviewer noted that these are different research questions and could lead to different answers. Continuing, this reviewer said from a decisionmaker standpoint, it may be helpful to know both what strategies would provide the most opportunity in terms of emissions reductions per dollar invested; but also yield some information about politically feasible or more shovel-ready strategies that could be implemented quicker or easier. The reviewer suggested getting input from the stakeholder is likely to yield more of the latter kind of strategies and expressed hope that this project is also able to explore the more ambitious or significant potential policies that might be beyond stakeholders are able to imagine. The reviewer said the timeline is ambitious be feasible if the research team is able to be efficient and strategic with how stakeholder input is incorporated. The reviewer emphasized the importance of clearly laying out what kinds of assumptions are being made to estimate the impact of strategies on GHG emissions. The reviewer mentioned a lack of clarity regarding why the transit scenarios chosen are no transit service. The reviewer asked would it not be more directly relevant/useful given the real-world context to test the impact of service cuts as this is likely to precede any sort of out-right transit shutdown in the near future? The reviewer further suggested that, as transit agencies wrestle with responses to budget shortfalls, it might be more helpful for Chicago Transit Authority and others to know what kinds of impacts to expect from different kinds of service cuts (e.g. shutdown of specific lines, cutting bus routes, changes to frequency or hours of operation, etc. The reviewer explained that this would be a unique contribution of this project, as this type of sophisticated modeling has not yet been a factor in answering those kinds of questions. The reviewer asked, on the transit analysis, is the project team able to take the results and convert to GHG emissions impacts stemming from behavior and car ownership changes? The reviewer added that it would be useful to know and also ensure that part of the analysis is aligned with the net-zero frame of the study. The reviewer continued, saying with the proposed future research, there is reference to making alternative suggestions for delivery routes in the Freight and Local Delivery box. The reviewer suggested it would be great if the research is also able to yield parallel suggestions for more energy efficient options for the other five boxes of future research areas. The reviewer concluded by noting this would take advantage of the sophisticated modeling work to make science-based recommendations for alternative suggestions; for example, could one similarly make suggestions for how to lower GHG emissions impacts of CAV deployment, parking, land-use choices, etc.?

Reviewer 3

The reviewer commented that the project approach makes sense, and the timeline and work planned appear reasonable. The reviewer noted that the presentation clearly lays out the approach, including the five areas of focus, planned regional studies on decarbonization strategies in three regions, and initial barriers. One potential barrier to success (which the presentation addresses) is the potential for lengthy agreement negotiations between the various project partners, of which there are many.

Reviewer 4

The reviewer said this is a complex project with a lot of moving parts (five tasks) and collaborators (over 27 from what the reviewer could count). The reviewer continued by asserting that 3 years is too short to execute this project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that, given the complexity of the research approach, the researchers have made satisfactory progress towards completion with initial modeling results and partner set up. The reviewer stated that to fully assess this element, it is important to know more about what is going into assumptions about the GHG impacts of the scenarios; in other words, what specifically is going into the “deploy scenarios” bullet in Task 6? The reviewer concluded by saying this could be a minor or significant time commitment depending on the extent to which inputs and assumption are using established metrics from prior work versus real-world testing or additional modeling efforts needed to estimate GHG consequence of specific scenarios.

Reviewer 2

The reviewer noted that though the project has just begun, the presentation explained one study that had already been completed, which was an analysis of what would happen if transit completely vanished in the Chicago region. The reviewer added that the study demonstrates the outsized impact transit has on the region, and that without transit congestion and car ownership would increase, but that mobility and economic activity would decrease as increased congestion would cause people to cancel activities.

Reviewer 3

The reviewer said the results presented from this endeavor are not always intuitive; these results can show the power and purpose to conducting the research. The reviewer finished by asserting that few models have the capabilities of what is being worked on in this effort and the results themselves lead to additional questions to investigate that we would not otherwise have known to ask.

Reviewer 4

The reviewer stated that they could not offer a fair assessment of a project that has been active only for six months.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project has an impressive set of stakeholders, and it is expected to yield a tremendous amount of valuable input and ensure more actionable scenarios and results to inform decisionmakers. The reviewer stated appreciation for the incorporation of stakeholders from different relevant private sector entities, as well as Federal, state, and local partners. The reviewer cautioned that in order to ensure time efficiency and useful feedback, it will be important to use partner input strategically and for the researchers to recognize any bias in the kinds of input they might receive from partners (e.g. decision makers might suggest a level of ambition in GHG reduction strategies that match what they understand to be feasible for them to implement specifically, rather than thinking broader; industry stakeholders may be incentivized to assume greater GHG reductions than data might show). The importance of being thoughtful in how this input is incorporated into research decisions and outputs is noted.

Reviewer 2

The reviewer commented that the collaboration partners for this keystone project are impressive and represent a wide swath of potential sectors, research institutions, laboratories, and industry.

Reviewer 3

The reviewer remarked that this project will require a lot of coordination among project partners, and it appears there are good plans in place to support that coordination. The reviewer noted that the presentation addresses that initial agreements among partners may take some time.

Reviewer 4

The reviewer stated that they could not offer a fair assessment of a project that has been active only for six months.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the list of questions proposed for future research were deep and worthwhile and answering them should help improve the scope of the model.

Reviewer 2

The reviewer remarked that, based on the proposal, there is confidence that the researchers will be able to execute the plan, given the level of work that is already been accomplished in this space and the clear approach laid out. The reviewer finished by saying the purpose is clear and it stands to be impactful and useable for decisionmakers across levels of government, provided the results and recommendations are clear and accessible for key stakeholders and decisionmakers.

Reviewer 3

The reviewer noted that because this project is only just beginning, there is no proposed future research beyond the plans for the current project. The reviewer commented that the presentation does clearly define a purpose for the future work under this project, and it does seem highly likely to achieve its targets, and the presentation does highlight linkages to other DOE projects.

Reviewer 4

The reviewer stated that they could not offer a fair assessment of a project that has been active only for six months.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said yes; this project is able to support the Analysis section of the VTO program.

Reviewer 2

The reviewer commented that the use and expansion of the POLARIS model in this fashion absolutely seems in line with the goals of EEMS.

Reviewer 3

The reviewer stated that this project is highly relevant to the EEMS program objectives of improving mobility, energy, and efficiency.

Reviewer 4

The reviewer said that this project is extremely aligned with EEMS scope and goals and will make useful contributions to our understanding of range of mobility futures that could result from disruptive transportation technologies and policy levers, and the extent to which they can contribute to lower energy use and decreases in GHG emissions from the transportation sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that this project could use whatever level of funding was allocated to it, as long as it was minimally sufficient; more resources provided will yield more results. The reviewer concluded that the values provided seem to be a good use of resources.

Reviewer 2

The reviewer said the resources appear to be sufficient for the proposed work.

Reviewer 3

The reviewer commented that resources appear sufficient to execute the project. The reviewer noted that the research should monitor the proportion of resources going toward the collaboration and coordination elements of the project; given the substantial number of stakeholders; this could easily consume significant resources if not deployed efficiently and strategically to meet the goals of the study.

Reviewer 4

The reviewer expressed serious concerns that a $7 million project will be executed in a 3-year time frame with 27 collaborators; there are a lot of moving pieces for such a short timeframe for complex research. The reviewer recommended to consider extending this project, 1 to 2 years.

Presentation Number: EEMS123
Presentation Title: Freight in the Loop
Principal Investigator: Kevin Stutenberg, Argonne National Laboratory

Presenter

Kevin Stutenberg, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

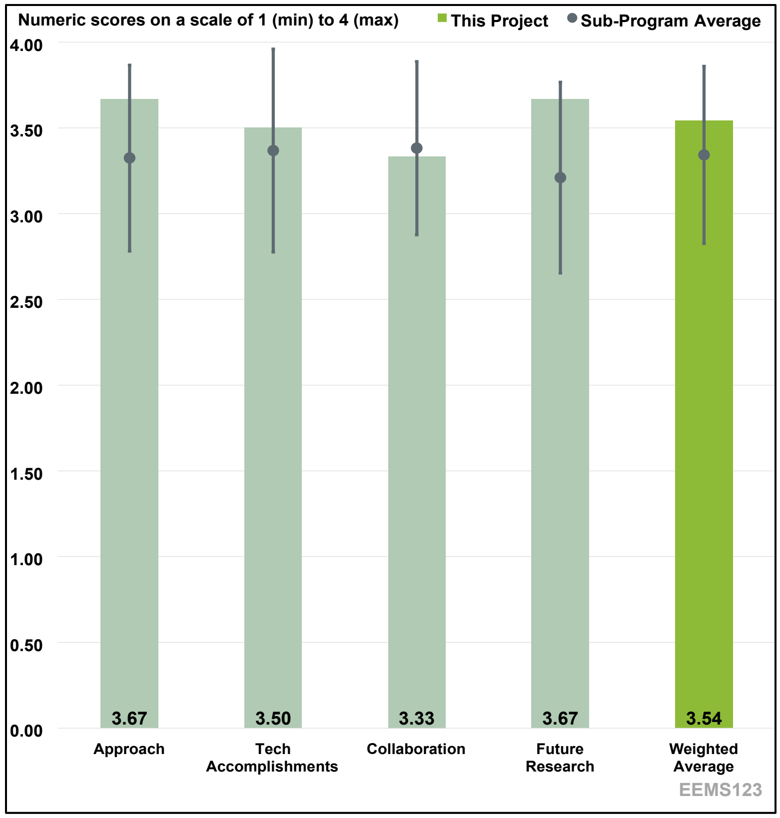

Figure 4-32. Presentation Number: EEMS123 Presentation Title: Freight in the Loop Principal Investigator: Kevin Stutenberg, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project is on track to provide insight into the real-world energy impacts of advanced vehicle technologies, which is difficult to do.

Reviewer 2

The reviewer pointed out that the presentation is not a research update but an update for the construction of a new facility.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that, based on the presentation, the project team has made good progress.

Reviewer 2

The reviewer noted that within seven months of the project start-date, the dynamometer has been selected and meets or exceeds all the request for proposal (RFP) requirements. The reviewer stated that this is a significant component of the overall project plan; as of submission of the review report, the project was on time and within budget.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said that according to what was presented, great collaboration has occurred between teams.

Reviewer 2

The reviewer observed that the team is leveraging expertise across ANL as well as key private contractors with strong expertise in dynamometers, and the team is also being supported by universities such as Illinois Institute of Technology. The reviewer finished by saying it is unclear exactly what contributions the universities have made.

Reviewer 3

The reviewer pointed out that the presentation is not a research update but an update for the construction of a new facility.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the future research is clearly aimed to finishing the XIL construction and dynamometer setup in order to eventually test heavy and MD CAVs and thus so far it appears very likely that the team will achieve its targets.

Reviewer 2

The reviewer remarked that the proposed idea and plan sounds interesting.

Reviewer 3

The reviewer pointed out that the presentation is not a research update but an update for the construction of a new facility.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented yes.

Reviewer 2

The reviewer said yes, this award seems to be part of the EEMS VTO programmatic priorities.

Reviewer 3

The reviewer commented that the project is relevant, because it helps quickly test how new mobility technologies will perform under various real-world conditions. The reviewer finished by saying the project will help us learn about the technologies’ energy impacts.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project team has a lot of work to complete in 1.5 years and significantly, the XIL site construction RFP was not issued as of April 2024. The reviewer stated that after the project is awarded in October, the team has just one year to construct the site, install the dyno, and run an XIL pilot to meet their expected timeline. The reviewer concluded by stating that it is great that the dyno that was selected was within budget and uses a known interface that will make its setup easier.

Reviewer 2

The reviewer said they are not an expert in this topic, and thus cannot weigh in on the resources needed.

Reviewer 3

The reviewer observed that this award seems to be dedicated to infrastructure, and it is unclear what is the expected timeline and the total award.

Presentation Number: EEMS124
Presentation Title: Deployment of Real-Sim/Real-Twin Scenario Library Generation and Benchmark of Energy Centric CAV Controls
Principal Investigator: Ross Wang, Oak Ridge National Laboratory

Presenter

Ross Wang, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

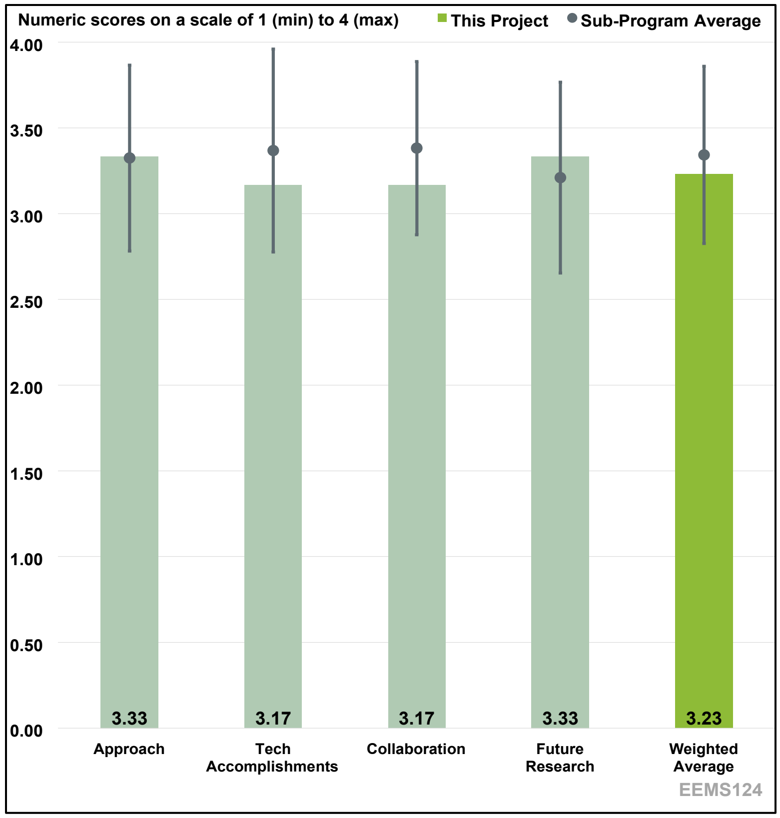

Figure 4-33. Presentation Number: EEMS124 Presentation Title: Deployment of Real-Sim/Real-Twin Scenario Library Generation and Benchmark of Energy Centric CAV Controls Principal Investigator: Ross Wang, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project approach is well designed to create a library of CAV simulation-based scenarios applied to real world road networks. The reviewer mentioned that it is not entirely clear what is the level of detail required in the 3D digital maps and the approach to acquire these maps for the specific scenarios. The reviewer asked if the APaCK-V vehicle-based 3D data collection will be sufficient for the needs of the scenario simulations, or will additional 3D data collection approaches/techniques also be required?

Reviewer 2

The reviewer pointed out that the project is just getting started, and the overall plan looks good.

Reviewer 3

The reviewer stated that the approach to the work appears reasonable—the team will develop digital twin scenarios in 15 real-world locations (including universities) with the goal of creating a shareable library for others to run models and to benchmark CAV technologies. The reviewer pointed out that the project has just begun, but the presentation laid out the list of project milestones over the next 2 years. According to the reviewer, the timeline makes sense. The reviewer wondered what will be the quantity of data that will be captured at each location—the locations chart in the presentation indicated a large number of intersections, but the speaker mentioned during the presentation that the goal is 10-40 intersections per location.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that so far, since the project has only just kicked off recently, the project team has made good progress on their objectives. The reviewer pointed out that the project team has identified test locations, and they seem to have a good understanding of the data availability for most test locations.

Reviewer 2

The reviewer pointed out that the project is just starting. The reviewer said the selection of locations has good variation of locations, and the project team should also assess elevation changes, min/max grade, grade at intersections, road surface, impact of energy for lateral vehicle control.

Reviewer 3

The reviewer commented that the project is still in the early stages, so there has not been a lot of accomplishments or progress to date.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the project has a very good set of partners.

Reviewer 2

The reviewer noted that the project is in its early stage, but it appears that coordination and collaboration among project partners is good so far.

Reviewer 3

The viewer observed that coordination and collaboration efforts appear to support the project efforts, and partners include a number of local/state agencies and universities. The reviewer wondered how partners in each location will influence specific locations of data collection/scenario development, and what the plan might be for locations with unknown data quality (e.g., Atlanta and Athens). The reviewer finished by asking two questions: 1) Will this impact the work? 2) Does the team have backup locations identified or a plan for if a selected testing site falls through?

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project has a strong plan and (Specific, Measurable, Attainable, Realistic, and Timely) SMART milestones.

Reviewer 2

The reviewer commented that the plan for future research appears sound, and milestone targets appear reasonable.

Reviewer 3

The reviewer commented that the project is still in its very early stages and there is a large amount of future work remaining. The reviewer suggested that perhaps the biggest challenge will be in successfully collecting meaningful data for 10+ real world locations (this is the goal) of sufficient detail to generate the simulation scenarios. The reviewer concluded that initial milestone of successfully collecting data for the first two sites will be extremely insightful to the potential future success of collecting for 10+ sites.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project is highly relevant to EEMS program goals, and the shareable digital twin scenario library will be very useful for future EEMS projects and others to support CAV technologies.

Reviewer 2

The reviewer remarked that the project is a good match to EEMS program objectives.

Reviewer 3

The reviewer explained that the project supports EEMS and Analysis by providing sufficient real-world data to build analysis and simulation scenarios that allow for the estimation of energy benefits of CV applications. The reviewer added that sharing this data with the broader research community would also help to extend to additional simulation-based analyses since acquiring real-world data to build scenarios is often very difficult.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer emphasized the need to continue to assess resources during the project.

Reviewer 2

The reviewer commented that resources appear sufficient for the proposed work.

Reviewer 3

The reviewer commented that the project is in its very early stages, so it is difficult to judge if the funding is sufficient. The reviewer advised that collection of the 3D data has the potential to be very expensive, so making an assessment after the first two data collection sites will be important.

Presentation Number: EEMS125
Presentation Title: Energy Metrics in Traffic Signal Performance Measures
Principal Investigator: Joseph Fish, National Renewable Energy Laboratory

Presenter

Joseph Fish, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

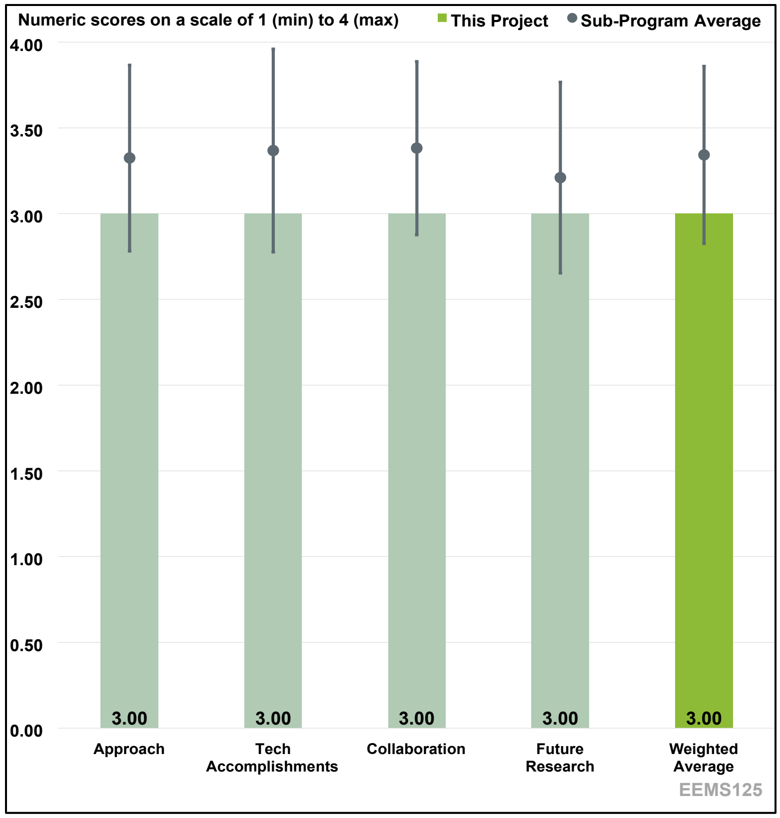

Figure 4-34. Presentation Number: EEMS125 Presentation Title: Energy Metrics in Traffic Signal Performance Measures Principal Investigator: Joseph Fish, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

Thie reviewer noted that this project seeks to change the state of the practice by incorporating energy into automated traffic signal performance measures, which is now becoming more widespread in highway operations practices.

Reviewer 2

The reviewer described the overall approach as satisfactory but pointed out that the presentation material and the presenter at the VTO AMR did not describe an approach to account for the type of vehicle within the calculation of energy impacts of vehicles at traffic signals. The reviewer noted that energy impacts would be extremely dependent on the class of vehicle, the type of powertrain, and whether the engine is shutoff when the vehicle is stopped at a traffic signal, and no approach was described to account for any of these characteristics. The reviewer suggested that a simple approach would be to apply some overall estimate of fleet mix based on known vehicle ownership and travel survey data. The reviewer reiterated that no approach was presented. The reviewer posed a question related to the approach which is not clear in the presentation, which is whether all or certain aspects of the ATSPM-E would be propriety to Iteris, Inc., the traffic control vendor and project partner. The reviewer added that if this is a proprietary system, ultimate deployment could be limited; clarification on this would be helpful.

Reviewer 3

The reviewer noted that the project team has a good idea about the barriers necessary to overcome; the team is, however, only 17% into the project at this time.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the project is still at a very early stage, but apparently there has not been a lot of significant progress, other than establishing that there is some market interest in the proposed ATSPM-E product from some number of current Iteris, Inc. clients.

Reviewer 2

The reviewer commented that the project is in too early a stage to be reviewed in a meaningful way. The reviewer added that, given the prominence of "assess the market potential, competitive advantage, and approach to communicate the benefits of ATSPM-E to customers" at an early-mid stage of the project, some indication of how the research teams plans to tackle this would have been good to see to alleviate any concerns that not much thought has gone into this element.

Reviewer 3

The reviewer noted that the project is early in its development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project is early in its development, but collaboration across industry and NREL seems to be good.

Reviewer 2

The reviewer commented that that NREL and Iteris, Inc. project team members appear to be collaborating and coordinating to establish the market potential of the ASTPM-E product and Iteris, Inc. has reached out to some of its clients to assess marketability of such a product.

Reviewer 3

The reviewer remarked that there is little discussion presented about the nature of collaborations related to this project, and more should be presented at the next review. The reviewer noted that the primary research partners are from NREL and Iteris, Inc, and added that the three case study communities should also be regarded as and approached as partners. The reviewer stated that identification and engagement of case study communities is a major part of this project, which requires a methodology. The reviewer highlighted a mention that "additional collaborators will be developed through the project, including state and local implementation partners," and commented that the way these various partners are identified, approached and interacted with during the project will be areas of interest in future reviews.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer pointed out that, because the project is still in the early stages, there is much future work remaining. The reviewer noted that some of the challenges for the future work were highlighted in the presentation material, including the need to find a new third-party source of vehicle trajectory data. The reviewer concluded by saying another key part of the future work is how ASTPM-E system will determine or estimate the vehicle classification and powertrain type for vehicles using the traffic signalized intersection.

Reviewer 2

The reviewer said that with only 17% of the project accomplished, most of the scope proposed in the project lies ahead.

Reviewer 3

The reviewer noted that the project is progressing in its early stage.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project identifies a problem that is small but ubiquitous, resulting in a likely large cumulative impact. The reviewer concluded that, "Traffic operations community lacks energy-focused metrics and calculating excessive energy for individual traffic signals requires significant computational and data resources; off-the-shelf solutions are needed."

Reviewer 2

The reviewer stated that adding an energy component to ATSPM measures is important, because ATSPMs are becoming more important in signal practice.

Reviewer 3

The reviewer commented that the project supports EEMS by aiding in the development of a real-world system to calculate the energy impact of vehicles using traffic signalized intersections.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said that the resources appear to be sufficient.

Reviewer 2

The reviewer noted that the project is still in the early stages but appears to have sufficient funding resources.

Reviewer 3

The reviewer commented that at this time, there is nothing reported to suggest misalignment between the project and available resources.

Presentation Number: EEMS126
Presentation Title: Arena Mobility Hubs for an Equitable Low-Carbon Future
Principal Investigator: Jeff Baer, The EV Button

Presenter

Jeff Baer, The EV Button

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

33% of reviewers felt that the project was relevant to current DOE objectives, 67% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

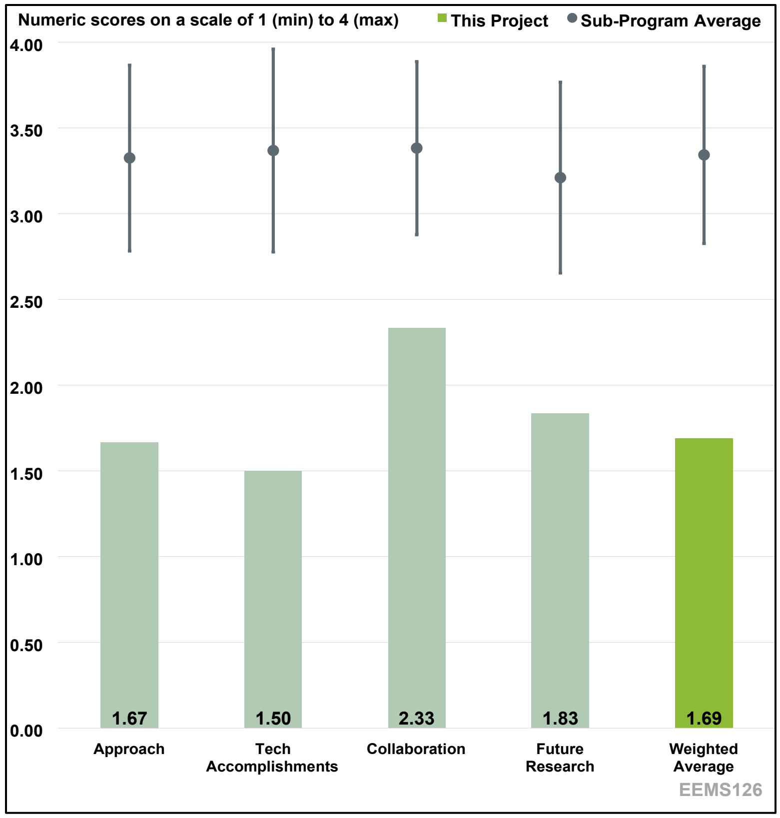

Figure 4-35. Presentation Number: EEMS126 Presentation Title: Arena Mobility Hubs for an Equitable Low-Carbon Future Principal Investigator: Jeff Baer, The EV Button

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer recognized this project is in its early stages and did expect all the technical barriers to be addressed. The reviewer acknowledged that the proposal creatively addresses an issue around siting EV chargers where there is already existing electrical capacity; a critical issue that can also be extremely time consuming and expensive.

Reviewer 2

The reviewer commented that the presenter could not provide a clear argument that there was a market for the arena-focused charging hub as proposed. The reviewer said that for commercial activity and trucks in particular, it was very unclear whether there was demand for charging infrastructure that would be subject to periodic restrictions to manage load. The reviewer stated that it may be that there is a location where there is a nexus of large-scale periodic power availability and demand for such power, but there was no demonstration that the proposed location is that place.

Reviewer 3

The reviewer stated that the project describes itself as trying to make it possible to profitably operate EVs by using the existing infrastructure at Amerant Arena as the starting point. The reviewer asserted that it is not clear what the project itself has actually done.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that technical accomplishments and progress referenced work that has been accomplished mostly by other organizations and parties at this stage in the project. The reviewer finished by saying research showed multiple key factors for consideration in siting chargers in key locations, as well as how they could accomplish additional goals such as Justice40.

Reviewer 2

The reviewer stated that the need for and benefits of this project were not demonstrated.

Reviewer 3

The reviewer acknowledged that it is important to have meetings with the community and understand specific need but wondered what has the project actually done other than displaying a map of underserved communities.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented it seems at this stage of the project, a significant effort to collaborate with the community by reaching out to a large number of local businesses and organizations to solicit feedback has been made. The reviewer acknowledged that getting the right input is a challenge and ensuring that there is a diverse stakeholder group will be important to the success of this project.

Reviewer 2

The reviewer observed that, at least partly because of turnover, there appear to be substantial communication gaps.

Reviewer 3

The reviewer noted that the project has solicited and met with businesses in the local area and is acquiring feedback; however, the project did not communicate any impact, saying that is “ongoing.” The reviewer stated that not much more could be discussed, such as early findings, interesting nuggets, or anything to confirm that the project is on the right track.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that it is good to see that additional outreach is ongoing to ensure compatibility between the project and the local community. The reviewer advised that as direct current fast chargers are often used by transient population, it would seem important to see how these fit into the wider network of available chargers and needs. The reviewer concludes by saying they expected to see more in this future research section considering the stage of the project.

Reviewer 2

The reviewer asserted that at this point, a clear purpose and market should have been defined, but they are not. The reviewer stated that there was not a clear path forward that was presented for the project.

Reviewer 3

The reviewer raised concerns about the project producing significant impacts. The reviewer observed that one glaring problem is that the very basic assumptions for the project seem to have fundamental flaws, and in others, even if what they posit is true, it is not clear how the project is actually addressing the concerns; for example, it is true that installing public charging is not easy and is not cheap. The reviewer provided two points: 1) It is getting easier and faster and funding through National Electric Vehicle Infrastructure (NEVI) is addressing this. 2) But more importantly, the project claims that can provide charging in months and not years is not borne about by any evidence, since it does not appear the project has actually charged even one vehicle (let alone used connectivity or automation to address the mobility concerns of underserved communities). The reviewer said it is also not clear how one of the project's claimed advantages (access to power from the arena during non-events) will translate to creating value for businesses or consumers who utilize electrified vehicles. The reviewer concluded by stating that if businesses/consumers (and what about underserved communities) can only charge during arena non-events, this sporadic availability seems to be a significant impediment, and how the projects seek to address this was not discussed (or even raised as an issue, which seems even more concerning).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that EV charging will require a lot of creative problem solving, especially in this early stage, and experimentation is key to finding solutions that work.

Reviewer 2

The reviewer commented that the location of this project seemed to be predetermined based on the willingness of the arena to participate, so it is not clear at all that the project as proposed can be generalized. The reviewer suggested that perhaps a different study of how future transportation-based electric loads might be balanced within a context of other variable loads might be useful, but given the uncertain market, even that would be highly speculative at this time.

Reviewer 3

The reviewer stated that the response to this question was referenced in prior comments.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources seem sufficient, and planning and expediency would seem to have some room for improvement.

Reviewer 2

The reviewer stated that the response to this question was referenced in prior comments and said this question is really moot.

Reviewer 3

The reviewer has concerns about the impacts the project is capable of providing.

Presentation Number: EEMS127
Presentation Title: Deploying Autonomous On-Demand Energy Efficient Mobility Solutions in Tulsa's Underserved Communities
Principal Investigator: Samitha Samaranayake, Cornell University

Presenter

Samitha Samaranayake, Cornell University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

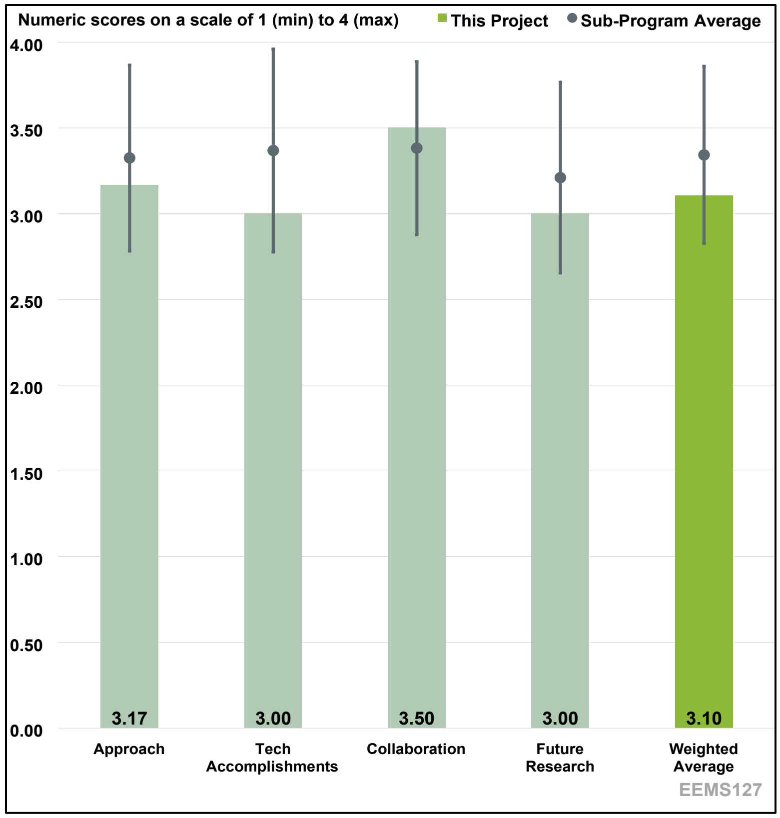

Figure 4-36. Presentation Number: EEMS127 Presentation Title: Deploying Autonomous On-Demand Energy Efficient Mobility Solutions in Tulsa's Underserved Communities Principal Investigator: Samitha Samaranayake, Cornell University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described the approach as excellent. The reviewer cautioned that the term "digital twin" is often misused and overused (not the fault of the researchers). The reviewer concluded by asking within the context of the project, is this just a traffic microsimulation?

Reviewer 2

The reviewer commented that the project is still in the early phases, but it appears that the project plan will address the identified technical barriers.

Reviewer 3

The reviewer noted that the project recently kicked off, and the approach seems to be relatively well thought out. The reviewer said the inclusion of community participation and engagement is key to the project, and it seems strong. The reviewer observed that because this project is diving into new territory, being perhaps the first non low-speed autonomous vehicle (AV) microtransit pilot in the United States, there are many barriers to the project's success, including regulations, community buy-in, vehicle procurement, implementing the vehicle technology, and more. The project's plans to deploy four vans for a one-year pilot are mentioned. The reviewer expresses being nervous that the vans are not yet procured, given recent issues procuring transit vans. The reviewer concluded by acknowledging there is quite a bit of work to be done on the microtransit service: determining service area, completing routing algorithms, etc.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer mentioned that per the presentation, the project is a bit late getting started due to contracting issues; however, it appears sufficient progress is being made across the three fronts of engagement, vehicle acquisition, and modeling.

Reviewer 2

The reviewer commented that although the project has only recently begun, the team is making good progress. The reviewer commented that the presentation did not include a list of milestones and their target dates to better assess how and when technical progress would be made, but it seems that initial work of community engagement, some work on the microtransit algorithms, and some steps of vehicle procurement have taken place.

Reviewer 3

The reviewer said it was not clear if the AV retrofit on the E-transit van would have a safety driver.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that it appears there is significant collaboration and cooperation in this project, and that the team continues to consider collaboration efforts that will support this project. The reviewer followed up by pointing out that, for example, early coordination with the local community has already take place, and the project team is coordinating with other localities who are deploying AV microtransit, such as Houston and Oslo.

Reviewer 2

The reviewer said the proposed collaboration appears to be well thought out and effective, and there is a good distribution of work across stakeholders, with each contributing per their area of expertise.

Reviewer 3

The reviewer noted that Slide 6 has a nice description about who is doing what.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the proposed future work aligns well with the project objectives.

Reviewer 2

The reviewer stated that the proposed future research for the most part looks good, and the presentation addresses work to be completed in the next 2 years. The reviewer noted that milestones and target dates are not clearly defined, and there will be a lot of coordination required for this project’s success; for example, successfully retrofitting of the transit vans with AV tech, successfully deploying the AV vans, coordinating with Tulsa Transit and the local community, and more.

Reviewer 3

The reviewer mentioned that the Federal Transit Administration (FTA) has conducted pilots similar to this (i.e. May Mobility in Arlington, Texas), and suggested that the team should reach out to FTA to understand results.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project is absolutely relevant, and expressed they were looking forward to monitoring progress.

Reviewer 2

The reviewer asserted that this project directly supports the EEMS subprogram, and the framework of identifying user needs, modeling/simulation and a pilot project to check results is sound.

Reviewer 3

The reviewer said the project is highly relevant to EEMS program goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project has sufficient resources.

Reviewer 2

The reviewer commented that resources appear to be sufficient but expressed uncertainty over whether the timeline is sufficient to achieve the amount of work proposed.

Reviewer 3

The reviewer said that cost overrun issues are foreseeable in the acquisition/deployment/maintenance of the AV fleet.

Presentation Number: EEMS128
Presentation Title: National Impacts of Community-Level Strategies to Decarbonize and Improve Convenience of Mobility
Principal Investigator: Christopher Hoehne, National Renewable Energy Laboratory

Presenter

Christopher Hoehne, National Renewable Energy Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

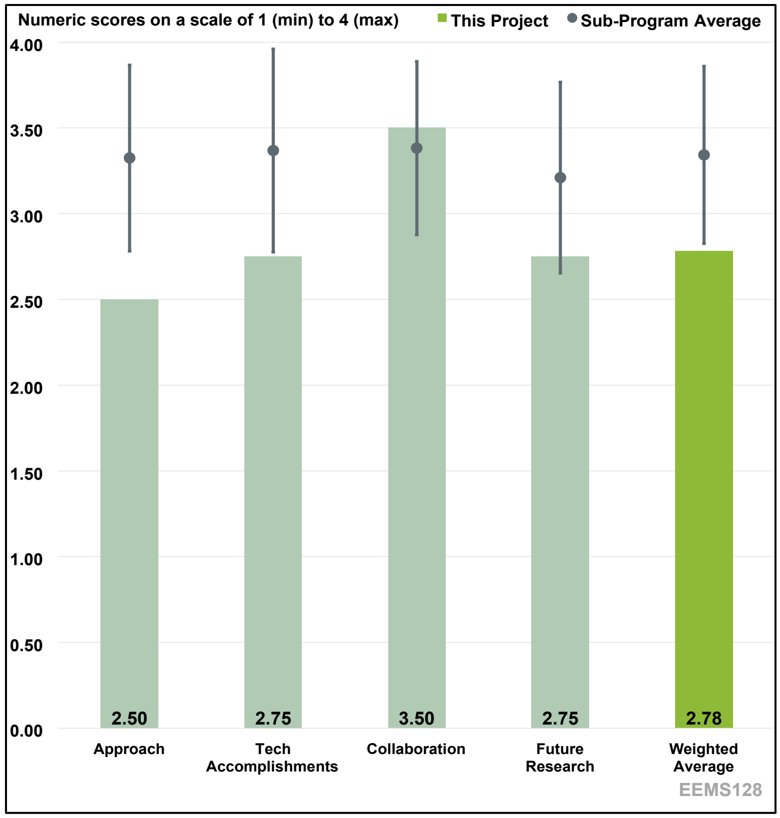

Figure 4-37. Presentation Number: EEMS128 Presentation Title: National Impacts of Community-Level Strategies to Decarbonize and Improve Convenience of Mobility Principal Investigator: Christopher Hoehne, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project appears to be well constructed to address the technical barriers; however, it remains to be seen if the mapping between tools will be successful. The reviewer suggested it would be beneficial to re-apply learned decarbonization strategies back to the existing regional-scale models after initial mapping on a partial/half regional model set. The reviewer concluded this will help determine if the correlation works on similar geo-type regions, or if other factors have a stronger influence.

Reviewer 2

The reviewer said that the Blueprint calls for an “interagency group to develop tools and collect data to better understand behavioral changes and opportunities to manage travel demand” (assuming that this project is one of those tools) does not make that a technical barrier to this project; it creates an impetus for the project, but it is not a barrier. The reviewer noted that the project’s objective is to extend the high-fidelity regional modeling (POLARIS) to the national scale (Transportation Energy and Mobility Pathway Options (TEMPO)), via Geospatial Transportation Technology (GTT), which will create county-wide results and generate insights. The reviewer described the project as incredibly ambitious and but also a bit conflicted. The reviewer elaborated by explaining that the intended audience (the person or entity who will utilize the outputs from this project) is not clear. The reviewer wondered if this a tool for policymakers, and if so, at what level (fed, state, regional, or local)? The reviewer observed that it seems the project is trying to nationalize a regional model with which to inform communities. The reviewer expressed that it is not clear how this will be done, although it seems that is what the project hopes to do in future years. The reviewer asked how exactly will this tool and/or the knowledge generated from this project be used, and what can the intended audience do with this tool/knowledge that it otherwise could not do?

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the project was recently initiated but appears to be on track for progressing towards Year 1 deliverables.

Reviewer 2

The reviewer noted that the project is only just getting started, and the major accomplishment is developing a crosswalk to connect POLARIS outputs to GTT model, seen in Slide 7. The reviewer acknowledged and recognized the inherent limitations of the AMR format, but it was not clear what the 6 geotypes were (A-F) and how that related to the microtypes (1-6). The reviewer suggested that, in general, it would have been helpful to have a better explanation of what outputs are needed from POLARIS to feed into GTT, and what outputs from GTT feed into TEMPO (which is presumably what the approach is (based on process flow on Slide 4). The reviewer recommended VTO should have a strong go/no-go stage gate to assess if the project is making meaningful progress and to take appropriate steps to re-scope/de-scope as results warrant.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged that project team collaborates very well across national laboratories. The reviewer added that the project steering committee appears to have a wide range of stakeholders.

Reviewer 2

The reviewer commented that intra-lab coordination appears to be smooth and noted the importance of the external advisory board/steering committee. The reviewer did, however, say the project seems a bit heavy at the federal and national level, given that a key desired goal is to help communities with “limited resources”.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the future work plan appears to be sufficient to complete the project.

Reviewer 2

The reviewer acknowledged that from SMART 1.0 to SMART 2.0, both DOE and the national laboratories have discovered that integrating disparate models is very challenging. The reviewer observed that the national laboratories have learned how to make improvements and how to better identify integration issues around data formatting and so forth. The reviewer raised a major concern: even if successful at integrating these models, will that be able to generate insights in a manner and format that is straightforward to implement?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project supports the EEMS subprogram objectives.

Reviewer 2

The reviewer stated the project is certainly relevant to VTO.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that resources are sufficient to successfully complete the project.

Reviewer 2

The reviewer states that this is not a trivial amount of funding.

Presentation Number: EEMS129
Presentation Title: Using Artificial Intelligence to Predict Ridership and Optimize Shared Mobility
Principal Investigator: Josh Rands, Terracity

Presenter

Josh Rands, Terracity

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

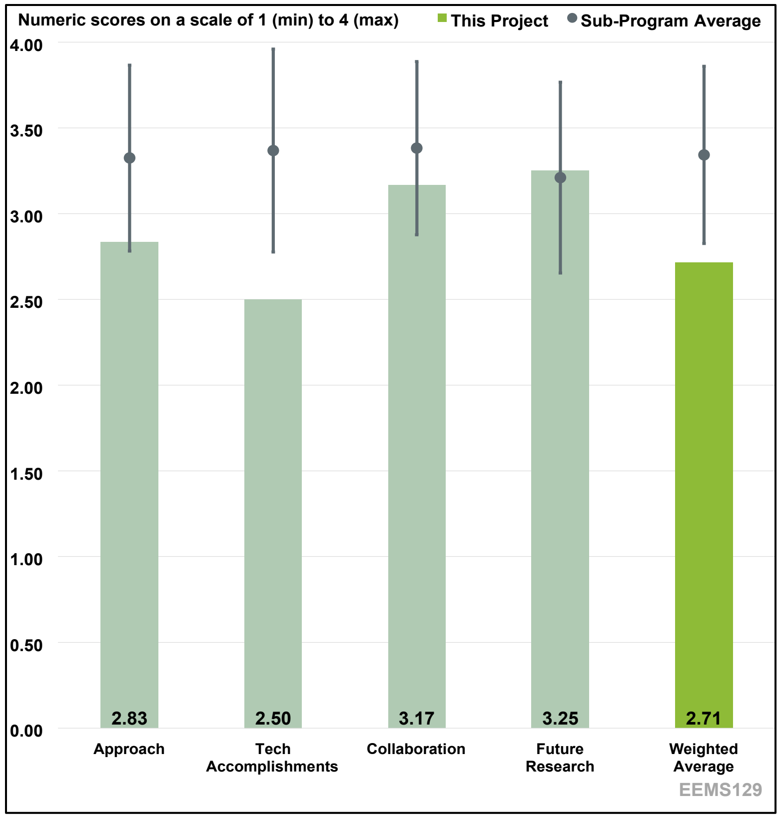

Figure 4-38. Presentation Number: EEMS129 Presentation Title: Using Artificial Intelligence to Predict Ridership and Optimize Shared Mobility Principal Investigator: Josh Rands, Terracity

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that there were not significant technical details presented about their approach, but the general approach they followed for gathering data and leveraging ML approaches for analyzing the data and providing meaningful insights seemed solid.

Reviewer 2

The reviewer said the project seems very well designed and has a practical approach to obtaining and using data sources. The reviewer stated that the workflow and data sources seem to be informed by a significant amount of additional expertise, and there are clear timelines to follow.

Reviewer 3

The reviewer stated that, from the material, it could not be determined if the alignment of the tool to the results on Slide 14 was because the tool was fed and calibrated with the available data, making the results of the tool a circular logic loop. The reviewer finished by saying the material does not show any of the math, inputs or constraint, only graphs of use.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer pointed out that the project team has successfully built and proven, to some extent, a model that has some value. The reviewer followed up by mentioning that the team admits, however, that the landscape is quite complex, and a lot of work will need to be done, to get a better picture of transportation behaviors of large numbers of people.

Reviewer 2

The reviewer acknowledged that the system appears to be providing meaningful results and is in a stage of tweaking and improvement. The reviewer explained that this can be an infinite source of work to do, as there will never be perfection, but the results shown versus actual data seems to be remarkably in line at this stage for the scenarios presented. The reviewer concluded by saying multiple pilot projects will provide useful input into what improvements the model could use.

Reviewer 3

The reviewer commented that there is no discussion of what makes regions different and why scheduled use of the different modes of transportation is why it is for the give cities/regions on Slide 14. The reviewer wondered why there is such high amount of walking in Denver and Boulder, but a small walkable downtown like Golden is less than one half of those? The reviewer finished by saying Slide 15 shows demographics but no link to why they are important for modes of transportation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that key partners specified in this project seem to be useful key players. Interviews with over 50 industry experts and the industry advisory group are noted for providing a strong base of coordination for ensuring project success.

Reviewer 2

The reviewer said it seems the project team needs to further emphasize collaboration with other entities. The reviewer added doing so can help them gain access to more and more useful kinds of data and help the project team establish partnerships that will drive adoption of this technology.

Reviewer 3

The reviewer pointed out that the project utilized NREL for progress. The reviewer did not see how Go-Vuba participation leads to results but understands it may have been in the data for Slides 15-17.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Proposed future work to complete their evaluation is solid. It is difficult to say if future work beyond that, at least at a similar level, will yield significant impacts.

Reviewer 2

There were clear next steps and proposed future research for this project, and they would seem very much in line with the stated objectives.

Reviewer 3

The reviewer commented that the project is complete as of May 2024.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated the work is relevant to the EEMS objectives because it aims to increase understanding of traffic and usage patterns of a wider range of transportation modes.

Reviewer 2

The reviewer remarked that multimodal and shared mobility modeling of transportation and the interactions between modes is still an active area of exploration, and this project seems to bring a deep well of information to inform decision-makers on the topic.

Reviewer 3

The reviewer expressed uncertainty over whether the ridership of the various mode of transportation will result in lower energy or CO_2 emissions. The reviewer suggested that the work can potentially be coupled with optimization of CO_2 use for reduction, but there are similar types of optimizations already being done. The reviewer finished by saying that the project might not be to be additive to those projects.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the program is complete and no future funding is needed.

Reviewer 2

The reviewer commented that resources seem to be sufficient but was unclear from the presentation if any additional resources were needed to be successful.

Reviewer 3

The reviewer said as the team showed, the limited data they were able to get access to and the limited scope seemed to hamper gaining understanding at sufficient scale or understanding sufficiently in more detail other existing methods that provide more insight. The reviewer continued by saying it could be a worthwhile path to pursue to gain better insight about these kinds of behavioral and traffic patterns, but it currently seems like it will require more resources to gain access to more and more types of data and do more sophisticated modeling.

Acronyms and Abbreviations – EEMS

Abbreviation	Definition
3D	Three-dimensional
ACC	Adaptive cruise control
ADS	Automated driving system
AI	Artificial intelligence
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AV	Autonomous vehicle
APaCK-V	Argonne Perception and Connectivity Kit - Vehicle
ATSPM-E	Automated Traffic Signal Performance Measures-Energy
AVL	company name
BEAM CORE	Behavior, Energy, Autonomy, Mobility Comprehensive Regional Evaluator
BP	Budget Period
C-V2X	Cellular-vehicle-to-everything
CARB	California Air Resources Board
CAV	Connected and automated vehicle
CDA	Cooperative driving automation
CERPMs	Chip-Enabled Raised Pavement Marker(s)
CO_2	Carbon dioxide
CRC	Cyclic redundancy check
CV	Connected vehicle
DGMARL	Decentralized graph-based multi-agent reinforcement learning algorithm
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Eco-ATCS	Ecological Adaptive Traffic Control System

Abbreviation	Definition
ECO_PI	Ecological Performance Index
EEMS	VTO Energy Efficient Mobility Systems subprogram
EV	Electric vehicle
FFC	Federal Communications Commission
FHWA	Federal Highway Administration
FIXS	Flexible interface for XIL simulation
FTA	Federal Transit Administration
GHG	Greenhouse gas
GM	General Motors
GSA	General Services Administration
GTT	Geospatial Transportation Typology
HD	Heavy-duty
HV	Human-driven vehicle(s)
INL	Idaho National Laboratory
IOO	Infrastructure Owner Operator
LBNL	Lawrence Berkeley National Laboratory
MD	Medium-duty
MEP	Mobility energy productivity
MITIE	Micromobility-Integrated Transit and Infrastructure for Efficiency
ML	Machine learning
N/A	Not Applicable
NEVI	National Electric Vehicle Infrastructure
NHTSA	National Highway Traffic Safety Administration
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer

Abbreviation	Definition
ORNL	Oak Ridge National Laboratory
PI	Principal investigator
PNNL	Pacific Northwest National Laboratory
POLARIS	ANL's high fidelity predictive transportation system model
PR	Pooled rideshare
QA	Quality assurance
RDD&D	Research, development, demonstration, and deployment
RFP	Request for proposal
RRC	Rolling resistance characterization
RR(s)	Radar retro-reflector(s)
SAE	SAE International, formerly Society of Automotive Engineers
SBIR	Small Business Innovation Research
SMART	Specific, Measurable, Attainable, Realistic, and Timely [milestones]
SMART	Systems and Modeling for Accelerated Research in Transportation
SoS	System of System(s)
SPaT	Signal phase and timing
T3CO	Transportation, Technology, and Cost of Ownership
TAT	Traffic analysis tool
TEMPO	Transportation Energy and Mobility Pathway Options
TFHRC	Turner-Fairbank Highway Research Center
TTS	Traffic Technology Services
UCI	University of California, Irvine
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything

Abbreviation	Definition
VECTOR	Visual-Enhanced Cooperative Traffic Operations
ViL/VIL	Vehicles-in-the-loop
VISSIM	PTV VISSIM – Traffic Simulation Software
VMS	Variable message sign
VOICES	Virtual Open Innovation Collaborative Environment for Safety
VRU(s)	Vulnerable road user(s)
VTO	Vehicle Technologies Office
VTOL	Vertical take-off and landing
XIL	Everything-in-the-loop
ZEV(s)	Zero emission vehicle(s)

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5. Materials Technology

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources. The Materials Technology subprogram supports VTO's goals of achieving 100% decarbonization of the transportation sector by 2050. This ambitious goal will be realized through the increased deployment of electric and hydrogen fuel cell vehicles. Materials play a significant role in increasing the efficiency of electric vehicles (EVs) through weight reduction and enabling faster charging and sensing technologies. The materials research also contributes to the goal of reducing GHG emissions and recyclability, helping reduce the overall embodied energy of vehicles.

Lightweight Materials activities support national laboratory, academia, and industry-led research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber (CF) composites, and multi-material systems. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light-duty and heavy-duty vehicles.

Lightweight Materials activities support these VTO program level goals:

- Enable a 25% weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, without significantly increasing costs; and
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing (AM) methods resulting in a 25% weight reduction in powertrain and suspension components by 2030.

Powertrain Materials activities similarly support research to develop higher performance materials needed by electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, helping transition to all electric light duty vehicles by 2035. Weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles are being advanced through this work, addressing challenging components such as inverters, motors, and geartrains. Current priority focus areas for the subprogram include: (1) lightweight alloys with high fatigue strength for suspension components, (2) high-temperature materials for lighter brakes, (3) predictive models for powertrain materials, and (4) Integrated Computational Materials

Engineering (ICME) tools that use high-performance computing capabilities, multi-length scale (atoms to components) material models, and boundary layer resolved thermo-kinetic models.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below. If a reviewer believed that no score was needed, not applicable (N/A) is used.

Table 5-1 – Project Feedback

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT146	Ultra-Lightweight Ductile Carbon Fiber Reinforced Composites	Seokpum Kim (Oak Ridge National Laboratory)	5-11	3.38	3.38	2.88	3.00	3.28
MAT159	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion - Fundamental Fatigue and Creep in Advanced Lightweight Alloys	Amit Shyam (Oak Ridge National Laboratory)	5-15	3.63	3.50	3.00	3.17	3.45
MAT160	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion - Hybrid Dispersion Strengthened Al Matrix Composites for Higher Efficiency EV powertrains	Mert Efe (Pacific Northwest National Laboratory)	5-20	3.40	3.50	3.10	3.00	3.41
MAT174	Carbon Fiber Technology Facility (CFTF)	Merlin Theodore (Oak Ridge National Laboratory)	5-25	3.00	2.83	3.17	2.67	2.90

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT196	High-Temperature Carbon Fiber Carbonization via Electromagnetic Power	Felix Paulauskas (Oak Ridge National Laboratory)	5-29	3.33	3.67	2.83	2.00	3.40
MAT197	Multi-Functional Smart Structures for Smart Vehicles	Patrick Blanchard (Ford Motor Company)	5-33	3.75	3.75	3.75	3.33	3.71
MAT198	Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure	Venkat Aitharaju (General Motors Company)	5-38	3.67	3.67	3.67	3.67	3.67
MAT199	Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)	Kevin Simmons (Pacific Northwest National Laboratory)	5-43	3.67	3.50	3.00	3.00	3.46
MAT200	Additive Manufacturing for Property Optimization for Automotive Applications	Seokpum Kim (Oak Ridge National Laboratory)	5-47	3.00	3.00	3.20	2.90	3.01
MAT202	3D-Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles	Rigoberto Advincula (Oak Ridge National Laboratory)	5-52	2.88	2.50	2.75	2.75	2.66
MAT203	Low-Cost High-Throughput Carbon Fiber with Large Diameter	Felix Paulauskas (Oak Ridge National Laboratory)	5-56	3.38	3.38	3.38	3.50	3.39

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT205	Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites	Amit Naskar (Oak Ridge National Laboratory)	5-61	2.88	3.00	2.88	2.17	2.88
MAT206	Soft Smart Tools Using Additive Manufacturing	Matthew Craps (Savannah River National Laboratory)	5-65	3.50	3.50	3.50	3.38	3.48
MAT207	Multi-Material Functional Composites with Hierarchical Structures	Christopher Bowland (Oak Ridge National Laboratory)	5-69	3.50	3.50	3.13	N/A	3.45
MAT208	Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste	Daniel Merkel (Pacific Northwest National Laboratory)	5-72	3.50	3.67	3.00	3.25	3.51
MAT209	Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling	Nicholas Rorrer (National Renewable Energy Laboratory)	5-76	3.38	3.50	3.25	3.25	3.40
MAT211	Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles	Masato Mizuta (Newport Sensors Inc.)	5-80	3.40	3.60	3.80	3.50	3.56

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT212	Integrated Self-Sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles	Amrita Kumar (Acellent Technologies Inc.)	5-84	3.30	3.30	3.10	3.25	3.26
MAT221	Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials	Dean Pierce (Oak Ridge National Laboratory)	5-88	3.88	3.88	3.75	3.67	3.84
MAT222	Extending Ultrasonic Welding Techniques to New Material Pairs	Jian Chen (Oak Ridge National Laboratory)	5-93	3.25	3.13	2.88	2.50	3.05
MAT223	Extending High-Rate Riveting to New Material Pairs	Kevin Simmons (Pacific Northwest National Laboratory)	5-97	2.25	3.50	2.50	2.00	2.88
MAT224	Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness	Piyush Upadhyay (Pacific Northwest National Laboratory)	5-100	3.13	3.13	3.00	3.00	3.10
MAT225	Surface Modifications for Improved Joining and Corrosion Resistance	Yong Chae Lim (Oak Ridge National Laboratory)	5-104	3.17	3.50	3.50	2.83	3.33
MAT226	Machine Learning for Joint Quality and Control	Keerti Kappagantula (Pacific Northwest National Laboratory)	5-107	3.50	3.63	3.50	3.50	3.56

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT231	Lightweight Metals Core Program Introduction	Glenn Grant (Pacific Northwest National Laboratory)	5-111	3.75	3.75	3.88	4.00	3.77
MAT235	Lightweight Metals Core Program - Thrust 4 - Residual Stress Effects	Ayoub Soulami (Pacific Northwest National Laboratory)	5-114	3.25	3.38	3.38	3.00	3.33
MAT236	Advanced Characterization and Computational Methods	Thomas Watkins (Oak Ridge National Laboratory)	5-117	3.75	3.88	3.25	3.25	3.69
MAT237	Materials Lubricants and Cooling for Heavy Duty Electric Vehicles	Jun Qu (Oak Ridge National Laboratory)	5-122	3.50	3.83	3.33	3.67	3.67
MAT241	Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems	Beth Armstrong (Oak Ridge National Laboratory)	5-126	3.75	3.50	3.00	3.50	3.50
MAT242	Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs	Tolga Aytug (Oak Ridge National Laboratory)	5-129	3.50	3.75	3.88	3.63	3.69

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT243	Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system	Srikanth Pilla (Clemson University)	5-134	3.33	2.67	3.00	2.17	2.81
MAT244	Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation	Scott Whalen (Pacific Northwest National Laboratory)	5-137	3.60	3.70	3.50	3.00	3.62
MAT245	Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet	Alex Plotkowski (Oak Ridge National Laboratory)	5-141	3.50	3.25	3.50	3.50	3.41
MAT246	Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet	Mert Efe (Pacific Northwest National Laboratory)	5-144	3.67	3.50	3.50	N/A	3.55
MAT247	Lightweight Metals Core Program P2A - Solid Phase Processing of Aluminum Castings	Saumyadeep Jana (Pacific Northwest National Laboratory)	5-147	3.75	3.75	3.50	N/A	3.71
MAT248	Lightweight Metals Core Program P2B - High Intensity Thermal Treatment	Aashish Rohatgi (Pacific Northwest National Laboratory)	5-150	3.00	3.00	3.50	N/A	3.07

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT249	Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings	Alex Plotkowski (Oak Ridge National Laboratory)	5-152	3.50	3.25	3.25	3.00	3.31
MAT250	Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation	Vineet Joshi (Pacific Northwest National Laboratory)	5-155	3.75	3.50	3.25	N/A	3.54
MAT251	Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Magnesium Castings	Mageshwari Komarasamy (Pacific Northwest National Laboratory)	5-159	3.25	3.25	3.38	3.50	3.27
MAT252	Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle	Jeff Spangenberger (Argonne National Laboratory)	5-163	3.10	3.10	2.90	3.25	3.09
MAT254	Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers	Yinghua Jin (Rocky Tech Ltd.)	5-167	3.00	3.13	3.25	3.00	3.08
MAT257	Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires	Kurt Swogger (Molecular Rebars LLC)	5-170	3.40	3.50	3.30	3.38	3.44
MAT265	Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles	Xiaodong Li (University of Virginia)	5-174	3.20	3.30	3.50	3.20	3.29

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT266	Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles	Amrita Kumar (Acellent Technologies Inc.)	5-179	3.67	3.50	3.50	3.50	3.54
MAT267	Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles	Lorenzo Mencattelli (Helicoid Industries Inc.)	5-182	3.20	2.80	3.50	3.10	3.03
MAT268	Upcycling of Polymer Composites for Vehicle Decarbonization	Roger Crane (Composites Automation LLC)	5-186	3.30	3.60	3.70	3.10	3.48
MAT269	Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene	Daniel Mulqueen (Climate Robotics LLC)	5-190	2.50	2.75	3.13	2.67	2.73
MAT280	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies	Amit Naskar (Oak Ridge National Laboratories)	5-194	3.38	3.25	3.00	3.25	3.25

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT281	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures	Christopher Bowland (Oak Ridge National Laboratories)	5-198	3.25	3.13	3.38	3.00	3.17
MAT282	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites	Kevin Simmons (Pacific Northwest National Laboratory)	5-202	3.63	3.75	3.38	3.63	3.66
MAT283	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing	Vlastimil Kunc (Oak Ridge National Laboratories)	5-208	3.17	3.00	3.17	3.00	3.06
Overall Average				3.36	3.38	3.28	3.12	3.34

Presentation Number: MAT146
Presentation Title: Ultra-Lightweight Ductile Carbon-Fiber Reinforced Composites
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

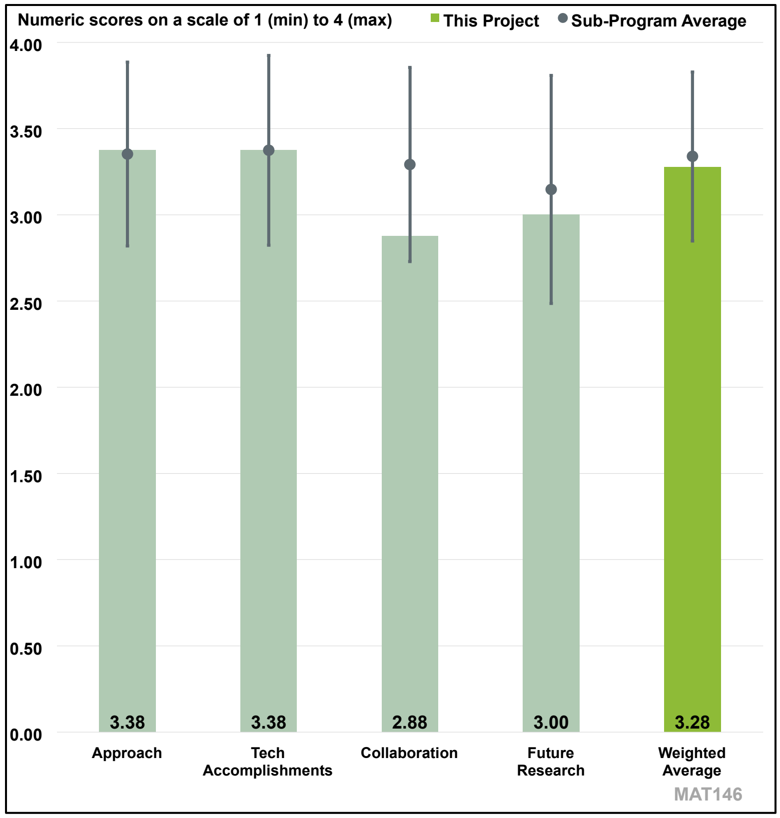

Figure 5-1. Presentation Number: MAT146 Presentation Title: Ultra-Lightweight Ductile Carbon-Fiber Reinforced Composites Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the presentation listed various technical barriers, and the team addressed the challenges with a well-planned and articulated technical approach. The well-designed micro-hierarchical architecture of the structures has helped to achieve higher mechanical properties out of a low-density material. However, there are some other technical challenges that need to be addressed in the coming year related to improving the accuracy, scale, and speed of the AM technique.

Reviewer 2

The reviewer explained that overall, this work aims to take an ultraviolet curable resin and three-dimensional (3D) print it to form structures that afford both strength and ductility. During the length of the project, the team has scaled up their production from the millimeter scale to the near meter scale. The approach is straightforward and well laid out. The reviewer noted that there are challenges that must be overcome in the work that include maximizing CF loading while still ensuring printability. The researchers also found that the composites were multifunctional because their resistance could be used to calculate their stress response. The reviewer noted that the researchers design in this space demonstrates that they could detect the stress response as a function of orientation through their design and approach. The reviewer noted to the project team that it would be beneficial to follow the prescribed presentation template format for the Annual Merit Review (AMR) to make sure they are adequately addressing all questions and their approach thoroughly. As an example, no milestone table was shown in this work.

Reviewer 3

The reviewer stated that this project aims to address the technical barrier of designing lower-density materials with suitable mechanical properties, specifically materials with higher strength-to-weight and/or higher stiffness-to-weight ratios. The target is hybrid hierarchical CF-reinforced materials that are ultralight, strong, tough, and suitable for large-scale 3D printing. The reviewer stated that the project is well-designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer agreed the project is well designed with a timeline that is reasonably planned and executed such that the milestones have all been achieved. The reviewer pointed out that the technical barriers have been addressed, and the development of the proposed system can be seen.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer asserted that the project achievements presented are well-aligned with the project milestones. They noted that prototypes have been produced, and samples are evaluated and characterized, which align with the project plan.

Reviewer 2

The reviewer agreed that the project accomplished its goals and demonstrated robust design and a characterization of the developed system. The reviewer noted that the researchers have described the barriers that they encountered in their work. The reviewer added that it would be easier to comment on the project progress if the team followed the presentation template approach prescribed for the AMR to discuss project milestones, go/no-go decisions, and the like.

Reviewer 3

The reviewer acknowledged the presented technical progress demonstrated a well-planned and well-executed project. The reviewer felt that the technical details in the presentation are thorough, and the project delivery is considered very successful.

Reviewer 4

The reviewer asserted that given that all the milestones identified have been achieved, the technical progress on this project has been excellent.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that this project is in one of the four thrust areas and is well-coordinated among the different teams working on the other thrusts. Furthermore, the team has worked in collaboration with Nissan as an industrial partner.

Reviewer 2

The reviewer explained that the team includes Oak Ridge National Laboratory (ORNL) and University of California, Berkeley. The reviewer remarked that the collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 3

The reviewer noted that the team is at ORNL and thus there is a lot of interaction with that team. Additionally, during the presenter's future remarks, they commented that Nissan is interested in their approach. Otherwise, this was not explicitly addressed. The reviewer concluded by mentioning that the University of California, Berkeley manufactured the machines for this work.

Reviewer 4

The reviewer was critical that no information was presented in the slides on the collaboration between University of California, Berkeley and ORNL (the sponsoring organization). The reviewer commented that the reviewers learned during the question-and-answer period that ORNL provided guidance while University of California, Berkeley performed all the process development. However, it is not clear to the reviewer how the coordination was conducted through the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer described that the project proposed to develop multi-functionality for a self-sensing composite material. The preliminary work has been done, and the reviewer expects the team will achieve the proposed future goals.

Reviewer 2

The reviewer stated that the presenter mentioned that their Composite Core Program 2.0 project will work on further scale up and piezo electrics.

Reviewer 3

The reviewer described that the proposed future research includes demonstrating multifunctional self-sensing CF reinforced composites (CFRC) and developing a design and printing method with responsive (piezoelectric), structural (CFRCs or ceramic), and conductive (copper, liquid metal, silver, etc.) architected structures for smart sensing and actuation. This will be conducted in the Composite Core Program 2.0. The reviewer asserted that project has clearly defined the purpose of future work, which is advanced characterization, and the future work is likely to achieve its targets.

Reviewer 4

The reviewer pointed out that given that all the milestones have been achieved and the project is ending soon, the reviewer rated N/A for this question.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated the project is relevant because there is work on additive manufacture of high strength materials. The material structure has well-tailored material properties for specified industrial applications. The reviewer stated that with improved resolution, speed and quality, the AM technique can play a vital role in the manufacturing industry.

Reviewer 2

The reviewer agreed that this work is aligned with the DOE VTO Lightweight and Propulsion Materials subprogram's goals. Through their intelligent design, the researchers can use less material and ensure ductility, though the reviewer noted that the ductility was not explicitly shown compared to the strength. The reviewer agreed that this is aligned with the goals of addressing current issues associated with CFRCs.

Reviewer 3

The reviewer acknowledged that the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Lightweight and Propulsion Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer asserted that this project is relevant to the composites research performed in the Lightweight and Propulsion Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that there are adequate financial, technical and equipment resources for the project.

Reviewer 2

The reviewer stated that the project budget seems sufficient for the work performed.

Reviewer 3

The reviewer noted that the resources seem sufficient to the scope and schedule of the project.

Reviewer 4

The reviewer affirmed that ORNL and University of California, Berkeley provide sufficient and powerful resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT159
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Fundamental Fatigue and Creep in Advanced Lightweight Alloys
Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

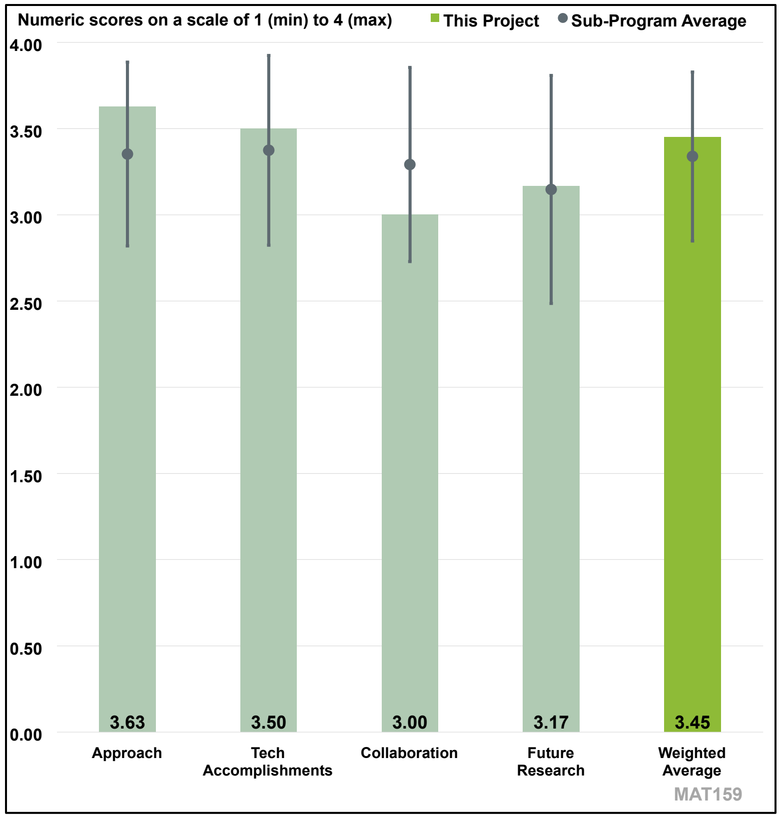

Figure 5-2. Presentation Number: MAT159 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Fundamental Fatigue and Creep in Advanced Lightweight Alloys Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

Presenter

Amit Shyam, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated creep is a common engineering challenge that causes many issues and limits some innovation. The reviewer said the work here is excellent and this project holds potential to create a new space where these issues are controlled and could therefore facilitate additional innovation. The work is well defined and well executed. The publications related to this work will have high impact because this is a fantastic way to increase overall vehicle efficiency, and therefore also increase vehicle range which is the largest impediment to more widespread adoption of electric propulsion. Lightweighting is one of the most effective ways to increase both range and efficiency.

Reviewer 2

The reviewer affirmed the project addresses barriers necessary to enable widespread use of battery electric vehicles (BEVs) once BEVs are more widely available. However, the project does not enable the technology to go to market.

Reviewer 3

The reviewer stated this is a creep mechanism study of aluminum (Al)-copper (Cu)-manganese (Mn)-zirconium (Zr) alloy prepared by casting and AM methods. The team used the classic metallurgical methods to study the alloy's properties as well as the microstructural and phase distributions of the two alloys. The researchers then proposed two hypotheses to explain the observation.

Reviewer 4

The reviewer commented the approach used in this work is adequate to address the question raised by the project and to achieve the goals of the project. The project is adequately designed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked the project team's work in this space is very high quality. This is a well-executed project that has delivered at each milestone. The work on properties of the Al-Zr-tin (Sn) based electrical conductor alloy is superb and the need to optimize conductors in electric vehicles is critical. The need for lower-weight, higher-efficiency conductors is a large opportunity, and the project team has well documented the need for as well as the capability of this very attractive Al-Zr-Sn alloy.

Reviewer 2

The reviewer praised the project team's excellent work and noted substituting low-cost iron (Fe) for nickel (Ni) and cobalt (Co) will have increasing value as researchers will be competing for the resource with others who need Ni and Co for EV batteries. This is especially true for Co, due to its environmental impact and the political instability of its major producer, the Democratic Republic of Congo.

Reviewer 3

The reviewer stated for the cast sample, the project team found Fe is a cost-effective alternative to Ni and Co, albeit the amount of Cu needs to be increased to balance the Cu consumed by the newly formed Al-Cu-Fe intermetallic phase. The reviewer commented the project team found the AM sample exhibits the highest creep resistance at 400°C for a monolithic Al alloy and attributed the strengthening mechanism to the Orowan strengthening caused by the resistance of hard reinforcement particles to the passing of dislocations and the load-transfer strengthening mechanism that is transferred to the hard intermetallic particles.

Reviewer 4

The reviewer praised the researchers for their excellent work and acknowledged this work focuses on fundamental understanding, which will be used to guide more applied work. The researcher confirmed some questions remain to be answered or addressed in this or subsequent work such as:

(a) Is creep the right degradation mechanism to evaluate the brake rotor materials? The reviewer commented creep is usually good for evaluating materials and components under load at set (or variable) temperatures (usually high) for extended periods of time. Brake rotors are typically under load when brakes are applied, which is usually a matter of seconds. The reviewer would also like additional information regarding why the researchers chose this attribute for materials evaluation.

(b) In the Al-Cu-Mn-Zr (ACMZ) precipitation hardened materials, is creep resistance dependent on the presence of Al-Cu-Fe intermetallic compounds (IMCs)? The reviewer stated the research results indicate ACMZ precipitation hardened materials will be demonstrably good for creep resistance but may have a negative impact on corrosion resistance. There is a long history documenting the effects of these IMCs on corrosion of the Al matrices. Al-Cu-Fe IMCs tend to cause trenching of the Al-matrix around it. An investigation of the effects of corrosion on rotors made from ACMZ material is warranted to make sure solving one problem (creep) does not inadvertently create another (severe/unacceptable levels of corrosion). This investigation should also be extended to the Al-cerium alloys.

(c) The reviewer acknowledged the last question they would like answered is “How does cost and target properties relate to the fundamental nature of the work as mentioned in (a) and (b) above?” Therefore, the following comment is not as critical as it would have been if the work were fully applied. The reviewer stated, nonetheless it would have been beneficial for the project team to have included an estimated cost of these new materials including a brief comparison with what was already obtained. The cost estimate would have provided researchers pursuing the work for applied purposes an idea of what challenges (if any) to keep in mind as they pursue full commercialization of the products to market. The reviewer also mentioned it would have been helpful for the project team to state the target properties from a performance perspective (e.g., expected operating window, hardness/ductility, wear resistance, corrosion resistance targets, etc.) for this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that clearly the project teams all participating strongly and there was good cross company collaboration among these diverse teams.

Reviewer 2

The reviewer commented collaboration between the project teams appeared light and was primarily conducted at ORNL.

Reviewer 3

The reviewer remarked the team partnered with Northwestern University, but the role of the university is not clear.

Reviewer 4

The reviewer stated that the partners listed in this work include ORNL, Northwestern University and NanoAl, a limited liability corporation (LLC). Apart from the high-level task descriptions, this reviewer did not get a sense of the level of coordination between these partners during the presentation. This reviewer can only assume the coordination was adequate and seamless because the work has concluded. The presentation was not focused on showing collaboration, but on addressing progress made in one aspect of the work on brake rotors. The other aspects of the work were not addressed in the latest presentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer affirmed the proposed future research is relevant and meaningful. The work has clearly increased the project team’s insight, and they are addressing specific opportunities that can make a real difference in the speed of the technology to market and increasing environmental conservation without sacrificing mobility.

Reviewer 2

The reviewer verified the proposed work is relevant.

Reviewer 3

The reviewer clarified the team will study the Al-conductor alloy's mechanical behavior in the next phase.

Reviewer 4

The reviewer commented that the possible corrosion issue with the two materials highlighted was not mentioned in the presentation, although the presenting researcher mentioned that it would be good to address this in future work. This reviewer agreed and remarked that other matrices apart from creep resistance should also be investigated or considered for materials that would pass or fail the selection criteria. The areas highlighted by the researcher should also be considered as potential future work areas.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented once again, the relevance of this project, as well as the program initiatives, are positioned to be able to allow these talented researchers to deploy technology which has a short runway to production and clear impact. This type of work is fundamental and doing it will have ripple effects in several adjacent areas which also may create new and unique further uses of the science. The project is clearly well aligned to the VTO Materials subprogram and is creating tangible value to the mobility industry.

Reviewer 2

The reviewer expressed many barriers must be overcome for BEVs to gain acceptance in the marketplace. The project addresses concerns once commercial manufacturing occurs.

Reviewer 3

The reviewer stated that the understanding of creep mechanism for the Al alloys will pave the way for the lightweight materials development.

Reviewer 4

The reviewer expressed this work is relevant to developing optimized materials for EV manufacturing and supporting their efficient operation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed resources were indicated to be sufficient, high-quality data was well utilized, and all project milestones were met.

Reviewer 2

The reviewer affirmed resources did not appear to be a concern for the project.

Reviewer 3

The reviewer stated the team received $265,000 per year for the mechanism study and commented this amount is somewhat insufficient.

Reviewer 4

The reviewer remarked the project seems to have been completed without an additional request for funding.

Presentation Number: MAT160
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains
Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

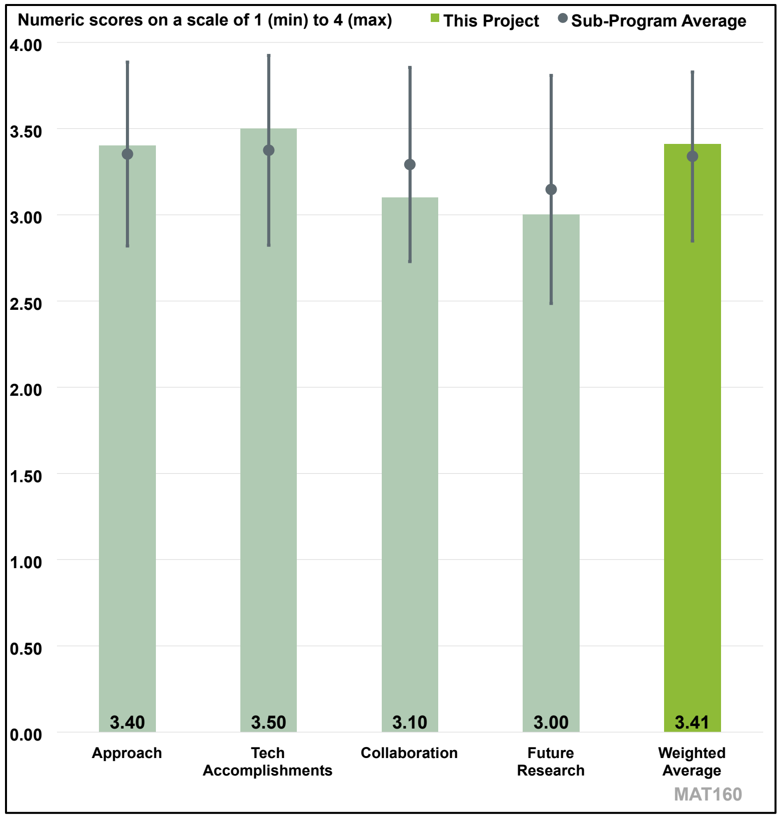

Figure 5-3. Presentation Number: MAT160 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Presenter

Mert Efe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked it is a great concept to use an Al metal matrix composite (MMC) to replace cast iron for brake pads. The friction consolidation of Al alloy 7075 with a titanium diboride (TiB_2) strengthening particle is an innovative approach to strengthen the Al alloys.

Reviewer 2

The reviewer said the scope is well documented and explained. Critical barriers are identified and clearly addressed, including cost and the performance of current materials. The challenge is to quantify the net gains available due to the decreased mass to offset the cost differential.

Reviewer 3

The reviewer commented the approach seems to be adequate and addresses most, if not all, technical issues presented in this project.

Reviewer 4

The reviewer said the project reached its objectives and goals in fiscal year (FY) 2023.

Reviewer 5

The reviewer said this project developed two different methods to fabricate an Al metal matrix composite (Al MMC) with various concentrations of TiB_2 flakes. TiB_2 is a ceramic material with relatively high strength and durability. The stir and squeeze casting at Loukus Technologies, Incorporated (Inc.) (LoukusTech) a collaborator, resulted in a lower cost method to compete with cast iron. Pacific Northwest National Laboratory (PNNL) developed a friction consolidation and forging method to create the composite. This method would result in near-net-shapes with high strengths. The reviewer said the project created and benchmarked MMC brake rotors against cast iron to compare characteristics.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said this project completed all the stated milestones, including the production of a disc-shaped Al-MMC component that contains at least 8% by volume of micron- and submicron-sized reinforcing particles with less than 2% porosity. The team was able to demonstrate the production of composites by two different methods, stir and squeeze casting. The team created Al MMC brake rotors that resulted in a 2.7x lower wear rate than cast iron. Various alloys of the composite showed different coefficients of friction and wear rates. These processes could eventually result in lighter, more rugged brake rotors. The reviewer noted EV applications that use regenerative braking decrease the amount of energy that must be dissipated by the mechanical brakes by as much as 40%, so the thermal properties of an Al MMC would be sufficient. The lower wear rate of these rotors could improve maintenance intervals, lower corrosion rates, and decrease particulate material emissions. The reviewer said using Al MMC to replace cast iron electric motor components could result in considerable weight savings while maintaining strength and durability. The resulting volumetric torque density of an electric motor could potentially be increased by 400%.

Reviewer 2

The reviewer said the project has completed all milestones.

Reviewer 3

The reviewer noted that physical properties of the MMC's were well documented, and their performance was evaluated via bench testing. Grain refinement is a strong asset. The team's high strength Al MMC is a very positive accomplishment. The reviewer noted the effect of the oxidation layer on wear was not defined, this should be understood to see how it effects overall performance. The improved wear resistance compared to cast iron is a great accomplishment for this low weight option.

Reviewer 4

The reviewer noted the project demonstrated a squeeze casting process; validated the superior wear rate of the Al-MMCs; demonstrated the process of friction consolidation of an Al-MMC; and showed the impressive improvement in ultimate tensile strength, modulus, and elongation, albeit at the expense of ductility. But even at a great loss of ductility, for a brake pad application, this loss may not matter much, considering the target is cast iron.

Reviewer 5

The reviewer noted the project concluded in March 2024 and useful technical accomplishments were documented. These results will contribute towards achieving current and future materials development goals for VTO.

The reviewer said some other information that would have been good to know include residual stress and strain profiles of the discs produced on Slides 9-13, and whether other production methods would have been cheaper and faster in achieving/contributing to this goal. A full treatment of the interplay between the friction coefficient and wear rate of the materials evaluated, especially with brake pads optimized for ceramic (rather than for steel) rotors would have been useful as well as quantification of the importance of ductility for the various applications being considered. Low ductility does not necessarily mean that the materials are inadequate or have a performance deficit. This would depend on the application.

The reviewer said the impression given on Slide 15 (80% loss of ductility) seems to suggest that this loss is a performance deficit. The reviewer asked if this is true for all applications, in all cases.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the collaboration between PNNL, ORNL, and LoukusTech gave the appearance that most of the effort was completed by the national laboratories.

Reviewer 2

The reviewer noted that LoukusTech is the industry partner. The team worked synergistically, with PNNL on friction consolidation while LoukusTech worked on the squeeze casting.

Reviewer 3

The reviewer commented coordination amongst the listed partners (PNNL and LoukusTech) seemed to have been adequate.

Reviewer 4

The reviewer remarked PNNL collaborated with LoukusTech to develop the technologies in this project. LoukusTech specialized in a process that can produce a functionally graded preform, placing a higher volume fraction of ceramic in one region, with reduced gradient elsewhere in the MMC. The reviewer said further details were not provided in this presentation.

Reviewer 5

The reviewer said publishing on a partner website does not document equal collaboration by the team. This could be better represented with a better understanding of where each set of data was generated, and where each analysis was performed. As presented, collaboration appears very PNNL-centric.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the work has ended and was reported as such.

Reviewer 2

The reviewer said “none,” project reached its objectives and goals in FY 2023.

Reviewer 3

The reviewer said the project has ended by the time of the review.

Reviewer 4

The reviewer commented the only future work proposed includes application of the current results in axial flux motor applications, which is being pursued in what appears to be a new project (Powertrain Materials Core Program 2.0 [PMCP 2.0]), which is focused on permanent magnet production. The reviewer recommended that the comments made in Section 4 should be considered for incorporation, as appropriate, into future work plans.

Reviewer 5

The reviewer stated, “N/A. This project has ended.”.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the target values were exceeded for both applications of this technology, indicating there is significant opportunity in this area. This does fit well with the VTO Materials subprogram objectives, as it is simple to draw a direct correlation with the target values and the ability to increase efficiency with deployment.

Reviewer 2

The reviewer commented the project will reduce brake weight.

Reviewer 3

The reviewer said this work is important for its contribution towards optimized lightweighting and powertrain efficiencies in EVs.

Reviewer 4

Accelerating the development of lightweight alloys for EV propulsion for advanced EVs is a major thrust of the VTO Materials PMCP. Cost-effective lightweight alloys made from hybrid-dispersion strengthened Al MMCs has the potential to replace heavier cast iron components in vehicles. Al MMC brake rotors also have the potential to decrease particulate material emissions from brake dust. Al MMCs can offer multifunctionality for compact and high-power density components in gearboxes, electric motors, and differentials.

Reviewer 5

The reviewer said the project tangentially supports the development of BEVs. The work on the gears will have more impact than the rotor work.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said $600,000 in two years was insufficient to create the Al-MMC materials, but the team managed to succeed.

Reviewer 2

The reviewer remarked resources appeared to be appropriate for the work performed, including sample creation, data generation, and analysis.

Reviewer 3

The reviewer said the project appeared to have the required resources to complete the work.

Reviewer 4

The reviewer commented the project was completed/concluded with the funding provided.

Reviewer 5

The reviewer said funding provided to this project was sufficient to meet the stated goals, milestones, and objectives.

Presentation Number: MAT174
Presentation Title: Carbon-Fiber Technology Facility (CFTF)
Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Presenter

Daniel Webb, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

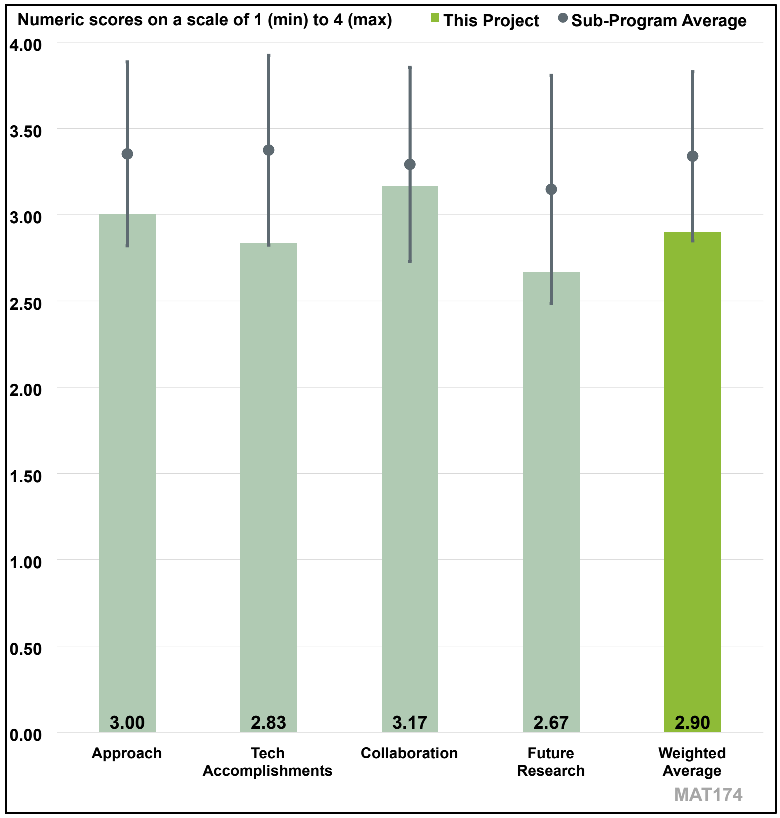

Figure 5-4. Presentation Number: MAT174 Presentation Title: Carbon-Fiber Technology Facility (CFTF) Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that the project clearly presented the technical barriers and how the project is designed to meet those barriers. The motivation behind the approach was clearly communicated. However, the reviewer was confused about the length of this project. The “Overview” slide said the timeline is “Oct. 1, 2013, to present”, so the reviewer was unclear if the work presented is just a one-year project. Also, the budget says “$1 million up to FY23” even though this project is presented in FY 2024, and the budget table lists much more money than $1 million. The reviewer asserted that in future AMR presentations, the researchers should clarify the exact funds for the project that is presented. The reviewer also remarked that it would also be better to have a research and development (R&D) staff member with more technical expertise to present the project at the next AMR.

Reviewer 2

The reviewer expressed that high quality mesophase pitch is critical for production of high-performance CFs. Deriving pitch from halogenated wastes secures the supply chain, decarbonizes the domestic CF industry, and achieves circularity. The reviewer praised that the project is well-designed, and that the timeline is reasonably planned. The facility is critical for scaling up and technology transition to industry through industry partners.

Reviewer 3

The reviewer agreed that the project has made certain progress in addressing various challenges, however, there are still existing challenges that need to be addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer asserted that the project is on track and making progress, adding that the newly built reactor processed 20 grams of isotropic pitch (a critical step) that will be further derived into the mesophase (50%) for the precursor fiber. The plan to scale up and lower the cost is promising. The reviewer highlighted that the process has low carbon emission compared to the traditional mesophase pitch production.

Reviewer 2

The reviewer noted that the project has multiple objectives under developing a low-cost CF fabrication method, however, the progress of the project appears to be ahead of schedule.

Reviewer 3

The reviewer indicated that satisfactory progress has been made to date for creating a reactor that converts the isotropic pitch to mesophase pitch, and all the milestones have been achieved. This project has shown satisfactory progress to start scaling up the process as outlined. However, due to this being a $1 million project, the reviewer expected a bit more to be accomplished and a bit more analysis of the pitch that was converted to show the homogeneity of the final product and how the mesophase content is quantified to validate that the reactor design is appropriate. The reviewer mentioned that the presentation was lacking data for characterizing the product after going through the reactor.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that collaboration with one industrial partner, JR Automation, was mentioned for performing the design and scale-up of the developed process. The reviewer expressed that one thing that should have been addressed is the deadline date for JR Automation to deliver the reactors to show how the date fits into the project timeline.

Reviewer 2

The reviewer commented that the project is run through a collaboration between multiple stakeholders, including ORNL and University of Tennessee.

Reviewer 3

The reviewer pointed out that the project resulted in intellectual property and that the team will utilize existing collaborative partnerships in pitch and graphite foam to help the technology transition to industry. After scaling up, the mesophase pitch is anticipated to be of low cost and low carbon emission.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future research is well-planned with clearly defined deliverables and timelines. With the success of a newly built reactor, the future work will achieve the project targets. The scaling up is going to help further reduce the cost.

Reviewer 2

The reviewer commented that the proposed future work was discussed in a couple bullets on the summary slide. However, more details could have been included about the future work to show the project targets and how those targets will be achieved. The reviewer explained that the proposed work mentioned was a bit vague. For example, one bullet in the future work is "carbon fiber structure property relationship determination from candidate pitches"; this bullet could have used much more explanation. The reviewer asked if the researchers are proposing to use the mesophase pitch and go through the entire CF production process during this project. That seems very ambitious.

Reviewer 3

The projected listed future works which the reviewer considered as the main goals of the project. With the existing time constraint and the depth of required work, the reviewer had reservations about the achievement of the project goal.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is very relevant for producing an alternative CF precursor. This is important for VTO's vehicle lightweighting efforts and this project could potentially drive down the cost of CF for more widespread adoption in vehicles.

Reviewer 2

The reviewer believed the project is highly relevant for developing a low-cost and energy saving production process that aligns with the objective of VTO Materials subprogram.

Reviewer 3

The reviewer commented that the excessive cost of CFs hinders their applications in automotive composites. The reviewer explained that the precursor is about 50% of the CF cost and the project aims to produce mesophase pitch from halogenated wastes, lowering the precursor cost and resultant CF cost and enabling the use of CFs in automotive composites for lightweighting and decarbonization.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer agreed that there are sufficient technical, financial and facility resources to achieve the objective set.

Reviewer 2

The reviewer stated that the CFTF has the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 3

The reviewer commented that the funds are excessive for this project. The reviewer opined whether they interpreted the presentation correctly that this is a one-year project valued at $1 million. If so, those funds seem a little excessive for the scale of this project and what has been achieved so far. If this is a longer-term project, then that should be clarified at the next AMR and that would change the evaluation of the resource utilization.

Presentation Number: MAT196
Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

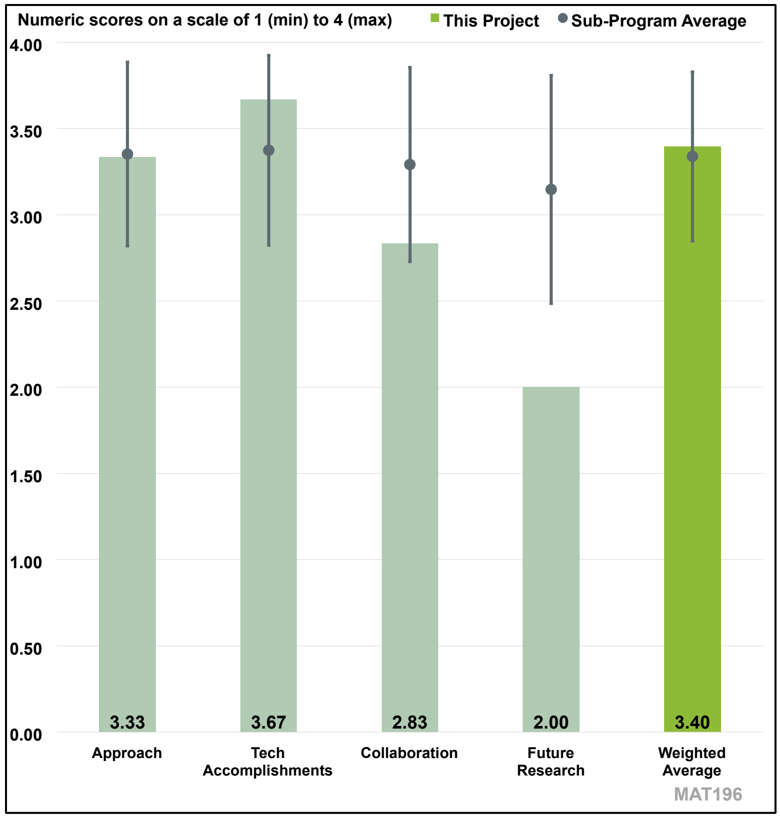

Figure 5-5. Presentation Number: MAT196 Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer explained that the technical barriers of reducing energy consumption, total cost of CF, and increased overall throughput are addressed in the project through a novel approach of using electromagnetic (EM) energy to provide a low-energy, high-temperature source to directly couple and indirectly heat a low-temperature carbonized fiber to produce a fully carbonized fiber. This approach also allows for operating a process at atmospheric pressure. The goal is to reduce energy consumption by 20% which will realize about a 5% reduction in the cost reduction for the overall manufacturing process and produce equal or better-quality CF. The reviewer agrees that this approach fully supports the VTO goals of reducing energy and improving the manufacturing process. This project has built on the research performed since 2015 and ends in 2024, so no timeline was presented, only FY 2024 milestones. The project was originally well designed, but unforeseen circumstances with equipment needed for the subsystems created a significant slippage in the project timeline.

Reviewer 2

The reviewer noted that the proposed work is focused on dielectric heating technology with the scope based on fundamental theories of EM energy. However, the reviewer asked what the EM power/energy difference between low temperature carbonization (LTC) and high-temperature carbonization (HTC) is, and asked how it will work if higher power is used in LTC.

Reviewer 3

The reviewer commented that the project was well designed with clearly defined performance goals and a baseline (Hexcel AS4 fiber) to compare. While the chosen baseline fiber is a high performance (aerospace) grade fiber rather than a comparable industrial grade fiber, the project team identified clearly that their process and the resulting CF is targeted for industrial applications where more variance and “lower” performance would be acceptable. This reviewer agreed that during the multi-year project, the principal investigator (PI) encountered multiple challenges including a global pandemic and challenging equipment failures. The reviewer applauded the persistence of the project team that resulted in accomplishing the project goals and is to be commended. The HTC phase of carbon conversion that was used to focus on the energy-intensive and time-consuming conventional process and to shorten residence time which reduces the total energy required is clearly an improved approach to expanding capacity and reducing total cost and environmental impact of CF production. The project execution was well done. Given the complexities of the HTC process using EM-coupled dielectric heating, the reviewer appreciated the multiple process parameters that the project team were able to explore. The reviewer suggested that it would be just more informative if the presenter had expanded on the theoretical (or notional) impact of the chosen process settings (LTC and HTC line speeds). The reviewer noted that the process stretch conditions were held constant and the identification of optimal process conditions for the LTC and HTC elements followed by a series of tests with variable stretch/temperature conditions is well done.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer explained that because of equipment problems, the system had to be rebuilt, which was not part of the original project plan and created delays in the schedule. Once the system was online, progress was good. Line speeds of 40 in/min and 20 in/min with set stretch and temperature conditions resulted in exceeding the VTO Materials subprogram targets of 550 ksi tensile stress and 29 Msi modulus. The reviewer noted that the energy consumption for conventional HTC industrial furnaces is likely in the range of 2.27-4.34 kWh/lb. EM energy in a high-temperature application was used to produce four tows with 1.98 kWh/lb of energy (in contrast to 2.27-4.34 kWh/lb for conventional processes), which is conservatively 30% lower than conventional high-temperature conversion applications. The reviewer highlighted that this is well above the original goal of 20% reduction in energy consumption.

Reviewer 2

The reviewer stated that the project completed all milestones, and the final report was submitted in December 2023.

Reviewer 3

The reviewer remarked that more comment is necessary given that the project team met or exceeded the minimum performance goals established at the onset of the work. The combination of tensile strength, modulus, and total energy consumed is a compelling result. The reviewer asserted that congratulations is due to the PI's involved. The reviewer noted that it is understood that stretch and temperature conditions are proprietary elements of the processing. The reviewer suggested that it would have been helpful to clarify in the HTC8 results that the orange, yellow, and purple trials were differentiated as being all run at a LTC line speed of 40 in/min and an HTC line speed of 20 in/min (unique from HTC6 trials). The reviewer assumed this was the case and stretch/temperature conditions were the only differential in these trials.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer expressed that collaboration was minimal and only included ORNL and one industry source, 4X Technologies, LLC (4XT). There was no involvement with academia or other external entities, which may not have been required because of the advanced stage of the research.

Reviewer 2

The reviewer expressed that it was somewhat disappointing and concerning that the equipment challenges were so dominant in the timeline for execution. The implication is there are significant hardware challenges associated with this technology. The reviewer noted that little has been said about technical details associated with the extensive time lapses required to remediate the equipment. The reviewer asserted that the only reasonable conclusion is a disconnect among the team members, but the reviewer noted that this is an inferred conclusion and not one clearly stated by the PI. Given the achievements of the project team, it is difficult to be critical but resulted in this reviewer giving a relatively low score based on this inferred conclusion.

Reviewer 3

The reviewer remarked that the role of 4XT was not mentioned clearly throughout the presentation but was acknowledged at the end with some tasks.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that no future research was presented; however, the technical accomplishments indicated that using a better generator technology with a better yield will strongly impact the net energy required, which implies that future work may be needed.

Reviewer 2

The reviewer was more concerned about the lack of future recommendations contained in the project summary given the positive results yielded by the project and meeting all technical goals for fiber performance coupled with energy reductions.

Reviewer 3

The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed this project is relevant and directly supports the overall VTO Materials subprogram objectives of reducing energy consumption and improving production volume.

Specifically, the project addresses the Materials subprogram technical objectives of weight reduction >25%, strength of >250 ksi, and modulus of >25 Msi.

Reviewer 2

The reviewer stated the project is very much relevant to the mission of the VTO Materials subprogram.

Reviewer 3

The reviewer explained that the project holds the promise to significantly reduce the energy required in the HTC zone of CF processing as well as increasing the rate (or shortening the time) required for processing large tow industrial CF. The reviewer observed that both outcomes, if commercialized and entered for serial production, supports specific VTO Materials subprogram objectives to expand the use of CF materials in automotive and energy applications through a reduction in the cost of these highly specific property materials. Similarly, increasing capacity of manufacturing to expand availability and lower embodied energy (thus reducing GHG emissions) will support stated goals to improve energy efficiency for commercial automotive and transportation sectors.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer summarized that the project resources were $3.5 million over four years ($875,000 per year) for one national laboratory and one supplier. The reviewer stated that the resources are considered sufficient because of the materials and equipment requirements to achieve the stated milestones in a timely manner.

Reviewer 2

The reviewer stated that the resources are adequate.

Reviewer 3

The reviewer explained that the project team in collaboration with a commercial supplier of equipment met all the technical and performance goals stated at the outset of the project. While the team was hampered by a combination of technical challenges (e.g., rebuild of HTC chamber) and delays related to a global pandemic, the researchers were able to close out the project without additional funding requests (using a no-cost time extension of the project). The reviewer concluded that by stating this clearly, the resources were sufficient.

Presentation Number: MAT197
Presentation Title: Multi-Functional Smart Structures for Smart Vehicles
Principal Investigator: Patrick Blanchard, Ford Motor Company

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

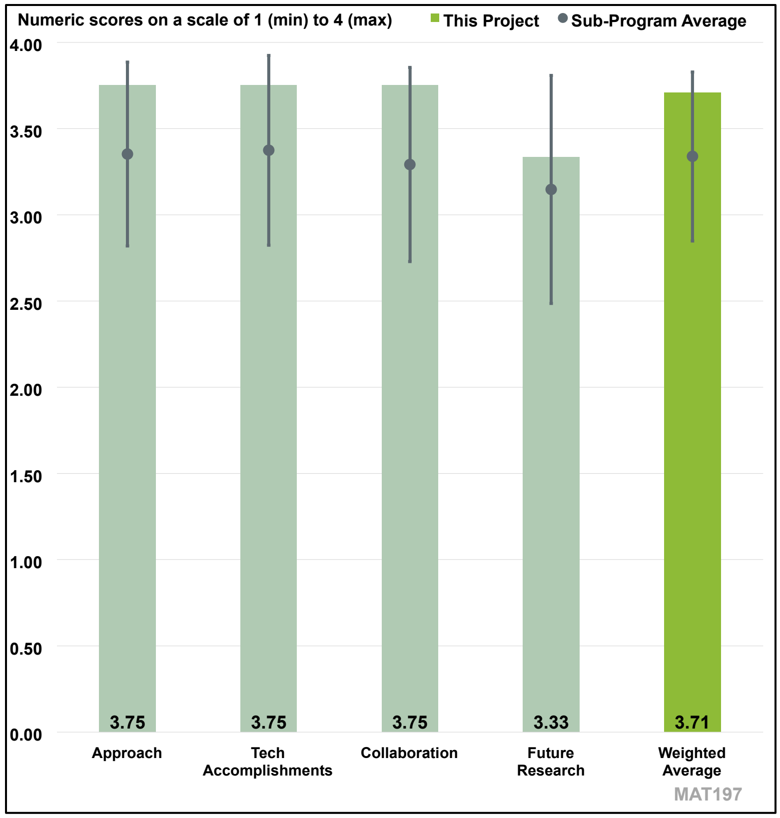

Figure 5-6. Presentation Number: MAT197 Presentation Title: Multi-Functional Smart Structures for Smart Vehicles Principal Investigator: Patrick Blanchard, Ford Motor Company

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that this project encompasses wide ranging work plans and targets that were logically laid out, tracked, and completed with a nice “real” demonstration article. The reviewer noted that it would be good if more projects were like this one in terms of clear objectives and tangible impacts. The reviewer felt that the targets were sufficiently challenging for incorporation of advancing multiple materials and processes of broad interest to vehicle applications. Although the reviewer imagined the tooling was relatively expensive, showing conclusive capabilities of this approach over projections was good.

Reviewer 2

The reviewer explained that this work attempts to translate continuous and discontinuous fibers into an actual vehicle part which was done. The design of the part is intricate, including the smart use of fiber types to translate stresses as needed. The reviewer acknowledged that even with an 11 co-current workstream schedule, the team documented the work and their collaborations well.

Reviewer 3

The reviewer remarked that for the complexity of the project and the interaction of many groups, this project was very well designed and conducted. The timeline was followed extremely well until the very end and was slowed due to testing availability although most tests will be completed at no additional costs. The reviewer praised that shifting away from AM to a lower cost, more conventional process, for certain parts was an excellent decision allowing the project to stay on track and not become diverted.

Reviewer 4

The reviewer described that the project illustrated a complex set of interactions that were followed through a well-designed project and in a reasonable amount of time. There was a no-cost time extension contract modification executed due to resource availability, but the plan is to be completed by the end of the calendar year 2024. The project integrated several electronic systems into an injection molded component and evaluated the cost and weight savings. The project nearly completed all their tasks, and the overall management of the project was orchestrated well.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer indicated that much has been accomplished in advancing technologies; however, the reviewer was unclear as to how much can actually be transferred to the automotive community, pathways were demonstrated towards the critical lightweighting mission with approaches that appear to be scalable and are moving towards the ability to buy their way into production. The reviewer suggested that it would have been good to get a better sense of Ford Motor Company's (Ford) assessment of the likelihood for implementation and potential timeline for doing so.

Reviewer 2

The reviewer stated that the work was well documented and impressively achieves VTO Materials subprogram targets around mass savings and cost. The reviewer noted that with the research team's final prototype part, they have 30+% mass reduction at competitive costs and less than 3-minute part-to-part manufacture time. Overall, the approach is impressive. The only area the reviewer identified for more work is the recycling portion, as it appears to be done with a little brute force. There are probably better methods for recovering fibers.

Reviewer 3

The reviewer explained that the overall project achieved many sub-accomplishments that can be used for other projects such as better processing for hollow parts, use of recycled materials, and integrated sensors.

Reviewer 4

The reviewer summarized that the project's successful execution demonstrated a weight reduction of nearly 40% for a slight cost increase over the baseline metallic part. The multifunctional use of the component consolidated several features that provided structural health monitoring (SHM) and embedded electronics, increasing the component's functionality, and reducing part count for assembly. The reviewer summarized the technical accomplishments that achieved automation using robotics to achieve less than a three-minute cycle time and a future direction that looks to achieve nearly a two-minute cycle time.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that this project was an excellent job of bringing together a talented team and effectively integrating separate activities into an impressive relatively complex demonstration.

Reviewer 2

The reviewer described that this project defines the team in early slides and how the team collaborated, which was impressive to the reviewer to see this, especially from an industry project.

Reviewer 3

The reviewer explained that this was a large-scale project with many contributors over four years. The reviewer asserted that the project management was excellent and accomplished the goals when they needed to be completed.

Reviewer 4

The reviewer noted that the project had several partners with a specific role for each partner. The project lead did an excellent job coordinating the activities and collaborating with each partner in their specific discipline. The reviewer noted that the integration of national laboratories and academic resources with the timing of the industrial lead can be challenging, and the project demonstrated success on each element of the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the project is ending this calendar year, and the remaining work is to be completed with a no cost extension that focuses on completing the design, validation, and testing using facilities at Ford. Efforts will include sun load testing, air bag deployment, steering column, dynamic impact, dimensional checks, and noise, vibration, and harshness. The reviewer noted that the project will most likely complete these last few tasks since all the molded components are complete and delivered for the testing and validation work.

Reviewer 2

The reviewer observed that it would have been informative to hear about the implementation plans and, more importantly, the identification of any deficits still needing to be addressed as next steps.

Reviewer 3

The reviewer noted that the future work was focused just on the end of this project and was looking at component testing. The reviewer stated that this is appropriate for an AMR presentation, but the question is how this work is translatable beyond this current work. The reviewer noted that the researchers mentioned that an implementation phase may be next.

Reviewer 4

The reviewer commented that until the testing is over, the fact that is somewhat unknown is whether Ford will use the entire concept or not as they go through their stage gate process. The reviewer feels that Ford is likely to use this concept, but the decision to commercialize or to not is unknown.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believed this is an excellent example of advancing technologies and providing an effective demonstration of what can be accomplished with a wide-ranging research program that DOE has assembled in coordination with industry, academia, and the national laboratories. While it would be impossible to have many projects resulting in similar demonstrations such as this, the reviewer desires to have such demonstrations periodically to motivate the automotive community to better envision potential real-world solutions as endpoints for disparate pieces of technology. This project demonstrated a good balance of technology development resulting in actual hardware that appears closer to implementation than some advanced concept demonstrators.

Reviewer 2

The reviewer remarked the project is extremely relevant, noting that the team used metrics to show that they are achieving goals around weight saved, cycle time, and actual part manufacture.

Reviewer 3

The reviewer did not mention program relevance but explained that one project objective was to develop lightweighting technology which was accomplished. Another objective was to add sensor capacity to monitor part stability and other required functions, which was accomplished.

Reviewer 4

The reviewer implied program relevance by stating that the project meets the overall VTO Materials subprogram objectives through reducing weight with around $2/lb cost saved. The project is determined to be a success for the VTO Materials Composites Core Program (CCP).

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer explained that this was a relatively expensive project that perhaps limits the breadth of other projects possible. Apparently, there is a much more dominant trend towards spreading research projects too thinly and maybe sometimes to interesting areas that have limited application. The reviewer noted that having at least a few projects like this one helps the supporting research community to see examples of where their research can be applied. Achieving a balance of having more medium funding level projects of maybe $500,000 to $1,000,000 per year should be a programmatic objective which the reviewer thinks would result in greater impact towards the DOE mission in this area.

Reviewer 2

The reviewer applauded that the team executed their project extremely well. Even though this might get more funding than most projects presented at the AMR, the resources were used extremely well.

Reviewer 3

The reviewer stated that, as this complex project was done except for some tests, the project resources were adequate. The scheduling for final testing delayed reporting the results for several months but this was not a significant issue.

Reviewer 4

The reviewer agreed that the project was well-executed, meeting milestones in a timely fashion except for the resource limitation at the industry lead, who will complete the remaining few items by the end of 2024.

Presentation Number: MAT198
Presentation Title: Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure
Principal Investigator: Venkat Aitharaju, General Motors Company

Presenter

Venkat Aitharaju, General Motors Company

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

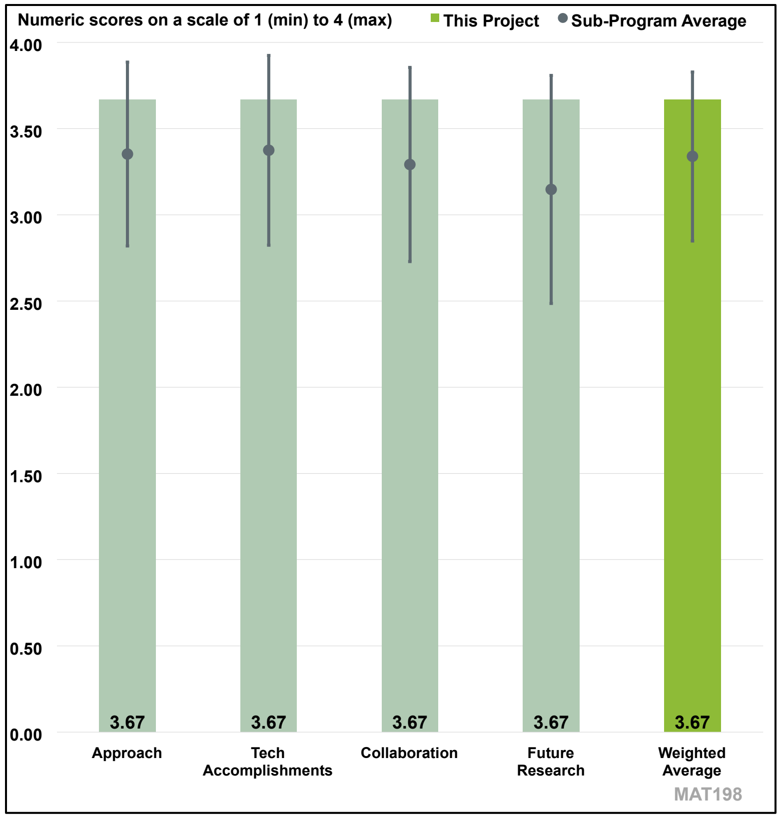

Figure 5-7. Presentation Number: MAT198 Presentation Title: Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure Principal Investigator: Venkat Aitharaju, General Motors Company

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer explained that the project team has proposed and executed an ambitious project applying three critical high-rate production methods to process novel material systems to a critical automotive component necessary for electrification of the transportation sector. The integration of hybrid (glass/carbon) reinforcements with fire resistant matrices (phenolic) and SHM methods is ambitious. The reviewer mentioned that coupling artificial intelligence (AI)/machine learning (ML) technology with predictive modeling tools results in an ambitious program that advances several important technologies.

The reviewer felt that the SHM integration has not been fully engineered, and particularly the way such a technology would be used in a commercial application to inform the user or service center on the condition of the battery enclosure or specific components. Similarly, little has been revealed about the approach and methods used for training the system through ML and use of AI to inform manufacturing operations. Regardless, the reviewer stated that the approach used by the project team is very strong and should yield meaningful results.

Reviewer 2

The reviewer expressed that the project is taking into consideration all the critical issues to be a successful project such as lightweighting, monitoring, fire resistance, ability to manufacture, and cost reduction. The schedule is on time and on budget and the team is waiting for tooling to be built. The leader involved the expertise of quite a group of experts on each aspect of the project and led them to put all the aspects of the project together. The reviewer noted that the part developed is a critical safety component, so getting the design for replacing the metal part is a major endeavor.

Reviewer 3

The reviewer stated that the project completed several challenges associated with the deep-drawn molding processing, integration of the SHM system, and development of a commingled carbon/glass tow that is used as a sensor in the part. The work successfully overcame the challenges of developing a nice battery tray with integrated structural features. The reviewer remarked that the team accomplished the development of a self-health sensing technology that can be scaled for cost-effective high-volume manufacturing. Further accomplishments were developed using the AI/ML method developed. High-pressure resin transfer molding (HP-RTM) process monitoring was installed on the machine, and work continued for validation and improvements. The reviewer described that the AI/ML capability also developed and validated a novel AI/ML-based multi-scale structural performance model. The list of the accomplishments was well-documented in the presentation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the project team has made excellent progress in the prior year with a design path that accomplishes targeted weight savings and performance requirements for thermal, impact and electromagnetic interference (EMI) protection of the structural enclosure. The structural models were validated by sub-scale (e.g., a miniature battery enclosure prototype) manufacturing and impact testing was completed and results compared favorable to a significantly more massive steel design. The reviewer praised that the design and demonstration of a viable integrated strain sensing system is quite novel. The reviewer noted that the preliminary testing results at the coupon level (meso-scale) are promising but suggested that further refinement is needed.

The reviewer noted that the approach to create technical preforms using a hybrid reinforcement scheme of fiberglass and selective reinforcement with carbon is a solid approach to ensure meeting cost goals while similarly meeting weight and performance requirements. The reviewer’s only concern was the researcher’s claim that 80% of the work is accomplished but the ambitious tasks of manufacturing a the full-scale “final composite battery enclosure assembly”, along with demonstrating the use of AI/ML techniques and completing crash testing, still needs to be completed. The reviewer cautioned that these tasks appear to be costly aspects of the project with a mere 20% of the effort (funding?) remaining. Meeting cycle time requirements for the tray component is ambitious.

The reviewer noted that there does not appear to be any documentation regarding the manufacturing of the tray preform. That would include the cycle time needed for the tailored fiber placement process and the economics of this approach.

Reviewer 2

The reviewer stated that the technical accomplishments for the complex project are very impressive. Several accomplishments, such as the self-health sensing, the AI performance, and the HP-RTM process modeling will allow the one-step molding to be used in other applications besides the battery enclosure project. The reviewer apprised that the apparent 40% reduction of weight versus a goal of 25% is a massive overachievement. The reviewer expressed that if the process cycle time can be shown to be less than three minutes to make quality parts, this project will be a big winner.

Reviewer 3

The reviewer described that the project designed and developed approaches in molding deep-drawn molding technologies for battery trays with integrated sensors in the composite. All the partners provided their expertise with preform development and fabrication, sensor development, and SHM integration with AI/ML. The reviewer stated that the project was successful in completing their milestones and working to wrap-up the remaining task objective for the year. The reviewer recognized that the team accomplished self-health sensing technology that can be scaled for cost-effective high-volume manufacturing. Further accomplishments were developed using the AI/ML method developed. HP-RTM process monitoring was installed on the machine, and continued validation and improvements were made. The reviewer described that the AI/ML capability also developed and validated a novel AI/ML-based multi-scale structural performance model. The reviewer pointed out that the list of accomplishments was well documented in the presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer described that this technically complex project, combined with a broad array of novel integrated technologies demands a cohesive project team. The reviewer highlighted that the demonstrated technical accomplishments of the project suggest that each specialized team member is making appropriate contributions to this collaboration. The reviewer praised that the project management and leadership by the PI appears to have kept this program on track, though the reviewer noted that the final 20% needed to complete the program within budget is a concern or question. The reviewer stated that the only weakness that can be identified relates to the lack of detail in the use of the AI/ML methods to inform the processing. The reviewer is very interested in the final reporting on the use of these methods to ensure consistent manufacturing and continuous improvement in manufacturing processes that utilize these technologies.

Reviewer 2

The reviewer praised that the project management is excellent to keep three universities and three suppliers working together to deliver the on-time needed results. The reviewer noted that an advantage for the project management is that they work for the end-use customer. The reviewer mentioned that this project is quite impressive with the many requirements using experts in the various technologies from disparate entities.

Reviewer 3

The reviewer described that the collaboration team is made up of academics and industrial partners. Each partner is contributing to the project and is providing valuable inputs in preforming, sensors, modeling, and fabrication integration of the sensors. The reviewer expressed that the collaboration of the team is demonstrated through the accomplishments in the design and development of the features and components to date. The reviewer described that the researcher’s presentation, as well as a sensor demonstration to the presentation room attendees, well defined the product of the team’s work embedded in a composite sample.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the proposed future work is ambitious (considering it is a mere 20% of the total work), but successful completion will clearly result in meeting all the goals originally proposed for the project. The reviewer found no deficiency (other than concerns for the extent of the remaining work required given both funding level and schedule). The reviewer concluded by offering the research team a “well done.”

Reviewer 2

The reviewer described that the next phase is to complete the project by making parts and checking cycle times, quality, and performance. The reviewer expressed that this should be very exciting. The reviewer suggested that the team might benefit by having an alternative approach if there is a processing issue. For example, what is the plan if the cycle time is longer than three minutes?

Reviewer 3

The reviewer described that for the remainder of the year, the team will build the tools, manufacture components for building, and evaluate the assembly. This is the final objective of the project and is a culmination of the work being pulled together and demonstrated. The reviewer noted that the project is on track to be completed by the end of the year.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer described that the current program relates to four of the six VTO subprograms identified as relevant to the VTO goals. Successful commercial deployment of advanced lightweight battery enclosures will impact cost, performance, and reliability of these critical components. The reviewer stated that the results will impact performance of the Batteries subprogram, reduce cost and expand the pace of technology addressed in the Electrification subprogram, provide more benefits for the Energy Efficient Mobility Systems subprogram, and result in validating new materials for the Materials subprogram that integrate SHM to improve long-term reliability by identifying problems before they become critical. The reviewer concluded by affirming that the relevance of this project is not in question.

Reviewer 2

The reviewer expressed that lightweighting with no increase in safety risk is a major goal of the VTO Materials subprogram to improve the economics of using EVs and this project meets that criterion.

Reviewer 3

The reviewer stated that the project meets the objective of 40% weight reductions and built-in sensor technology for the batteries and for the health monitoring of the enclosure. The reviewer described that the demonstration of the design shows progress in achieving weight reduction goals for vehicles and progresses technology for battery vehicles with safety sensors both for batteries and for the structural health of the battery containment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer agreed that the resources appear sufficient based on the reporting of the PI. However, the remaining work to be conducted appears extensive and one may worry that the final manufacturing demonstration (three-minute cycle time) and technologies to be highlighted (SHM, AI/ML, and crash validation) are in danger of being underfunded, or fall short of completion, due to an over-compressed schedule. The reviewer is anxiously anticipating the final reporting.

Reviewer 2

The reviewer stated that the project is on schedule with no apparent need for more resources,

Reviewer 3

The reviewer remarked that the project has been well-funded and appears to have sufficient resources to complete the remainder of the tasks this year to demonstrate the build, to complete the assembly, and to perform the testing.

Presentation Number: MAT199
Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

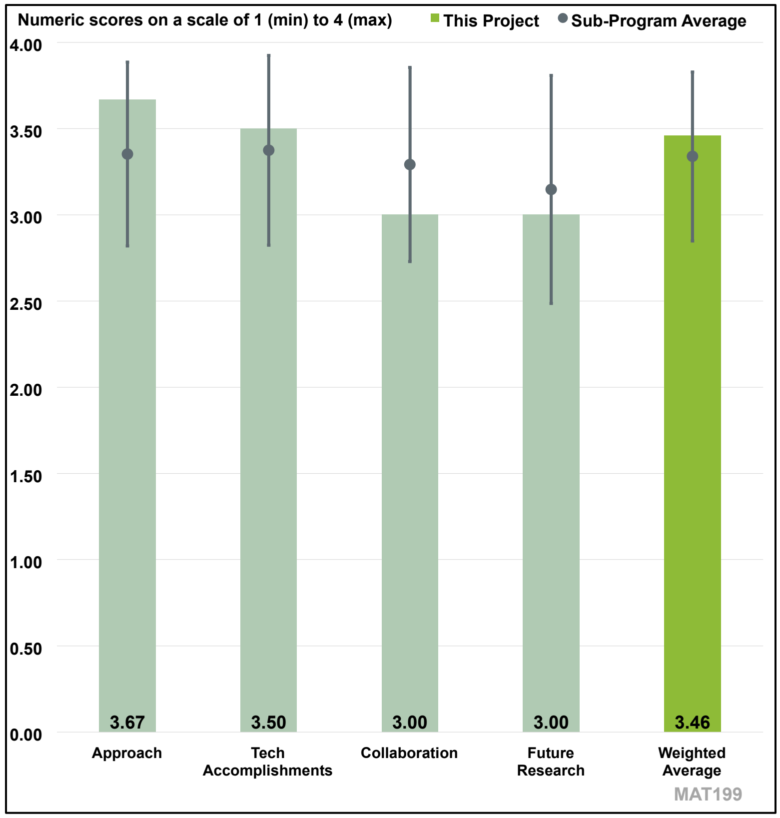

Figure 5-8. Presentation Number: MAT199 Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project) Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that the challenges and hypothesis were defined, a literature search was conducted, and validation work planned to prove the hypothesis. The reviewer noted the well-defined responsibilities between PNNL and ORNL. The reviewer noted a solid focus on fabricated high-performance fiber and optimization of the fabrication process to be able to maintain the higher performance properties of the fiber while gaining good fiber/matrix adhesion.

Reviewer 2

The reviewer described that the technical barriers were clearly discussed in the Overview slide, and the subsequent slides discussed how those barriers were addressed. The project was well designed and had a clear timeline with measurable targets. The reviewer observed that most of the milestone targets were clearly quantitative, so it was easy to evaluate their success, and they had good property targets. However, the reviewer stated that Milestone 11 could be more quantitative for how success was measured for demonstrating recyclability.

Reviewer 3

The reviewer described that the researchers identified three technical barriers: low-cost high-volume manufacturing, low-cost CF, and recyclability. The recyclability aspect of this work is a major selling point but was not addressed thoroughly in Slide 8, nor at all in the remaining technical challenges. The reviewer described that polymer-fiber-reinforced polymers, which have been around for quite some time and are commercially available, have seen renewed interest due to increasing consciousness around sustainability. So, the reviewer suggested that a better understanding of the quality of the recycled materials and challenges need addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer simply stated that the researchers met their milestones.

Reviewer 2

The reviewer pointed out that each milestone was addressed, and the technology was developed and advanced. The reviewer stated that the thermoplastic fiber/thermoplastic matrix composites produced showed significant property improvements over the thermoplastic alone.

Reviewer 3

The reviewer acknowledged that all the milestones were met for this project, so excellent progress was made. The reviewer mentioned that some results even went beyond the outlined milestone criteria to further demonstrate the success of the developed composites. The reviewer mentioned that one aspect that was lacking was a final estimate of the cost of the developed polymer/polymer composites. A cost target was mentioned in the relevance slide, so the reviewer was interested to see if the researchers' composite reached that target.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged that the project had an excellent collaboration with ORNL that leveraged its fiber and composites expertise. However, the reviewer criticized that the project was lacking an industrial partner or collaboration outside of national laboratories.

Reviewer 2

The reviewer noted that there is a good workflow between ORNL and PNNL. The reviewer suggested that it would be nice to see more industry engagement or even just identification of where these materials might be drop-in replacements on vehicles now. The reviewer asked if these would be applicable for battery cases on EVs.

Reviewer 3

The reviewer noted the well-defined responsibilities outlined between PNNL and ORNL, with clear understanding of the core capabilities each was bringing to the project. The reviewer believes that a future step to consider would be getting an industry partner that can work to validate the technology in a commercially viable part.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project has ended.

Reviewer 2

The reviewer is anticipating the results of the complex shape demonstrations for molding. The reviewer was not sure of the relevance of the cooling rate or low temperature fracture testing. The reviewer suggested testing for other characteristics like heat deflection temperature and creep.

Reviewer 3

The reviewer expressed that the project clearly defined a purpose for the future work which makes sense. The future work included investigating other thermoplastics that will increase a potential property profile that can be achieved. The reviewer noted that one concern with some of the polymers discussed for future work would be cost, even with polypropylene (PP). If you move from non-isotactic grades, then the cost will increase, e.g., commodity isostatic PP and polymers like polyphenylene sulfide are more expensive than polyolefins. In addition to the items outlined during the presentation, the reviewer thinks that future research should include validation of a bi-component fiber containing a lower melt-point sheath on a higher melt temperature core. The reviewer suggested that this could be done with high-density polyethylene / linear low-density polyethylene (LLDPE), in combination with ultra-high-molecular-weight polyethylene (UHMWPE)/LLDPE, then use the matrix material as an LLDPE. For PP, the reviewer thinks that sticking with homopolymers makes sense but if a bi-component fiber is used, a PP random copolymer can be applied to the skin with a lower melting point and then a random copolymer can be used for the matrix.

Processing temperatures would still need optimization, but the reviewer believes that this would help maximize properties imparted by the fibers by improving fiber/matrix adhesion. The reviewer suggested that the research should also include evaluation of different molecular weights of polyethylene for the matrix to increase wettability/adhesion, reduce voids, and increase the overall properties of the composite. Converting the matrix materials into powder sounds like a great idea to the reviewer. Overall, the reviewer noted significant potential in developing this technology further.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is very relevant and aligns well with the VTO Materials subprogram objectives for lightweighting vehicles. The reviewer noted that the project utilized polymer/polymer composites to produce high specific strength materials that could replace more costly materials, and these composites have the added advantage of being recyclable.

Reviewer 2

The reviewer stated that this project is relevant to the VTO Materials subprogram objectives of vehicle lightweighting and alternatives to CF composites.

Reviewer 3

The reviewer described that the project enables the development of low-cost, lightweight, high-strength materials for automobiles. The recyclability aspect also helps with future circularity objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that since the project has ended with all milestones met, the funds seemed sufficient.

Reviewer 2

The reviewer agreed that the resources are sufficient to achieve the stated objectives.

Reviewer 3

The reviewer stated that the resources were adequate.

Presentation Number: MAT200
Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

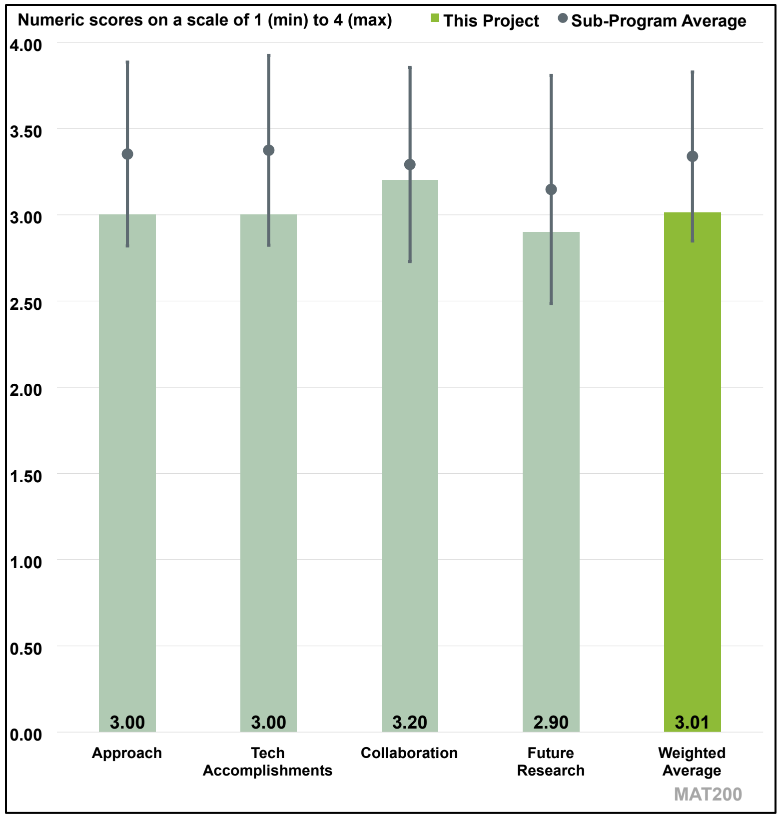

Figure 5-9. Presentation Number: MAT200 Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer agreed that the approach is sound and will result in solving most of the project challenges, if not all.

Reviewer 2

The reviewer observed that the approach is articulated well. The inverse design approach is interesting and is becoming popular for the discovery of innovative designs, materials, and processes. The reviewer asked if the inverse design is taking data purely from simulations and not from experiments. If so, the reviewer opined that the inverse approach relies on simulated data and continues to scout for innovative designs and materials in virtual space without practical validation. The reviewer asked if the innovative design meets the criteria set by the inverse approach, why there is a need to create a refined design which may be an overkill and waste of resources. The reviewer also criticized that the refined model selection seems to be arbitrary.

Reviewer 3

The reviewer stated that the project is well designed from various perspectives, including material selection, AI/ML integration, AM, testing, and further optimization. The AI/ML-assisted design aspect is particularly intriguing and innovative. The reviewer commented that the intricate designs produced through AM demonstrate significant potential. However, the reviewer noted a point to consider is how these designs can be effectively incorporated into current volume production, because AM is currently a time-consuming process. Exploring how the project can accommodate future potential for volume production to ensure scalability would be beneficial. The reviewer agreed that the timeline is reasonably planned.

Reviewer 4

The reviewer criticized that the material properties are quite poor due to the material selection. The reviewer asked why the researchers used such a poor material when other better materials, at similar cost, are available and might be used in production. The reviewer observed that a ML approach does not quite appear to be ML. This work is doing a traditional optimization problem and calling it ML since the problem is over constrained. The ML algorithm is being trained by simulations which are innately inaccurate. The reviewer asked how this approach can be used to produce confident optimizations. The reviewer pointed out that the selection of the properties seems arbitrary. The optimization process uses an arbitrary input to design the material design. The reviewer cautioned that the average impact force of an impact loading cannot be used since the force present due to the impulse nature of the impact will be drastically underrepresented. The reviewer stated that it is very hard to believe a 26 miles per hour impact with a pole will cause a peak load of under one megapascal (MPa) force.

Reviewer 5

The reviewer stated that the project is well planned. The reviewer noted that some of the tasks are too constrained to realize the potential of the technology being pursued, especially where the discussion around the ML programs were more optimization-oriented problems than AI-based discoveries.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the milestones are on track.

Reviewer 2

The reviewer stated that the research team seems to have achieved most of the milestones associated with the project plan. There seems to be a delay in getting real-size sample test results from the industrial partner, but everything else seems to be on track.

Reviewer 3

The reviewer noted that satisfactory progress has been made on the project to date. The project work is 85% complete and has many moving parts including AI, testing and fabrication components. The reviewer noted that the researcher’s explanation of the critical aspects of the work missed a few details because of time constraints. The reviewer suggested that the PIs should keep this in mind the next time they present the work, including defining all the acronyms and pointing out aspects of the work (or methodologies) that have been abandoned since the inception of the project. The reviewer described that understanding the reasoning behind some of the testing and parameters evaluated/investigated would also be very helpful for the audience and reviewers in future presentations.

The PIs are commended for employing AI/ML in the design/architecture and especially in the manufacturing of their vehicle part. However, the reviewer cautioned that the interplay between process control and the ML method(s) needs to be further elucidated. Their audience needs to be clear about the limitations of this approach on part production, performance, and reproducibility. The reviewer acknowledged that the authors attempted to elucidate this last point, however, more detail would be helpful to close this loop/aspect of the work. The reviewer asserted that a cost analysis with a value proposition of this approach to manufacturing the part in question needs to be included in the work. The reviewer acknowledged that the PI mentioned that the cost analysis is forthcoming in the future. Slide 9 has a mix of “Nm” and “mm” as units. Please be consistent with the units used in the future to forestall confusion. The reviewer highlighted that to many people NM is newton meters and mm is millimeters. One unit is force, and the other measures distance, so it is confusing when both are used in the same column.

Reviewer 4

The reviewer suggested that the material selection process could be more thorough, especially when selecting and combining different plastic materials and using them as the matrices in a composite. The complementary mechanical properties and the compatibility of the chosen plastics are both important considerations.

Reviewer 5

The team is making progress, but the reviewer does not believe that the technical approach is a good one. The reviewer criticized that there is also very little comparison to traditional materials currently used for this purpose.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that little was said about the specific contributions of each partnering team member (Ford, University of California Los Angeles, and University of California Berkeley) beyond the high-level summaries on Slide 20. The reviewer stated that one can only surmise that the collaboration has served its purpose, because 85% of the work has been completed.

Reviewer 2

The reviewer observed that the collaboration is well coordinated. The reviewer suggested that it would be good for the researcher to mention the individual aspects of contributions throughout the presentations.

Reviewer 3

The reviewer described that the project is developed in collaboration with Ford and the University of California Los Angeles. Ford provided the design and testing requirements, while University of California Los Angeles offered ML support. The reviewer agreed that these contributions complement the capabilities of the leading ORNL team.

Reviewer 4

Given that the lead organization is performing follow-on work based on the results from one of the sub-contractors, the reviewer commented that the coordination between the team appears to be excellent.

Reviewer 5

The reviewer's understanding was that the team was taking more time than expected to provide materials for testing to Ford and, therefore, there may be some breakdown in the schedule that was not clearly articulated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the proposed future work will contribute to meeting project goals. The reviewer suggested that the authors should consider the comments made about the interplay between AI/ML and process control in Section 4 of this review in their future work.

Reviewer 2

The reviewer commented that the pending tasks and timeline are on track and planned well.

Reviewer 3

The reviewer described that the project has clearly defined future work, targeting the 3D printing of a full-scale bumper and its performance evaluation, which seems achievable.

Reviewer 4

The reviewer said that the proposed future research is the entire project. The stated future work includes: (1) full-scale printing of a performance-optimized, multi-material lattice, structure-based frontal bumper (a few bumpers are already printed) and (2) mechanical testing of lattice structures and performance evaluation of a full-scale bumper.

Reviewer 5

The reviewer commented that the future work is reasonably highlighted and discussed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project contributes toward materials manufacturing and optimization for vehicles.

Reviewer 2

The reviewer stated that the project supports the VTO Materials subprogram objectives.

Reviewer 3

The reviewer simply stated that the project is relevant.

Reviewer 4

The reviewer agreed that conceptually, the project is relevant, but the execution may pose a missed opportunity.

Reviewer 5

The reviewer highlighted that the design aspect could greatly benefit the VTO Materials subprogram mission of reducing component weights while still meeting performance requirements. However, the reviewer cautioned that it is important to further consider and evaluate whether the AM approach can reduce manufacturing costs, given the long production times and limited scale production associated with this method.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the funding appears to be adequate for this work.

Reviewer 2

The reviewer affirmed that the project has adequate resources to successfully execute the project.

Reviewer 3

The reviewer agreed that the resources are sufficient.

Reviewer 4

The reviewer did not believe the team is using a ML approach but rather a simple optimization. The reviewer further criticized that the selection of materials is poor and felt that the loading used for the design to be impossible for a car hitting a pole at 26 miles per hour. Lastly there is no comparison to traditional manufacturing methods, or the time required to fabricate a part which is most likely impossible for the automotive industry.

Reviewer 5

The reviewer believed that this question was not applicable.

Presentation Number: MAT202
Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles
Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Presenter

Karen Cortes Guzman, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

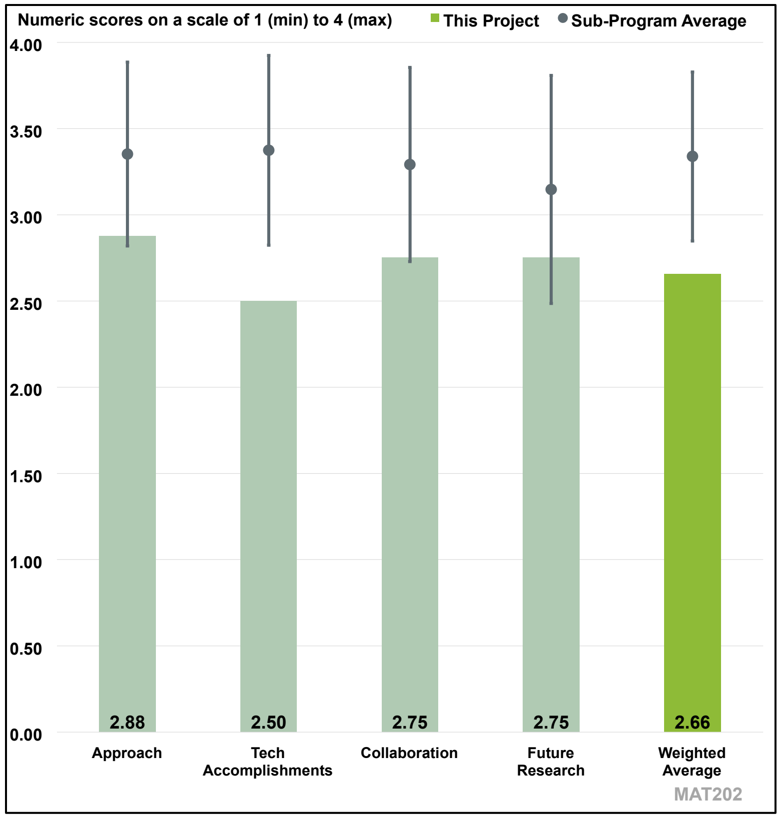

Figure 5-10. Presentation Number: MAT202 Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is very well designed, but the reviewer imagined the four designed tasks are supposed to have transitions between each other that would enable decent quality 3D-printable composites with sensing capabilities.

Reviewer 2

The reviewer agreed the project clearly outlined the technical barriers and had a good execution plan to address those barriers with a reasonable timeline. The team did a decent job dividing the tasks to be performed by the collaborators and clearly showed who was performing what task. To improve the presentation for future use, the reviewer suggested that including the challenges and barriers from the U.S. DRIVE Materials Technical Team Roadmap report that was mentioned in the AMR instructions document would be beneficial.

Reviewer 3

The reviewer described that the project aims to develop a 3D printing process for integrating a sensing layer within a composite layer. Various materials and 3D printing methods have been developed, including 3D printing of continuous fiber composites, zinc anodes, and polyvinylidene fluoride (PVDF)-Mxene composites. The reviewer stated that while these developments are significant and demonstrate technical advancement, their alignment with the central goal of the project is loosely demonstrated. The reviewer recommended a more concentrated approach to strengthen the focus of the research and ensure that all efforts are directed towards the main objective.

Reviewer 4

The reviewer criticized that the strength and modulus goals are extremely low. This can be obtained with a non-continuous fiber composite. The reviewer asserted that the interfacial measurements are clearly wrong since the interfacial strength is higher than the matrix shear strength. This is possible with a functional gradient, but this is not the case here. The reviewer asked about the type of sensor being developed. The reviewer also asked why molybdenum disulfide (MoS_2) and PVDF would form a sensor, since the PVDF will be non-polar alpha phase and the MoS_2 is not piezoelectric. The reviewer highlighted that this is not well thought out and would indicate a lack of understanding of piezoelectric materials. The reviewer also mentioned that the results did not include error bars on the strength and modulus data.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that four main tasks are demonstrated. Task 1 focuses on CF surface modification and its interactions with resin systems. However, the reviewer highlighted that the improvement in tensile properties after the surface modification is limited with tensile strength increasing only from 62 MPa to 65 MPa. Task 2 Involves computational studies of fiber-matrix interface interactions in both the sensor layer (PVDF-MoS_2) and composite layer (epoxy-CF). The reviewer agreed that this seems to be well-developed. Task 3 developed 3D-printing techniques for continuous fiber epoxy composites. The reviewer was unclear as to whether this is another type of composite layer or if the previous epoxy and milled CF composite was only for studying interface interactions. Task 4 focused on the fabrication of continuous sensor-embedded polymer/CF composite 3D printing. The reviewer agreed that this task is well-aligned with the project plan.

Reviewer 2

The reviewer commented that the team presented some excellent technical accomplishments that appeared to meet most of the milestones for the project. The milestone table clearly shows the milestone progress, but the reviewer suggested that it would also be good to include the milestone on the slides with data to show what the milestone criteria was achieved. The reviewer had difficulty determining what accomplishments were achieved previously and what accomplishments were new for this year. The reviewer suggested that in future presentations, the use of “Previous Accomplishment” should be noted on the slides that were from past years of the project. This way reviewers can judge what was done in the most recent year of work.

Reviewer 3

The reviewer criticized that this project has made little progress towards the goals. Work has been done on each task, but efforts are weakly related to the objective. For instance, the reviewer asked how will working with a non-piezoelectric structure demonstrate a sensor. The reviewer commented that if the team does not understand piezoelectricity, then they should seek support from someone who does. The reviewer cautioned that the 3D-printing methods do not make much sense. The interfacial functionalization is weak and poorly characterized. The reviewer noted that the team must have access to x-ray photoelectron spectroscopy to perform a true analysis.

Reviewer 4

The reviewer commented that it seems like the four tasks have progressed independent of each other. The material systems being evaluated do not have much overlap. The reviewer was not clear on how the transitions will proceed from task to task. The reviewer expressed that some of the constituent component choices are also puzzling. Several milestones still need to be achieved with minimum time and resources remaining in the project charter.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project consisted of a good collaboration between ORNL, the University of North Texas, and University of Oklahoma. However, the reviewer would have liked to have seen some involvement from private industry to demonstrate the path toward deployment for the developed technology.

Reviewer 2

The reviewer described that this project is a collaborative effort between the ORNL and University of North Texas teams. The ORNL team focuses on developing materials and 3D printing techniques, while the University of North Texas team provides computational modeling support. The reviewer suggested that involving an industry partner could be beneficial, as they could offer materials design guidance and industry-specific specifications, further enhancing the project's relevance and application.

Reviewer 3

The reviewer cautioned that the actual coordination is not clear, just that the team meets every two weeks.

Reviewer 4

While it seems like the project partners meet regularly, the disjointed information in individual slides led the reviewer to believe that there may not be more effective information transfer between tasks. Apparently, the interfacial developments seen in Task 1 are not the focus of modeling in Task 2 - and so on. Not just frequent, but more effective coordination might be required.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future research is clearly defined and well-targeted towards achieving the objectives for this project.

Reviewer 2

The reviewer noted that a clear future research work plan was presented. Because the project will be ending soon, the future work proposed is reasonable for the period remaining, so the reviewer believes this is an achievable plan. The reviewer suggested that to improve the future work plan, more quantifiable metrics would be good to be able to judge the success of the future work plan.

Reviewer 3

The reviewer was critical stating that the future work is also ad hoc. The reviewer asked why the team is switching to MXenes, etc. (which are not going to be piezoelectric) from the piezoelectric materials. They also asked how a genetic algorithm will help the 3D printing; a structure was never demonstrated just a line.

Reviewer 4

The reviewer highlighted that at this stage, the future work outlined might not sufficiently achieve the final targets of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this work supports the VTO Materials subprogram objective of vehicle lightweighting by addressing issues with fiber-matrix adhesion, continuous-fiber 3D printing, and integrated sensing. The fiber adhesion work is especially relevant to the automotive industry to progress towards lighter vehicles.

Reviewer 2

The reviewer noted that the project supports the overall objectives of the VTO Materials subprogram.

Reviewer 3

The reviewer simply stated that composites and multifunctional materials are relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that this project is nearing the end of its timeline, so few tasks are remaining. The funds seem sufficient to complete the remaining tasks under a one-year, no-cost extension period.

Reviewer 2

The reviewer stated that the resources are sufficient for the project.

Reviewer 3

The reviewer observed that the work is not homogenous and too many separate and confusing tasks are being performed that do not support the others.

Presentation Number: MAT203
Presentation Title: Low-Cost High-Throughput Carbon Fiber with Large Diameter
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

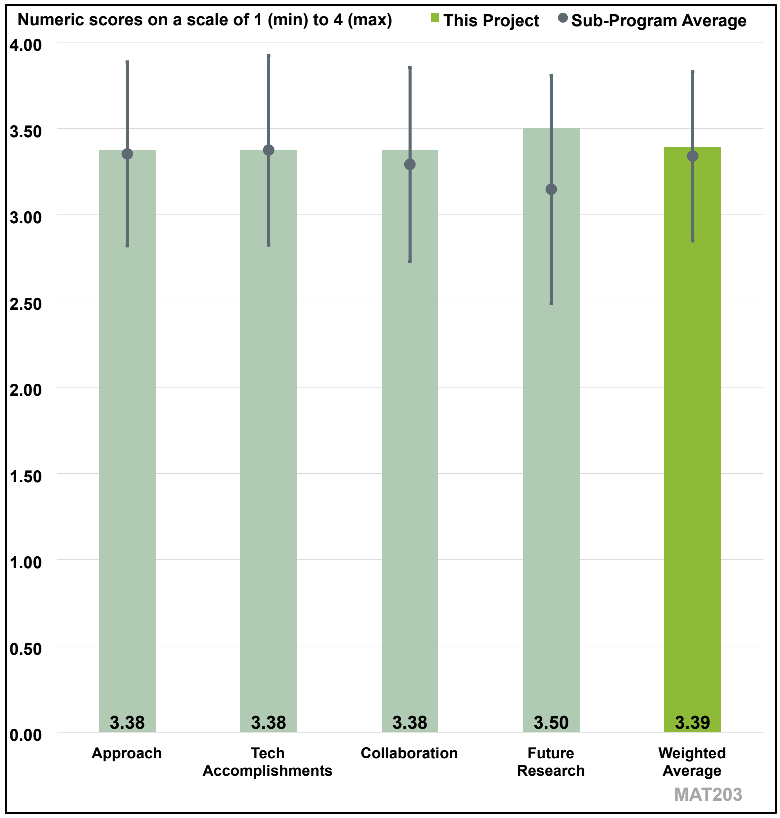

Figure 5-11. Presentation Number: MAT203 Presentation Title: Low-Cost High-Throughput Carbon Fiber with Large Diameter Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that this project addresses the technical barriers of the cost of CF feedstock and production, and the availability of lower-cost CF at a level necessary for a large-scale impact in lightweight vehicle production. Although there was no Gantt chart or specific project schedule presented, the project appears to the reviewer to be well-designed from the aspects of establishing a baseline for 25% larger effective diameter CF converted from a textile-grade precursor that will meet the minimum DOE performance requirements of 250 ksi strength, 25 Msi modulus, and 1% strain-to-failure as well as projected cost savings due to enhanced production speeds. This was followed by producing CF with at least 50% larger diameter than a baseline fiber and minimum performance requirements of 350 ksi, 33 Msi, and 1% strain and a cost target of 25%–30% or greater savings using large-diameter CF. The project would then demonstrate and evaluate the new CF produced at as close to pilot scale as practical and test composite articles made with a production-type process to demonstrate the advantages of using large-diameter CF to achieve the performance requirements. The reviewer agreed that this appears to be a reasonable approach to meeting the project goals within the given timeline.

Reviewer 2

The reviewer noted that the project aims to produce low-cost CFs with large diameters. The project is well designed with a reasonably planned timeline.

Reviewer 3

The reviewer highlighted that the team has access to great experimental facilities which have been used to execute the approach of the project. The reviewer noted that the project is built on many years of experience which is reflected in the approach to the project.

Reviewer 4

The reviewer described that small diameter polyacrylonitrile (PAN) precursor fibers are expensive and that large diameter PAN fibers with lower cost take longer for conversion (oxidation and carbonization) time. The reviewer stated that the project team, in collaboration with 4XT and 4M Carbon Fiber Corp., (4M), processed the large-diameter fibers with plasma treatment, remarkably reducing the conversion cost and lowering the carbon footprint. The reviewer said that the researchers have the plan to build (with industry partners) a line in the United States to produce high-quality, large-diameter PAN fibers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that although there were several project delays because of precursor and equipment availability, the major technical accomplishment in the final year of this project was completion of the production of the dry spun precursor fiber at ORNL and 4XT using advanced plasma oxidation, conventional carbonization, and advanced plasma surface treatment. The results showed that the precursor fibers could be produced with average diameters of 8 micrometers (μm) (a 37% increase over a minimum CF diameter of 5 μm for commercial fibers), an average strength of 363 ksi, and an average modulus of 27 Msi which exceeds the VTO Materials subprogram requirements of 250 ksi and 25 Msi. The reviewer applauded that this is an excellent accomplishment. The work in progress includes introduction of a new commercial precursor supplier and testing of demonstration articles from production preforming and molding processes which could result in another significant technical accomplishment.

Reviewer 2

The reviewer expressed that progress has been significantly delayed due to the industry partner's inability to supply the fiber precursor. As a result, the progress has been limited.

Reviewer 3

The reviewer noted that the team has accomplished the major technical goals of producing larger diameter fibers by a process which may be economically feasible and scalable. The reviewer stated that it is still to be proven that the technical accomplishments for this project are fulfilling the economic targets set forth in the project.

Reviewer 4

The reviewer pointed out that the project is on track and has made progress. The resultant CFs meet the performance of the VTO Materials subprogram minimum requirements (250 ksi strength, 25 Msi modulus, and 1% strain-to-failure).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that the collaboration is outstanding because it included a national laboratory lead (ORNL), a manufacturer (4XT), three suppliers (Dralon, Dolan, and Sudamericana de Fibras), and academia (University of Tennessee). The reviewer noted that the responsibilities for each partner appear to be well-defined. The reviewer described the team roles including, ORNL provided project management, CF and composite evaluation and economic assessment; 4XT provided development, demonstration, and deployment of the advanced oxidation process, the suppliers provided precursor materials, and the university demonstrated article fabrication and compared the fibers to baseline materials.

Reviewer 2

The reviewer commented that the collaboration has been great. 4XT/4M provided a critical conversion technique - plasma treatment - that shortened the conversion time and cost, and reduced carbon emissions.

Reviewer 3

The reviewer suggested that the collaboration could have been more effective if all partners had been able to work efficiently and according to the plan.

Reviewer 4

The reviewer agreed that the project seems to be well-coordinated but has been hampered by the departure of a key partner (Dralon) which led to change of the partner contribution in the project. The reviewer was somewhat surprised that only one supplier is fully suited as supplier of the base fiber for the process. The reviewer remarked that even if one other supplier has been identified the materials are not optimal. The reviewer cautioned that this might raise questions about the robustness of the supply chain for the proposed process.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that although the project is ending in FY 2024, the future research focuses on concerns of long-term availability of a dry-spun CF and the possibility of using a combination of lower-cost fibers and advanced conversion technologies to produce a broader range of fiber diameters with equal or improved performance characteristics. The reviewer noted that the recommendations also included an evaluation of resin infusion processes to potentially improve interfacial properties.

Reviewer 2

The reviewer acknowledged that the future research plan is clearly defined and, if successful, could achieve the targets.

Reviewer 3

The reviewer agreed that the proposed future work makes sense but asserted that it will be essential that a realistic technical cost analysis is performed to give a first indication of the viability of the process.

Reviewer 4

The reviewer pointed out that all the proposed testing was completed by the AMR date, and that a cost/performance analysis remains to be completed by early fourth quarter of FY 2024.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is relevant and directly supports the overall VTO Materials subprogram objectives of reducing the cost of CF precursors and improving production and availability of low-cost CF. The project also addresses the VTO Materials subprogram technical objectives of weight reduction >25%, strength of >250 ksi, and modulus of >25 Msi.

Reviewer 2

The reviewer stated that the project supports the overall VTO Materials subprogram objectives and will be significant if the project could develop low-cost CFs with high performance.

Reviewer 3

The reviewer explained that for specific low-cost applications where performance reliability is not of ultimate importance, the fiber produced could be of interest. However, the reviewer noted that this is ultimately dependent on the cost targets being reached, which is still to be proven. The reviewer stressed that it will also be of major importance that the scaling to larger volume production is feasible. Proven performance/cost will be essential to position these fibers in the ranking position between conventional CF and glass fiber composites for the very cost-sensitive automotive applications.

Reviewer 4

The reviewer agreed that CFRCs are needed for automotive lightweighting and decarbonization. The excessive cost of CFs hinders their applications in the automotive industry. Large diameter precursor fibers are low cost, enabling CFs and composites in lightweight vehicles. The reviewer agreed that the project supports the overall VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer described that the project resources were $1.5 million over four years ($500,000 per year with a no-cost extension of one year) for one national laboratory, one manufacturer, three suppliers, and one university because funding was limited to ORNL, 4XT, and the University of Tennessee. The reviewer stated that the resources are considered sufficient because of issues with the availability of the materials which delayed achieving the stated milestones in a timely manner.

Reviewer 2

The reviewer highlighted that the supplier of the CF has been the bottleneck to achieving the stated milestones in a timely fashion and an alternative vendor should be found.

Reviewer 3

The reviewer stated that the project is hosted in a renowned facility, so there is no reason to question that the adequate resources are available.

Reviewer 4

The reviewer observed that ORNL and 4XT/4M have sufficient resources for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT205
Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites
Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Presenter

Amit Naskar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

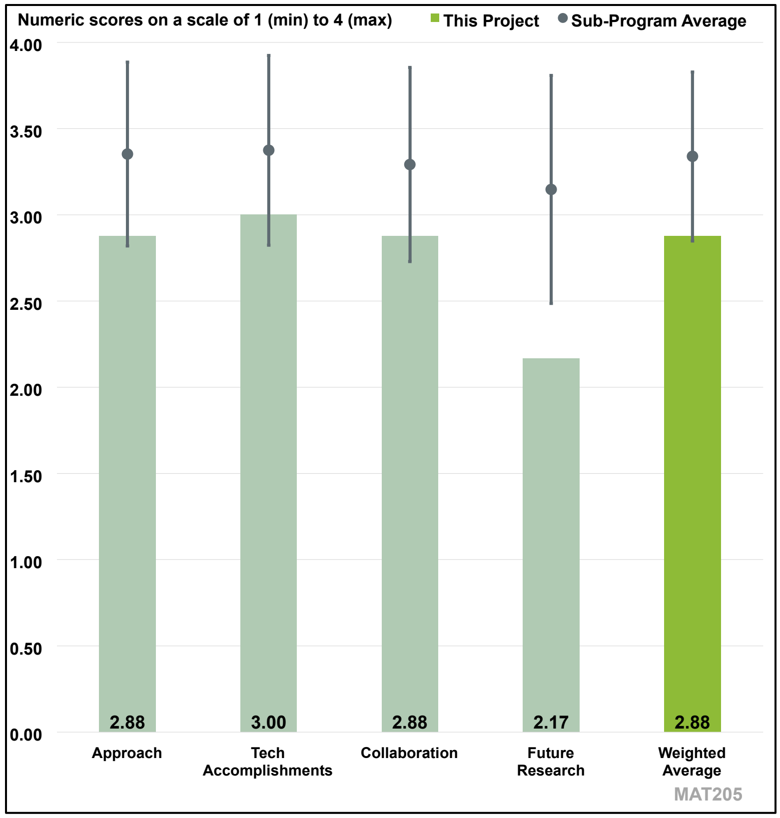

Figure 5-12. Presentation Number: MAT205 Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that overall, this project aims to use CF and PP to make recyclable composites. Ideally, the presence of the CF can lead to crystallization of PP on its surface and result in better properties. The reviewer agreed that the project clearly lays out both the milestones and scientific approach in a clear fashion, where the project narrative builds off the previous steps. The reviewer described that the researchers noted that the material was recyclable a couple times but did not show recyclability. The reviewer agreed that the thermoplastic nature of these materials should enable the recycling but asked if recycling affects the material performance at all.

Reviewer 2

The reviewer stated that the first objective of improving interfacial adhesion seems to be met using controlled crystallization and cooling of the composite; but the reviewer stated that there was no mention of the repairable aspect and no cost analysis to show the 30%–50% reduction in costs.

Reviewer 3

The reviewer commented that one of the technical barriers identified is rapid cycle time for high volume production, but a major conclusion of the work was that the process should be slowed down to achieve the best properties. The reviewer mentioned that this seems to be at odds with what they would want to do next. Moreover, the reviewer added that the researchers stated that the "current fiber surface treatment methods are developed for epoxy matrices and are not applicable for thermoplastics with less polarity than the epoxies," but the reviewer did not think this is entirely true as companies like Michelman offer many sizing agents tailored to both thermoplastic and thermoset resins.

Reviewer 4

The reviewer criticized that this presentation was extremely hard to gain any information from because of poor figures, labels, and bullet points. The hypothesis that crystallization will improve performance is not clear from the data when a quenched sample (e.g., iPP-CF30) has high strength and equivalent interlaminar shear strength compared to the isothermal sample and all are lower than air. The reviewer added that there was no measurement of the interfacial properties, so it cannot be concluded that the interface is affected. Additionally, all measurements are bulk. The reviewer pointed out that interlaminar shear strength is not an interfacial test - it is an interlaminar test - and there is no interlaminar region in this composite. The reviewer asked if the authors checked to see if the failure was in shear since the reviewer imagined this as a ductile failure with no crack generation and therefore more a measure of the matrix properties. The reviewer also asked what the lines represent on Slide 10 since there is no legend.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that even though the work seems to be extremely based on fundamental science, they were able to show a clear translation of the crystallization kinetics. The reviewer commented that the work on the Nylon 6,6 was a little bit confusing because results did not follow the same trend as the PP. The reviewer noted that showing multiple relevant materials was good.

Reviewer 2

The reviewer praised that the technical quality (the science) is very good. However, the reviewer mentioned that no interfacial chemistries were developed, as proposed in the original work, but the composite production is well aligned with lightweighting and material development initiatives, especially with regards to the non-woven wet-lay process which would enable the reuse of recycled fibers (CF or glass) as well as inherently discontinuous fibers like hemp.

Reviewer 3

The reviewer applauded that avoiding the use of sizing agents by carefully controlling the cooling rate was very clever. With the gain in properties, the question of cost versus competition was not addressed. The reviewer highlighted that another objective that was not addressed directly is the repairable aspect mentioned in the project proposal and title. The reviewer remarked that addressing these issues in the presentation would have been very helpful.

Reviewer 4

The reviewer labeled the accomplishments as "fair" since the data is not convincing that the desired behavior is being achieved and the mechanical testing methods used will not show the behavior.

The reviewer expressed that the presenter did not provide a clear plan to achieve the desired program goals.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the presenter noted that the project team includes Endeavor Composites, and their process was used to accomplish some of the initial blending. Collaboration beyond that was not clear to the reviewer.

Reviewer 2

The reviewer noted that the project is in collaboration with University of Tennessee, Knoxville, and Endeavor Composites (a Tennessee local start-up).

Reviewer 3

The reviewer described that the team is small, and it was difficult to see how Endeavor Composites is a team member. The reviewer added that Endeavor Composites was added in response to questions from the 2023 VTO AMR, but that it is hard to see how they offer support to the objectives, either in commercialization or the R&D.

Reviewer 4

The reviewer remarked that the effort was missing an end-use industrial partner who could have helped with the cost issue. The team made some timely progress on understanding crystallization impact showing good collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer described that the project team stated that the project is concluding and ran out of time in their presentation to describe this portion. The reviewer is unclear about how this work will translate to an actual product or further technology development.

Reviewer 2

The reviewer requested that the researcher please address what is motivating the use of large fiber tows for automotive applications. The future direction should expand beyond processing-property relationships that are relatively well understood for polymer composites. Also, for a non-woven wet-lay process, the reviewer thought that there could be an analogous study to the high-fiber tow by really testing the limits of how much CF you can put into the composite and the process itself adaptable to water-based surface treatments that could improve wettability, which was noted as an issue for the higher fiber loadings. The reviewer suggested that showing the actual demonstration pieces of the composites produced would be ideal to better understand the relative advantages for developing these materials and where they would be used in a car.

Reviewer 3

The reviewer stated that the project is ending, but there is no clear plan for future work, just a description of challenges.

Reviewer 4

The reviewer simply stated that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that the impact of the relevance could be increased if the descriptions of an application or future work were clearer.

Reviewer 2

The reviewer stated that the development of processes that enable the reuse of various fiber forms is well-aligned.

Reviewer 3

The work on thermoplastic composites is relevant, but the reviewer was not sure about heavy-tow materials.

Reviewer 4

The reviewer commented that improving thermoplastic composites that are more easily recycled if they have the needed properties for use is helpful to VTO.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that there is no reason to believe the resources would be excessive or insufficient. The project team made reasonable progress given its scope.

Reviewer 2

The reviewer simply stated that the resources were sufficient.

Reviewer 3

The reviewer concluded that since only one of the three objectives were met, there might have not been enough resources.

Reviewer 4

The reviewer was critical that the work has not generated remarkable results for $1.5 million in funding.

Presentation Number: MAT206
Presentation Title: Soft Smart Tools Using Additive Manufacturing
Principal Investigator: Matthew Craps, Savannah River National Laboratory

Presenter

Matthew Craps, Savannah River National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

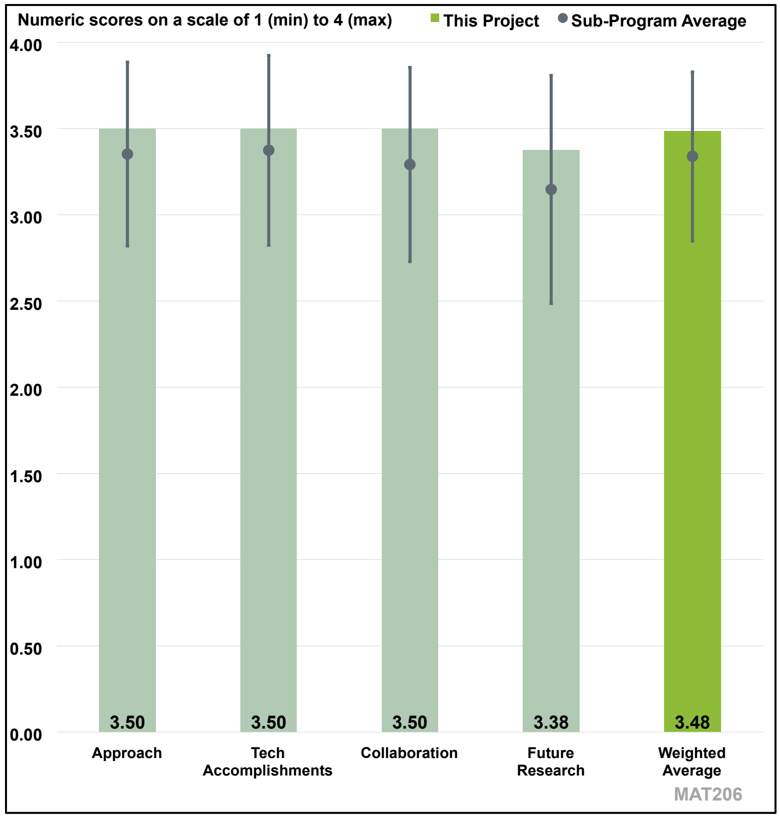

Figure 5-13. Presentation Number: MAT206 Presentation Title: Soft Smart Tools Using Additive Manufacturing Principal Investigator: Matthew Craps, Savannah River National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that the team clearly presented the technical barriers this project would address. They also did an excellent job justifying the need for thermos-stamping due to the energy benefits compared to compression molding and autoclaving. The reviewer, however, was confused by the timeline of the project compared to the milestone table. The milestone table shows that the milestones were all completed as of 3/29/2024, but later in the presentation, a no cost extension is being requested to extend the project into FY 2025. The reviewer understood the justification for this extension, but the extension needs to have some associated milestones.

Reviewer 2

The reviewer explained that the project aims to develop 3D-printing technology for soft smart tooling, which could significantly reduce the time, cost, and GHG emissions of the automotive tooling process. The project is well designed, covering materials development (e.g., carbon nanotube [CNT]-coated continuous fiber filament [CCF] filament development) and processing techniques (e.g., 3D printing of tooling as well as thermocouple sensors compatible with the composite). The timeline seems reasonable, although there was some delay due to the co-PI’s relocation.

Reviewer 3

The reviewer commented that this project aims to address the technical barrier of the extensive time spent engineering filament coating scale-up and optimizing annealing parameters with CNTs. The project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer agreed that the development of smart tooling for composite part fabrication is an excellent goal, and smart tooling will offer significant benefits to enhance part manufacturing rate via microwave heating. The approach involves 3D printing of CF impregnated tows that are decorated with CNT suspended ink for enhanced microwave susceptibility leading to rapid curing of composite. No doubt this is a good approach. The reviewer clearly observed that the temperature can be increased quickly via application of microwaves. The reviewer noted, however that the presenter did not discuss how the temperature distribution would be further controlled.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that the team presented noteworthy progress on the project plan and appears to have met all the milestones for the project. There were several different topics that were covered within the presentation, such as scaling up the fiber coating process, ink development for printed thermocouples, and cyclic testing of the 3D-printed tool. The reviewer liked that there was both a life cycle analysis (LCA) and techno-economic analysis (TEA) included within this work to validate this approach. The reviewer desired to see a higher loading in the cyclic tests since 1kN seems a little low for this large of a tool.

Reviewer 2

The reviewer highlighted that significant technical progress has been achieved. Scalable CNT-coated CCF filament development, thermocouple design for asymmetric tooling, 3D-printable ink development for thermocouple sensors, and 3D printing techniques for CCF composite tooling with compatible printed thermocouples have all been successfully demonstrated. Both a LCA and a TEA were also performed. The scanning electron microscope image on Slide 7 shows well-aligned CNT bundles. The reviewer asked if these are CNTs aligned as shown even after the 3D-printing process or does this microscopic image simply show that part of the thermocouple contains CNTs, without necessarily indicating that they are aligned as shown in the picture.

Reviewer 3

The reviewer remarked that the technical progress demonstrated a well-planned and well-executed project. The reviewer suggested that the uniformity of the coating might be a challenge during the scale-up process, but it seems the process is under control and monitored. The reviewer felt that the technical details in the presentation were thorough, and the project delivery was considered successful.

Reviewer 4

The reviewer noted that the project is complete, and the tooling manufacturing has been demonstrated and life-cycle energy analysis has been conducted. The reviewer offered that the CNT supply chain and cost may impact tooling manufacturing cost.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged the team consisted of excellent collaboration between a national laboratory, a university, and private industry. Including private industry with the fiber coating work and demonstrating some scale-up potential really helps justify the commercialization potential of the developed technology.

Reviewer 2

The reviewer commented that the project is conducted through collaborations between the lead Savannah River National Laboratory (SRNL), the University of Delaware Center for Composite Materials, and Mainland Solutions. They have clearly defined roles and complementary expertise.

Reviewer 3

The reviewer described that the team includes SRNL, University of Delaware, and Mainland Solution LLC. The collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 4

The reviewer noted that the external collaborator has moved his laboratory and set up was delayed. Nonetheless, the project is complete.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer explained that the team laid out a good amount of future work to be completed, and there was a clear purpose for each task. The future work appears achievable within the timeline that consists of a no cost extension through the middle of FY 2025. The reviewer stated that it was mentioned that there has been a delay in the subcontract to the University of Delaware that slowed down that portion of work, but those specific tasks were not mentioned. The reviewer suggested that the presenter should have given some specifics about the University of Delaware tasks.

Reviewer 2

The reviewer agreed that the proposed future work is closely aligned with the project goal and well planned.

Reviewer 3

The reviewer commented that the proposed work is a needed continuation in addition to the success of the current project and could further answer the remaining questions. The project clearly defines the purpose of future work, and the future work is likely to achieve its targets.

Reviewer 4

The reviewer described that the plan for manufacturing a polyether ether ketone/CF/CNT composite tooling and the potential impacts were discussed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is relevant to VTO objectives and is very relevant to the automotive industry to increase the efficiency of fabricating thermos-stamping molds. The developed technology could reduce the cost and lead time to manufacturing molds thus improving vehicle manufacturing efficiency.

Reviewer 2

The reviewer acknowledged that the project supports the overall VTO Materials subprogram objectives. 3D printing is highly suitable for producing smart composite tooling for automobile parts due to its ability to create customized, lightweight designs with integrated smart features, reduced lead times, cost efficiency, and material versatility. The reviewer agreed that this technology also enhances performance, precision, and sustainability in the manufacturing process.

Reviewer 3

The reviewer described that the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer remarked that the development of smart tooling for composite part fabrication will offer significant benefits to enhance part manufacturing rate. Although LCA data with energy benefit in processing cycle was presented, recycling potential of these parts still need to be addressed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that a no cost extension was requested to complete some work into FY 2025 and the funds seem sufficient to meet the stated remaining tasks.

Reviewer 2

The reviewer simply stated that the resources are sufficient.

Reviewer 3

The reviewer explained that SRNL, University of Delaware, and Mainland Solution LLC provide sufficient resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer commented that the resources for this project were adequate, and the project is complete.

Presentation Number: MAT207
Presentation Title: Multi-Material Functional Composites with Hierarchical Structures
Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Presenter

Christopher Bowland, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

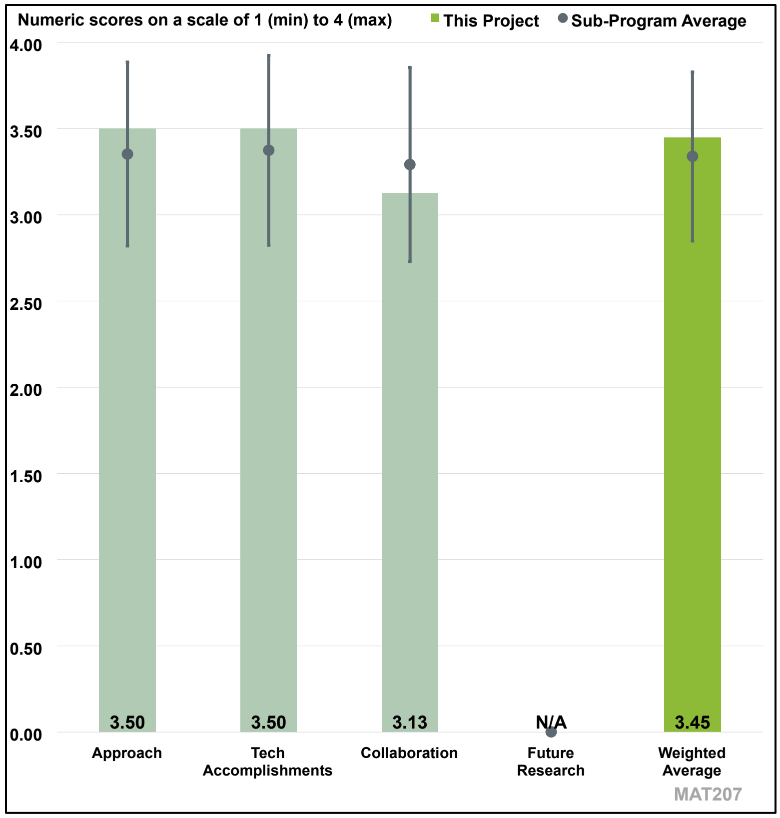

Figure 5-14. Presentation Number: MAT207 Presentation Title: Multi-Material Functional Composites with Hierarchical Structures Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project listed a couple of points as a barrier. From the presentation, the reviewer observed that most of the barriers are addressed. However, there are some which are not considered or are not presented, particularly those related to a self-sensing capability.

Reviewer 2

The reviewer noted that the approach is well planned and executed that has led to meeting the milestones.

Reviewer 3

This project aims to address the technical barrier of the critical challenge for multi-material systems: “Nondestructive evaluation (NDE) and Life Monitoring.” The reviewer explained that other challenges include enhancing crash energy management, optimizing mass reduction, and improving the recycling of CF materials. Integrating passive sensing into fiber-reinforced composites helps improve the system-level strength-to-weight ratio and provides data to better model the service life and detect damage to the composite. The reviewer pointed out that the project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer stated that the team achieved their objectives adjusting to the issue of geometry with dip coating to switch to PAN electrospinning. The project was a bit delayed due to the pivot, but the greatly improved interfacial adhesion was a great result.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project followed the planned timeline and completed as scheduled.

Reviewer 2

The reviewer noted that the project accomplished the proposed milestones.

Reviewer 3

The reviewer stated that the technical progress demonstrated a well-planned and well-executed project. An in-depth study on nanofiber diameter and alignment on nonwoven CF mats has been performed associated with a TEA. The reviewer felt that the technical details in the presentation are thorough, and the project delivery was successful.

Reviewer 4

The reviewer praised that boosting the interfacial adhesion from a 20-60% improvement is a major change. The PAN process seems to be well understood, and the new products can be readily scaled, which is another objective of this project. The reviewer also noted that detecting damage using voltage sensing is another objective achieved.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project has multiple collaborators included Columbia University as subcontractor and Enfluxx Tech providing license for passive sensing.

Reviewer 2

The reviewer stated that the collaborations were well laid out, and that each partner has a specific task they accomplished.

Reviewer 3

The reviewer described that the team includes ORNL and Columbia University. The collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 4

The reviewer stated that this project was led mostly by ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer simply stated that the project has ended.

Reviewer 2
The reviewer noted that the project is now completed, so no proposed future research was discussed.

Reviewer 3
The reviewer said that there is no remaining proposed future research for this project.

Reviewer 4
The reviewer pointed out that there is no future research to be supported by DOE, however there should be future licensing opportunities to generate more work based on this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer agreed that the project aligns with the VTO Materials subprogram objective for developing smart composite structures.

Reviewer 2
The project supports the overall VTO Materials subprogram objectives.

Reviewer 3
The project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4
The reviewer agreed that the stronger and lighter weight composite with sensing is extremely valuable to the composites needed for EVs. The technology was selected to be in the FedTech program which helps support its relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer agreed that sufficient resources were available including financial, technical, and equipment (from the collaborators).

Reviewer 2
The reviewer stated that the project had sufficient resources that helped to achieve and accomplish the milestones.

Reviewer 3
The reviewer remarked that ORNL and Columbia University provide sufficient and powerful resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Reviewer 4
The reviewer stated that the program is complete and there was no need for more resources.

Presentation Number: MAT208
Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste
Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Presenter

Daniel Merkel, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

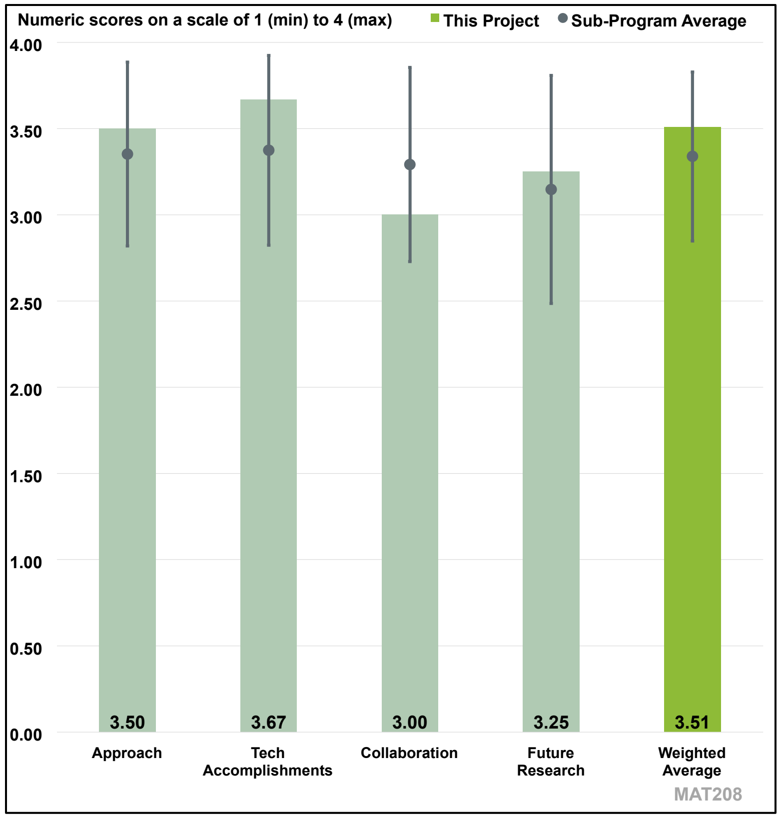

Figure 5-15. Presentation Number: MAT208 Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the PNNL team seems to have a clear understanding of the project and have executed it well. The researchers also did a cost analysis to show the benefits from their polyethylene terephthalate (PET)-based aramid fiber development.

Reviewer 2

The reviewer described that this project addresses the technical barriers of the excessive cost of precursor materials and CF conversion to produce composites at high-volume production rates that will achieve weight reductions of up to 60%–70% over current baseline materials. The reviewer explained that the approach is to use direct depolymerization of PET waste plastic, generation of terephthalolyl chloride (TCl), and repolymerization using an aromatic diamine to produce a lower cost polyaramid fiber. This process has the advantages of faster reaction rates and easy removal of contaminants. The reaction product would then be used to fabricate unidirectional composites, and a TEA of the PET-derived fiber would be compared to virgin sources. The reviewer said that although there was no project schedule Gantt chart presented, the project milestone descriptions provided insight to a well-designed approach and a reasonable timeline for the three-year project to achieve the project objectives of demonstrating the synthesis of aramid polymers and fibers from PET plastic waste, demonstrating a low-cost route to producing aramid fibers, and developing composites containing PET-derived aramid fibers.

Reviewer 3

The reviewer praised the excellent approach with upcycling of PET waste via depolymerization followed by polymerization of polyaramid for fiber manufacturing. Feasibility of this approach has been demonstrated (although the fiber properties remain very poor).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The team successfully completed their milestones even though one of their primary team members left during the project, established a process to develop the fibers, clearly demonstrated performance as compared to current state of art commercial versions, and showed a 20% cost reduction for aramid fibers using their method.

Reviewer 2

The reviewer explained that the primary project objective was to demonstrate the synthesis of aramid polymers and fibers from PET plastic waste. PET was obtained from mixed-waste PET beverage containers with contaminants at ~10 wt.% that was mostly PP labels and colorant dyes. The PET was depolymerized to generate TCl and then the TCl was polymerized with six different diamines to produce polyaramids at an 85% synthesis yield. The reviewer noted that this technical accomplishment achieved the primary objective. The reviewer stated that a high molecular weight polymer with 40 repeating units was synthesized in quantities ≥20 g. The resulting inherent viscosity (molecular weight) increased 25% to values typically used for fiber spinning.

A PET-derived fiber was produced with a diameter ≤20 µm which is larger than the typical CF feedstock and better for carbonization. The project also demonstrated additional technical accomplishments of achieving 100% increase in modulus by high temperature drawing, up to 30% cost reduction for PET-derived terephthalic acid with plastic recycling credits, up to 20% cost reduction for PET-derived aramid fiber with plastic recycling credits, a 40% cost reduction of PET-derived aramid fibers as compared to commercial Kevlar para-aramid, and a 13% reduction in GHG emissions for PET-derived terephthalic acid compared to the commercial enzymatic process. The reviewer praised that all are considered significant and outstanding technical accomplishments considering the budget and timeline for this project.

Reviewer 3

The reviewer stated that nearly an equivalent molecular weight of polyaramid (~4 deciliters per gram intrinsic viscosity) was prepared and spun into fiber form with 15-20 µm filament diameter. The reviewer mentioned that for some reason the filaments are not strong enough to display good tenacity. The reviewer observed that it was very likely the rudimentary spinning device did not deliver high enough fiber orientation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team is mostly from PNNL, with no industry partners. The reviewer highlighted that a commercial perspective from industrial partners will be beneficial in moving forward in the next phase.

Reviewer 2

The reviewer stated that there was no collaboration slide presented, nor was collaboration discussed probably because of the technical readiness level (TRL) for this research. The PNNL research team consisted of eight co-PIs and internal collaboration appears to be good because of the technical accomplishments that were achieved.

Reviewer 3

The reviewer noted that the project involves a single entity, PNNL and that a Collaboration and Coordination slide was not presented.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer described that the team was uncertain about the possibility of creating a process for scale up of the aramid fibers. It is possible that scale up will be addressed in a different project.

Reviewer 2

The reviewer commented that although this project was completed at the end of FY 2023, future research was proposed for recovery of paraphenylene diamine from waste sources to achieve further cost/emissions benefits in synthesis process and evaluating other PET-derived fibers. The presenter indicated that this future work would continue under the Composites Core Program 2.0 Thrust III Circularity in FY 2024.

Reviewer 3

The reviewer described that the second phase of this project has been included in the newly established Composite Core Program 2.0.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that cost reduction of materials that can be used in composites is a key focus area for VTO.

Reviewer 2

The reviewer agreed that this project is relevant to the DOE VTO Materials subprogram objectives of developing low-temperature and high-strength hybrid composite systems for vehicle components, reducing current cost barriers to implementing aramid fiber composites in automotive applications, and recycling of materials to support clean energy and a circular carbon economy through reduced material and energy costs.

Reviewer 3

The reviewer agreed that the project is relevant because of the upcycling of PET to value-added polymer and fiber product. These fibers can be used in automotive composite manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that PNNL seems to have all the capabilities and resources to conduct the project efficiently.

Reviewer 2

The reviewer stated that the funding amount of $820,000 over three years is considered sufficient for the level of research that was needed to complete this project and meet the milestones within the performance period.

Reviewer 3

The reviewer simply stated that the resources are sufficient for this project.

Presentation Number: MAT209
Presentation Title: Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling
Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Presenter

Nicholas Rorrer, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

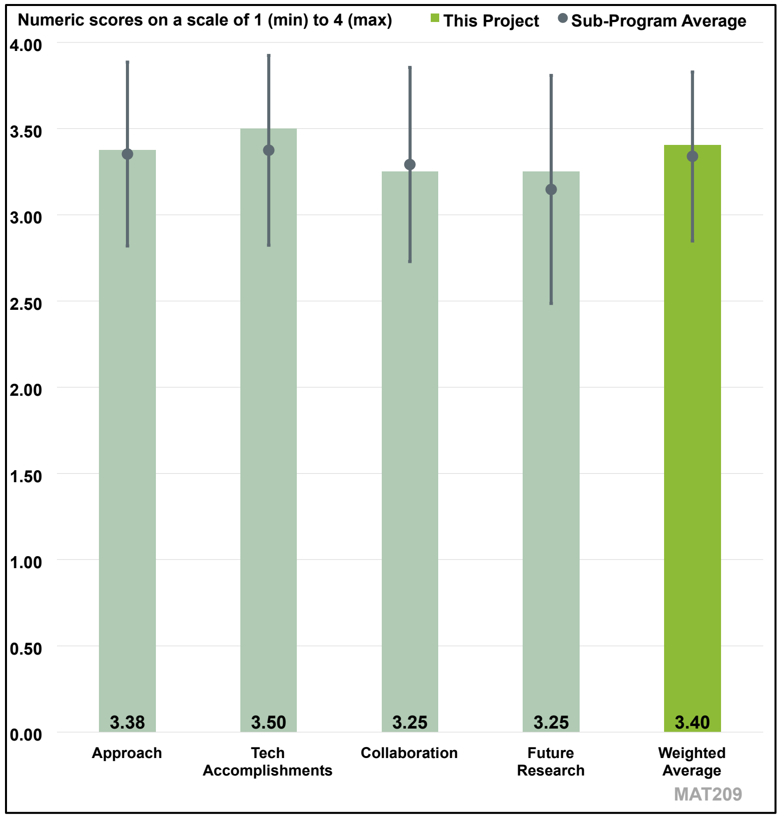

Figure 5-16. Presentation Number: MAT209 Presentation Title: Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer expressed that the pathway to recycling and recovery offers potential, but the application space may be limited by the thermal properties of the bio-derived resins. The reviewer stated that automotive structures often require painting to meet long-term corrosion and surface finish requirements. Therefore, material subjected to these processes must be able to tolerate the higher temperatures encountered during electrocoat and paint bake processes.

Reviewer 2

The reviewer noted that barriers were addressed by the work scope and approach.

Reviewer 3

The reviewer applauded that the work is technically excellent and important considerations like aging/weathering and recyclability of the materials for the application were included in the design of experiments.

Reviewer 4

The reviewer described that sourcing, recyclability and reusability is addressed through application of the National Renewable Energy Laboratory (NREL) variation on polyester covalently adaptable networks (PECAN) resin that was developed for wind blades and other applications. The project was executed following a clear plan, however the approach focused more on advancing the science of PECAN resin rather than addressing automotive related challenges. Processing material with continuous fiber cloth is relevant only to the highest performance, lowest volume, vehicles. Screening tests to standard potential exposures for the resin (fluids, temperatures etc.) were not considered in this work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that all project goals have been completed per the original intent.

Reviewer 2

The reviewer commented that the project accomplishments demonstrated the versatility of the resin and composites, and the TEA shows a cost advantage.

Reviewer 3

The reviewer praised that the technical progress is exceptional for the budget having demonstrated both large scale parts and comprehensive LCA/TEA.

Reviewer 4

The reviewer commented that scientific technical accomplishments were addressed but cautioned that the connection to automotive challenges is tenuous.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer highlighted that extensive collaboration with feedstock producers was demonstrated. However, additional engagement with end user candidates could have provided additional insight.

Reviewer 2

The reviewer asserted that the collaboration is broad and not project specific, but generally expected to provide industry-relevant input and guidance.

Reviewer 3

The reviewer commented that the project appears to be well aligned with the major Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment or BOTTLE consortium. The reviewer was surprised this technology has not been accepted by wind energy applications which would consume substantial amounts of this type of resin and apply to a large end-of-life waste-to-life use problem where the resin would be well suited.

Reviewer 4

The reviewer commented that the project would have benefited from direct industry feedback.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that, although the project has reached its conclusion, the proposed future work has potential to expand the commercial opportunities. The project PI should consider application of the bio-derived resins to short-fiber chopped composites. The reviewer noted that woven material formats continue to be cost prohibitive for high-volume automotive applications.

Reviewer 2

The reviewer thought that one area of improvement would be to better explain how this work aligns with vehicle manufacturer interests and expectations since the reviewer's perception of vehicle original equipment manufacturers (OEMs) is that they are leaning heavily towards thermoplastics that can be more easily fit into the recycling infrastructure. From the collaborator list/technical direction, the reviewer was unclear about the potential of this material to be recycled. Someone once said there is a difference between being recyclable and being recycled. The reviewer asked where the material would go if it ended up at a sorter.

Reviewer 3

The reviewer simply stated that the project has ended.

Reviewer 4

The reviewer simply stated that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project goals are aligned with the VTO mission statements.

Reviewer 2

The reviewer commented that the project is relevant to the VTO Materials subprogram objectives (improved composites, lightweighting, recycling).

Reviewer 3

The reviewer agreed that these types of resin systems would greatly enable the recovery of CF at the end of life of parts.

Reviewer 4

The reviewer agreed that the work is relevant to the VTO Materials subprogram objectives, however the specifics of the projects could be more applicable to the automotive needs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that, given that the project completed, sufficient resources were deployed to meet the stated milestones.

Reviewer 2

The reviewer thought that the resources were sufficient.

Reviewer 3

The reviewer described that $1.5 million was expended on incremental improvements of NREL's PECAN resin, thermoforming trials, experiments, and analysis. The funds were sufficient to perform this work.

Reviewer 4

The reviewer noted that the funding level appears excessive for the work presented relative to other projects.

Presentation Number: MAT211
Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles
Principal Investigator: Masato Mizuta, Newport Sensors Inc.

Presenter

Masato Mizuta, Newport Sensors Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

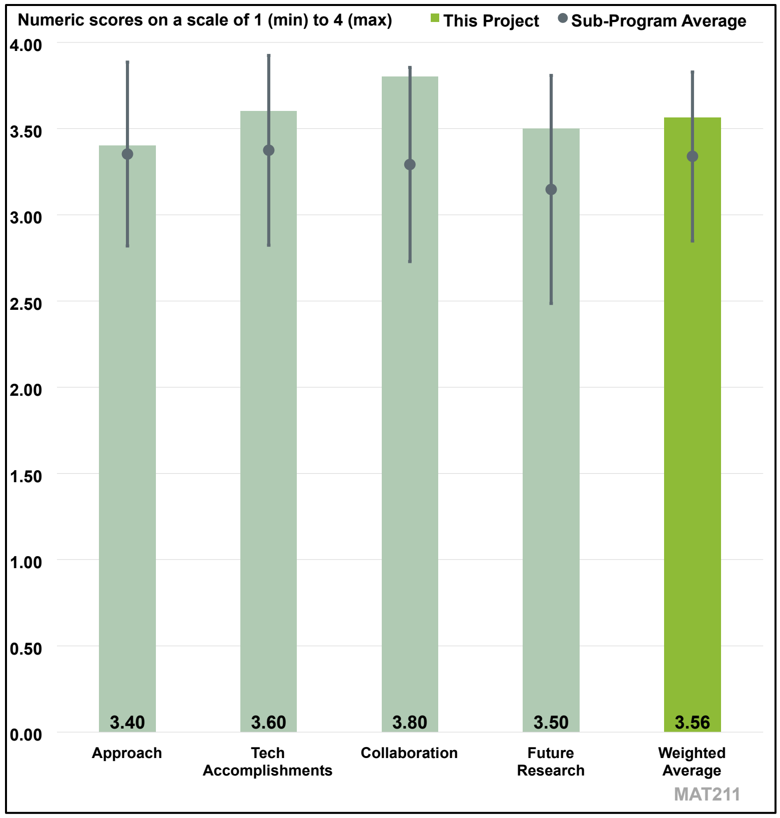

Figure 5-17. Presentation Number: MAT211 Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles Principal Investigator: Masato Mizuta, Newport Sensors Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the technical barriers include high fiber costs and fiber damage detection. The project certainly addresses damage detection, but the impact on fiber cost is not clear.

Reviewer 2

The reviewer stated the project approach is good. The project team incorporates a Sustainable Lightweight Intelligent Composites (SLIC) sensor strip to vehicle parts using a sheet molding compound (SMC). The sensing capability seems already proven, and the focus is to determine how to incorporate it into vehicle components in cost-effective and energy efficient ways. While general milestones are reasonable, the milestones are not SMART (Specific, Measurable, Achievable, Relevant, and Time-bound). The milestones should include quantifiable targets. For example, there was some uncertainty about the cost competitiveness. Considering commercialization, cost is one of the most important aspects. And because the technology seems to have performance, cost reduction will be key for practical deployment. Collaboration with Teijin Automotive Technologies provides satisfactory progress toward realistic commercialization.

Reviewer 3

The reviewer commented that this project identifies high fiber cost and difficulty with damage inspection as the two key barriers to target. Task 1 has a component for developing a hybrid composite battery enclosure but there was no mention of how the excessive cost will be addressed in this project. The entire presentation was centered around health monitoring and sensing.

Reviewer 4

The reviewer stated the research approach is good, and it includes design and fabrication of the battery enclosure, and development and integration of the sensor system. The integration of sensors with SMC is very interesting.

Reviewer 5

The reviewer commented that Phase IIB of the project aims to integrate two types of sensors into one strip using corrugations in the front section of the shield panel. The project is on track and making progress in terms of tasks and deliverables.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the work demonstrates an effective method for damage detection.

Reviewer 2

The reviewer commented that, considering the project has just started, satisfactory progress has been demonstrated from the Phase I effort. The incorporation of a SLIC sensor using SMC for the underbody impact shield was successfully performed. While the process needs refinement, good data including piezoelectric sensor test data have been obtained.

Reviewer 3

The reviewer remarked that the technical progress seems good compared to the project plan considering this project is a fresh start.

Reviewer 4

The reviewer enquired about the pressures that the sensor withstood and sought clarification on pressure limitations for SMC fabrication. The reviewer expressed concern about whether the sensor would conform to a curved geometry or get damaged.

Reviewer 5

The reviewer noted the project started in January 2024 and design tasks in Task 1 and manufacturing procedures in Task 2.1 are in progress. The project achieved one-step sensor/composite molding.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the team collaboration includes industry partners and commercial manufacturers who actively contribute to the effort.

Reviewer 2

The reviewer commented that the team collaboration is excellent. The involvement of Teijin Automotive Technologies and Owens Corning is very good. They are key players for commercialization.

Reviewer 3

The reviewer acknowledged that this project is supported by three entities, all from industry. Tejin Automotive Technologies seems responsible for composite manufacturing and Owens Corning for impact testing. The presenter discussed coordination efforts during the presentation. However, including a research institute would be very helpful in addressing technical challenges.

Reviewer 4

The reviewer mentioned that the team collaboration is excellent and included very frequent interactions between partners.

Reviewer 5

The reviewer commented that the team collaboration between Newport Sensors, Teijin Automotive Technologies and Owens Corning has been great.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed future work appears to address the technical barriers and challenges relevant to the project.

Reviewer 2

The reviewer stated that the general directions of the project approach are good, however, some details could be more carefully defined, examples include what is needed to make the technology more cost effective and what performance targets are required to make the technology commercially viable. To bring this technology to commercialization, these details may need to be mapped out and clearly defined.

Reviewer 3

The reviewer commented that the future work plan seems reasonable and aligns with the project goals. Likely, the project targets will be achieved in a timely manner.

Reviewer 4

The reviewer remarked that the future scope is planned well and, if successful, would be relevant to the objectives of the project.

Reviewer 5

The reviewer commented that the proposed future research has clearly defined tasks and deliverables and will likely achieve its targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project is relevant to VTO Materials subprogram for composites.

Reviewer 2

The reviewer commented that a capability for sensing technology is important for lightweight materials. Damage sensing is an important aspect for various vehicle parts beyond lightweight materials.

Reviewer 3

The reviewer noted that this project supports the overall VTO Materials subprogram objectives, especially from the multifunctional material and self-sensing perspectives.

Reviewer 4

The reviewer commented that the project supports the overall VTO Materials subprogram objectives.

Reviewer 5

The reviewer acknowledged that current autonomous vehicles rely on optical, laser and radar sensors, which can still miss blind spots. The proposed SLIC sensors can detect impact, damage, and thus enable true autonomous functions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that additional resources would help offset the excessive cost of fabrication and sensor design and help show additional relevance outside of a single demonstration component.

Reviewer 2

The reviewer noted that the project resources are sufficient.

Reviewer 3

The reviewer commented that the project resources are sufficient to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer stated that the project resources are adequate.

Reviewer 5

The reviewer commented that Newport Sensors, Teijin Automotive Technologies, and Owens Corning have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT212
Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles
Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Presenter

Amrita Kumar, Acellent Technologies Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

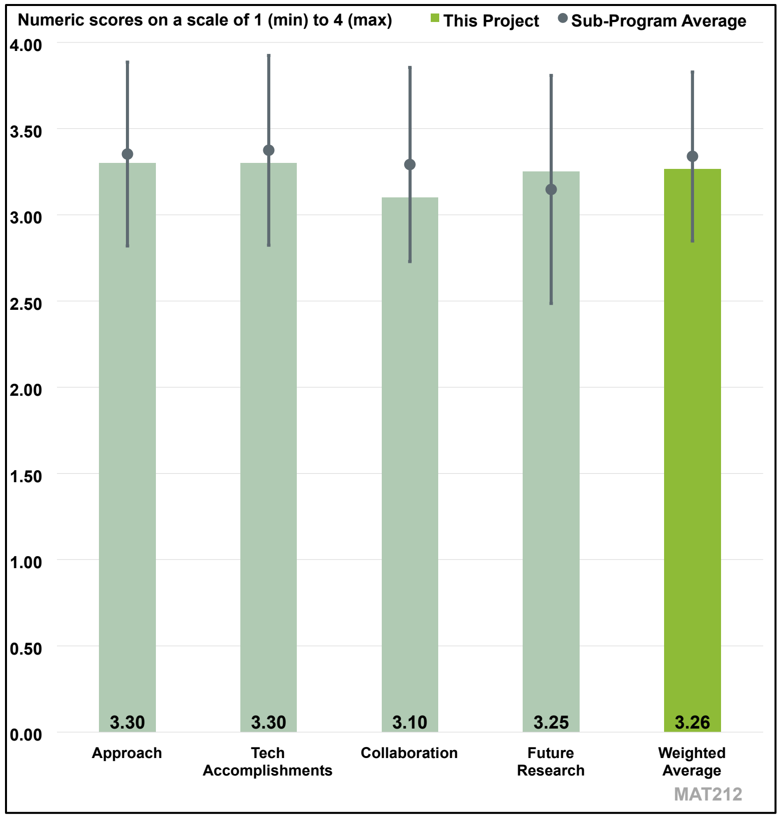

Figure 5-18. Presentation Number: MAT212 Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the research approach was reasonably described for both the impact sensor and battery energy management portions of the work, although it was not clear why these topics were combined in this completed project versus separated from the energy management portion of the recently initiated MAT 266 project. Both areas can positively impact DOE mission areas by enhancing pedestrian safety, saving weight, and increasing structural efficiency.

Reviewer 2

The reviewer commented that the project is complete, and the approach was well outlined to accomplish the proposed milestones and objectives.

Reviewer 3

The reviewer commented that the approach to perform the work is good and is supported by experience in the field. The project case studies appear to somewhat defocus the project.

Reviewer 4

The reviewer commented that the technical approach related to the application of frequency appears to discriminate the difference from the impact modality. Passive sensing requires little to no power and could be readily implemented in vehicles. Although the project was completed on time, the reviewer was unclear about what novel activities were essential to re-contextualize this data from prior efforts. As a bumper technology, what can be done to improve safety at the point of impact? Of course, the sensor would be triggered by some sort of hood response to prevent injury to the pedestrian's head, but this has not been properly considered in the scope of work. Also, this technology has been developed for some time. The novelty of this work pertains to discriminating the type of impact through sensor spatial distribution and algorithmic signal interpretation. The reviewer was unclear as to what is currently limiting deep market penetration of this technology by now.

Reviewer 5

The reviewer commented that the approach was well thought out and executed. The project used an actual bumper from Ford and generated relevant results. The work is licensed and is now progressing in another project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer mentioned that significant data has been acquired and analyzed. For example, sensor data related to identifying differentiating frequency ranges for several types of impact. Response times with this technique of three milliseconds versus competitive techniques at approximately five milliseconds were highlighted by the presenter. The reviewer also stated that the structural load capability of the energy storage system was briefly mentioned but not highlighted during the discussion of the results, so the accomplishments are not clear. Advancements related to the energy management system are also unclear.

Reviewer 2

The reviewer commented that the use of a real bumper and simulated pedestrian mock-up for understanding the sensor network is very interesting.

Reviewer 3

The reviewer commented that the main accomplishments achieved in collaboration with Stanford some years ago made it difficult to determine what was uniquely developed within this project. The accomplishments within this project and the MAT266 project seem difficult to identify.

Reviewer 4

The reviewer mentioned that the team adhered to the product plan and clearly showed a working concept and the support from industry should lead to a marketable product. The reviewer remarked the work could be impactful if it reduced pedestrian injury and death during collisions especially for autonomous vehicles.

Reviewer 5

The reviewer stated that the team distinguished a human leg impact from other objects within 3 milliseconds, which is faster than the current state-of-the-art technologies and added that the project is a success as a Phase 2 Small Business Innovation Research (SBIR) initiative.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that, considering both areas have benefitted from outside collaboration with Ford on the sensor portion and Stanford on the energy storage portion, the relative contributions of each collaborator was unclear. The reviewer questioned whether Ford provided significant technical contributions in addition to supplying the test bumpers and how Stanford's consulting in advancing the energy storage system beyond providing the initial technology license was applicable. Both partners could be very valuable in going forward in optimizing these systems towards commercialization; Tillotson Pearson Incorporated Composites (TPIC) was mentioned as actively partnering in the MAT 266 presentation.

Reviewer 2

The reviewer stated that the team worked very closely together and observed that Ford appears to be very much involved with the project.

Reviewer 3

The reviewer commented that the team seems to have built a strong relationship with both Stanford and Ford. However, it is difficult to evaluate the impact of the collaboration.

Reviewer 4

The reviewer commented that the project would benefit from additional, more in-depth collaboration with a Tier 1 manufacturer, however, these can be admittedly difficult to arrange.

Reviewer 5

The reviewer commented that there were tangible contributions from the partners and for a SBIR Phase 2 effort, this project was well coordinated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that although this project has ended, it appears that the MAT266 project is enhancing the energy storage system beyond the current capabilities of the MAT212 project, but it would have been interesting to see the potential next steps with the sensor approach.

Reviewer 2

The reviewer commented that there is no future research, but the team is part of a new DOE project to advance the manufacturability at scale.

Reviewer 3

The reviewer stated that even if the future work of this project seems relevant, it is intertwined with other DOE projects, so a clear picture of the future of this specific project is difficult to comment on.

Reviewer 4

The reviewer affirmed that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer previously stated that both areas can positively impact DOE mission areas by enhancing pedestrian safety, saving weight, and increasing structural efficiency.

Reviewer 2

The reviewer commented that the project supports the VTO Materials subprogram objectives.

Reviewer 3

The reviewer remarked that the project has great technical relevance with opportunities in several other areas. However, the ultimate relevance can first be evaluated once a clearer picture is presented regarding the cost for scaling and implementation.

Reviewer 4

The reviewer commented that the project provides a unique and potentially highly impactful route to improving EV safety and operability on the road. High profile accidents could impact the public opinion on VTO objectives in the future and therefore this a synergistic activity that imparts multi-functionality to the glider front end.

Reviewer 5

The reviewer commented that the program is relevant to the VTO Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the adequacy of the resources was hard to judge, considering the differences of the two focus areas. Another reviewer remarked that most of the effort was devoted to testing and analyzing data versus advancing the technologies, but this seems very reasonable for this type of project. Considering the lack of detail regarding next steps, the positive results seem to bode well for continuing interest.

Reviewer 2

The reviewer stated that the resources are adequate.

Reviewer 3

The reviewer commented that the project seems to be supported from several DOE sources. Thus, the needed resources seem well addressed.

Reviewer 4

The reviewer commented that for an industry project the resources were well allocated and used appropriately to achieve a targeted task. The reviewer was somewhat unclear about what development was included in this scope, however, the resources appeared proportional.

Reviewer 5

The reviewer commented that the resources were sufficient for this project.

Presentation Number: MAT221
Presentation Title: Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials
Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Presenter

Dean Pierce, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

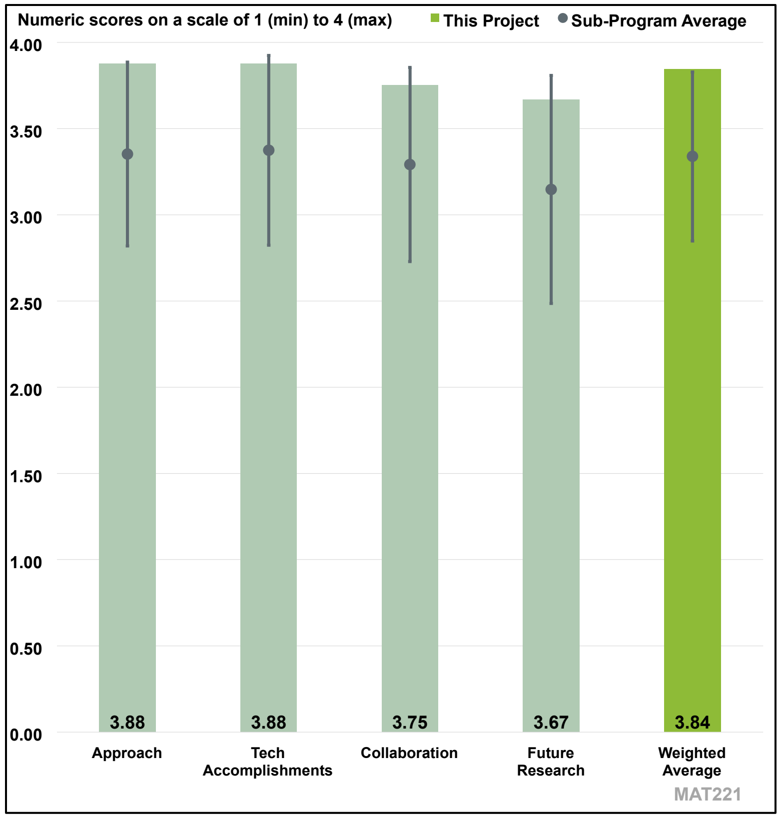

Figure 5-19. Presentation Number: MAT221 Presentation Title: Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer detailed that the project addresses challenges in the heavy-duty vehicle sector to improve state-of-the-art diesel engines and improvements needed to efficiently use lower carbon fuels applications. This is needed since the heavy-duty vehicle sector is difficult to electrify with significant trade-offs occurring between battery weight, payload weight, and vehicle range.

Near term applicability of this improved material will help reduce the consumption of fossil fuels while better batteries or other zero emission technologies for long-haul trucking are developed. The project also has possible application to hydrogen fuel system components since it resists hydrogen embrittlement. The work being done by this team will lay the groundwork for improved materials needed to help incorporate low carbon fuels in over the road trucks. Using alloys can increase strength and oxidation benefits but results in a decrease in thermal conductivity which raises piston temperature. The reviewer said the project has successfully identified and optimized the material to use for piston crowns. This material is machinable, weldable, and at an acceptable price point. These new piston materials are needed to operate in these more severe engine conditions that occur in high efficiency and low carbon fuel combustion environments.

The reviewer said that by leveraging ICME, laboratory scientists designed approximately 35 alloys that could withstand the conditions encountered in these higher temperature engines. The best candidate alloy was identified (G3-5M). The 5.5-year project created the material through identification to optimization to a commercial ready material that can be used as a roadmap for other material development projects.

Reviewer 2

The reviewer said the background and challenges of this component are well documented and presented. This data is relevant to the project and explains the intent and possible benefits. Computational modeling of the candidate alloys clearly allowed an accelerated timeline, and the team used this ability to move this material through to deployment in an engine test very quickly with reliable results. The reviewer remarked that thermal properties of the pistons are critical to efficiency, and this is a clear opportunity to increase that efficiency. Great cyclic oxidation work at two temperatures in early work drove the ability to specify and create a 1500-pound heat of this alloy for actual engine testing.

Reviewer 3

The reviewer remarked the project seeks to address optimization of properties of piston crown steels, machinability/weldability/affordability, scaling steel to larger sizes, and achieving higher power density. The project will be important to enable hydrogen fueled engines.

Reviewer 4

The reviewer remarked the team aims to solve the dilemma of the piston crown steel. On one hand the steel needs high strength and oxidization resistance and on the other hand, it needs thermal conductivity to limit the piston temperature. The team developed the G3 steel, assessed it, and found significant improvement of the 4140 alloy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said this project again shows the value of ICME and the ability to develop new materials needed for higher efficiency operations in both combustion and electrical systems. G3-5M was evaluated to document the key material properties needed for higher piston temperatures. An 85% increase in strength was demonstrated over 4140 steels at 600°C. A 28% increase in strength over H11 (5-chromium tool steel) despite much lower alloy content. High cycle fatigue is preferred rather than tensile strength because of the piston application. A G3-5M heat-treated alloy exhibited a significant improvement in fatigue strength at elevated temperatures. Test results showed a 107% increase in fatigue strength versus 4140 and 30% increase versus H11 in fatigue strength at 600°C after heat treating for 500 hours at 600°C.

G3-5M extends the oxidation resistance to about 575°C and demonstrates modest increases in thermal conductivity over H11. Friction welding characterization showed that post weld heat treatment is needed to reduce high interfacial hardness. The G3-5M material was of such interest to Cummins that they took on a significant additional cost to complete the peak power overfuel test. The reviewer pointed out that the G3-5M materials successfully passed this enhanced test which indicated Cummins is likely to bring this material to the commercial marketplace. G3-5M has a better trade-off between thermal properties, strength, and oxidation resistance over state of the art steels.

Reviewer 2

The reviewer remarked the technical work is high quality and on target. The work presented is clear and concise, creating efficiency opportunities. Very impressive for this project to take this from a computational model to a heat of steel and then on to a functioning component in a running engine such that the actual real effect can be quantified.

Reviewer 3

The reviewer said the team did an excellent job. The highlights include how the G3 steel exhibits an 85% increase in strength over 4140 steel at 600°C and G3 heat exhibits 107% increase in fatigue strength at 600°C compared to 4140 after aging at 600°C for 500h. G3 steel extended the oxidation resistance to about 575°C compared to 4140 and modest increases in thermal conductivity over H11. The G3 alloy can be nicely welded to medium alloy steel by rotary friction welding. G3-5M shows no severe damage after a modified 500h pure plant oil engine test beyond typical oxidation. The G3 steel successfully passed modified peak power overfuel test with enhanced severity. The team also understood the origin of these fantastic properties: the novel thermal processing and the alloy chemistry allowing the ultra-fine microstructure to form.

Reviewer 4

The reviewer commented the project is complete.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the team worked with Cummins, and Cummins contributed $1 million in cost share, twice the original planned cost share.

Reviewer 2

The reviewer found it was clear that all the stakeholders were participating, proposing, and evaluating several different iterations of alloys via computational models, then moving the new proposed alloy through the steel mill, validating the expected physical properties of the heat of steel, then sending the material to the piston manufacturer, then finished pistons to the engine manufacturer where it was ultimately tested. Very impressive!

Reviewer 3

The reviewer noted strong industry involvement with Cummins.

Reviewer 4

The reviewer noted the alignment of the project team with ORNL, and the team was able to leverage their unique capabilities with other related projects under Thrust 4 of the Powertrain Materials Core Program (PMCP) 1.0 to maximize DOE's investment. ORNL has established mechanisms needed to commercialize this technology through Cooperative Research and Development Agreements (CRADAs) with industry partners like Cummins. The reviewer said these arrangements are needed to help bring this material to the commercial marketplace. The CRADAs between Cummins and ORNL and the partnership established with Mahle, a prototype piston manufacturer, will permit the successful transition to a commercialized product.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that using this alloy for piston caps in hydrogen-powered internal combustion engines is an interesting opportunity for an adjacency of this steel. Other low carbon fuels are also indicated for additional impact of the material; this is important as the industry strives to lower carbon emissions using existing capital assets. The reviewer said opportunities were discussed for further refinement of the model and, therefore, the alloy.

Reviewer 2

The reviewer remarked that although this project is complete, researchers can use the knowledge gained in this project to determine possible application for EV powertrains to support the new direction of the PMCP 2.0 that is focused on identifying new materials for EV powertrains. This material also appears to be well suited for low carbon fuels like hydrogen, and applications in hydrogen-fueled internal combustion and hydrogen fuel cell vehicles. Possible applications for hydrogen engines include injectors, dies, valves, and elevated temperature fasteners. The G3 material will need to be produced economically at scale at a steel mill.

Reviewer 3

The reviewer said the project is complete. The project identified efforts that can be done to evaluate the suitability of this alloy for pistons of green-fueled (hydrogen, ammonia, natural gas) internal combustion engines and other applications (injectors, dies, valves, high-temperature fasteners).

Reviewer 4

The reviewer said the project has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this is clearly a win in the Energy Efficient Mobility Systems subprogram space and is also relevant to the DOE Decarbonization of Off-Road, Real, Marine, and Aviation (previously the Advanced Engine and Fuel Technologies subprogram). The reviewer said this type of development is critical to maintain mobility while decreasing environmental impact of the industry. The ability to continue to increase the efficiency of internal combustion engines is directly transferrable to this same style hardware operating on sustainable or low-to-no carbon fuels, given the industry options that can positively impact the environment immediately.

Reviewer 2

The reviewer remarked the project will help to enable engine development to meet the objectives to decarbonize the on-highway fleet. The effort helps to overcome material barriers to enable hydrogen combustion.

Reviewer 3

The reviewer said the ability to improve piston performance is critical for improving heavy-duty vehicle performance.

Reviewer 4

The reviewer remarked the project is directly relevant to the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said this project again illustrates the unique value of ICME and the PMCP (both 1.0 and 2.0 phases). This project has overcome material challenges encountered during high-efficiency combustion. The performance characteristics of this alloy permits engine builders to adapt their engines to use low-carbon fuels. The use of CRADAs should continue to be encouraged to allow industry to invest in this promising research. DOE should continue research to determine other possible applications for this alloy for low carbon and hydrogen fuel applications by leveraging its unique performance characteristics.

Reviewer 2

The reviewer said it was very impressive that the team was able to take this all the way to testing and validating in an engine after starting with a clean sheet alloy development. The team obviously was very efficient.

Reviewer 3

The reviewer remarked the lab and industry partners have excellent resources to complete this effort.

Reviewer 4

The reviewer noted that Cummins spent significant amount of its own resources on this project.

Presentation Number: MAT222
Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs
Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Presenter

Jian Chen, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

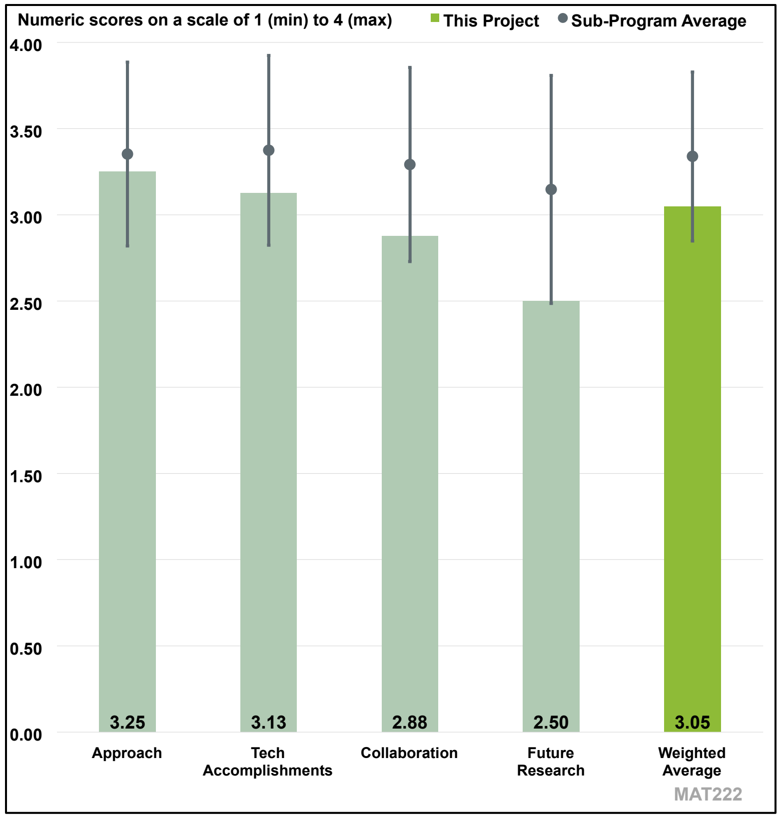

Figure 5-20. Presentation Number: MAT222 Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that, in four years, the project has successfully demonstrated ultrasonic joining as an effective method for several new material pairs—similar and dissimilar.

Reviewer 2

The reviewer noted that the project has done a decent job in addressing the issue of multiple ultrasonic welds in a structural component.

Reviewer 3

The reviewer said that the root cause to challenges in in-series joining quality was not evident or expressed. The close-loop control strategy seemed ad-hoc without pre-established correlation to support the close-loop control strategy that was presented.

Reviewer 4

The reviewer commented that the technical barriers are sufficiently identified and defined to begin experimentation. Detail of the specific process variables and controls are defined in the body of the presentation. The timeline is organized in a logical fashion and contains enough detail. The decision to prioritize Mg-steel joining over Mg-Al and Al-steel is unusual.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the team has made very good progress, especially in identifying the factors that can improve the repeatability of a joint made in series.

Reviewer 2

The reviewer remarked that the analysis of the microstructure and method of bonding of each joint was well studied and clearly documented. The strength targets were reasonably set and appear to have been adequately met. The project is proceeding according to the schedule in the plan with no significant shortcomings. In light metal joining, the forging force, or processing load as it is referred to in this project, is a significant process parameter. The reviewer stated that although ultrasonic spot welding (USW) accurately lists a low processing load as an advantage, not using it as a process variable may have limited the optimization of the process.

Reviewer 3

The reviewer observed that the slides state that the milestone for “Establishment of correlation between in-situ process parameters and joint quality” has been completed but no data was presented. Unfortunately, this seems to be a significant finding and the basis for the team’s purported control logic.

Reviewer 4

The reviewer pointed out that the root cause to challenges in in-series joining quality was not evident or expressed. The close-loop control strategy seemed ad-hoc without pre-established correlation to support the close-loop control strategy that was presented.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that collaboration and coordination appeared to meet expectations.

Reviewer 2

The reviewer observed while the presentation mentioned partners, it was not clear from the slides or the delivery which of the laboratories performed what work. More elucidation might be helpful.

Reviewer 3

The reviewer remarked that the work conducted by each laboratory is relevant and none of the tasks appear to have been created solely to give the laboratory something to do. The micrographs and chemical analysis gave some interesting insight into the method of joining and could suggest potential future project opportunities with respect to surface preparation and/or alloy development.

Reviewer 4

The reviewer said rather than collaborating on the singular USW process, ORNL and PNNL chose to investigate two alternatives with the greatest weight on the ORNL alternative. The reviewer felt this is a dilution of effort and focusing all resources on a singular topic would have been more effective. For example, PNNL has experience with algorithm development for friction stir welding (FSW) control, which could have been brought to bear on the USW control logic development. The reviewer believed that this would be better to create critical mass.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed that given the project is almost ending, the future work outlined is a good summary for the project charter.

Reviewer 2

The reviewer remarked that none of the future research topics are incorrect. A focus on difficult-to-weld combinations may limit the applicability of the technique in near-term applications because automakers will typically not design with such a joint combination without years of experience with less difficult joints. Studying more process variables, such as process load, may be valuable to define the process window more fully before attempting ML for optimization.

Reviewer 3

The reviewer believed work is needed to show that the proposed approach to closed-loop control is generally applicable to other stack designs.

Reviewer 4

The reviewer said the four topics should be narrowed to just one - ML. The varied material combinations can be part of the ML scope since the applicability of the model will need to be assessed. Joint strength characterization should be part of a higher TRL project focused on a specific application driven by an industry partner. The reviewer remarked a second topic could be looking at where the greater energy input is absorbed within the structure since the control algorithm increased the overall energy needed to create a weld. Understanding the boundary conditions and where the energy goes is critical for any application. A third topic could be the impact of changing the knurling pattern on the tooling and its effect upon the ML algorithm.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 2

The reviewer remarked that multi-material joining is a very relevant area of research for automotive manufacturing and design.

Reviewer 3

The reviewer noted this is a clear and fundamental project in support of the VTO Materials subprogram objectives. Robust and energy-efficient joining methods between light metals and between light metals and steel are relevant and will remain so.

Reviewer 4

The reviewer had no comment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed that sufficient resources have been available for the project team to achieve their goal of an adaptive control of USW as a function of sequence. Again, this is at a low

Manufacturing Readiness Level (MRL) and significant work lies beyond raising the MRL, but this is out of scope of the current work.

Reviewer 2

The reviewer believed more resources should have been applied in closed-loop control development. The reviewer did not know if those resources were available to this team.

Reviewer 3

The reviewer said the team members and equipment are effectively executing the project. An increased contribution of light metal welding expertise from the industry partners could be helpful to ensure that the correct process parameters are addressed.

Reviewer 4

The reviewer had no comment.

Presentation Number: MAT223
Presentation Title: Extending High-Rate Riveting to New Material Pairs
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

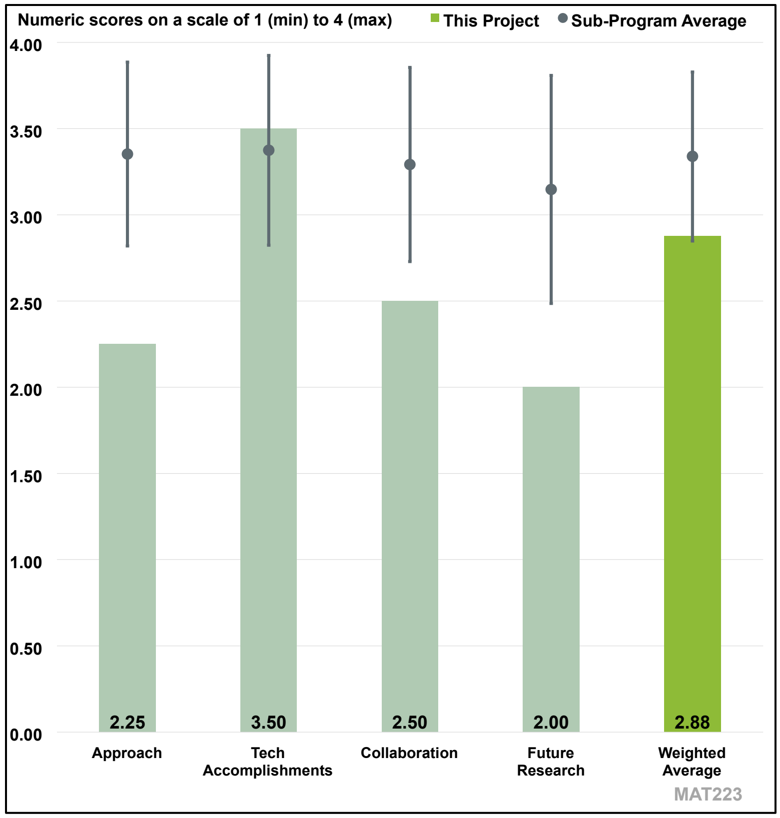

Figure 5-21. Presentation Number: MAT223 Presentation Title: Extending High-Rate Riveting to New Material Pairs Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed the benefit of the team studying both paste and tape type adhesives, because tape adhesives are industrially useful and often not included in studies. Polyphthalamide resin is well known for both its high performance, particularly at elevated temperatures, and for being difficult to bond to. This was a useful inclusion in the study. Studying short-fiber glass-filled composites would have been interesting because they are much more commonly used in automotive applications. The high-rate friction rivet process appears analogous to existing commercial friction rivet products such as EJOWELD CFF® friction welding. The reviewer was unclear on the advantage of trying to deliver this technology versus using those commercial products.

Reviewer 2

The reviewer elaborated the reason for the low score is purely driven by a lack of clarity in the problem being addressed by these two new processes. There are a multitude of commercial solutions on the market for joining of dissimilar materials. There is no mention of these nor of the gap that the project attempts to fill. This is so critical to understanding the potential for technology transfer and allocation of scant R&D resources.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the fundamental understanding of the effects of plasma on substrates and joint performance is significant. The reviewer was glad to see this being transferred to a Lightweight Materials Consortium (LightMAT) project.

Reviewer 2

The reviewer remarked that the plasma treatment process and adhesive fillers look plausible for production. The high velocity (HiVe) joining performance looks sufficient for industrialization pending a solution to questions related to the sound level produced and related safety/health implications. How effectively the electromagnetic actuator mitigates noise will be critical in determining whether this process can be industrialized.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the teams appear to have worked largely in parallel while remaining mutually relevant and compatible. Pairing computational analysis with physical process development is nice to see and allows for a more comprehensive solution to be delivered.

Reviewer 2

The reviewer felt that the project should have focused on the clinch and HiVe processes and that the thermoplastic adhesive composition work is out of place in this project. Reversible joining is important, but this reviewer felt that this overall project scope is too broad. Friction riveting is a process having been previously investigated and the reviewer felt dilutes this project’s scope.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said joining CF reinforced polymer (CFRP) is of no practical use, because the material has been largely abandoned by high-volume manufacturers. Extending the adhesive and HiVe studies to short-fiber injection-molded materials is more likely to be useful. Further development of high-rate friction riveting should more clearly demonstrate advantages versus existing commercially available friction rivet products. The reviewer suggested that high-speed in-situ radiography could be interesting if it leads to a more thorough understanding of the process phases and enables more detailed process simulation.

Reviewer 2

The reviewer agreed that the items listed in Future Work themselves are appropriate topics. However, the trend is further dilution of effort. Part of the problem is that the technology gap which these processes target is not identified. Once the gap is identified, some of these topics may be eliminated and others may increase in priority. Furthermore, there are several focus areas which should be identified as stand-alone one-pager projects with their own problem/hypothesis/plan.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 2

The reviewer commented this project is relevant to the VTO Materials subprogram and will help enable high-performance materials to be joined in an efficient and robust manner.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said correct technical and equipment resources appear to be available for this project.

Reviewer 2

The reviewer believed that the project scope is too broad and, as such, the current allocation of resources is insufficient. The reviewer believes it is better to have smaller, more focused projects which clearly move a technology towards a higher TRL rather that have disparate bits and pieces at various TRLs.

Presentation Number: MAT224
Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness
Principal Investigator: Piyush Upadhyay, Pacific Northwest National Laboratory

Presenter

Piyush Upadhyay, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

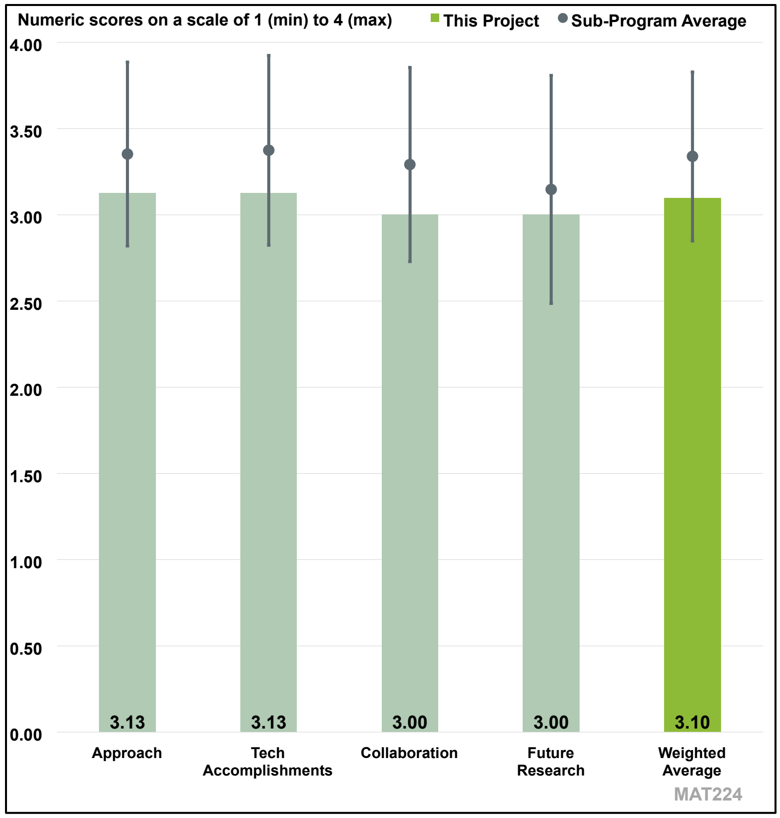

Figure 5-22. Presentation Number: MAT224 Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness Principal Investigator: Piyush Upadhyay, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the presenters address the barrier of a fast and reliable joining technology for dissimilar metals. The team tries to overcome the barrier to implement friction stir based linear and spot joining methods for assembly of multi-material components. Timely progress has been made to develop control parameters, fixture, and robotic design. While an OEM is involved, the reviewer was unclear if the technology is near adoption.

Reviewer 2

The reviewer said joining dissimilar grades of Al, such as wrought and cast or different strength levels of wrought, is relevant to modern automotive design. This type of joint is common, particularly in battery structures. The knowledge base and best practices for friction stir joining are still under development and in a position to benefit from research work.

Reviewer 3

The reviewer said the project utilizes a well-designed approach that includes both experimental work on friction-stir lap welding, modeling work on FSW joint strength, friction self-piercing rivet (F-SPR) process development, and characterizations for various material combinations.

Reviewer 4

The reviewer observed that the technical barriers listed on Slide 23 is more a laundry list of items to be completed for implementation of the technology rather that explicit technological barriers which need to be overcome.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said targets (e.g., lap strength) were demonstrated for some dissimilar material pairs of interest (e.g., Aural 2 – high-strength Al). Production speeds were increased in many cases.

Reviewer 2

The reviewer remarked that in recent work, the project team at PNNL (developing friction stir linear welding [FSLW] for three sheet stack-up Al joints) and ORNL (developing F-SPR for two and three sheet stack-ups) appears to have focused on further refining the joining technology, assessing tool life, ensuring quality assurance for high-volume manufacturing, and developing welding strategies for eventual demonstration in stamping.

Reviewer 3

The reviewer believed that satisfactory progress on the process development, modeling, and tool wear has been made to facilitate the technology transfer to other stack-up combinations.

Reviewer 4

The reviewer remarked that the joint configurations that were demonstrated are comparable to joints that have entered production recently. The joining speeds and results are comparable to current production, so the future development will be very relevant in determining the value of this research. The self-reacting robot unit will be an improvement over existing volume production equipment.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said two national laboratories and multiple industries participate in this collaboration.

Reviewer 2

The reviewer said that the project work seems to be well-coordinated between PNNL and ORNL, with clear-cut research roles for each.

Reviewer 3

The reviewer commented each national laboratory is focused on a separate process and it appears there is very little cross-laboratory collaboration although Honda is clearly working well with both national laboratories.

Reviewer 4

The reviewer remarked that the choice to separate the work between linear joining and point joining was logical and appears well executed for both.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the PIs appear to have a systematic plan going forward for FSLW and F-SPR development on wrought and castings in dissimilar configurations; demonstrating FSLW and F-SPR demonstration on stamping; and assembling, testing, and making FSLW runs in captive fixturing.

Reviewer 2

The reviewer said the projects ends in FY 2024.

Reviewer 3

The reviewer commented that the FSLW combinations proposed are already in production for battery structures in Europe. Duplicating work that is already being launched will put the laboratories at a timing disadvantage. Contacting a current linear FSW supplier, such as KUKA or TRA-C Industrie, as an additional industrial partner might be beneficial to identify the technical challenges that the team has not already solved. The reviewer said the F-SPR process appears functionally identical to the EJOWELD® REF process that is commercially available from the EJOT Group. Reviewing that process in some detail would be advisable before attempting more development to avoid duplication of effort.

Reviewer 4

The reviewer said the future work is clearly defined but again reads more like a list of to-do items rather than specific research challenges. For example, rather than a demonstration on stamping, why not focus on the F-SPR on stamped wrinkles which is the actual challenge. Or another topic of the size of the rivet head which impedes the assembly of the weather strip on the door surround flange.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked dissimilar metals joining is important for achieving lightweighting goals of VTO's Materials subprogram.

Reviewer 2

The reviewer said the ability to join dissimilar materials with specific properties is critical for lightweight multi-material design, which in turn closely fits in with DOE-VTO objectives for better-performing, more energy-efficient EVs having only relatively benign environmental impact.

Reviewer 3

The reviewer stated that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 4

The reviewer pointed out this work is relevant to both the VTO Batteries and VTO Materials subprograms with their related objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient.

Reviewer 2

The personnel and equipment appear well matched to the project and appropriate for future development work.

Reviewer 3

The reviewer remarked the project has continued at a steady spending rate of approximately $583,000 per year and all indications are that this amount is sufficient to meet project needs.

Reviewer 4

The reviewer believed that the resources are sufficient for the project team to demonstrate a robotic application of the FSLW at a MRL of 4. However, if the team wishes to achieve a higher MRL, then additional work and detail would be required.

Presentation Number: MAT225
Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance
Principal Investigator: Yong Chae Lim, Oak Ridge National Laboratory

Presenter

Yong Chae Lim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

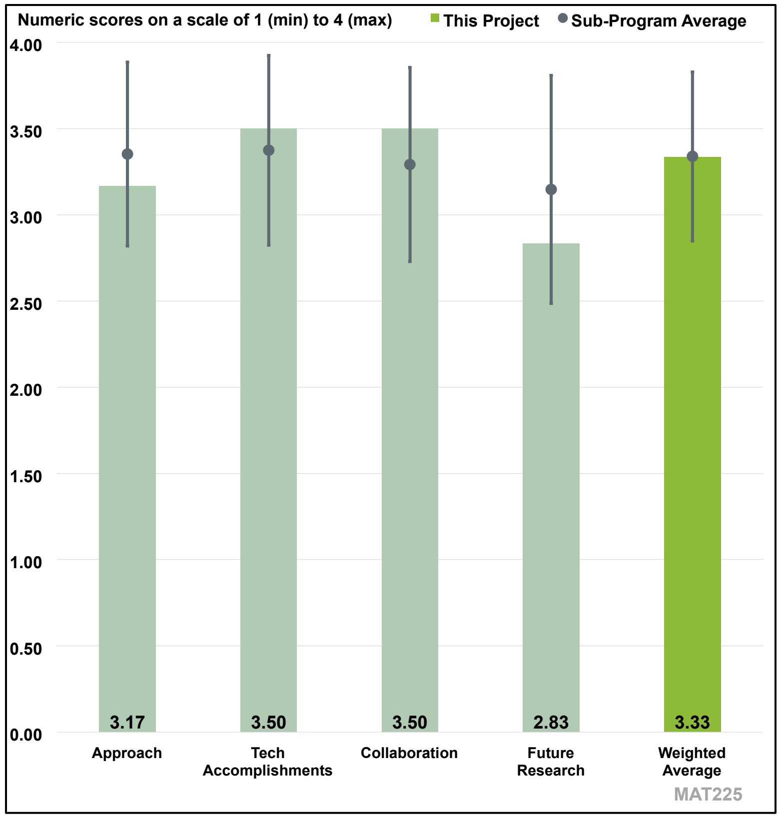

Figure 5-23. Presentation Number: MAT225 Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance Principal Investigator: Yong Chae Lim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project is reasonably designed and technical barriers are being addressed effectively.

Reviewer 2

The reviewer commented that the work on joint strength after corrosion/environmental aging is very relevant to modern vehicle structures. Corrosion mitigation of Mg joints is helpful going forward because there has been increasing interest in Mg for sustainable mass reduction. Joining CFRP remains a low priority pending a more environmentally sustainable and cost-effective way to produce such composites.

Reviewer 3

The reviewer remarked that the technical barriers are addressed but, unfortunately, through an opportunistic approach via development of two new joining methods. In this reviewer’s opinion, this approach dilutes the focus of this project specifically on the effect of surface modification for corrosion resistance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked experimental work which was originally scoped has been mostly completed and a significant body of knowledge captured.

Reviewer 2

The reviewer said the project is on track with satisfactory progress as planned.

Reviewer 3

The reviewer said plasma treatment looks promising with respect to Al-to-Al joints with steel fasteners. An alumina forming alloy rivet looks interesting, but an austenitic steel is likely too soft to make a viable rivet. Current rivets are martensitic steel with a hardness of around 450 Vickers Hardness. The reviewer said development of a harder alloy may be necessary.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the role of each contributing partner is listed; however, it would be helpful if the contributions from PNNL and ORNL are more clearly described.

Reviewer 2

The reviewer really liked the various groups the forming the team for this project. If not for that, the broad scope of the work would have prevented the team from making noteworthy progress.

Reviewer 3

The reviewer said the regular meeting schedule and clearly defined roles show that collaboration was a priority on this project and not a documentation afterthought.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the future research objectives are clearly defined but unclear on what the mitigation solutions are for potential barriers.

Reviewer 2

The proposed future work is clearly defined, and a logical extension of the work done to-date.

Reviewer 3

The reviewer remarked that the items listed as future research are individually of interest, but it is not clear to this reviewer what technology gap is being targeted since many of the items are titled “optimization.” Optimization is an engineering exercise and does not address a research issue. In some instances, the baseline is untreated Al but on Slide 9, the baseline is anodized Al. The reviewer stated that in cases of dissimilar materials, the industry standard is to use anodized Al which should be the baseline. Furthermore, understanding the relative performance of this baseline versus open air plasma coating and silane plasma coating would be of interest.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed that this project supports the VTO Materials subprogram objectives.

Reviewer 2

The reviewer remarked that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 3

The reviewer commented that the project is relevant to the VTO Materials subprogram and could facilitate effective use of light metals in vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer felt that the resources are sufficient with support from various laboratories and industries.

Reviewer 2

The reviewer observed that the resources are well organized and appear sufficient for the tasks.

Reviewer 3

The reviewer believed that the project scope is too broad and, as such, the current allocation of resources is insufficient. The reviewer felt that it is better to have smaller, more focused projects which clearly move a technology towards a higher TRL rather than having disparate bits and pieces at various TRLs.

Presentation Number: MAT226
Presentation Title: Machine Learning for Joint Quality and Control
Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Presenter

Keerti Kappagantula, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

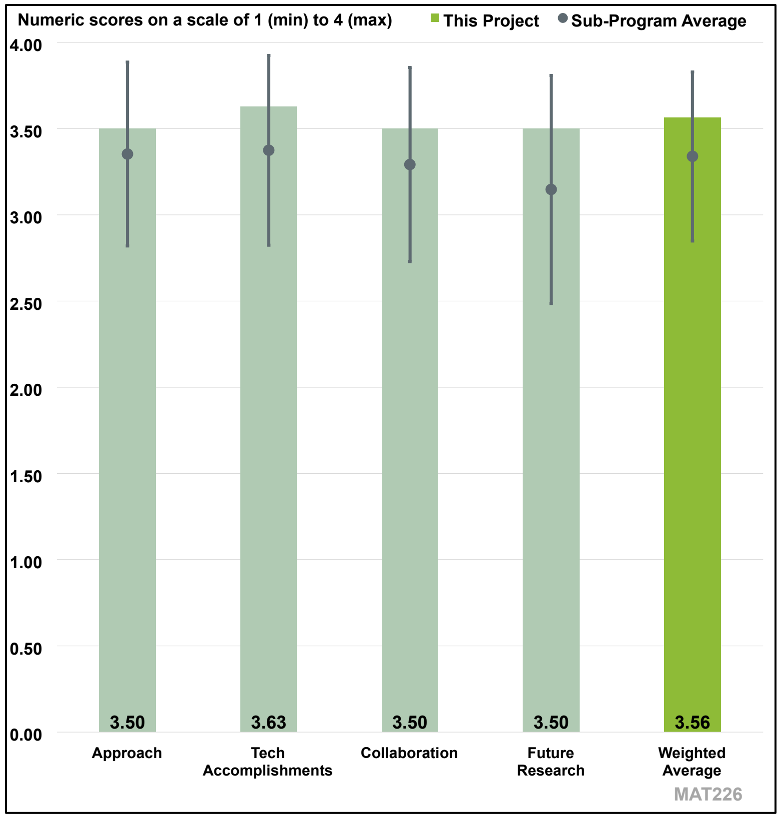

Figure 5-24. Presentation Number: MAT226 Presentation Title: Machine Learning for Joint Quality and Control Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that this project mostly addressed the technical barriers for controlling the weld quality through a data-driven ML approach.

Reviewer 2

The reviewer said the approach for performing the work is good and should lead to most, if not all, of the project goals being met. The project seems to be well designed and seems to have largely proceeded according to plan.

Reviewer 3

The reviewer detailed that the project is evaluating joints manufactured by the resistance spot welding of dissimilar materials. New steel-steel data (greater than 130 gigabytes) provided by General Motors (GM) is being used to develop and apply an AI/ML-based model framework to analyze post-processed joint data. This data set should be beneficial to help understand the risks in a production environment. The approach is excellent, well designed, and logical. Both PNNL’s and ORNL’s timelines are reasonable to accomplish the milestones. The reviewer said ML is an effective approach to understand the relationship between resistance spot welding parameters and weld attributes.

Reviewer 4

The reviewer remarked that the process development time is a topic that is relevant and not often considered in projects. This project is well-focused on the barrier defined. Modern ultra-high strength steel and third generation advanced high strength steel have very high carbon equivalent and resistivity compared to older materials. There is a clear need to optimize weld parameters on challenging material combinations, such as mild steel to ultra-high strength steel.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the project has been sharply focused on addressing the technical barrier during this review period and worked closely with the industry partner to identify the needs.

Reviewer 2

The reviewer said PNNL and ORNL have each completed two milestones with the remainder of the milestones under the current period of performance either on track or ahead of schedule. The ML model is currently showing over 98% accuracy in predicting the achievement of a nugget with desired size metrics, which is impressive, and promising for use in a production environment.

Reviewer 3

The reviewer commented the methodology shows very high predictive accuracy for nugget size, which is consistent with the project's stated goal.

Reviewer 4

The reviewer remarked technical progress made so far is satisfactory and seems to be consistent with the overall project plan. The PIs have made progress in designing the ML framework with what seems like substantial amounts of data from GM, their industry partner. Implementing the framework on the production floor is not part of the scope of this project. The reviewer recommended the PIs should take time to discuss the graphs and tables presented in more detail in the future. This reviewer had to figure out what some of the graphs and tables were saying, as very little in terms of a full explanation of the data was presented by the PIs.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out PNNL focused on identification of weld sensitivity to parameters and ORNL focused weld quality prediction. Both collaborated closely with GM for application of the ML models.

Reviewer 2

The reviewer said the interfaces in this collaboration were well described by the PIs in this project. The specific contribution of each team member was well articulated.

Reviewer 3

The reviewer detailed the project team consists of two national laboratories (PNNL and ORNL) and one industry partner (GM) and is a stellar example of both inter-lab and industry partner collaboration. The team appears to be leveraging the large GM dataset well to achieve the project's stated goals.

Reviewer 4

The reviewer remarked while the approaches between the two teams are different, they show comparable degrees of success and avoid unnecessary duplication of effort.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the proposed future work seems logical and appropriate to achieve the project's goals. This work should assist the team in overcoming the remaining barriers.

Reviewer 2

The reviewer said the project clearly defined the future work for each laboratory and it is highly likely to achieve their targets.

Reviewer 3

The reviewer had no issues with proposed work.

Reviewer 4

The reviewer said future work is appropriate as proposed. A higher value might be achieved by optimizing to minimize weld energy and/or maximizing weld strength and toughness on challenging alloys. That would deliver a benefit to the vehicle itself beyond the considerations of development time and efforts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project supports the Materials objective.

Reviewer 2

The reviewer said this project contributes to solving joining of materials (especially dissimilar) employed in lightweighting of vehicles.

Reviewer 3

The reviewer remarked joining of dissimilar materials enables vehicle lightweighting and therefore reduction in GHG emissions. This project directly supports and aligns well with DOE objectives to improve energy efficiency.

Reviewer 4

The reviewer commented this project is relevant to the Materials subprogram, particularly with the increasing use of advanced high strength steel with rich chemistries and relatively high resistance and carbon equivalent.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient for the project to achieve the stated milestones.

Reviewer 2

The reviewer remarked that the funding level seems to be adequate. There is no indication that the PIs are running out of funds to complete the proposed work.

Reviewer 3

The reviewer said the project is progressing well and the team has been able to complete milestones. The budget and resources allocated to the project appear to be sufficient to successfully complete future research goals.

Reviewer 4

The reviewer remarked that the resources appear be in accord with the demands of the project.

Presentation Number: MAT231
Presentation Title: Light Metals Core Program Introduction
Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

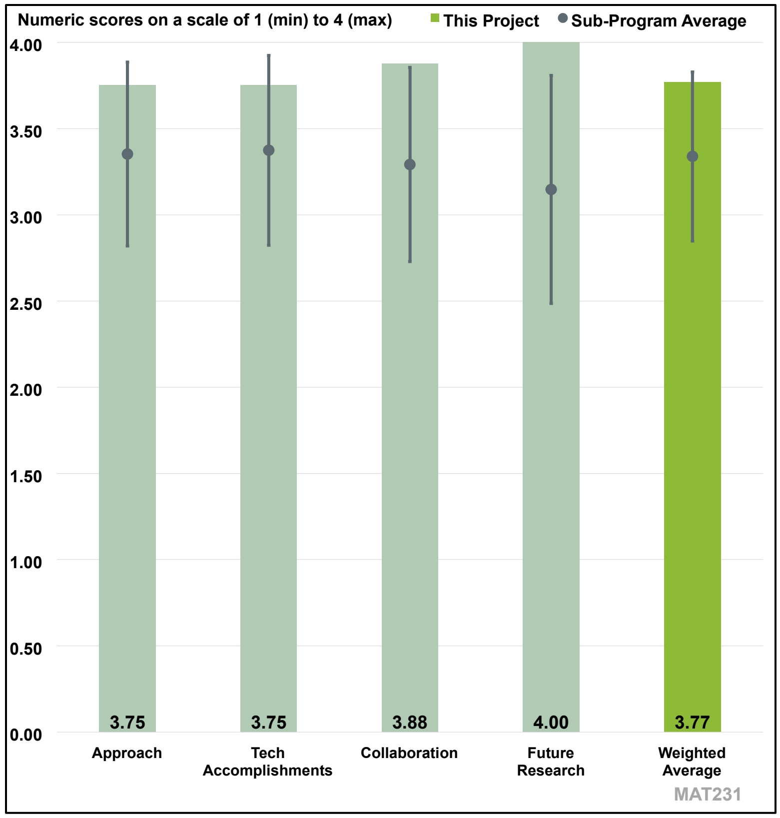

Figure 5-25. Presentation Number: MAT231 Presentation Title: Light Metals Core Program Introduction Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that this was an introductory presentation to the entire first phase of the Light Metals Core Program (LMCP). While there are some takeaways from the effort, e.g., “uni-alloy” concepts, the overall theme of local modification of properties to achieve vehicle lightweighting had mixed results.

Reviewer 2

The reviewer pointed out the program’s goal is to create lightweight alloy materials. The program is transitioning from Phase 1 to Phase 2 and looking to improve metal alloys. The program is still in preliminary stages of Phase 2 and is well designed.

Reviewer 3

The reviewer said the approach was very organized and well thought out to identify key research areas to focus on that will enable lower cost light metals use. The reviewer liked how five different thrusts were identified and said they make sense in order to drive project alignment to deliver on the overall program objectives.

Reviewer 4

The reviewer had no comments.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said good accomplishments were noted but there was no example of technology that the entire industry is looking to adopt.

Reviewer 2

The reviewer commented that the program is still in its preliminary stages and is building on the work done in Phase 1. No specific accomplishments from Phase 2 were highlighted.

Reviewer 3

The reviewer said progress was made during the LMCP 1.0 phase and the plan to build upon that progress was clearly articulated for the LMCP 2.0 phase.

Reviewer 4

The reviewer had no comments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said collaboration between national laboratories was excellent and well-highlighted.

Reviewer 2

The reviewer said the project is a collaboration between PNNL, ORNL, and Argonne National Laboratory (ANL). No industrial partners are identified at the current time but will be identified for guidance in the future.

Reviewer 3

The reviewer remarked the collaboration framework was clearly articulated between PNNL, ORNL and ANL, identifying both leads at each organization and key capabilities being leveraged.

Reviewer 4

The reviewer had no comments.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted the project has ended but some aspects are being pursued in LMCP 2.0 phase, which were highlighted in the poster session.

Reviewer 2

The reviewer remarked that the project has just started, and the team has identified the tasks and approach for execution of the project.

Reviewer 3

The reviewer believed that the appropriate areas for development have been defined, and with this focus progress will be made to achieve the defined targets.

Reviewer 4

The reviewer had no comments.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project supports the lightweighting objectives of the DOE VTO's Materials subprogram with 25% glider weight reduction at less than $5/kg saved.

Reviewer 2

The reviewer observed that the project's focus is on improving the properties and manufacturability of lightweight metals for vehicles. This meets the VTO Materials subprogram objectives and can lead to several benefits for vehicles including reducing battery size, utilization of sustainable materials, and reduction of GHG emissions in the glider platform.

Reviewer 3

The reviewer noted that the project has defined key areas to focus on to develop cost-effective materials and manufacturing processes to enable the use of lighter metals in a cost-effective manner.

Reviewer 4

The reviewer had no comments.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources were sufficient.

Reviewer 2

The reviewer remarked that the team has all the resources required to conduct the project.

Reviewer 3

The reviewer believed the resources to be sufficient and that the project is continuing with scientists who have been engaged with LMCP 1.0 to LMCP 2.0, which is good that the experience is being built upon.

Reviewer 4

The reviewer had no comments.

Presentation Number: MAT235
Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects
Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Presenter

Ayoub Soulami, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

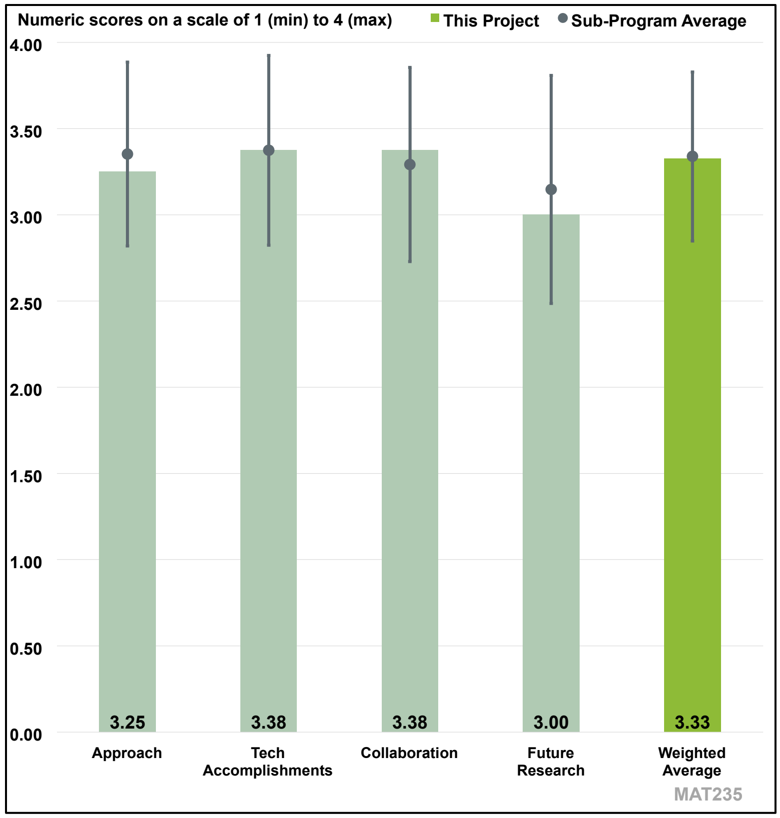

Figure 5-26. Presentation Number: MAT235 Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project team is developing an integrated suite of computational models and an experimental framework to address challenges associated with residual stresses. A few useful projects supporting the LMCP have been implemented.

Reviewer 2

The reviewer remarked that this work validated the residual stress simulation approach using a few dissimilar materials and processes, which can be used as a cost-effective tool for process optimization and stress relief.

Reviewer 3

The reviewer commented that the project has been well designed to explore residual stress prediction and characterization for FSP as well as for peening operations.

Reviewer 4

The reviewer remarked that a broad scope of work applying sound approaches was effectively described.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the overall performance of the team has been excellent with several useful examples of residual stress measurements, modeling, and validation.

Reviewer 2

The reviewer commented most of the simulated results agree reasonably well with the experimental measurements except for case of bending-unbending. Stress distribution associated with a wide variety of process was revealed for Mg and Al alloys.

Reviewer 3

The reviewer remarked that this work has shown residual stress may be directionally predicted; however, it is not clear what level of accuracy is required for engineering application.

Reviewer 4

The reviewer said the broadly presented scope of work indicated good technical progress on multiple projects.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the muti-laboratory collaboration was a highlighted aspect that appeared to have been accomplished.

Reviewer 2

The reviewer remarked that the collaboration and coordination with multiple tasks was clearly described.

Reviewer 3

The reviewer observed that good collaboration was demonstrated between PNNL and ORNL, however, the role of ANL in this project was not very clear. The reviewer noted that the PI only listed the team at PNNL on the project title slide.

Reviewer 4

The reviewer said the collaboration plan was good, but the projects seemed to largely support other PNNL efforts in the LMCP.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer affirmed that the PI clearly defined the scope of future work, which will aim to predict part performance considering heterogeneity in microstructure and residual stress profiles. Clarification on how the component life will be predicted and what are the technical barriers to overcome would be beneficial since the established database only serves for stress evolution analysis.

Reviewer 2

The reviewer remarked that the proposal to extend to component validation seems to be an appropriate and applicable next step.

Reviewer 3

The reviewer said the project has ended.

Reviewer 4

The reviewer said the project has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed that the project supports multiple overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer said residual stress measurement and control is important for several lightweighting projects.

Reviewer 3

The reviewer remarked that this project aims to establish an integrated suite of computational models for acceleration of product development cycle time for enhanced part performance through a stress evolution analysis.

Reviewer 4

The reviewer said that, though aspects are generally applicable to many engineering problems, this particular project is relevant for automotive materials and manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient.

Reviewer 2

The reviewer remarked that this project has been completed and achieved the listed milestones.

Reviewer 3

The reviewer remarked that the resources applied are sufficient for the target objective.

Reviewer 4

The reviewer commented that there are sufficient resources.

Presentation Number: MAT236
Presentation Title: Advanced Characterization and Computational Methods
Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Presenter

Thomas Watkins, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

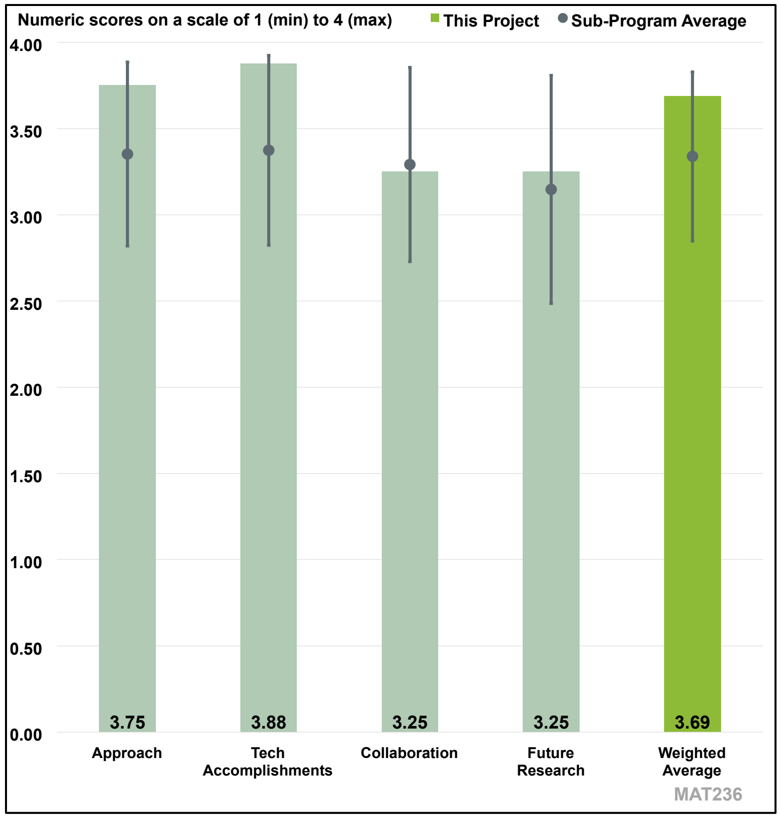

Figure 5-27. Presentation Number: MAT236 Presentation Title: Advanced Characterization and Computational Methods Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the overall objective of Thrust 4 by combining advanced characterization and computational tools supports the PMCP goals for accelerating development of new materials used in powertrain applications. The reviewer affirmed combining funds and resources from all the national laboratories and awarding proposals from the main tasks based on their needs is a logical and well-designed approach. Materials data collection for models and performance validation is important especially for conductivity, lightweighting, and magnetic applications which are critical technical barriers addressed in Thrust 4. Some FY 2023 tasks seemed to focus on high-temperature applications, which may not be significant technical barriers for EV powertrains.

Reviewer 2

The reviewer commented that the team of national laboratories are applying advanced materials characterization and computational tools to accelerate the development of the next generation powertrain materials with superior combinations of properties, manufacturability, and cost to enable the design of future advanced EVs. The establishment of a database of material properties accelerates the development of the materials needed to support the improvements required to successfully deploy EVs. The process to select these projects includes a review of the proposed project by the laboratory leaders, then either rejection, suggested revisions, or acceptance. This approach is a fair way to get tasks integrated into the project as these laboratory leaders are the most knowledgeable about the status of the database and where new capabilities are needed.

Reviewer 3

The reviewer observed that the slides did not mention specific TRLs that they planned to address, but the project titles cover a decent range of TRL levels. The project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer remarked that the main technical barrier to be addressed was reducing the weight of the integrated traction drive and that new powertrain materials are needed to address current technology applications for electric powertrains in light-duty, medium-duty, and heavy-duty vehicles.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer expressed that Thrust 4 delivered impactful, interesting, and novel results in both characterization and computational needs. Thrust 4 contribution to the publications was impressive. Aided by Thrust 4, the PMCP tasks published a sizable number of papers in high impact factor journals. The reviewer especially commends the achievements in round-robin testing efforts and high-throughput alloy design efforts. These are two excellent examples of accelerated materials discovery and performance testing.

Reviewer 2

The reviewer verified that multiple activities were completed over five years under this project. These research tasks are expanding the database of material characteristics needed to support the development of more efficient electric propulsion systems. Sixteen FY 2023 tasks were completed to help expand the understanding of advanced materials and their properties. Most work is being performed to understand and improve the electrical and thermal properties of materials. The materials with the most promise appear to be Al-Ni alloys and carbon nano-tube coatings. The national laboratories leveraged their impressive capabilities to perform the testing needed to understand these materials. Success is difficult to assess for these types of projects; however, the Impact factor assessment appears to be an effective metric. There were 77% (24 of 31) of the peer-reviewed journal publications assessed to have an impact factor of greater than 5.

Reviewer 3

The reviewer affirmed that the technical progress showed a well-planned and well-executed project.

Reviewer 4

The reviewer verified that the technical progress was completed on track because the project inputs have led to measurable milestones of output in the last five years of research and the project is 100% completed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that FY 2023 efforts seem to be focused on mostly ORNL projects and collaborations. In addition, collaboration with the LCA task is lacking. The reviewer suggests that interlaboratory collaboration should be prioritized.

Reviewer 2

The reviewer stated that the three national laboratories participating as program partners - ORNL (program lead), PNNL, and ANL - are working together and effectively using their unique tools to support the development of next generation EV powertrain materials. The NREL is supporting these projects by offering use of their High-Performance Computing User Facility. This arrangement appears to be an effective way to perform the work using facilities that are best suited to complete the proposed subtask activities.

Reviewer 3

The reviewer commented the team includes ORNL, ANL, and PNNL. The reviewer verified some projects showed highly integrated efforts.

Reviewer 4

The reviewer remarked interactions and collaboration existed for the project research studies involving multiple nationally recognized laboratories including PNNL, ANL, ORNL, and NREL. The reviewer also confirmed collaboration between and across laboratories was sufficient for the completion needs of the project based on the numerous specialized technology resources available to be shared.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer articulated a new phase of the PMCP was launched for FY 2024 with Thrust 4 maintaining its structure and approach from Phase 1. Thrust 4 will likely deliver high-impact research in this new program; however, a LCA task seems to be missing in Thrust 4. In the researcher's opinion, assessing the efficiency and emissions impact of new materials and component technologies is critical. Thrust 4 efforts can help with this aspect. Also, more details on the objectives and targets of the new program could have been provided.

Reviewer 2

The reviewer stated that research was concluded in September 2023 on efforts to improve electrical and magnetic measurements for materials used in EVs under this project. These critically important material properties were assessed for use in a variety of applications in EVs. Some important property characteristics were discovered by accident. Challenges remain regarding the high demand and limited access for some science tools. Challenges also remain surrounding the integration of characterization data with advanced analytics.

The reviewer suggested that a database of materials, which is needed to cost-effectively help improve the materials being used in EVs, could be developed by carefully assessing and characterizing these materials with unique properties. Although this project has concluded, a new project using a similar approach was launched in February 2024 and now aligns with the PMCP 2.0

phase. Many of the previously completed projects have been selected to continue based on encouraging results. Five tasks are underway in three research areas: Advanced Characterization of Materials (ORNL, PNNL, ANL), Electrical and Magnetic Properties Measurements (ORNL), and Computational Materials (ORNL).

Reviewer 3

The reviewer remarked that the proposed future research includes experimental and simulation efforts by three national laboratories: Task 4A1-24 Advanced Characterization of Materials, ORNL; Task 4A2-24 Electrical and Magnetic Properties Measurements, ORNL; Task 4A3-24 Advanced Characterization of Materials, PNNL; Task 4A4-24 Advanced Characterization of Materials, ANL, and Task 4B1-24 Computational Materials, ORNL. The project clearly defines the purpose of future work, which is advanced characterization, and the future work is likely to achieve defined targets.

Reviewer 4

The reviewer commented that the project has proposed future research program tasks planned to be started that is subject to change based on funding levels available. The likelihood of planned future research work achieving defined target was not clearly confirmed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed that the PMCP Thrust 4 supports the VTO Materials subprogram objectives of developing higher efficiency powertrains for EVs. With unique characterization and computational capabilities, Thrust 4 provides significant assistance in materials discovery and materials property testing for powertrain-relevant applications and components. Quick assessment of new materials can accelerate their transition to the application, resulting in efficiency improvements in EV powertrains, lightweighting, and lesser demand for critical materials.

Reviewer 2

The reviewer expressed that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3

The reviewer observed the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer stated the project is very relevant to the overall VTO Materials subprogram objectives because the project's research studies resulted in the development of a low-melting point element assisted nucleation mechanism proposed in the task, "Lightweight Materials for Improved on Electrical Properties", as well as the development of a better successful predictor for identifying "dirty" alloys developed from the round-robin test plan results in the thermodynamic study for computer coupling of phase diagrams and thermochemistry proposed in the task, "Design of Sustainable Lightweight Die Cast Structural Alloys for EVs".

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that the total funding of Thrust 4 is sufficient and recommends awarding fewer proposals with higher budgets to provide more funds for characterization and computational efforts that can benefit multiple development tasks. The reviewer also suggested allocating more funds for the LCA of various materials and technologies developed in the program.

Reviewer 2

The reviewer commented these subprojects complement the activities being performed outside of this Thrust 4 project. This approach is a cost-effective method to expand the ICME database and modeling which will keep the data and tools updated and accurate.

Reviewer 3

The reviewer expressed that the three national laboratories provided sufficient and powerful resources for the project to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer articulated that the resources were sufficient to achieve the stated milestones in a timely manner for the multiple industry and national laboratory partners collaborating on the project.

Presentation Number: MAT237
Presentation Title: Materials Lubricants and Cooling for Heavy Duty Electric Vehicles
Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Presenter

Jun Qu, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

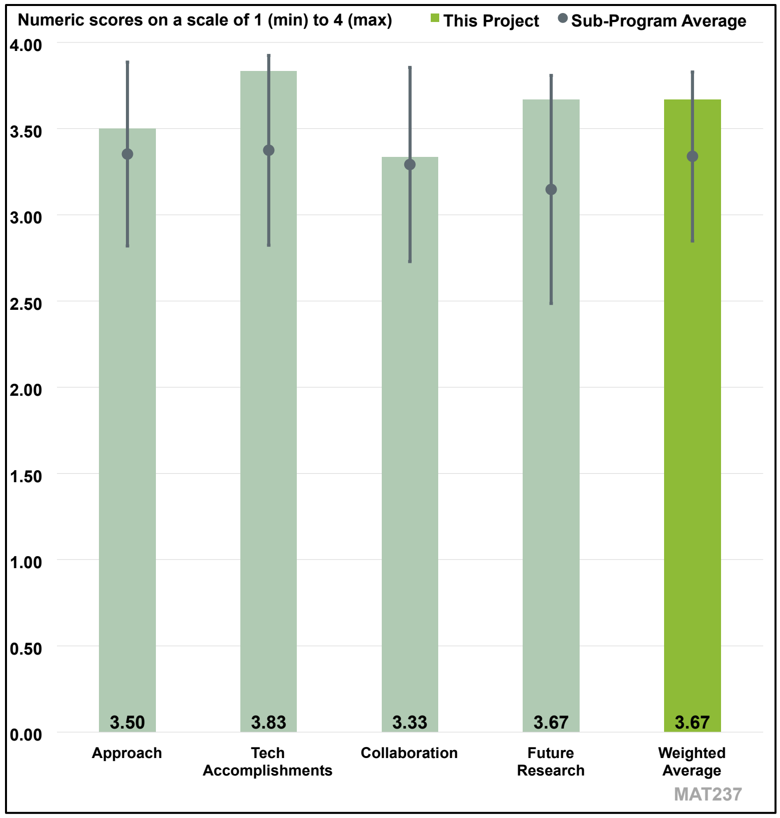

Figure 5-28. Presentation Number: MAT237 Presentation Title: Materials Lubricants and Cooling for Heavy Duty Electric Vehicles Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the project has completed, and the research addressed significant concerns with thermal dissipation and frictional losses.

Reviewer 2

The reviewer acknowledged that the approach is innovative because it involved adding modified CNTs to EV lubricants to enhance heat transfer and coating CNTs onto powertrain components to enhance thermal and frictional properties. This approach took advantage of the unique properties of CNTs for high thermal conductivity and low surface friction.

Reviewer 3

The reviewer mentioned that new propulsion materials are needed to address current technology gaps of increased heat dissipation from electric motors (e-motors) and reduced parasitic losses in the EV powertrains of heavy-duty vehicles. This recently completed project is performing some very exciting research that can have a significant impact when commercialized for real-world applications. The reviewer commented that the research plan is well developed and has successfully demonstrated that both super lubricity and heat transfer efficiency can be accomplished. By integrating CNTs, this approach provides a pathway for achieving both characteristics.

Through the research presented, the reviewer believes that a process to organically modify the CNTs has been established and a pathway was established for using polar CNTs and non-polar CNTs in lubricating oil with a significant improvement on viscosity. Notably, CNTs were assessed as an approach to improve thermal impedance reduction using a CNT coating as part of a thermal interface material. This project, which completed in FY 2023, also leveraged existing knowledge from an ICME database as a cost-effective approach to determine a possible solution to address EV cooling and parasitic friction challenges.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that the project has completed.

Reviewer 2

The reviewer acknowledged that the team successfully demonstrated the effect of CNTs on the thermal conductivity of EV fluids and the strong protection from wear in unidirectional sliding.

Reviewer 3

The reviewer noted that this two-year project obtained remarkable results related to efficient heat dissipation and lubricity improvements. CNTs can improve thermal and lubricity properties in lubrication fluids and will also provide an emergency coating to ensure that if lubricant is lost, low-friction operation can continue for an extended period. The reviewer noted that up to 18% improved thermal conductivity was observed by adding CNTs into EV fluids. Organic modification increased viscosity properties more than new CNTs and good compatibility was confirmed between the super lubricity CNT coating and EV lubricants.

Regarding the PMCP 1.0 phase coatings efforts, the reviewer expressed that the CNT coating showed robust super lubricity behavior under various loads and temperatures and in various EV lubricants which attracted global attention in broad fields of science and technology. Preliminary results also showed increased heating and cooling rates for the potential application of the CNT coating on a heat exchanger, which was also demonstrated with the PMCP 1.0 phase preliminary investigation of the thermophysical and tribological impacts of CNT coatings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer noted that the collaboration was between the ORNL resources and Valvoline.

Reviewer 2

The reviewer observed that there was good collaboration between the ORNL resources and Valvoline, an industrial partner through a CRADA.

Reviewer 3

The reviewer stated the alignment of the project team with ORNL as lead can leverage their unique capabilities from other related projects under Thrust 4 of the PMCP 1.0 phase to maximize the investment made by the DOE. ORNL is also establishing the mechanisms needed to commercialize this technology as they develop CRADAs with industry partners. The CRADA between Valvoline and ORNL will permit the successful transition to a commercialized product. These arrangements are critical to bringing this technology to the commercial marketplace.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer is interested in seeing where the planned aging behavior will be affected, especially when used as an additive (versus a coating). There will be some degradation due to shear that will affect CNT dimensions and numbers and may have an impact on viscosity and elastohydrodynamic boundary lubrication as well as the additives needed to maintain dispersion. questions how the cost of the additives compares with currently available coatings/additives and state-of-the-art materials. What is the electrical property benchmark for other additives currently being investigated?

Reviewer 2

The reviewer observed this project has ended but the team will start a new project aiming at further developing the CNT/fluid for lubrication and thermal management.

Reviewer 3

The reviewer stated that the scope of work assessing these technologies was completed under the PMCP 1.0 phase; however, there are several significant steps that are still needed to develop a commercial product with this technology. Challenges that should be investigated include developing a fundamental understanding of (1) CNTs networking visualization/confirmation by liquid-cell transmission electron microscopy and atomic force microscopy and (2) effects of the size and morphology of the CNTs. Also, a better understanding of long-term dispersion of CNTs in EV fluids as well as their compatibility with EV fluids and thermal pastes is needed.

In addition, the effect of aging on the behavior of CNT-containing lubricants and thermal pastes is not well understood and should be investigated. With the potential thermophysical and tribological properties of CNT coatings, investigating the coating growth of CNTs on heat exchanger materials like Al and Cu alloys should be addressed and studied.

The reviewer pointed out that continuation of this research under the PMCP 2.0 phase should be based on the encouraging results from PMCP 1.0 phase for both the CNTs and the ionic liquids technologies.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that improving thermal and friction efficiencies in e-motors will increase over efficiencies of EVs.

Reviewer 2

The reviewer highlighted the technology being developed will improve EV thermal management and prolong component service life. This objective and resulting improvements directly support the VTO Electrification subprogram.

Reviewer 3

The reviewer found this project is directly relevant to the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the laboratory and industry partners have excellent resources to complete this effort.

Reviewer 2

The reviewer found the team was given a sufficient budget of $240,000 per year on lubricant additives and $230,000 per year on CNT coatings for improving thermal management and lubricity.

Reviewer 3

The reviewer believed this innovative approach to lubrication and cooling has significant commercial applicability in EV space and throughout industry. The use of CRADAs should be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications of this exciting and innovative research.

Presentation Number: MAT241
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems
Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Presenter

Beth Armstrong, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

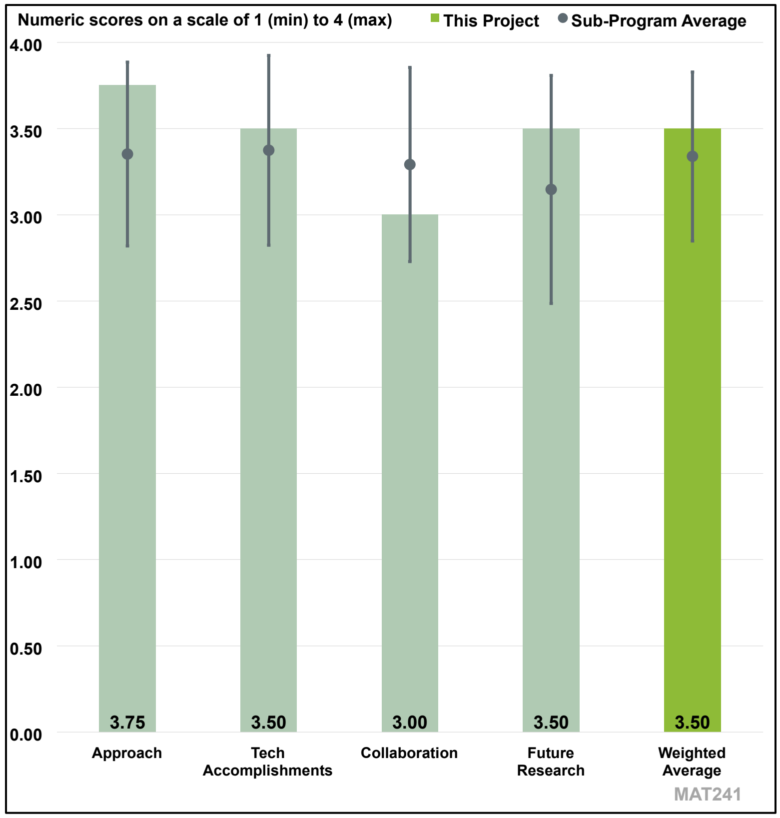

Figure 5-29. Presentation Number: MAT241 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer acknowledged that dynamic charging is an important research area that is being addressed by this effort.

Reviewer 2

The reviewer remarked that ORNL researchers are developing tunable and lighter weight advanced ceramic materials. They are also developing new processing methods for fabrication of wireless charging systems for EV applications. The reviewer noted this project was completed using a six-stage process: (1) determine properties of interest, (2) benchmark existing materials, (3) develop new materials, (4) optimize ferrite fabrication methods, (5) characterize materials, and (6) fabricate lightweight architectures using advanced processing techniques. This two-year project was started under the PMCP 1.0 and was completed in September 2023 and is considered reasonably planned. A project refocused on magnetic field control and alignment was started under the PMCP 2.0 phase in February 2024.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer highlighted that this project has successfully completed FY 2023 efforts and is on track to meet a FY 2024 milestone.

Reviewer 2

The reviewer observed that the team has successfully completed a baselining of common commercial materials, and an assessment of composite and porous architectures is possible. A nonmagnetic cementitious space leads to the applicability of a lighter weight porous structure. Dopant nickel ferrite materials meet the Curie temperature requirements to permit induced magnetism. A baseline was established with a 50/50 composition of nickel zinc, and the content of nickel was changed to adjust magnetic properties. To achieve this, three approaches can be used: (1) intrinsic (modify chemistry/doping), (2) extrinsic (change particle size/porosity/grain size/sintering aids), and (3) external (adjust magnetic dipoles).

The reviewer made the following observations:

- Additives were investigated to adjust properties for constructing complex parts.
- A more fundamental understanding of nickel dopant materials is needed since large grains are needed for optimum magnetic behavior.
- A processing method to achieve larger grains is needed since sintered microstructure is highly dependent on the starting particle size.
- The balance of sinterability and mechanical properties is critical.
- Doping creates complex spinel solid solutions and researchers have investigated the detailed defect chemistries of doped ferrites with computational thermodynamics.

Slip casting/printable AM formulations and bulk casting were initiated in this project and magnetic field enhancements were successfully demonstrated through the addition of ferrites. The reviewer stated that all milestones for this project have been completed and a final paper is being peer reviewed for journal publication.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that work appeared to be primarily conducted at ORNL.

Reviewer 2

The reviewer observed that the project team led by ORNL can leverage their extensive in-house capabilities that are required to advance the material development work. Using the National Transportation Research Center and the Manufacturing Demonstration Facility along with Raman microscopy and electron probe microanalysis, these facilities and tools provide the needed capabilities to assess the development of these materials.

The reviewer remarked that ORNL should be investigating potential university collaborators with magnetic characterization equipment availability for ceramics at high hertz testing ranges. The addition of the industry partner, Steward Advanced Materials (a commercial powder vendor providing virgin material), provided the team with a new capability to assess actions needed to bring macro scale material production to the commercial marketplace. The reviewer pointed out that leveraging other national laboratory capabilities should also be considered. In addition, when the time is right, connecting with an industry partner who would be interested in commercializing the material into a wireless charging solution could be executed with a CRADA.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer mentioned that a new task has been initiated: "Ferrite Ceramics for Magnetic Field Control and Enhancement" for the evaluation of processing to reduce weight and meet field and magnetic shielding needs, and software by CompuTherm called CALculation of PHAse Diagrams (CALPHAD) is being used for modeling efforts to guide the development of future ferrite material compositions.

Reviewer 2

The reviewer expressed that existing models are inadequate for the chemistry prediction capability that is needed to predict magnetic properties; however, the needed research aligned with the PMCP 2.0 phase has begun. Researchers are evaluating different processes (composition, colloidal processing techniques for casting and AM fabrication/sintering, use of field) to reduce weight and meet field and magnetic shielding needs. CALPHAD model enhancements will guide the development of future ferrite material compositions. The reviewer pointed out that research is still needed to evaluate intermediate and large-scale magnetic properties. A complete understanding of these magnetic properties is needed to develop a ferrite ceramic material for wireless charging systems.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that this project supports technologies to enable dynamic charging which is a focus of the VTO Electrification subprogram.

Reviewer 2

The reviewer asserted that this project is directly relevant to the VTO Materials subprogram objectives and is focused on the development of materials needed for increased EV deployment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer acknowledged that the laboratory and their industry partner have the resources to complete the project.

Reviewer 2

The reviewer observed that the resources appear to be sufficient to achieve the stated goals of the project, which is continuing under the guidance of the PMCP 2.0 phase.

Presentation Number: MAT242
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs
Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Presenter

Tolga Aytug, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

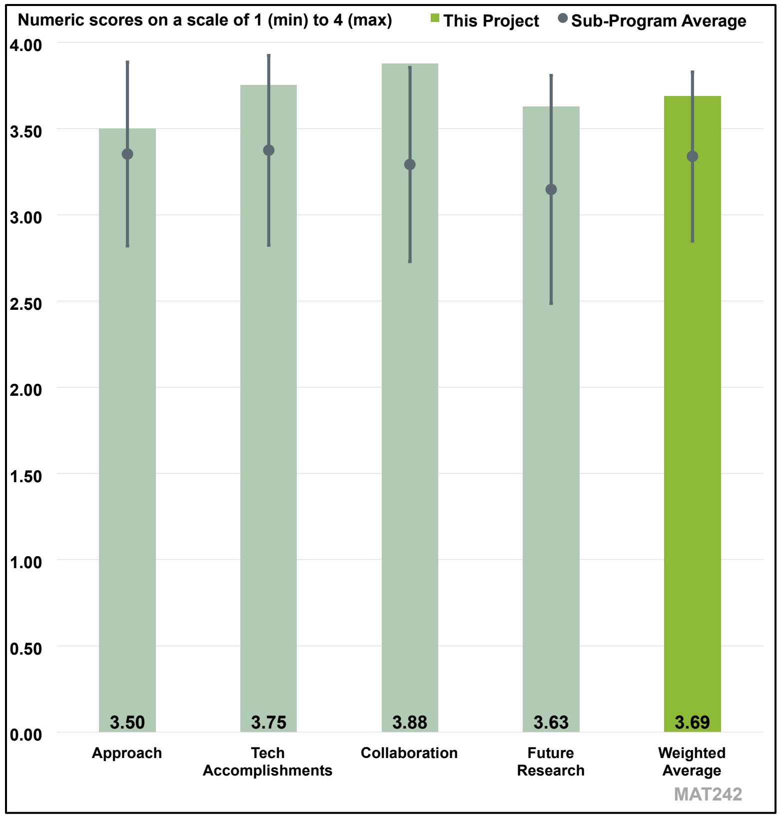

Figure 5-30. Presentation Number: MAT242 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer praised the project since a considerable amount of decent work was done on this research, however, an economic evaluation was not performed. What is the cost target? What is the justifiable cost increase that would be economically acceptable based on the increased efficiency? This is the major barrier to deployment of this technology and should be addressed. The reviewer observed that even if the technology is not economically viable, the presentation should include a statement of how much the cost will need to be reduced for commercial adaptation since the efficiency gains available was defined. Is that number possible? If so, what advancements are necessary to achieve it?

Reviewer 2

The reviewer noted that this project addressed important technical barriers for the reduction in volume and weight of EV components by improving electrical conductivity of Cu windings. As highlighted in the U.S. DRIVE Roadmap, ultra conductive Cu is a key enabler. Embedding CNTs into the Cu matrix by reel-to-reel processing is a novel and reasonable approach. The reviewer concluded that this process successfully increases conductivity of Cu due to significant advantages and properties of CNTs. The only limitation of the overall project approach is the thickness of Cu tapes produced by the process and its production volume output.

Reviewer 3

The reviewer remarked that this research on novel, ultra-high conductivity materials for EVs is being performed to provide means for reductions in volume and weight of EV components. Improvements in efficiency are limited by electrical conductivity of Cu windings and this research provides the materials to meet the DOE 2025 performance targets for power density, size, and reliability goals. Both efficiency and component volume and weight are currently limited by the electrical conductivity of Cu windings. U.S. DRIVE Roadmap aligns with this need and highlights CNT-based Cu materials such as ultra-conductive Cu as a key enabler.

Reviewer 4

The reviewer acknowledged that the barriers to production of Cu with CNT layers were clearly surmounted, and a reel-to-reel method was devised. This is the first step towards making the technology commercial. However, the reviewer expressed that additional work might be needed to reduce the process costs, which were not addressed in this project, while at the same time achieving a more significant increase in performance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that technical advancements of the powertrain components in both weight and efficiency were presented and demonstrated. These were significant in size to make a discernable difference to the end user.

Reviewer 2

The reviewer praised that, over its course, this project delivered outstanding results, especially a decrease in resistivity values and an increase in ampacity that is significant. These results are also confirmed by the computational study and by third-party testing by the project collaborators. The reviewer also noted that the study on doped CNTs is another highlight. In FY 2023, the researchers focused on scale-up efforts and showed continuous operation of their process. Electrical performance of the continuous reels was shown to be like stationary processing. The reviewer stated that the project reached all milestones and targets.

Reviewer 3

The reviewer pointed out that ultra-high conductive materials are needed since the market for Cu is growing significantly, and weight savings can be achieved if less material is used. Ultra conductive Cu (UCC) with CNTs embedded in a Cu matrix material is one example. Excellent interfacial adhesion was achieved between the Cu and CNT layers and Cu successfully infiltrated the CNT layer, which is very important for improved conductivity.

The reviewer noted that the project demonstrated a double layer matrix from a single layer and provided the validation that more layers can be added because the research continued to achieve a dual-sided UCC. However, improvements in resistivity did not scale linearly with additional layers. Also, improvement in the dual-sided CNT layers was lower than the double-layer CNT coated samples due to non-uniformity of Cu film.

Additionally, the reviewer asserted that cross junctions (e.g., CNT-CNT) can help to significantly increase the electronic charge density near the Fermi level. Nitrogen doping (e.g., pyrrolic-nitrogen) results in a 30-fold increase in the conductivity of semiconducting CNTs compared to graphitic doped CNTs. The reviewer affirmed that a scale up to an all-continuous reel-to-reel process was established and UCCs from this process have similar microstructural evolution and electrical performance as stationary processed UCCs.

Reviewer 4

The reviewer noted that, although no detailed project plan was provided in this presentation, the investigators completed all project milestones and demonstrated that the proposed combination of CNT with Cu could improve the conductive properties above those of pure Cu. This could enable somewhat more efficient use of our limited Cu resources.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that, from the presentation, the team at Southwire and ORNL clearly worked well together and shared data and learnings to optimize the composites.

Reviewer 2

The reviewer praised the collaboration efforts of this project that were outstanding. The project team collaborated closely with suppliers and end users and the fact that the end users verified the property improvements is very important. The project also leveraged PMCP Thrust 4 capabilities and demonstrated fruitful collaboration with the advanced computational work.

Reviewer 3

The reviewer highlighted that the alignment of the project team with ORNL allowed them to leverage their unique capabilities from other related projects under PMCP Thrust 4 to maximize the investment made by DOE. ORNL is using the Oak Ridge Leadership Computing Facility, specifically the Compute and Data Environment for Science data analytics research facility, and the Summit supercomputer to achieve the research goals. More importantly, ORNL is also preparing to move this project from laboratory research to commercial production. ORNL has partners with some leading organizations: Southwire, Chasm Advanced Materials, and General Graphene. The reviewer recommended that, with GM now collaborating on metallurgical joining of the UCC tape composites, a formal arrangement with the partners and GM in the form of a CRADA should be considered.

Reviewer 4

The reviewer commented that all the contributions by the partners combined to complete the project successfully.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the ability to continue optimization of the materials and further refine the characterization were proposed. These are areas where more work would create value. The ability to refine the theoretical models and validate them with the experimental data will be important in this space as well.

Reviewer 2

The reviewer found that the project reached its objectives, and the proposed future work is reasonable for the scale-up of their process. The reviewer contended that the scale-up efforts should also include a techno-economic analysis and a feasibility study. Thousands of tons of Cu wires are used in transportation applications, and it is important to demonstrate that this process can achieve such high demands and volumes.

Reviewer 3

The reviewer pointed out that to move this technology to the market, the researchers are proposing to optimize the complex parameter space and detail characterization efforts to enable scale-up of UCC fabrication. The optimization of the CNT dispersion formulation and annealing protocols on long-length UCC prototypes is also needed. ORNL is also proposing to investigate the effect of CNT-types (single-wall opposed to double-wall) on the electrical properties as well as activities to assemble and evaluate the influence of multilayer UCC composites with additional Cu/CNT stacks. The reviewer suggested that a comparison between recycled Cu versus virgin Cu should be completed to determine if there are any differences in UCC performance.

Reviewer 4

The reviewer noted that no additional work is planned because this project has been completed. Of course, refinements to the techniques and economic evaluations would be required before transitioning to commercialization.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer mentioned that the current largest barrier to widespread EV adoption in the United States is range anxiety. Heat is the major source of losses of efficiency in battery powered vehicles, and this technology can significantly reduce that loss. The increased resistance as a function of temperature makes this issue even more of a challenge. The reviewer remarked that this is a very needed technology.

Reviewer 2

The reviewer asserted that this project is highly relevant to the objectives of the VTO Materials and Electrification subprograms. Ultra-high conductivity Cu wires and windings can result in significant reduction in EV motor weights and volumes and wiring harnesses within the vehicles. This will also decrease the Cu demand by the electrification of the transportation sector. However, the correlation between the conductivity/ampacity increases to motor volume and weight savings should be quantified. Also, a correlation between the conductivity increases and reduction in Cu losses will be useful.

Reviewer 3

The reviewer asserted that this project is directly relevant to the VTO Materials subprogram objectives. Improvement in electrical conductivity over baseline Cu can reduce the weight of EVs. The reviewer noted that a 30% electrical conductivity performance can reduce the weight of e-motors by 14-20%.

Reviewer 4

The reviewer pointed out that one of the significant factors involved in the deployment of EVs in large numbers is the availability of the critical materials needed to manufacture the vehicles and their batteries. Although most discussions center on cathode materials, the suppliers of Cu for electrical systems, including batteries, are also expected to be constrained. Therefore, any technology that can serve to reduce the material requirements without reducing functionality is clearly supportive of overall VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed that the project was sufficiently completed within budget and delivered a large amount of quality data on well-developed samples. This is a great area of opportunity and was technically well explored by the team.

Reviewer 2

The reviewer observed that this project is 100% complete and achieved all milestones and targets with the allocated resources.

Reviewer 3

The reviewer commented that the resources appear to be sufficient to achieve the stated goals of the project. However, additional resources could accelerate UCC material to the commercial market. This should be considered because the demand for Cu is significantly increasing, and alternative ultra-conducting material is needed.

Reviewer 4

The reviewer observed that the project was completed within its budget.

Presentation Number: MAT243
Presentation Title: Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system
Principal Investigator: Srikanth Pilla, Clemson University

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 33% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

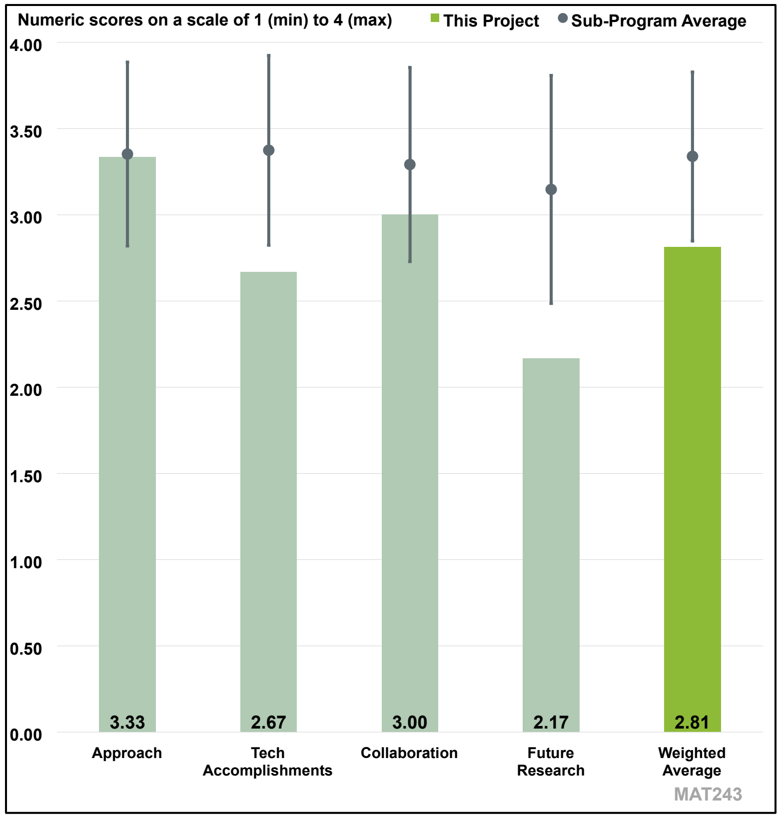

Figure 5-31. Presentation Number: MAT243 Presentation Title: Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system Principal Investigator: Srikanth Pilla, Clemson University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer praised that Slide 3 did an excellent job providing the various barriers and the technology readiness level associated with each. This should be used as an example for other projects.

Reviewer 2

The reviewer remarked that the overall approaches chosen for the proposed research make logical sense and the project and timeline is reasonably designed. The reviewer was unclear about how the accuracy of the prediction model can be improved to provide a better match to the experimental observations such as the discrepancy on Slide 9. The experimental results presented on Slide 10 demonstrated large variation ranges as well, which is more than “2% error range” claimed between the experimental and calculation results.

Reviewer 3

The reviewer praised the approach as good but is concerned that the Go/No-Go milestones for cost, corrosion, and CF transition joints have not been achieved. Continuation of this project should be reevaluated based on Go/No-Go status. The reviewer does not recommend this project to continue.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project is making reasonable progress into Phase 3 on design optimization using outcomes from Phases 1 and 2 for conceptualization and refinement.

Reviewer 2

The reviewer observed that the team listed the project as 45% complete despite being 2.5 years in progress with 1.5 years remaining. This indicates a risk of completing the project on time, however, overall progress is being made in all research areas.

Reviewer 3

The reviewer asserted that sufficient technical progress has not been made to continue this project. Cost, corrosion, and end-of-life recycling have not been achieved for the Go/No-Go requirements. The deficient performance of the recycled CF is a key factor. The reviewer believes the assumption that paint and e-coat are “the same” and, as such, the processes have been excluded is an incorrect assumption. The choice of the cumulative energy demand method versus GHG emissions is convenient and misleading.

Manufacturing and assembly costs are not included in the cost calculation. A three-minute cycle time does not result in low-coat high-volume manufacturing. End-of-life requirements and disassembly and repair have not been considered. Axial crush performance of composite material is not being considered.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the descriptions on Slide 12 regarding how the partners have been actively contributing to each aspect of this project were clear.

Reviewer 2

The reviewer believes that having a project on ultrasonic AM within the Joining Core Program would be a good collaboration aspect for this project. There are many unanswered questions around the multi-material transition joint that are not highlighted given the breadth of the overall project.

Reviewer 3

The reviewer observed that the collaboration between the OEM and the project team needs to be increased to achieve the desired project goal, to realize the project objective, and to avoid “another report in the file”. The assumption of utilizing existing OEM facilities and recycled materials is the key to success of the project appears not to be addressed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the cost modeling is reasonably planned with mitigation strategies reasonably identified. The design refinement that relies on the performance prediction models established in previous budget period may experience issues in inaccuracy, which is not sufficiently described.

Reviewer 2

The reviewer noted that the items listed as “Future Work” seem more like a laundry list of items to be done to complete the project rather than critical roadblocks which lack solutions and if not solved will keep the project from moving forward. At the minimum, there should be an aspect of the risk level associated with these items.

Reviewer 3

The reviewer does not recommend that the project proceed because the Go/No-Go milestones were not met. Without positive Go/No-Go results, further effort is not warranted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project supports the objectives for the VTO Energy Efficient Mobility Systems and Materials subprograms.

Reviewer 2

The reviewer noted that the project goal meets the VTO Materials subprogram objective. Until the Go/No Go milestones are met, demonstration projects are premature.

Reviewer 3

The reviewer remarked that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer affirmed that the project execution clearly demonstrates sufficient resources available for achieving the stated milestones.

Reviewer 2

The reviewer pointed out that the level of resources is insufficient to bring forward all aspects of the project to the same TRL. Unfortunately, if this is the case and even if they can produce a prototype, there is still significant work remaining and that jeopardizes the likelihood for technology transfer to industry.

Reviewer 3

The reviewer asserted that the focus of resources needs to be directed to achieve the Go/No-Go milestone decision. Further investment of resources is not recommended.

Presentation Number: MAT244
Presentation Title: Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation
Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

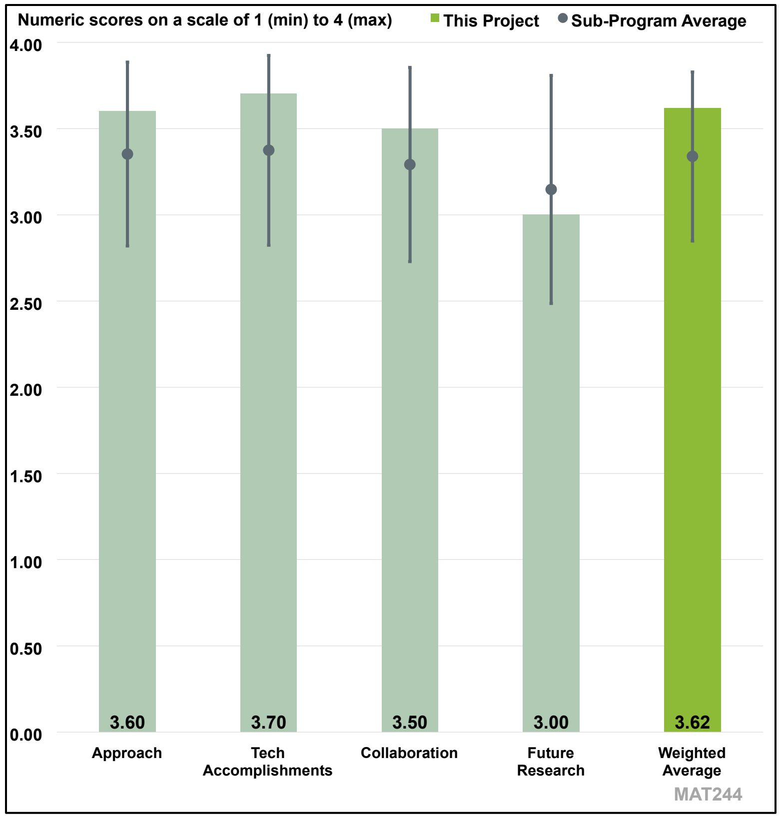

Figure 5-32. Presentation Number: MAT244 Presentation Title: Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the technologies under development offer significant potential for weight reduction through tailored wall thickness of Al extrusions. Experimental investigations confirm ability to achieve target thickness and properties, and the project has completed all milestones per the original project plan.

Reviewer 2

The reviewer pointed out that the project aims to utilize Shear Assisted Processing and Extrusion (ShAPE™) processing to extrude Al with mechanical properties customized within different regions. The reviewer believes that tailored properties and variable wall thicknesses can be achieved through the clever strategies that were implemented. The technology, however, remains far from being implemented in an automotive production environment since there are few ShAPE™ machines in use.

Reviewer 3

The reviewer observed that the team has a clear plan and approach to the project and to address technical barriers with the goal to extrude Al with mechanical properties customized within different regions.

Reviewer 4

The reviewer commented that focusing on development of the ShAPE™ process to enable Al articles to have the right property in the right place is a good approach to enabling greater use of lightweight Al in vehicles.

Reviewer 5

The reviewer noted that the project was well-designed to achieve all the technical milestones. The industrial participants provided the necessary materials and guidance on the choice of target part and desired properties. For future programs, the reviewer suggested that the project would be greatly enhanced if the industrial partner provided a cost target for the parts being demonstrated and some analysis should be performed at the end of the project to guide the path forward to achieve those costs, if possible.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer praised the project for being successful in demonstrating potential to both control material properties and local thickness of Al extrusions and for completing all milestones as planned.

Reviewer 2

The reviewer expressed that the project team has made excellent progress in relation to their goals and milestones by meeting all objectives of the project.

Reviewer 3

The reviewer noted that all milestones were completed. The team presented on the ShAPE™ process and their developments for selective property modification during bulk manufacturing, i.e., selectively modified strength and toughness.

Reviewer 4

The reviewer noted that all project milestones were completed in October 2023, and through this work, meaningful development was completed to show that the ShAPE™ process can enable the use of Al in terms of manipulating the properties of the Al-fabricated article to increase its value and potential for use.

Reviewer 5

The reviewer acknowledged that the SHAPE™ process is unique and provides the platform to evaluate continuous processes while simultaneously achieving controlled mechanical properties. The PI made considerable progress and achieved all the goals for the program. Foremost, the team demonstrated that the glider weight could be reduced by changing the wall thickness along the glide because the SHAPE™ process allows the shear imparted on the part to be changed along its length. The reviewer noted that the very nature of this process allows the strength to be changed and increased or decreased where needed. This is a significant accomplishment at scale and demonstrated that the SHAPE™ process also refined the part microstructure, producing high-angle grain boundaries. The significance of this is that there should be some increase in the fatigue resistance of the part. The reviewer recommends that this project should be continued.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the collaboration was reported to include not only national laboratory participants but key industry stakeholders.

Reviewer 2

The reviewer considered that there was good collaboration by three other industry partners and the lead lab, PNNL.

Reviewer 3

The reviewer noted that the team has members from national laboratories and industry.

Reviewer 4

The reviewer asserted that there was good collaboration by PNNL for input from Ford and materials from Rio Tinto and Wagstaff.

Reviewer 5

The reviewer commented that the team appears adequate to perform the work described. However, the reviewer was unclear on the contributions from the industrial partners until near the end of the presentation .

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that no further research is proposed because all the work has been completed.

Reviewer 2

The reviewer stated that the project has ended.

Reviewer 3

The reviewer commented that the project was completed, however, the team continues developing variable properties using post-consumer scrap metal as the feedstock for a ShAPE™ phase 2.0 effort.

Reviewer 4

The reviewer expressed that the suggested future work to use ShAPE™ to enable the use of post-consumer scrap metal in automotive parts makes sense because the feedstock/metal cost will be further reduced. ShAPE™ can be used to enable the use of a lower quality feedstock to meet automotive part requirements.

Reviewer 5

The reviewer observed that the proposed future work was minimal, with the only objective of evaluating the effect of using the SHAPE™ process with scrap feedstock. High shear processes tend to have high tool wear and cost. The reviewer suggested that, at some point in the future, there needs to be some emphasis on assessing both tool wear and cost. Additionally, this shear process leads to grain refinement and the formation of high-angle grain boundaries, which significantly increase fatigue resistance, so a future consideration should be to evaluate SHAPE™ for parts that need improved fatigue resistance.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project is fully aligned with the mission statement of the Vehicle Technologies Office.

Reviewer 2

The reviewer concluded that this project is relevant for local processing goals of the LMCP.

Reviewer 3

The reviewer stated that this project meets the goals of VTO for R&D to increase understanding of novel materials and to engage industry for further development and deployment of technologies to achieve more fuel-efficient light-duty and heavy-duty vehicles.

Reviewer 4

The reviewer said that the research performed enables Al to be used cost effectively in automotive parts which is consistent with the VTO Materials subprogram objective to deliver materials that reduce automotive weight.

Reviewer 5

The reviewer affirmed that this project supports the need for a future generation of materials and processes to reduce vehicle weight while increasing passenger safety. The use of emerging scalable high-shear processes to produce the glider form is novel and appears to be a step in a new direction for automobile manufacturing. The reviewer suggested that at some point, there needs to be an equipment analysis to determine part size versus SHAPE™ machine size, as well as a life cycle cost analysis to determine if SHAPE™ technology is cost-competitive with current manufacturing technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that appropriate resources have been deployed to meet all project objectives.

Reviewer 2

The reviewer said resources were sufficient.

Reviewer 3

The reviewer acknowledged that the project team has all the resources required to conduct the work.

Reviewer 4

The reviewer noted that all work was completed.

Reviewer 5

The reviewer observed that the resources were adequate to achieve the milestones laid out in the program plan.

Presentation Number: MAT245
Presentation Title: Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

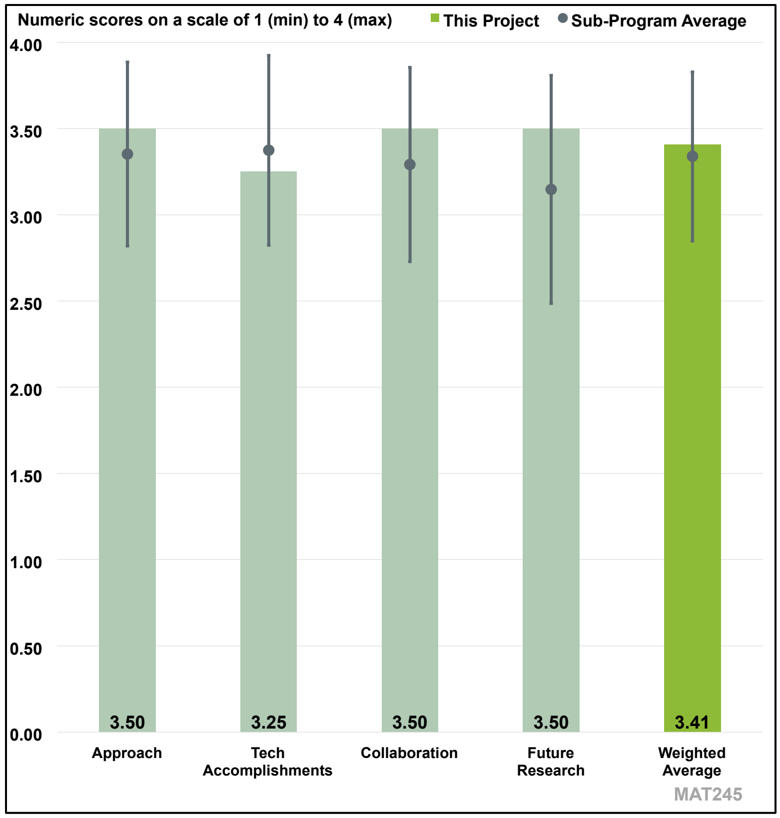

Figure 5-33. Presentation Number: MAT245 Presentation Title: Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer considered that the approach taken was well developed. Evaluation of AM for enabling property/performance enhancements to cost effectively use Al in automobiles is a sensible approach.

Reviewer 2

The reviewer observed that this project appeared to use a tool only because ORNL had one. At the outset, there was no discussion regarding the priority of the most important task to be accomplished—research on material hems, stiffness, or lap joints. The reviewer was unclear about whether the problem could be solved or if there was inadequate funding or something else because the results did not appear to have sufficient detail. Slide 10 seemed like a one-off because dissimilar plug deposition and porosity was discussed. There was no science discussed as to why or how the problem of porosity could be solved. The reviewer remarked that there should be a preference for fewer issues tackled with a deeper understanding of each issue rather than what was presented.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project team executed the plan for evaluating fusion joining of hems and dissimilar plug deposition. The reviewer was encouraged to see that fusion joining of hems did not cause melt-through, suggesting this process is likely achievable commercially. Porosity was an issue that was presented during the dissimilar plug deposition work and identified an area for future development. There were unexpected challenges with the Mazak system used, but the reviewer believed that the team did their best to work through them.

Reviewer 2

The reviewer stated that this project had potential but fell short of meeting needs. In the last year of a project, a nice touch would be to review all accomplishments to give a new reviewer a greater perspective of the work. Additionally, the relevance was not properly addressed because the presenter does not answer why AM can produce unique geometries, misconstrues how AM is useful and how AM helps the automotive industry. While the technical accomplishments appear satisfactory, the connection to the why AM is needed makes it hard to determine the impact and relevance of this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed a good collaboration team with ORNL, PNNL, and external collaborators including Ford for a discussion of application areas, Mazak, and Lincoln Electric for help with the Al deposition equipment, and CompuTherm for CALPHAD support.

Reviewer 2

The reviewer applauded the fact that the project listed a stellar team of participants. The reviewer was unclear about how this project integrates with the other project tasks and subtasks (P1A, P1C1, and P1C2) within Thrust 1 of the LMCP. Also, because the project is completed, more should have been presented about the computational task, which seemed to be an afterthought.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the proposed future work makes sense, focusing on process optimization to address the porosity issue, reducing cycle time, and understanding long-term performance.

Reviewer 2

The reviewer commented that the project is on target for identifying the issues that need to be addressed should there be a follow-up project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer determined that the project is relevant to achieving the weight reduction targets set by the VTO.

Reviewer 2

The reviewer stated that, if this project could be set up to operate aerobically at high throughput in the future, the project would be very relevant to the mission of EERE. The key issues that need to be addressed were highlighted (e.g., reducing defects, reducing the impact of oxygen via a cover gas, and optimizing the process to avoid melting through and enable welding of dissimilar materials). While the research is directionally appropriate, the reviewer felt that having one slide indicating that this technology can be scaled and implemented cost-effectively and addressing the development of deeper process science into solving the problem at hand would be very beneficial.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources were sufficient to achieve the current project objectives but more needs to be done going forward to further develop the viability of the AM technology in helping enable Al usage.

Reviewer 2

The reviewer said that this question is irrelevant since the project is not continuing.

Presentation Number: MAT246
Presentation Title: Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet
Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

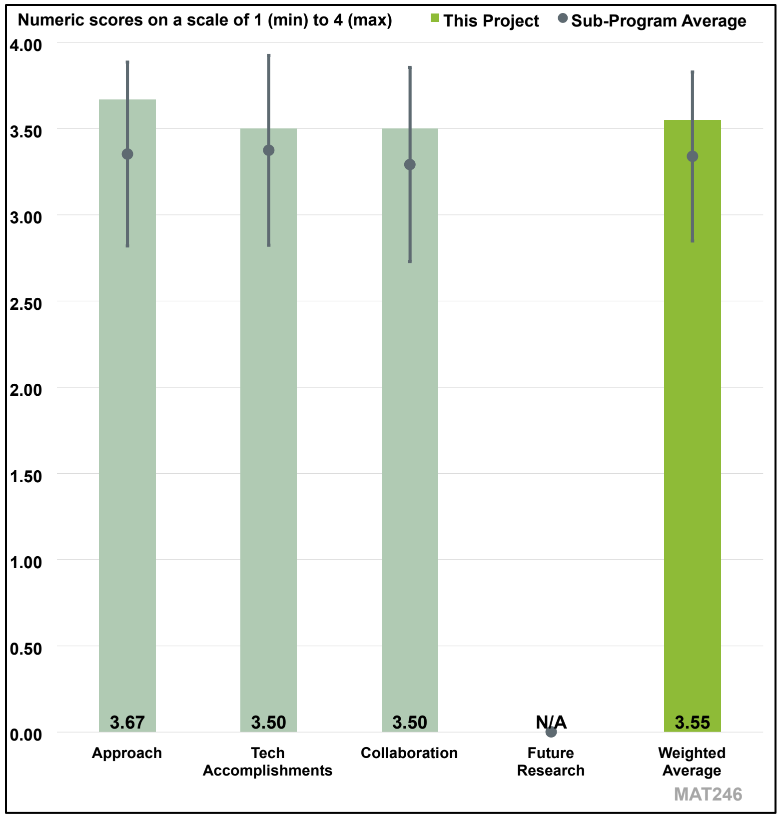

Figure 5-34. Presentation Number: MAT246 Presentation Title: Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Presenter

Mert Efe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the objectives are well-defined and the approaches to meet the objectives are scientific. A set of different methods have been investigated to improve the local formability of T6 heat-treated Al sheets which will contribute to weight and cost savings.

Reviewer 2

The reviewer observed that the approach by the research team to performing the work is well thought out and effectively addresses the technical barriers inherent in the project. Methodologies are sound and demonstrate a clear understanding of the current challenges. Furthermore, the timeline is reasonably planned, allowing sufficient time for each phase of the project to be executed meticulously. Overall, the approach used by the research team is adequate to address the technical challenges and achieve the project goals successfully. The reviewer remarked that a more in-depth microstructure characterization could be employed to enhance the results. This would improve the fundamental understanding of the processes and their impact on microstructure, which in turn affects performance. Such detailed analysis could provide valuable insights that lead to the refinement of process parameters and optimization of overall performance.

Reviewer 3

The reviewer observed that the approach to evaluating the use of three local thermal/mechanical processes (FSP, roller bending/unbending, and laser processing) to enable property improvement of Al sheets is reasonable and that the project was well designed and well planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that local process modification by FSP and bending/unbending combined with heating improved formability. The reviewer was unclear about the details of the joint bending/unbending plus local heat treatment results and the abbreviation "IH" on Slides 7, 11, 12, and 13. [Note: IH is abbreviation for induction heating]

Reviewer 2

The reviewer pointed out that the project team has developed four different processes and successfully demonstrated them in various applications. To further enhance understanding and optimizing the process parameters, a study of the correlation between the resulting microstructure and the laser modification process parameters would be beneficial.

Reviewer 3

The reviewer remarked that all technical milestones were completed. The only remaining milestone is the publication of a journal article detailing the research performed with ultrasonic modification on edge properties and microstructure. The inverted VDA test apparatus with digital image correlation development was effective to evaluate the dissimilar materials and to understand performance after FSP processing and showed the performance benefits of FSP. In addition, microstructure evaluations were conducted to understand crack propagation mechanisms in T6-treated samples after FSP that added insight into FSP.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project had several informal industry collaborations for supply of materials and testing procedures along with active collaboration with ORNL. This project also led to a LightMAT project with industry.

Reviewer 2

The reviewer noted a good collaboration between PNNL and ORNL, good collaboration for input into test method development from Ford, and good insight/feedback from GM on unique needs.

Reviewer 3

The reviewer observed that, although this is a collaborative project between ORNL and PNNL, the tasks were divided among both national laboratories and performed individually, which has led to a lack of interaction and integration. The project does have some industry collaboration, but the level of engagement and interaction among the partners appears insufficient. The collaboration with the other national laboratory on advanced characterization seems largely symbolic, without unmistakable evidence that it significantly contributes to a better understanding of the developed modification processes. The resources are heavily focused on process development, and additional investment in microstructure characterization is required. This would not only enhance the collaboration but also provide a more comprehensive understanding of how the processes impact microstructure and performance.

The reviewer pointed out that more active and integrated collaboration between all parties involved, including industry partners and national laboratories, is needed to fully leverage their expertise and resources. This would ensure that all aspects of the project are addressed synergistically, leading to more robust and impactful outcomes.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed that this question was not applicable to the project.

Reviewer 2

The reviewer noted that this project ended in FY 2023.

Reviewer 3

The reviewer commented that, although the project is complete, the future work proposed aimed at enabling recycled Al to be used in automotive manufacturing is reasonable reduce cost and increase the commercial viability of this technology.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer acknowledged that this project would enable vehicle lightweighting for improved energy efficiency and cost reduction.

Reviewer 2

The reviewer stated that the project goal is consistent with the VTO Materials subprogram objectives.

Reviewer 3

The reviewer noted that project efforts are consistent with the overall VTO Materials subprogram objectives to reduce glider weight by 25% at a cost of less than $5/kg.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer had no comments because the project has ended.

Reviewer 2

The reviewer believed that the resources are sufficient to achieve the project goals and milestones.

Reviewer 3

The reviewer found that the resources for this project were sufficient.

Presentation Number: MAT247
Presentation Title: Lightweight Metals Core Program P2A - Solid Phase Processing of Al Castings
Principal Investigator: Saumyadeep Jana, Pacific Northwest National Laboratory

Presenter

Saumyadeep Jana, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

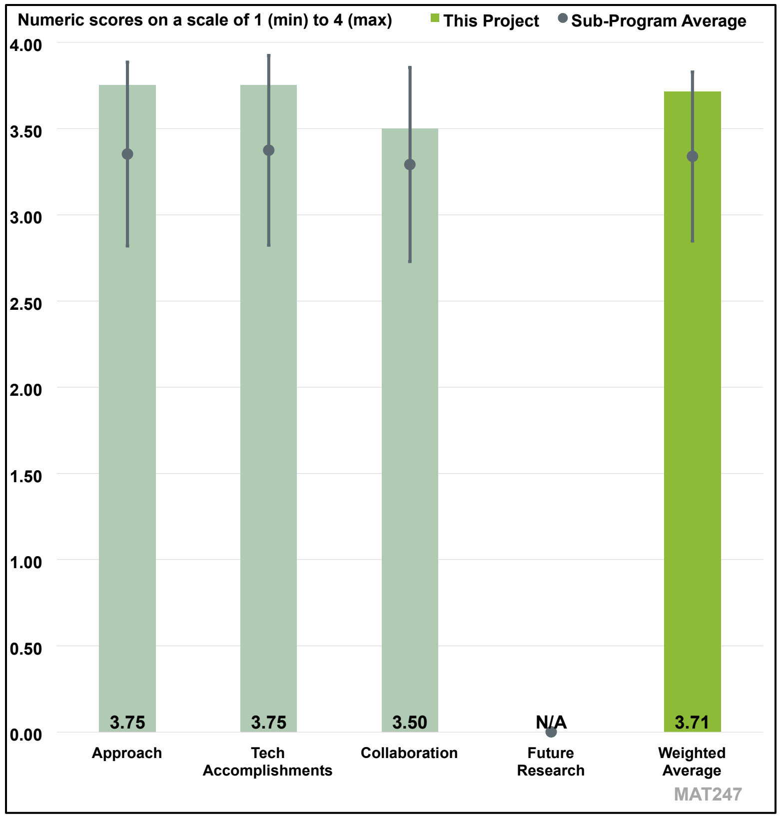

Figure 5-35. Presentation Number: MAT247 Presentation Title: Lightweight Metals Core Program P2A - Solid Phase Processing of Al Castings Principal Investigator: Saumyadeep Jana, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer expressed that the project is well designed and effectively addresses the technical barriers associated with enhancing the local thermo-mechanical properties of high-pressure die-casting (HPDC) alloys through modification of the microstructure and removal of casting defects. The project team aims to achieve improved fatigue and fracture toughness in locally modified HPDC Al-alloys, specifically A380 and Aural-5. Also, the team has successfully developed and demonstrated that both FSP and pulsed ultrasonic processing can effectively modify the local microstructure, thereby enhancing the fatigue and mechanical performance of the parts.

Reviewer 2

The reviewer noted that the project plan addressed the barriers/challenges. The reviewer stated that the approach was reasonable because the plan identified two methods to be developed and validated to overcome the barriers for FSP and power ultrasonic surface processing of HPDC Al alloys.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer provided the following positive feedback. To further strengthen the project, a clear criterion for the maximum size of casting defects that can be effectively removed should be established to be beneficial. This addition would provide a more comprehensive framework for evaluating the success of the defect removal processes and ensure consistent quality improvements. Regarding the design and timeline of the project overall, the reviewer commented that the project is well-conceived, and the timeline is reasonably planned, which allows for systematic execution of each phase. The methodologies employed are robust and show promise in achieving the project goals with the suggested minor improvement for thoroughness.

Reviewer 2

The reviewer remarked that all milestones were completed, and the project showed encouraging results and identified some potential areas to focus on understanding needs for the future.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project is primarily a collaboration between PNNL and ORNL with a strong focus on tool and process development. This collaboration has been successful in achieving the initial goals. However, additional microstructure characterization should be planned to better understand the relationship between the microstructure and process parameters. The project team recognizes this need and has mentioned plans to incorporate in the next phase of the project under PMCP 2.0.

The reviewer suggested that the project would benefit from increased input from industry partners to assess the practicality of the developed processes in a real production environment. Such collaboration would ensure that the processes are not only scientifically sound but also feasible and efficient for industrial application. By involving industry partners more deeply, the project could gain valuable insights into potential challenges and opportunities for process optimization in real-world settings. The reviewer affirmed that, while the current collaboration between PNNL and ORNL is effective, expanding the scope to include more comprehensive microstructure characterization and enhanced industry engagement would further strengthen the project’s outcomes and applicability.

Reviewer 2

The reviewer stated that the collaboration between PNNL and ORNL was good and support from Ford, GM, and Magna by providing die cast parts for the evaluations was beneficial.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer pointed out that the project ended in FY 2023.

Reviewer 2

The reviewer expressed that this project has completed, but for the LMCP 2.0 phase, the future work should consider using design and modeling to help eliminate die-cast defects. The methods evaluated in this project are helpful to repair or improve defects after the die casting, but an effort to develop methods through design/process to prevent the defects that would eliminate the need for post die-casting processes and rework would be beneficial.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project supported the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer pointed out that enabling giga-casting of Al parts supports the 25% weight reduction targets of the VTO Materials subprogram in a cost-effective manner.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the funding allocation is sufficient to achieve the stated objectives.

Reviewer 2

The reviewer stated that the resources were sufficient.

Presentation Number: MAT248
Presentation Title: Lightweight Metals Core Program P2B - High Intensity Thermal Treatment
Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

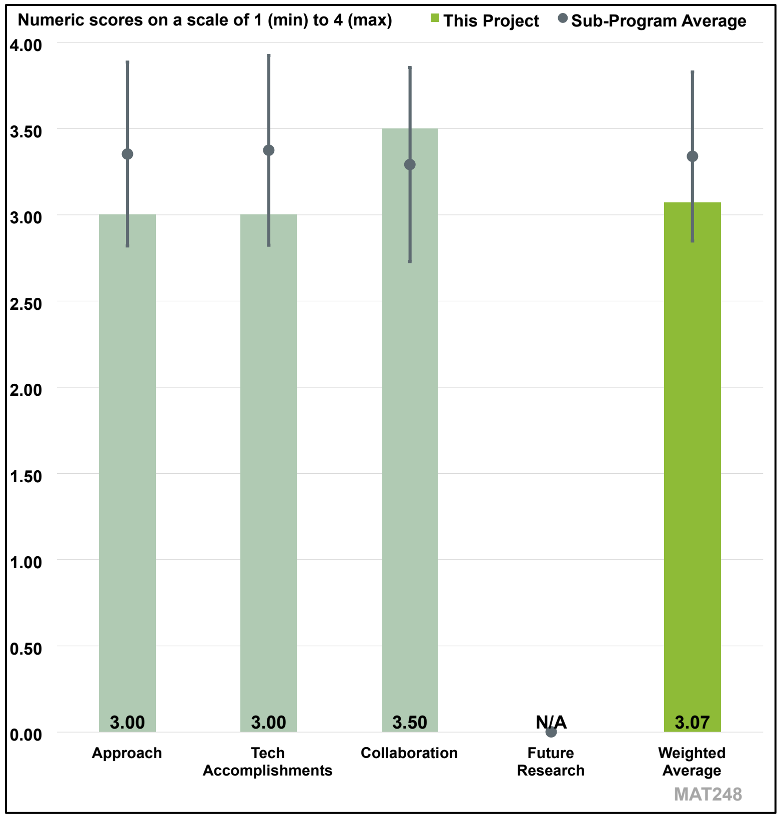

Figure 5-36. Presentation Number: MAT248 Presentation Title: Lightweight Metals Core Program P2B - High Intensity Thermal Treatment Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the two processes, ultrasonic intensification during solidification and water jet peening, were evaluated to improve properties of castings. Both processes have demonstrated some success in improving properties.

Reviewer 2

The reviewer noted that the approach to evaluate ultrasonic melt treatment, localized heat treatment, and surface processing to improve mechanical properties is rational. However, the reviewer was unclear regarding any constructive interaction between these methods. Otherwise, the scope of the work appears very broad.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that the progress is satisfactory and a unique in situ grain refinement measurement was reported. Fatigue life improvement was reported after water jet peening, but the interpretation of the improvement was not clear.

Reviewer 2

The reviewer considered that the demonstration of ultrasonic treatment to refine the grain size and, more importantly, and identification of the primary intermetallic aspect ratio are encouraging results towards the development of recycled Al alloys for structural applications. Similarly, water peening was demonstrated to improve the fatigue life of castings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that there was good collaboration with three separate industries reported in this project led by PNNL.

Reviewer 2

The reviewer concluded that there are multiple examples of great collaboration with other national laboratories (e.g., in situ synchrotron diffraction experiments with ANL) and industry (e.g., laser peening and water peening).

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project has ended.

Reviewer 2

The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the LMCP program goal for local property enhancement.

Reviewer 2

The reviewer observed that the development of recycled structural Al alloys will advance energy efficient mobility systems via vehicle lightweighting.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources were sufficient.

Reviewer 2

The reviewer noted that the project has been completed.

Presentation Number: MAT249
Presentation Title: Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al Castings
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

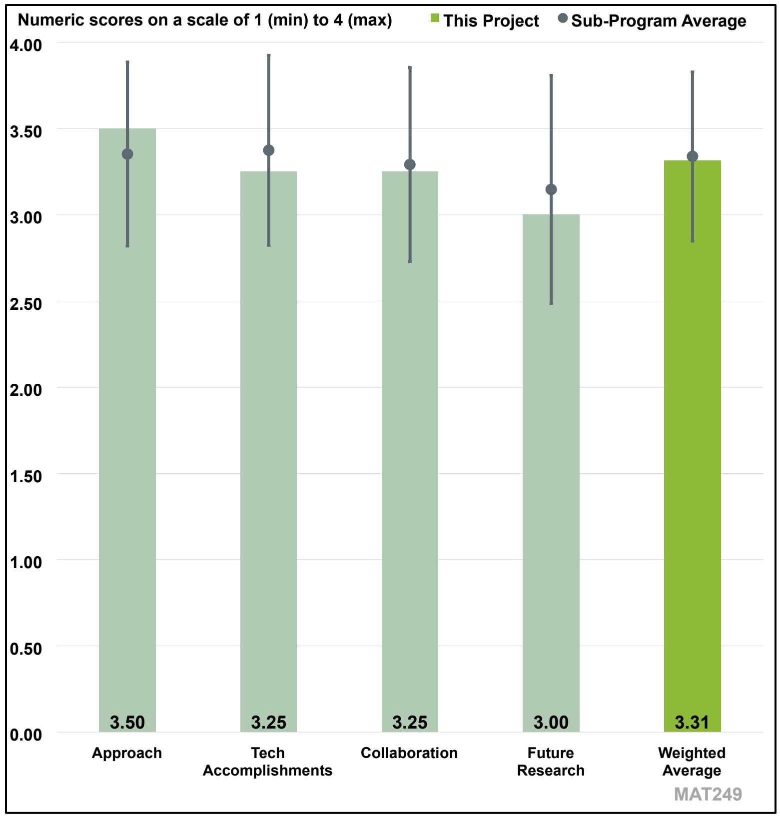

Figure 5-37. Presentation Number: MAT249 Presentation Title: Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al Castings Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project is well designed and effectively addresses the technical barriers associated with modifying the microstructure and geometry of Al alloy castings using AM. The selected approach, which combines wire AM with machining, is sound and well-suited to achieving the project's objectives. This hybrid concept enables advanced structural designs for light-weighting and local microstructure modification to improve material properties. The reviewer affirmed that, overall, the design of the project and the execution plan are well conceived, promising successful achievement of the project goals. The strategic planning and sound approach ensure that technical barriers are addressed effectively and future research into mechanisms of defects should further enhance the potential for success.

Reviewer 2

The reviewer stated that the project is well designed for exploring the potential of building AM structures for the purpose of enabling joining of previously layered cast parts.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed that, by leveraging AM, the project aims to enhance the mechanical performance of Al alloy castings making them more suitable for advanced applications. The focus on both structural design and microstructure modification demonstrates a comprehensive understanding of the technical challenges involved. The methodology for this project is robust and integrates innovative techniques to overcome potential obstacles.

The reviewer noted that the timeline was reasonably planned and allowed sufficient time for each phase of the project to be executed meticulously. However, to fully realize the goal of developing a defect-free process, additional investigation into defect formation mechanisms is required. Understanding the origins and behavior of defects during the AM process will be crucial in refining the techniques and ensuring consistent quality.

Reviewer 2

The reviewer commented that the project was well executed and demonstrated the basic feasibility of the concept. The reviewer noted that future work may determine if sufficient quality and scalability can be achieved beyond laboratory investigation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that collaboration within the project team is commendable, with major industry partners covering the automotive and tooling sectors. This collaboration is crucial for the successful outcome of the project to ensure that the developed processes are practical and relevant to real-world applications. The involvement of industry partners brings valuable insights and expertise that enhance the overall quality and applicability of the resulting technology.

Reviewer 2

The reviewer noted that collaboration between the laboratory and industry was highlighted and evident in the way the workplan was developed and executed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project ended in FY 2023.

Reviewer 2

The reviewer observed that the future work presented showed appropriate targets and identified technical barriers for the quality and scalability of this concept.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that the project supported the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer stated that this project is relevant to automotive material and manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer expressed that the resources ae sufficient to achieve the stated goals.

Reviewer 2

The reviewer said that appropriate resources were applied to achieve the stated objectives.

Presentation Number: MAT250
Presentation Title: Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation
Principal Investigator: Vineet Joshi, Pacific Northwest National Laboratory

Presenter

Vineet Joshi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

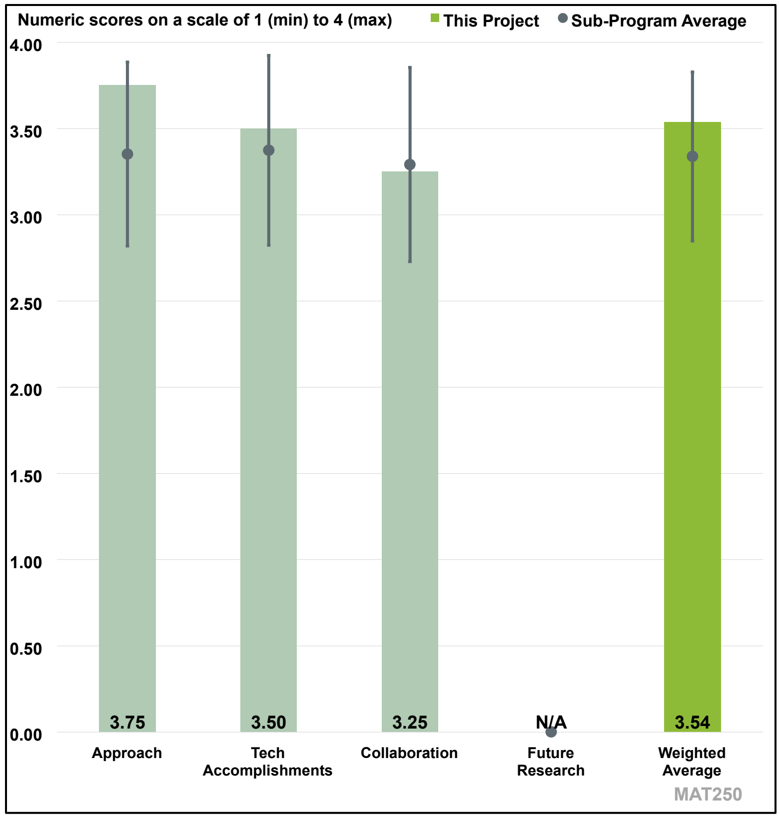

Figure 5-38. Presentation Number: MAT250 Presentation Title: Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation Principal Investigator: Vineet Joshi, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer determined that the project is well designed and effectively addresses the technical barriers associated with enhancing the local properties of Mg alloy castings. The objective of developing low-cost, advanced manufacturing processes to improve corrosion resistance and wear resistance is both ambitious and achievable. The collaboration between PNNL, ORNL, and ANL leverages the unique strengths of each institution, ensuring a comprehensive approach to tackling these challenges.

The methodologies employed, including surface alloying with cold spray, surface plasma treatment, and advanced characterization, are innovative and well-suited to achieving the project’s goals. By exploring processing windows beyond what is documented in literature, the project pushes the boundaries of current knowledge and capabilities. Additionally, the integration of ab-initio modeling work provides valuable baseline water stability studies, offering useful insights and comparisons with surface-modified reactive and alloying processes.

The timeline is reasonably planned, allowing sufficient time for each phase of the project to be executed meticulously. Strategic planning and clear milestones for this project ensure that technical barriers are addressed effectively, which leads to the successful development of scalable and cost-effective processing methods.

Reviewer 2

The reviewer acknowledged that this project demonstrated a clear understanding of key barriers (corrosion and wear resistance of Mg) and built a team of industrial and laboratory investigators to address and overcoming the barriers. The processing methods employed were both novel and commercial, indicating that if successful, they could be utilized in a large-scale manufacturing environment. The team used reactive processes to deposit improved coatings and surface alloying. Arguably, cold spray is just a deposition process. In all cases, considerable progress was made toward improving galvanic corrosion and reduction of wear.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed that the technical progress made so far has been impressive and aligns well with the project plan. Both surface treatment processes, cold spray (alloying) and plasma (reactive), have demonstrated superior corrosion, wear, and adhesion properties compared to the substrate material. This indicates significant advancement towards the objectives of enhancing local properties of cast Mg for broader implementation in lightweight vehicles. The methodologies utilized, including plasma, lithium salt, thermal carbon dioxide, cold spray, and AM have shown promising results.

The exploration of processing windows beyond what is documented in the literature has yielded innovative solutions and valuable data. The ab-initio modeling work has provided a solid foundation for understanding water stability, offering insightful comparisons with surface-modified reactive and alloying processes. Overall, the reviewer praised the project for making excellent technical progress and meeting or exceeding the planned milestones.

Reviewer 2

The reviewer expressed that Task 3A1 was nicely planned and executed. For both approaches, open-air plasma and lithium-salt assisted, the team made significant improvements in both the corrosion and wear resistance of Mg substrates. Also, the presentation indicated that these coatings work on non-conformal surfaces and the plasma technology is already a commercial process. The microstructures of the plasma coating were homogenous and had a coherent interface with the Mg substrate. The lithium-assisted thermal coating requires continued development to improve its microstructure.

The reviewer observed that Task 3A2 looks promising because cold spray is a low-cost deposition process. The team should consider adding an impact aid to the feed powder that helps adhesion to the surface but does not become part of the coating. This approach may allow improvements in surface finish.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the collaboration within the project team is strong because ORNL and PNNL played leading roles in the research and development activities. Industry partners provided valuable support by supplying materials and offering technical assistance with processing equipment. This industry involvement is crucial for ensuring the practical applicability of the developed processes and aligning them with real-world needs. Contributions by ANL have been valuable, particularly in providing advanced characterization capabilities. Leveraging expertise at ANL in advanced characterization has the potential to maximize this collaboration, especially in residual stress characterization of cold-spray surfaces as well as phase characterization of plasma coating and would provide deeper insights into the effects of surface treatments and help optimize the processes further.

In summary, the current collaboration is highly effective, and with increased involvement from ANL and potentially other external entities, the project could achieve even greater success. This enhanced collaboration would lead to a more comprehensive understanding of the materials and processes, ultimately driving the project towards its ambitious goals.

Reviewer 2

The reviewer affirmed that this project has demonstrated solid collaboration among the team members. The team members meet regularly, use the same materials, and are focused on solving the same issues, albeit using different approaches. One differentiator from other programs in this area is that the external collaborators participate beyond just supplying materials or ideas. They are depositing coatings and broadening the approaches being evaluated as potential commercial solutions. This effort epitomizes the meaning of a team, and the results demonstrate significant accomplishments in the art of coating Mg materials.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project ended in FY 2023.

Reviewer 2

The reviewer commented that the program has concluded and no proposed or suggested future work was indicated.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer acknowledged that the project supports the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer observed that this project is directed at improving corrosion resistance in Mg components for lightweight vehicles. The project is absolutely on target to support VTO Materials subprogram objectives and processing science. For Mg components to gain more traction for use in vehicles, the project focused on improving galvanic corrosion between dissimilar materials which is a key challenge to the deployment of Mg components in vehicles across the United States. The project targeted the key technical challenges and addressed them with focused research targeting novel coating methods to improve corrosion and wear resistance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient to achieve project goals.

Reviewer 2

The reviewer concluded that the resources were adequate to conduct the research described.

Presentation Number: MAT251
Presentation Title: Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Mg Castings
Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Presenter

Mageshwari Komarasamy, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

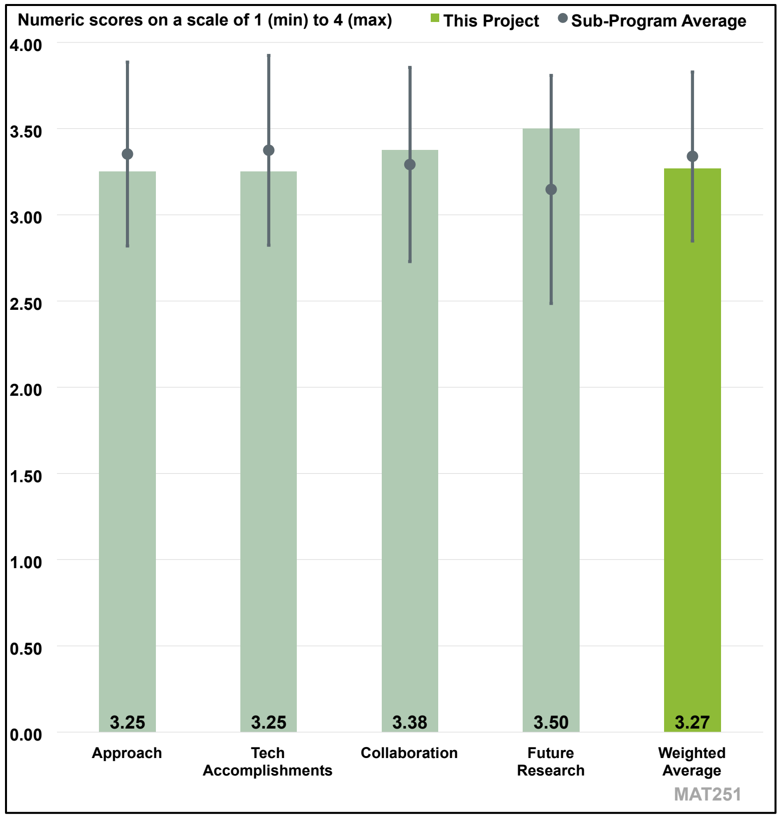

Figure 5-39. Presentation Number: MAT251 Presentation Title: Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Mg Castings Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the primary technical barrier for this project is to demonstrate new cast alloys with strength and ductility necessary to meet the increased demands for specific safety-related components envisioned for future vehicle applications that are currently unavailable. The approach is to evaluate the modifications of AZ91D Mg and AM60B cast alloy properties using local friction processing of high-strength, non-rare earth, cast Mg alloys to increase strength locally via friction stir deposition and friction stir plug processing. This would include processing of curved high-pressure die-cast Mg plates and deposition of high-strength AM experimental alloy on a low-strength AM60B substrate by varying rotation speeds, traverse rates, and changes in the applied force to obtain quality deposits. The approach of using FSP for deposition of dissimilar alloys is considered novel but, if successful, this is an excellent and well-designed approach to meet the project objective within the specified period.

Reviewer 2

The reviewer verified this project was well design to explore friction stir deposition Mg.

Reviewer 3

The reviewer clarified that the barriers for this project are porosity, low strength ductility, and fatigue life limits in HPDC Mg components. The three tasks set out to address the barriers in differing ways. Task 1 evaluated property modification in two alloys, Task 2 addressed increasing the strength in non-rare earth cast Mg, and Task 3 evaluated curved surfaces. Tasks 1 and 2 specifically addressed many of the barriers described and delivered valuable and tangible results that demonstrated that the use of flame spray pyrolysis could deliver an increase in strength, reduce porosity, refine the grain structure, and increase fatigue resistance. The tasks were well-designed and executed. Hopefully, this project may be continued or some part of it picked up by industry for continuation.

Reviewer 4

The reviewer stated that, considering the barriers, the project was well designed and some of the technical barriers were addressed. The practicality of the friction stir approach deserves some scrutiny, due to the necessary rates of production for high-volume automotive manufacturing. The described approaches appear to be much more suitable for lower volume, higher cost margin industries, rather than automotive. It is certainly possible to reduce defects with solid state deformation into the volume of a thin wall casting, but the practicality of friction stirring multiple sites, or even full surface regions, on millions of complex castings seems very unlikely. Surface finishing was also not convincing. The project seemed more focused on using the existing tools rather than the practical manufacturing and materials needs of the automotive sector. But the laboratory scale project was very well planned and executed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked the FSP samples were reported to exhibit significant improvement in fatigue life over as-cast by more than two orders of magnitude. Methods such as overlapping double passes and varying tool design reduced the porosity fraction to <1%–3% that of AM60B Mg cast alloy by greater than two orders of magnitude. Samples that had <0.01% porosity in the gage section were reported to exhibit fatigue run off. After FSP, the porosity was reduced from ~2% in the base material to ~0.04% and ~0.1% in the 45º and 65º curved surfaces, respectively. The deposition of a stronger material onto a weaker substrate was successfully demonstrated and the deposit thickness was uniform at lower rotation rates compared to higher rotation rate. There was no measurable variation in quality or densification from top to bottom of the deposited material and no major difference in microstructure across the width and height of the deposited material. Microscale particles with an average diameter of 1.20 µm and few particles above 3 µm were identified and an increase in particle size was observed with increase in tool rotation rate which may contribute to the strength of the deposited material being 2.6 times that of AM60B in the as-cast and friction stir processed conditions. These are considered outstanding technical accomplishments for improving the properties of cast Mg alloys.

Reviewer 2

The reviewer commented this project demonstrated the laboratory scale feasibility of the concept and highlighted some the property advantage for friction processed Mg over that of cast Mg.

Reviewer 3

The reviewer expressed that this project demonstrated noteworthy progress on Task 2, friction surface layer deposition. By controlling the FSP rate, the researcher was able to refine the microstructure and substantially reduce porosity while refining the grain structure, which led to increased fatigue resistance. The reviewer praised the researcher for this significant achievement. The project team also demonstrated the ability to deposit stronger alloys onto a weaker substrate alloy, producing a layered composite, increasing its overall strength. This project team delivered significant valuable research advancing Mg processing science.

Reviewer 4

The reviewer affirmed that the project team described the technical progress adequately. Defects were mitigated by friction stirring to reduce porosity and improve mechanical properties. Deposition of a stronger material was a bit less convincing. Processing of curved plates was a helpful demonstration, but deformation of the part due to the necessary pressure of the friction stir tool was a concern and the proposed mitigation was machining which added a second manufacturing step to the additional friction stir step.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaboration consisted of three national laboratories (PNNL, ORNL, and ANL), a materials supplier (Meridian) and an industrial Canadian metals and materials research center (CANMET Materials). There was no involvement by academia, but the level of research did not necessarily require academic involvement since an industrial research center was one of the partners. The research team appeared to be well coordinated and involved in the research to make significant contributions to the project objective.

Reviewer 2

The reviewer remarked that national laboratory and industry collaboration appears to have been effective.

Reviewer 3

The reviewer commented that the tasks and team appeared cohesive, and the work appeared well coordinated. The reviewer questioned whether a linkage to an automotive OEM is missing. Their presence would indicate that there is interest in expanding the use of Mg in vehicle technology.

Reviewer 4

The reviewer affirmed that several internal and external collaborations were described, including Meridian (supplier), CANMET Materials, and two other national laboratories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer verified that this project ended in FY 2023 and no future research was proposed by the presenter.

Reviewer 2

The reviewer questioned what future research would be possible on this topic based on the presentation content.

Reviewer 3

The reviewer stated there is no proposed future research as this project has ended.

Reviewer 4

The reviewer stated that the response to the proposed future research is not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this project is directly relevant to the VTO Materials subprogram goal of producing higher performance Mg alloys with properties meeting or exceeding strength and ductility requirements of lightweight alloys for use in lightweighting vehicles.

Reviewer 2

The reviewer commented this is relevant research for exploration into automotive materials and manufacturing.

Reviewer 3

The reviewer expressed that this project is directed at improving Mg components for lightweighting vehicles. It is absolutely on target to support VTO Materials subprogram objectives and processing science. For Mg components to gain more use in vehicles, stiffness (ductility) and fatigue resistance need to be improved. The project targeted the key technical challenges and addressed them with focused research targeting novel processing methods to drive the improvements. The use of FSP is a unique approach to improving the microstructure and properties of Mg casting and has clearly shown promise in reducing porosity and increasing fatigue resistance. The use of FSP for surface layer deposition is also novel and shows potential for a viable novel approach to improving materials properties locally as needed by design specifications.

Reviewer 4

The reviewer affirmed that the project has some relevance, but primarily for low-volume, higher cost margin automotive applications for lightweight castings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer articulated that the funding of $300,000 over three years is considered sufficient to support the level of research required for this project although there were three national laboratories, and two industries involved in a collaborative effort.

Reviewer 2

The reviewer observed the resources applied were appropriate for the targeted objectives.

Reviewer 3

The reviewer verified this project is 100% complete. The researcher and project team accomplished a significant amount of work and delivered valuable science with the available funds.

Reviewer 4

The reviewer stated the resources were sufficient.

Presentation Number: MAT252
Presentation Title: Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle
Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Presenter

Jeff Spangenberger, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

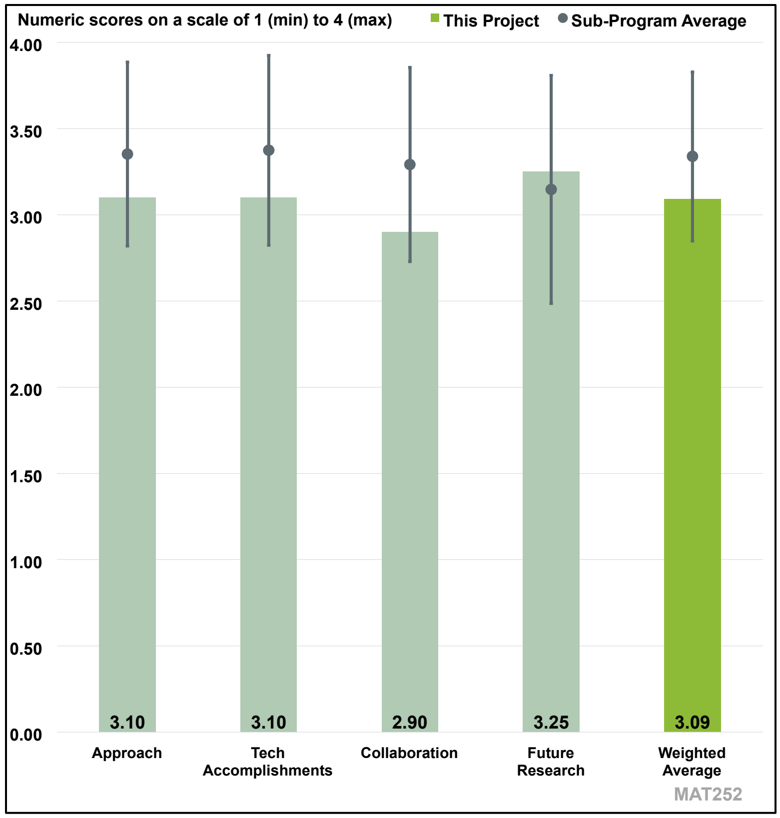

Figure 5-40. Presentation Number: MAT252 Presentation Title: Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the team has made satisfactory progress in materials LCA and has developed several tools for such analysis that is important for industry and other stakeholders.

Reviewer 2

The reviewer noted that the PI addressed the technical barrier most sufficiently in evaluating the complex technical challenges associated with Al recycling .

Reviewer 3

The reviewer found difficulty in fully evaluating the approach without more detail on the model developed and the assumptions and data that were input to the model. The project, as designed, provided insights into the life cycle benefits, and identified opportunities for improving and expanding recycling of Al. Additional research on scrap metal properties and processing by industry, as well as the impacts of Al and Mg aging on recyclability, is needed to inform further development of the model.

Reviewer 4

The reviewer observed that this project has performed well and is timely in exploring the major challenges in recycling of lightweight materials by tying together cost and impact of material sustainability for material selection.

Reviewer 5

The reviewer criticized that this project seems to offer little that is novel or relevant, although it showed more results this year than in previous years. The presentation did not address the stated objective of “identifying opportunities to improve wrought-to-wrought Al recycling” nor were practical insights on how to reduce costs provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that this project analyzed the lifecycle of GHG emissions reduction through two LMCP technologies: (a) local thermomechanical processing and (2) HPDC. Good actionable conclusions were made for both technologies in terms of improving their GHG footprint.

Reviewer 2

The reviewer commented that the PI has delivered milestones 1 through 4 successfully and is progressing to deliver Milestone 5.

Reviewer 3

The reviewer observed that the project has completed all milestones except releasing the Ever LightMat model. The presenter stated that although the original plan was to release the standalone model, the plan has been changed to release the model after an interactive framework between the Ever LightMat model and the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) is established which seems reasonable.

Reviewer 4

The reviewer stated that this project made very good progress regarding the level of deliverables.

Reviewer 5

The reviewer pointed out that the Ever LightMAT model is the first clear output that this project has provided over the three-year period of performance. However, the approach used, and the value of results were not clearly described. As one example, one conclusion wat that using local thermomechanical processing on vehicle closure panels can lead to a net life cycle reduction of 13kg of carbon dioxide per vehicle. Yet, nothing in the inputs to the model described on Slide 5 relate to processing except cycle time. Thus, the reviewer is unclear on how these conclusions about a specific process were reached. Based on the little information that was provided in the presentation, one would suspect that any process that enabled recycling would deliver a very similar result.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that this project is led by ANL who reported collaborations with ORNL and PNNL and that there was an excellent effort by the project team to engage industry stakeholders.

Reviewer 2

The reviewer commented that the PI collaborated with various groups from different industry stakeholders and other national laboratories, however, the partners seemed to mainly serve as providers of information for this project.

Reviewer 3

The reviewer asserted that the project team has achieved strong collaboration with the other LMCP partners, but more collaboration with OEMs of automobiles and trucks will ensure that recycling considerations are fully understood. Industry stakeholders that were consulted were not specified in the presentation or in the question-and-answer period. The reviewer suggested that examples of how the TEA and the LCA are guiding LMCP research efforts would be good to see in future presentations, i.e., how the LMCP research is reducing the number of alloys in the recycling mix.

Reviewer 4

The reviewer stated that a strong national laboratory collaboration effort was evident.

Reviewer 5

The reviewer was unclear about what process information was collected from a small sample of the program tasks offered as an outcome for the program, or even what process information was collected. Slide 10 claims to collect process information from the entire LMCP team but it was never made clear what outcome or value was produced by such collaborations. For example, the Ever LightMAT model framework for "Component Manufacturing" described on Slide 5 does not have any processing input, other than cycle time. This seems extremely odd for a model that was designed to support a program based around multiple processing approaches to enable lightweight and recycled materials.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project has ended.

Reviewer 2

The reviewer commented that the proposed future research is clearly defined, and the project is highly likely to achieve the goals presented.

Reviewer 3

The reviewer pointed out that the end date is shown as December 2023, but the presenter indicated that establishment of an interactive framework between Ever LightMat and GREET is underway or will soon be underway. The reviewer was unclear about whether the remaining work is being conducted as part of this project or a follow-on project. The proposed future research will add significant value in guiding the research of the LMCP. In addition to continuing conversations with industry, new conversations with additional industry stakeholders (especially domestic and international OEMs for automobiles and trucks) should be initiated.

Reviewer 4

The reviewer encouraged continuing development of the framework linking the Ever LightMat model and the GREET model.

Reviewer 5

The reviewer remarked that the value of the approach adopted by this former project was never clear as noted in the comments by this reviewer in Question 3 above which give some examples of a few obvious gaps.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that this project supports the lightweighting mission of the LMCP 1.0 phase.

Reviewer 2

The reviewer affirmed that this project supports the VTO Materials subprogram objectives.

Reviewer 3

The reviewer observed that the TEA and the LCA of the lightweighting materials and recycling needs provide insights that can help guide material R&D projects to achieve cost and performance goals while considering the end-of-life requirements for automotive materials, components, and products. Understanding the barriers to recycling is critical to developing sustainable materials and products.

Reviewer 4

The reviewer noted that this project is directly applicable to materials.

Reviewer 5

The reviewer found that this project is relevant, but the approach did not deliver outcomes that were clearly relevant to the overall program goals of local processing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project resources are sufficient.

Reviewer 2

The reviewer contended that the resources for this project seem to be sufficient for the project to achieve the stated milestones since the project mainly expands from Al to a wider range of lightweight materials and from light-duty to medium-duty and heavy-duty vehicles.

Reviewer 3

The reviewer observed that the project received $150,000 in FY 2021 through FY 2023, and $25,000 in FY 2024 which seems appropriate for the research that was conducted. The reviewer was unclear if the proposed future work will be completed under a separate project or if FY 2024 funding has been added to the project to pursue the proposed future work.

Reviewer 4

The reviewer commented that the resources applied were sufficient for the target objectives.

Reviewer 5

The reviewer concluded that the resources were more than adequate for what was produced.

Presentation Number: MAT254
Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers
Principal Investigator: Yinghua Jin, Rocky Tech Ltd.

Presenter

Yinghua Jin, Rocky Tech Ltd.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

0% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 0% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

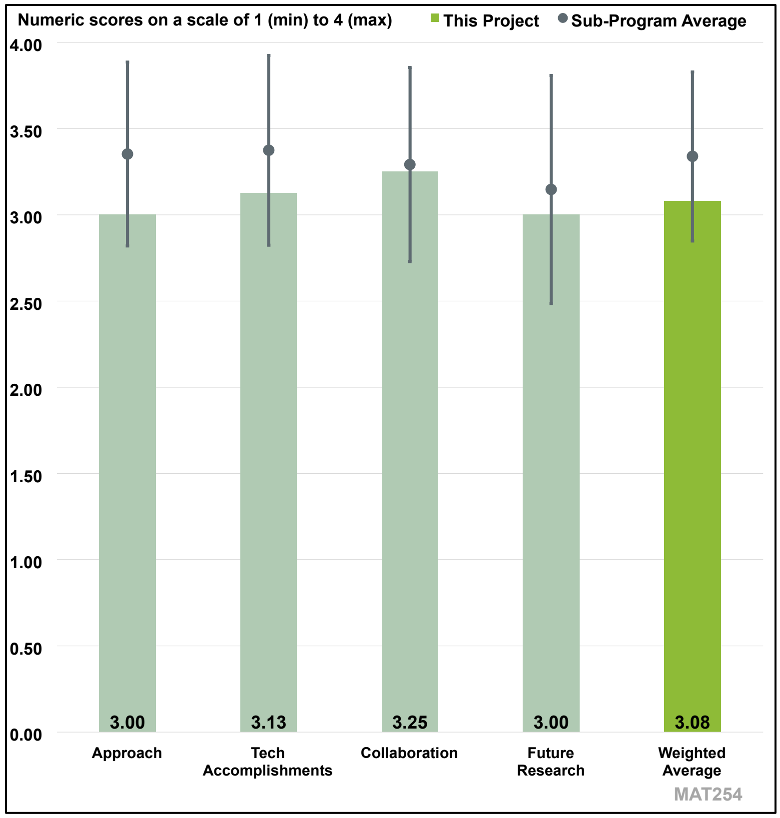

Figure 5-41. Presentation Number: MAT254 Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers Principal Investigator: Yinghua Jin, Rocky Tech Ltd.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project results appear satisfactory.

Reviewer 2

The reviewer commented that the effects of fabrication conditions, fiber types, and variance in vitrimer on mechanical properties of the composites have been addressed. The reviewer also remarked that the project is designed well, and the timeline is reasonably planned.

Reviewer 3

The reviewer praised the collaboration in this project highlighting the partnership with an excellent chemistry department for vitrimer formulation. The reviewer commented on the use of computational techniques and structural variation to search for ideal structural intermediates.

Reviewer 4

The reviewer noted that the research approach involved synthesis of non-isocyanate-based polyurethanes with adaptable covalent networks (vitrimer) that are filled with milled recycled carbon fibers (rCF). Milling of rCF enhances electrical conductivity by increasing percolation potential. However, the milling step adds cost.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted the project progress is as described.

Reviewer 2

The reviewer questioned the optimal ratio of nano-fillers to micro-fillers and inquired whether using only micro-fillers, is better than using hybrid fillers. The reviewer remarked that the contribution of nano-fillers needs to be more clearly addressed.

Reviewer 3

The reviewer commented that the chemical formulation work can be time consuming but noted the company has identified some clear opportunities in this space.

Reviewer 4

The reviewer acknowledged that the vitrimer composition with enhanced ductility was synthesized but questioned why milling of rCF is desired for the composite application if the impregnation of CF fabric will be targeted. The reviewer also noted that the milled fibers must have compatible functionality for bonding with the matrix and sought clarification on sure how those functionalities are created. The reviewer added that project will end in August 2024.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the team's collaboration with the appropriate university laboratory.

Reviewer 2

The reviewer commented that the roles of the company and the university are clearly presented noting the university's contributions included surface modifications of fillers, mechanical, and thermal characterizations. The reviewer affirmed that no national laboratory participated in the project based on the presentation.

Reviewer 3

The reviewer affirmed that the primary project partners are the company and University of Colorado at Boulder which is assisting with formulation and characterization.

Reviewer 4

The reviewer praised the excellent teamwork and collaboration between RockyTech and the Chemistry and Mechanical Engineering Departments at University of Colorado at Boulder.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Slide 12: The reviewer commented that the presenter highlighted three research approaches in the slides but questioned which approach was better in terms of consistency. On Slide 16 regarding reproducibility, the reviewer commented that the open circuit voltage appears high and questioned how it could be reduced.

Reviewer 2

The reviewer questioned whether the coating of rCF-reinforced vitrimer is applied to the fabric or the composite lamina. The reviewer also noted that a comparison of the mechanical properties between the two cases should be addressed.

Reviewer 3

The reviewer commented that the scale up process for vitrimers, their rCF composite manufacturing, and consistent demonstration of their properties are shown as potential future work. However, the reviewer noted the project is ending this year.

Reviewer 4

The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented “none” as a response to the relevance of the project supporting the overall VTO subprogram objectives.

Reviewer 2

The reviewer commented that the research supports the repurposing and reusing of the materials to re-manufacture the composites with enhanced properties.

Reviewer 3

The reviewer commented that the new recyclable formulations presented are composites of the future, highlighting this is a key area of research for matrix formulation.

Reviewer 4

The reviewer commented that the project supports the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the project resources are sufficient.

Reviewer 2

The reviewer commented that based on the presentation, the project resources are sufficient. There are sufficient tools to prepare the hybrid fillers, vitrimer and composite fabrications, and characterizations.

Reviewer 3

The reviewer commented that the project resources seem appropriate and are correctly allocated between the recipient and sub-awardees.

Reviewer 4

The reviewer noted that the resources were adequate for this project.

Presentation Number: MAT257
Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires
Principal Investigator: Kurt Swogger, Molecular Rebar Design, LLC.

Presenter

Kurt Swogger, Molecular Rebars LLC

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

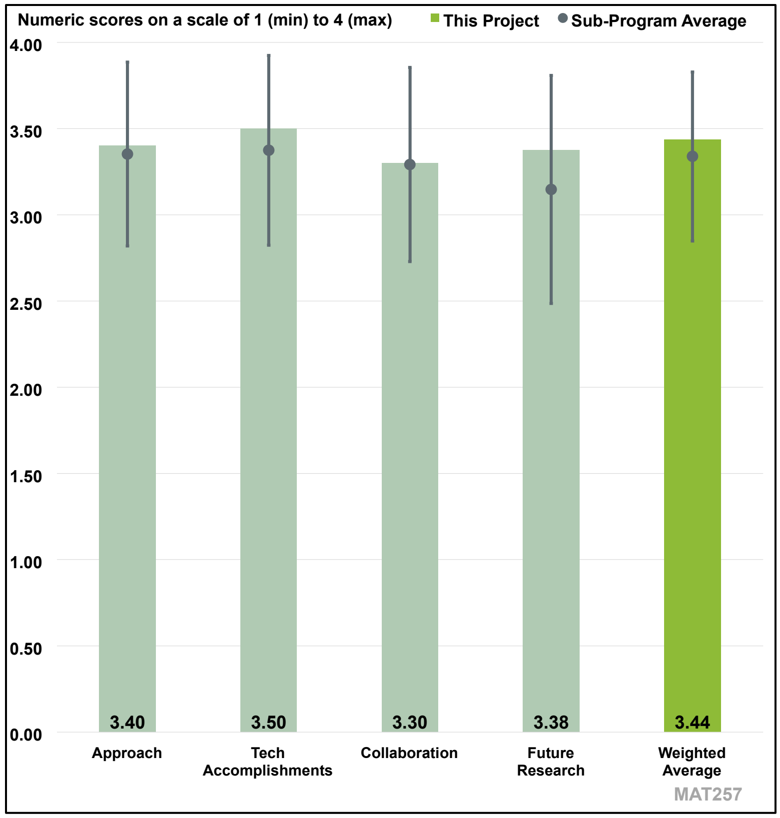

Figure 5-42. Presentation Number: MAT257 Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires Principal Investigator: Kurt Swogger, Molecular Rebar Design, LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the research approach addresses the stated technical barriers.

Reviewer 2

The reviewer exclaimed the design of the project and timeline were “Great!”

Reviewer 3

The reviewer observed that the approach to modifying rubber using the Molecular Rebar Design, LLC (MRD) CNT materials coupled with silane is described; however, the approach to optimizing is not described. Criteria and methods for determining success in the screening and iteration is not described and the reviewer is not clear about what “success” looks like. The approach includes producing “enough” high-quality silane-molecular rebar to supply Goodyear to build prototype tires. Again, no benchmarks are identified, and no specific quantity of material (or number of tires) is prescribed. The overall project would be strengthened by identifying critical parameters being optimized and specifying the amount of material to be supplied.

Reviewer 4

The reviewer commented that this project was very hard to evaluate because specific details and technical content were limited in both presentation and documentation. Overall, the project appears to have generated interesting results, indicating a relevant project approach.

Reviewer 5

The reviewer commented that the work seems impactful, and the properties of the tires clearly seem to be a leap forward from existing technology while maintaining a cost advantage.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project accomplishments appear to meet all objectives.

Reviewer 2

The reviewer exclaimed that the technical progress was " Good!"

Reviewer 3

The reviewer commented that the technical accomplishments of the project are well described which includes methods to determine the "optimal" blend of silane-molecular rebar to silica loadings based upon matching hardness and matching modulus of incumbent silica loaded tires. The reviewer praised the further optimization described for tread improvement noting significant improvements in abrasion, rolling resistance, and tread weight while maintaining wet grip of the tire.

The reviewer noted that the technical approach toward scaling primary batch material appears to be complete setting the stage for commercial scaling, which is critical for transitioning the technology to production. And while current manufacturing rates are modest, this approach appears to be a major step toward commercialization. The reviewer concluded that the (9.5kg/day) rate will support the project goal of building 30 "good" test tires.

Reviewer 4

The reviewer commented that, based on the limited information provided, the project has demonstrated relevant progress.

Reviewer 5

The reviewer commented that scale up potential with rubber and tire partners is evident. While the intellectual property may be hard to defend over the long term, the project is an excellent achievement with clearly benchmarked results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the research team partnered with industry collaborators who actively contributed to the effort.

Reviewer 2

The reviewer commented that the team has collaborated with one of the largest producers of commercial automotive tires in the world which is critical for transitioning the improvement to tires for EVs. The reviewer praised the team and its collaborative partners highlighting a commitment by Goodyear to use the MRD material to mold up to 50 tires to support his effort. The reviewer was not entirely clear about the role of other identified collaborators, specifically Arlanxeo. The organization's role in the approach or technical accomplishments is not described. The reviewer assumed that their role will be more important for potential Phase III (i.e., commercialization) efforts to expand the implementation of silane-molecular rebar in tire manufacturing.

Reviewer 3

The reviewer commented that team claimed a healthy collaboration with Good Year but needs further clarification on the impact of this collaboration.

Reviewer 4

The reviewer acknowledged the coordination between the research team and tire manufacturer; however, the reviewer noted no additional collaborators were mentioned.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that future work will address remaining challenges to development and demonstration of the technology.

Reviewer 2

The reviewer said in progress.

Reviewer 3

The reviewer commented that MRD has demonstrated a useful method of improving tires to address the challenges of accelerated wear and generation of micro-particles from EVs. Their proposed future research lacks details but expresses the clear need to continue to improve and optimize the formulation of tire rubber including exploring a variety of coupling agents and specific chemical species, both of which are helpful.

The reviewer suggests that scaling the technology to demonstrate the economic impact on tire manufacturing would be an important and necessary path forward while noting that MRD provides limited details regarding the methods and approach for scaling aside from suggesting collaboration with pilot production units operated by other synthetic polymer manufacturers.

The reviewer further remarked that this work will be most likely receive private funding, so the proposed plans are perfectly acceptable to remain private and out of public view.

Reviewer 4

The reviewer commented that the team indicates additional testing and scale-up, both of which seem important and necessary.

Reviewer 5

The reviewer commented that the project has ended and is poised for impactful new products.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project addressed the VTO Materials subprogram objectives.

Reviewer 2

The reviewer had no comments.

Reviewer 3

The reviewer stated that the work presented is clearly relevant to the VTO goals to expand opportunities for electrification of transportation markets, as well as improving energy efficiency. Insight to the impact of CNTs on material properties of rubber and synthetic rubber materials is relevant to the VTO Materials subprogram objectives. The reviewer noted the work is interesting and useful for commercialization.

Reviewer 4

The reviewer commented that the project has relevance within the DOE program if it can prove the scaled-up advances proposed.

Reviewer 5

The reviewer commented that the project shows a clear benefit to downstream value cycles for tires and noted this is a larger issue for EVs than for traditional vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project resources are adequate for the work.

Reviewer 2

The reviewer had no comments.

Reviewer 3

The reviewer commented that although work conducted under the SBIR program is clearly constrained in terms of funding levels, MRD has demonstrated that Phase II funding is sufficient to show a meaningful impact on EV tires. The reviewer commended MRD’s use of SBIR Phase II funding to address and achieve the goals outlined at the start of this project for improving abrasion resistance of the tire rubber while deriving added benefits of lower rolling resistance and tire weight. The added mass and increased torque delivered directly to the tires would clearly lead one to expect accelerated tire wear. The reviewer concluded that the project results should position MRD for successful Phase III commercialization efforts.

Reviewer 4

The reviewer commented that the project cannot be evaluated for resources due to the limited information provided.

Reviewer 5

The reviewer commented that the project appears to be on time and within budget, noting the budget has been well utilized for an industrial entity.

Presentation Number: MAT265
Presentation Title: Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles
Principal Investigator: Xiaodong Li, University of Virginia

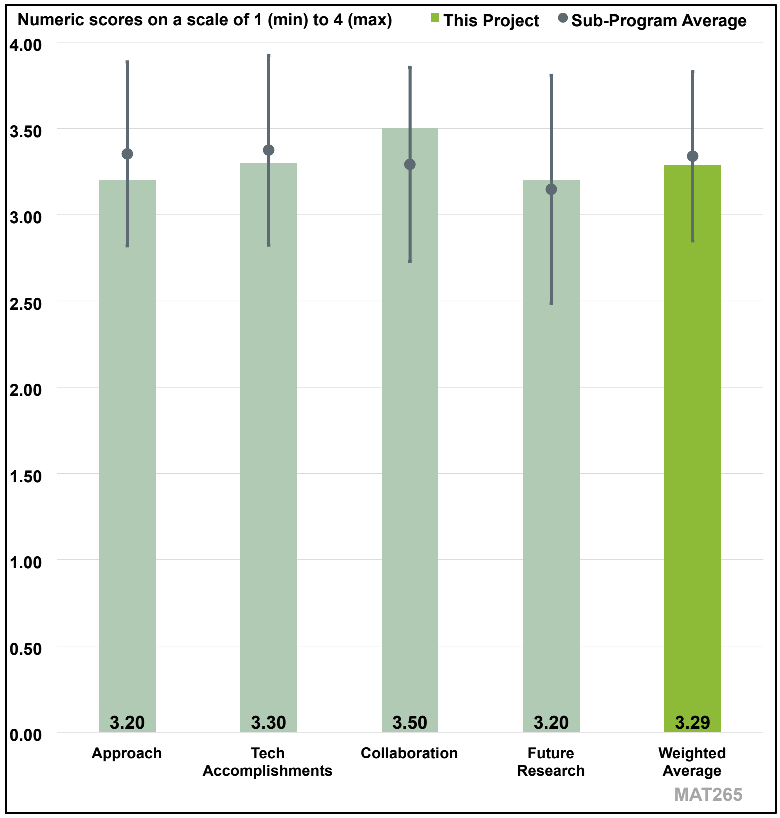

Figure 5-43. Presentation Number: MAT265 Presentation Title: Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles Principal Investigator: Xiaodong Li, University of Virginia

Presenter

Xiaodong Li, University of Virginia

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the technical barriers addressed, the project design, and the timeline were “Okay” as a response.

Reviewer 2

The reviewer commented that the approach to performing the work appears to be fine, but the value of the targeted outcomes is not clear. No background was provided on the demonstration article or how the technology supports the DOE mission since the baseline junction box appears to not have been optimized for weight or performance. Therefore, the reviewer is not clear about how the comparative results will show significant technological advances or overcome significant barriers.

The reviewer further remarks that the plans and practicality of the SHM approach towards implementation should be described and presented much more convincingly beyond stating that more cameras and digital image correlation techniques will ultimately be employed to resolve the health of the structure.

Reviewer 3

The reviewer commented that the general approach of this project, led by the University of Virginia, is good. Due to significant industry involvement, the team can achieve scalable technologies quickly. Focusing on recovering graphene from graphite anodes is important because battery recycling and obtaining graphene are important, rather than reusing it as graphite, and provides an interesting avenue. Also, utilizing recycled CFs from Sonoco Recycling is a good approach, however, the reviewer was not clear about what kind of recycled CF are being used, their properties (strength, length etc.), and what loadings are being targeted.

The reviewer further commented that focusing on EMI shielding and the use of recovered graphene are very good. As questioned during the AMR, the target mechanical properties seem too low and may not satisfy most of the applications for the vehicle parts. The reviewer suggests that the team revisit and clearly define the targeted mechanical properties for each of their targeted parts and seek industry input to define baseline targets. The reviewer concluded that the strategy to try various resins was not clear and it would be beneficial to define which parts of the vehicle they are targeting and why they are looking into certain resins.

Reviewer 4

The reviewer acknowledged that this work targets utilizing recycled materials to produce lightweight composites for EV applications. The technical barriers are well identified, and the tasks are well designed to address those barriers. The reviewer further remarked that the teaming arrangement is well structured for the proposed work and the timeline also appears reasonable.

Reviewer 5

The reviewer stated that the research approach involves manufacturing multifunctional materials from both thermoset and thermoplastic matrices reinforced with recycled CFs and reclaimed graphene from waste lithium-ion batteries. The reviewer further remarked that the scope of the work is too broad and expressed uncertainty about how graphene will be isolated from lithium-ion batteries and made solvent free after separation of lithium ions. The reviewer concluded that, nonetheless, this is a new project with much more to learn.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Regarding Slide 11, the reviewer commented that recycled PP shows the highest tensile strength, while the modulus shows a different value influenced by the rCF (e.g., an increase in rCF results in an increase in modulus), which needs clarification. The reviewer further remarked that the purity of graphene from recycled electrodes depends on the separation process, which needs addressed.

Reviewer 2

The reviewer acknowledged that, at the time of the review submission, the project had only been executing for six months. Some of the material performance targets have been achieved, but it was not clear that they represented major advances over existing systems or how they were critical to meeting project goals. The reviewer was unclear about how success would be determined and how effort would be allocated against competing structural systems such as reinforced recycled PP (likely expected to be lower cost) and reinforced Nylon 6 which should have little trouble achieving performance targets. The reviewer stated that while EMI suppression technology is relatively well known, it is not clear that utilizing very small amounts of recycled materials will have a significant impact. The reviewer concluded that correlation of strain with resistivity changes may be useful for real time monitoring but plans to exploit those observations and development strategies were scarce.

Reviewer 3

The reviewer commented that considering this is a new project, timely progress was made. Targets are clearly defined; however, the team should carefully tailor their directions toward satisfying the targets needed for commercial deployment .

Reviewer 4

The reviewer commented that considerable progress has been made on all relevant tasks for this project given the short performance period. The initial test results of the composites made from recycled materials indicate more room for further improvement. Impurity in recycled materials was mentioned as a key challenge, however, there seems no specific plan for addressing impurities. The reviewer further remarked that the digital image correlation work does not appear well designed and may not provide any benefits towards addressing the key challenges of the project.

Reviewer 5

The reviewer commented that although this is a new project, some of the data presented raised concerns. For example, the recycled polymer matrix reinforced with recycled CFs shows enhanced modulus (as expected) but surprisingly lower strength than neat resin even after a 7 wt.% fiber loading. The reviewer concluded that some degree of fiber matrix incompatibility exists and expressed hope that future research will address this.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that they did not observe any effort from the collaborators.

Reviewer 2

The reviewer commented that there are several key partners, and apparently, they are working together well although interaction plans and details were relatively sparse.

Reviewer 3

The reviewer praised the project which consists of an effective team of collaborators from various institutes but highlighted that one potential challenge may be communication.

Reviewer 4

The reviewer praised the excellent teaming arrangement for the project. The team is comprised of an EV manufacturer, a composite manufacturer, a battery recycler, a plastic recycler, and research institutes. The reviewer also acknowledged the significant contributions from industry as the plastic matrix and recollected graphite materials were provided by industry.

Reviewer 5

The reviewer acknowledged that this is a new project and remarked that it is a multi-team effort with significant potential for collaborative research and opportunities to gain experience from each other.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer referenced prior comments.

Reviewer 2

The reviewer commented that the requirements and plans for refinement of the material and properties need more details, especially if the targeted performance has not been met. The reviewer found the future work plans for EMI and SHM to be sparse.

Reviewer 3

The reviewer remarked that the directions for future work are good; however, the future milestones are not SMART. The reviewer recommended that the team use measurable values as targets that will relate to practical requirements. Once these are defined, the project will have a clearer focus.

Reviewer 4

The reviewer commented that the proposed future research appears reasonable but added an established commercialization or marketing plan would be beneficial. The reviewer also stated that while TEA work is proposed, including a LCA would be even better. .

Reviewer 5

The reviewer commented that the challenges and barriers to be addressed were presented and suggested that the polymer-fiber interface design should be prioritized.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented, “None”, as a response to the question.

Reviewer 2

The reviewer commented that the project appears to support the general objectives of vehicle weight reduction and focuses on use of recycled materials (PP, CF, and graphite) to enhance manufacturing sustainability. The reviewer explained that the SHM to support alternative approaches for repair and replacement issues along with EMI protection to replace the natural protection from steels could be enabling for the use of composite materials. Elaborating that the introduction of those alternative materials requires novel approaches to mitigate material deficiencies compared to traditional metallic structures.

Reviewer 3

The reviewer commented that the concept of this project is highly relevant to the future direction of lightweight materials with a focus on addressing circularity and sustainability. The reviewer praised the investigation into EMI shielding as being good.

Reviewer 4

The reviewer commented that this work strongly supports the lightweighting objective of the office.

Reviewer 5

The reviewer commented that the project is relevant and supports the lightweighting goals and sustainability objectives of the VTO Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the project appears to be very well funded for the proposed achievements. The reviewer elaborated that there will always be more to be done considering the work to date demonstrated that defined key structural properties were meeting project needs and presumably will meet weight reduction goals, which are most important to the DOE mission, which have already been achieved in less than nine months. The reviewer concluded that the evidence supporting the work plan to achieve the project goals and project resources were insufficient.

Reviewer 2

The reviewer had no comments regarding resources.

Reviewer 3

The reviewer commented that the project resources appear sufficient to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer commented that the project resources are sufficient to execute the work. However, the reviewer noted that the team is trying to accomplish too much, and tasks need prioritized.

Presentation Number: MAT266
Presentation Title: Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles
Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Presenter

Amrita Kumar, Acellent Technologies Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 33% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 33% of reviewers did not indicate an answer.

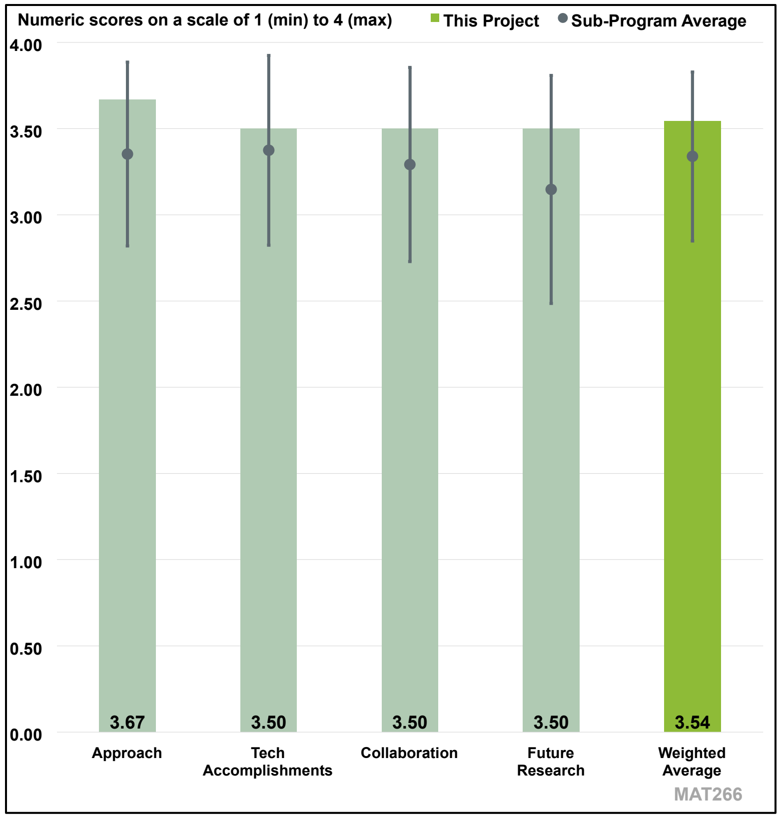

Figure 5-44. Presentation Number: MAT266 Presentation Title: Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the project approach is expected to address technical barriers.

Reviewer 2

The reviewer commented that the project is well-designed, and the timeline is reasonably planned. The reviewer noted that both the Multifunctional Energy Storage Composites (MESC) structures and the monitoring system have been developed and the preliminary mock-ups have been demonstrated.

Reviewer 3

The reviewer stated that the project is a very important area of research for the VTO Materials subprogram and further explained that structural composites with cellular architecture are being designed for a vehicle battery pack assembly. The reviewer clarified that the composites are capable of monitoring battery health and concluded that the project plans for the budget periods have distinct approaches to materials design and manufacturing goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project has shown considerable progress toward the objectives.

Reviewer 2

The reviewer commented on the interlocking rivets buy enquired about the design criteria, such as spacing and quantity, and sought clarification on whether numerical modeling or mathematical analysis was part of the design approach.

Reviewer 3

The team investigated design parameters including battery capacity (kilowatt-hours), discharge rate, charge rate, thermal characteristics and both static and dynamic loading (identify battery type and mass), and identified composite enclosure design parameters. The team also established contacts with multiple battery suppliers.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the industry collaborators were actively contributing to the work.

Reviewer 2

The reviewer commented that the role of the collaborator, TPIC, was working on structures, composites design and manufacturing, and MESC integration was clear but noted that no universities or national laboratories participated.

Reviewer 3

The reviewer remarked that Acellent and TPIC formed an excellent team and noted that the collaboration and work plans with TPIC have been established.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed work is expected to contribute directly to achieving the targets.

Reviewer 2

The reviewer commented that while the project defined the future work in the early slides, future research was not clearly defined on the Proposed Future Work slide. The reviewer also noted that the Budget Periods 2 and 3 on the slide for proposed future work appear more like achievements than proposed future work.

Reviewer 3

The reviewer commented that the project identified clear tasks for each budget period. The reviewer explained that, in Budget Period 2, experiments with system components will be conducted and numerical simulations established. Commercial design tools will also be developed to guide the fabrication process for the final prototypes. The reviewer noted that sensors will be designed for incorporation into the battery enclosures and prepared for preliminary component testing. Budget

Period 3 will conduct prototype production and estimate mass production cost. The reviewer concluded that the community benefits plan had training opportunities identified.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project is relevant to the VTO Materials subprogram objectives.

Reviewer 2

The reviewer stated that the MESC is very relevant to multi-functional composites and energy storage for automotive vehicles.

Reviewer 3

The reviewer commented that this program is very timely and well aligned with the VTO Materials subprogram objectives and added that safe battery enclosures for EVs are needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources appear adequate for the large amount of design and prototyping work required.

Reviewer 2

The reviewer remarked that the resources are sufficient for the project and there are sufficient tools to develop the MESC structures and monitoring system.

Reviewer 3

The reviewer found that the resources are appropriate for this project and added that the costs will be appropriately shared by both entities.

Presentation Number: MAT267
Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles
Principal Investigator: Lorenzo Mencattelli, Helicoid Industries Inc.

Presenter

Paul Myslinski, Helicoid Industries Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

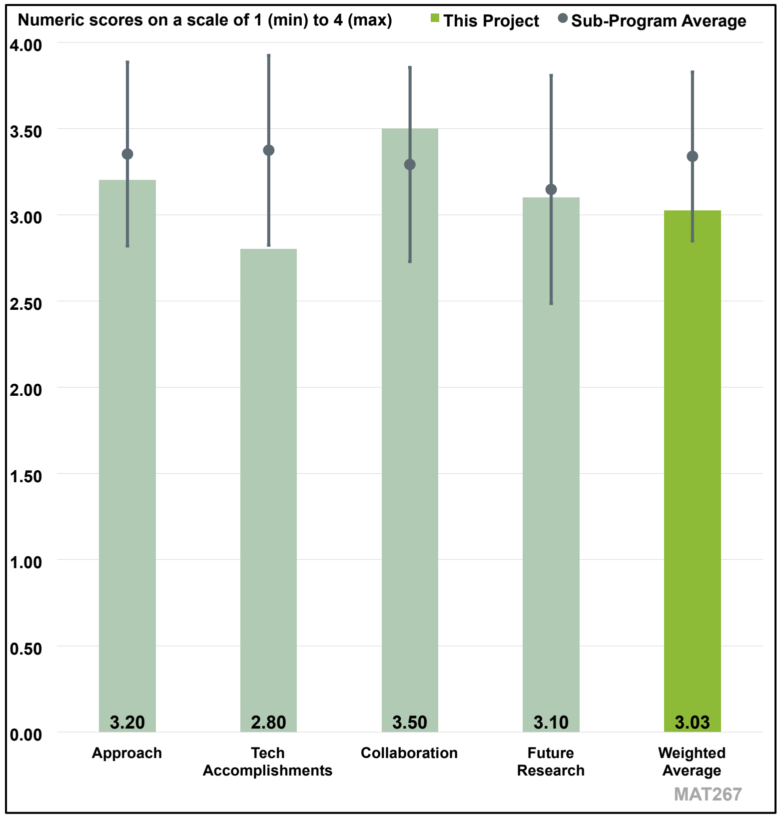

Figure 5-45. Presentation Number: MAT267 Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles Principal Investigator: Lorenzo Mencattelli, Helicoid Industries Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project approach is well designed to address the technical barriers.

Reviewer 2

The reviewer commented that additional work may be needed. For example, investigating the compatibility between the hydrophobic polymer and hydrophilic flax fiber to better address the hygroscopic performances of the natural fiber product, such as dimensional stability, water absorption.

Reviewer 3

The reviewer acknowledged that this work builds off their Phase I project where they developed “helicoid” bio based flax fiber tapes to make flax fiber and polylactic acid composites. In Phase II, the company aims to develop an optimized process for their flax fiber and other thermoset systems. The work has a clear workplan and research approach. The reviewer noted that it would be worthwhile to understand how the research progresses from the materials development phase to the final product beyond just mechanical modeling to get the properties correct. The reviewer enquired about what additives and other materials will be added to accomplish their goals.

Reviewer 4

The reviewer remarked that this is an interesting project with a relevant approach elaborating that the team performed several materials analyses addressing some of the potential barriers. For example, as indicated in the battery use cases, the team needs to show more evidence for managing fire resistance.

Reviewer 5

The reviewer noted that the company has worked on government projects before and seems to be well organized; however, not much progress was shown to date because the project is in the early stage of the performance period.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that technical progress is in the right direction because there was a considerable amount of sound experimental results from the experiments conducted, but the project is still in a very early phase.

Reviewer 2

The reviewer remarked that more effective methods should be considered for functionalization of the fiber because many other methods can be found in the literature.

Reviewer 3

The reviewer commented that the project has demonstrated reasonable progress towards the goals and has a clear project plan. Despite this, the reviewer found difficulty in determining what materials the project team is using as a baseline. The reviewer explained the project utilizes a wide degree of experimental techniques that makes their data clear to understand and concluded that the team compares materials in the project to polylactic acid materials, which have been the main thrust of their work.

Reviewer 4

The reviewer stated that the team presented several results, but the results showed limited impact on the developmental approach.

Reviewer 5

The reviewer commented that the mechanical properties were not on target, but the project team outlined a likely approach to address the technical issues in subsequent work.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the involvement of a strong partner in the collaboration.

Reviewer 2

The reviewer stated that further engagement with the collaborator at Michigan State University is needed.

Reviewer 3

The reviewer acknowledged the project partners at Michigan State University and TPIC as well as their fabric supplies. The reviewer noted the team has identified problems with the fabrics and have iterated properties to make them better.

Reviewer 4

The reviewer commented that the team seems to have good relationships with companies who provide relevant material systems and collaborates well with the Michigan State University research units

Reviewer 5

The reviewer commented that the collaboration team is small and well-integrated. The reviewer also remarked that the funding distribution appears reasonable and well structured.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the planned work is consistent with objectives.

Reviewer 2

The reviewer referenced prior comments.

Reviewer 3

The reviewer noted that the project team mentioned early on that they experienced delays in some of their commercialization milestones and “go-to-market” discussions. The team is aiming to make three full-scale materials for battery enclosures; however, the reviewer is not clear whether their materials have the properties to perform in an enclosure or not.

Reviewer 4

The reviewer commented that the team indicated a shift towards increased activity with thermoset materials instead of thermoplastics, which can limit the risk of thermal degradation due to lower processing temperatures. This shift could provide greater potential for elaboration on the fiber-matrix interaction.

Reviewer 5

The reviewer commented that the future research objectives were mostly centered around solving the challenges with the fiber mats in terms of controlling the structure to achieve the mechanical property targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project supports the VTO Materials subprogram objectives.

Reviewer 2

The reviewer commented, “None,” as a response to the question.

Reviewer 3

The reviewer commented that this work attempts to find an alternative fiber for composites which is always an admirable and worthwhile activity.

Reviewer 4

The reviewer stated that this is an interesting project and well-suited for VTO funding; however, the project must show an impact with relevant use cases.

Reviewer 5

The reviewer commented that this project addresses the core needs of composite materials for glider components.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the project resources are sufficient.

Reviewer 2

The reviewer commented, “None,” as a response to the question.

Reviewer 3

The reviewer affirmed that there are no reasons to believe the project funding is excessive or insufficient.

Reviewer 4

The reviewer observed that there is no indication that resources limit the project.

Reviewer 5

The reviewer stated that the project resources are proportional to the deliverables.

Presentation Number: MAT268
Presentation Title: Upcycling of Polymer Composites for Vehicle Decarbonization
Principal Investigator: Roger Crane, Composites Automation LLC

Presenter

Roger Crane, Composites Automation LLC

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

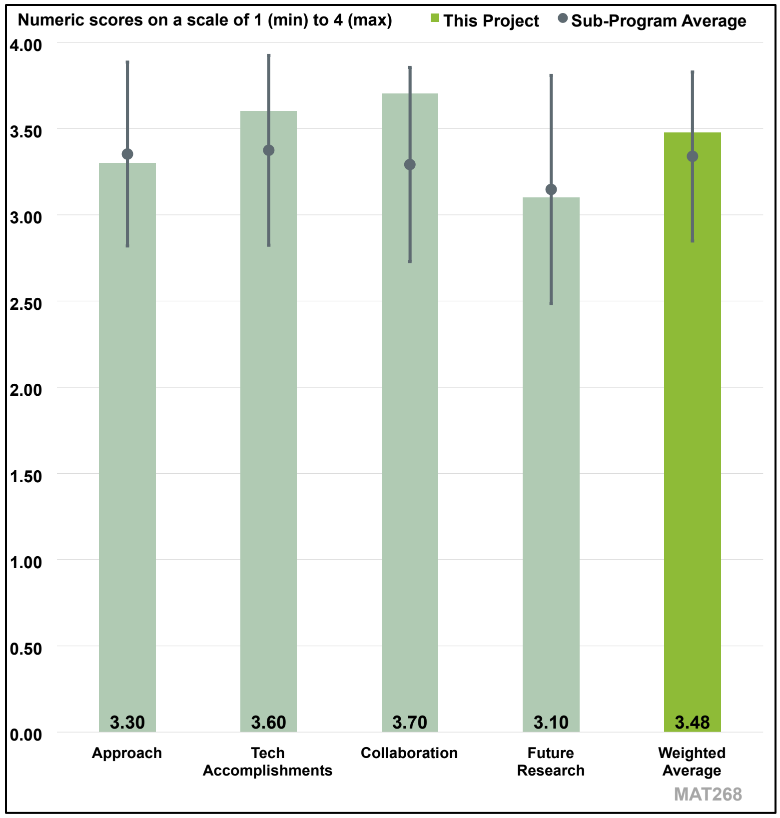

Figure 5-46. Presentation Number: MAT268 Presentation Title: Upcycling of Polymer Composites for Vehicle Decarbonization Principal Investigator: Roger Crane, Composites Automation LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that since they have Tailorable universal Feedstock for Forming (TuFF) technology, the major objective was to apply this technology to rCFs. The team has focused on commercial sources of rCFs, which is good; however, that comes with various challenges, elaborating that several sources exhibited various issues (residual resin, fiber length etc.). They seem to be pleased with some of the recent results and some identified sources and, if everything works well, this is fine. The reviewer stated implementing a quick screening process prior to the TuFF process (maybe prior to fiber alignment, just remove ill-dispersed or aggregated fibers) needs to be considered to ensure quality control is established. The reviewer concluded that fully relying on fiber quality from those commercial providers is a risk.

Reviewer 2

The reviewer commented that the project is intended to recycle CFs for automotive applications, and various efforts were performed to address technical barriers.

Reviewer 3

The reviewer stated that the project team clearly explains why their work is needed and how they aim to address the technical barriers. The approach and results are logically arranged.

Reviewer 4

The reviewer praised the team's excellent alignment of the reuse and cost reduction of CF through recycling CF in a discontinuous form making high volume processing seem highly likely.

Reviewer 5

The reviewer commented that this project aims to address the technical barriers of weight reduction using CF composite materials, sustainability, and cost reduction using rCF, as well as net shape manufacturing of composites meeting automotive rate, performance, and cost targets. The reviewer concluded that the project is well-designed, and the timeline is reasonably planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the team identified various issues of rCF quality, which impacts the TuFF process. They achieved a good mechanical property with more recent rCF batches which showed promising results. The process will need to be further fine-tuned, but accomplishments have been sufficiently.

Reviewer 2

The reviewer commented that the project accomplished various achievements and obtained noteworthy results. However, there are a list of tasks that need to be accomplished during the next period of the project.

Reviewer 3

The reviewer commented that the technical accomplishments are impressive and expressed interest in the TuFF process and how it could be used to identify fibers when the supplier is unsure of the fibers. The reviewer praised the team for overcoming the supply chain issue and maintaining the >90% property retention in most cases.

Reviewer 4

The reviewer commented that the project appears to be meeting all milestones.

Reviewer 5

The reviewer stated that the technical progress demonstrated a well-planned and well-executed project. The main objectives of this project are to evaluate recycled TuFF processing and resultant material mechanical properties using commercially available rCFs, demonstrate recycled TuFF forming processes meeting automotive rate requirements, and investigate transition opportunities with vehicle OEMs. The reviewer feels that the technical details in the presentation are thorough, and the project deliverables are considered successful. The reviewer also notes that this is a one-year project, and, within a few months, the team delivered on the progress as proposed, demonstrating good team management capability.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the rCF providers are the major collaborators for this project. They may have some communication difficulty, but they have been collaborating well overall. Mutual parties seem to have signed a non-disclosure agreement, and they are trying to co-develop the optimum process.

Reviewer 2

The reviewer noted that the PI is collaborating with various stakeholders from the suppliers and OEM.

Reviewer 3

The reviewer stated that the team is integrated with multiple different CF recyclers and directly using their samples which makes their collaboration excellent.

Reviewer 4

The reviewer commented that the team is highly aligned with key automotive players and their rCF supply chain.

Reviewer 5

The reviewer commented that the team includes Composites Automation LLC, Carbon Conversions, Inc., R&M International, Inc., and Carbon Fiber Recycling, Inc. The collaboration skillsets and coordination have been demonstrated by the successful project deliverables.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer explained that since the rCF quality significantly impacts the dispersion and TuFF process, the major focus is to validate the process by adding a cleaning pyrolysis step, then evaluating fiber dispersion using TuFF coupons. In general, the plan is good. The reviewer is uncertain whether the team is doing the cleaning step by themselves but highlighted that those steps are needed. It is also not clear whether the fiber length issue was solved. Also, there is an attempt to demonstrate processing with snap-cure, which is fine for now. The reviewer recommends that the team consider exploring the other resin system.

Reviewer 2

The reviewer commented that the project is ending very soon; however, the PI proposed future work that needs to be completed within the remaining very short time. The reviewer expressed concern regarding the PI's ability to accomplish the proposed tasks within the performance period.

Reviewer 3

The reviewer commented that considering the presentation was short and Phase I is ending, there was minimal focus on future research. For future work, the reviewer suggested that the team improve cycle time and evaluate insertion opportunities.

Reviewer 4

The reviewer commented that the TRL of this project appears to be rapidly advancing, and the future work is well aligned to demonstrate the utility of the process. An assessment of cost (could be relative even) and environmental impact would be beneficial to confirming the value of this process for making composites. The reviewer enquired about how much rCF is available for this process and if that would be the limiting factor for using in vehicles.

Reviewer 5

The reviewer explained that the proposed future research includes selecting OEMs for the Phase II component of interest, establishing requirements including structural performance, crash and fire, integration, manufacturing processes, designing, fabricating, testing, and validating recycled TuFF properties established in Phase II, implementing the recycled TuFF supply chain with recycling partners, and transitioning the process to Tier I or OEM partners. The presenter clearly defined the purpose for future work. With outstanding performance within a few months, the reviewer feels confident that the team will successfully conduct the proposed tasks for their future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project is highly relevant. The use of rCF of a specific fiber length to allow high-performance CFRP is a strong and unique technology, which is highly relevant for lightweight materials.

Reviewer 2

The reviewer commented that the project involves recycling of CFs which supports the VTO Materials subprogram objective.

Reviewer 3

The reviewer commented that this work is extremely relevant, especially as we consider more sustainable composites.

Reviewer 4

The reviewer stated that this process is a disruptive technology that could significantly enable the reuse of recycled fibers and inherently discontinuous fiber types.

Reviewer 5

The reviewer noted that the project directly links to the VRO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the team's resources are sufficient.

Reviewer 2

The reviewer commented that there are sufficient resources and support for this project.

Reviewer 3

The reviewer remarked that the project has had success that is in line with the project budget.

Reviewer 4

The reviewer recommended increasing the team's budget to incorporate the TEA/LCA of the developed process. The reviewer expressed interest in learning about the potential impact of this technology while noting that the abundance (or lack thereof) of rCF is the limiting factor. The reviewer also suggested addressing the current availability of the rCF.

Reviewer 5

The reviewer commented that the team consisting of Composites Automation LLC, Carbon Conversions, Inc., R&M International, Inc., and Carbon Fiber Recycling, Inc., provides sufficient resources for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT269
Presentation Title: Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene
Principal Investigator: Daniel Mulqueen, Climate Robotics LLC

Presenter

Daniel Mulqueen, Climate Robotics LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

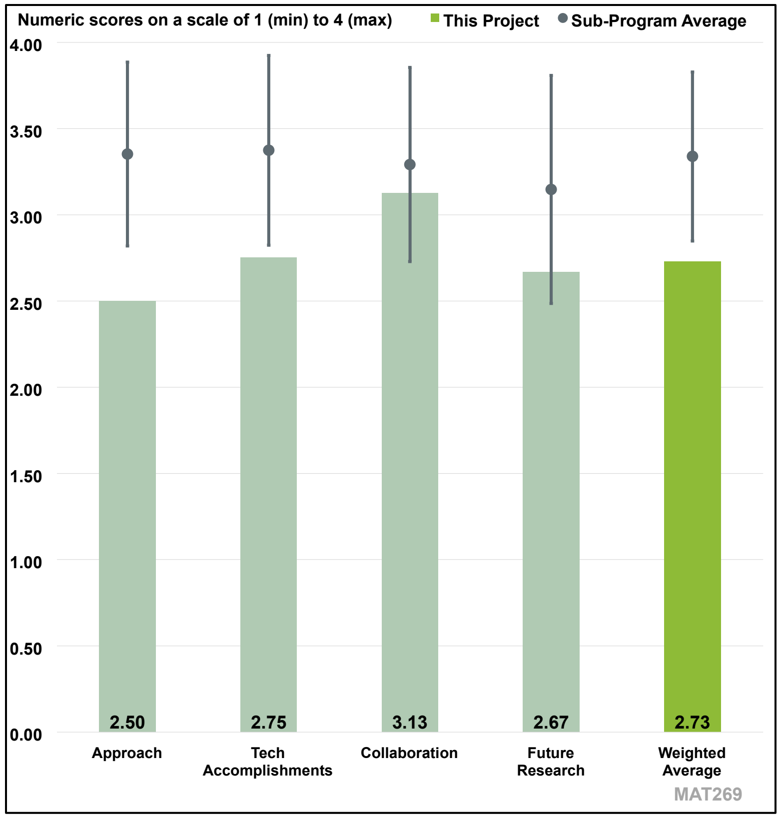

Figure 5-47. Presentation Number: MAT269 Presentation Title: Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene Principal Investigator: Daniel Mulqueen, Climate Robotics LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the presentation had clear points about the impact graphene would have on the composite materials for automotive applications, and the technical barriers to using graphene were clearly mentioned. The reviewer noted that the project was well-designed in its approach to creating cheaper and higher quality graphene from a renewable source, and the timeline for achieving the milestones was reasonable. The reviewer explained that main deliverables for the project concentrated on using the graphene in composites, which is very valuable, but it seems like the major barrier to entry for graphene is production cost and quality. However, not much was mentioned about the production of the graphene. The reviewer concluded there should have been more discussion about how this graphene production approach is better than existing methods.

Reviewer 2

The reviewer remarked that the project is well designed to address the main technical barrier. However, the reviewer believed that there appears to be a time constraint, and would like to see more characterization works to be accomplished.

Reviewer 3

The reviewer commented that barriers relevant to VTO subprograms were not clearly articulated enough but the relevance of graphene as a material was.

Reviewer 4

The reviewer remarked that this project was to develop a low-cost, bio-based process to make graphene. There was limited data on the process and the cost or any scaleup issues, and the graphic in the technical backup slides did not include the entire process. The reviewer acknowledged the team tried different conditions of temperature and catalyst loading and fabricated and tested samples to show some properties that seemed to be competitive to existing products.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that the project has demonstrated timely progress in making composites and quantifying their conductivity, flame resistance, and EMI shielding. Additional evidence to validate the claim of producing high-quality graphene would have been beneficial since the reviewer is not convinced that the composite is of high quality based on the provided data. The reviewer noted that there was a nice reduction in resistance using the graphene; however, the summary slide claims a resistance of one ohm per square surface resistance which appears very different from the resistance shown in the resistance values plot. The reviewer is interested in knowing the plan to achieve one ohm per square surface resistance.

Reviewer 2

The reviewer noted that the project is almost complete and has produced sound achievements. Overall, several tasks were accomplished related to the objective of the project goal.

Reviewer 3

The reviewer commented that it is difficult to judge the technical progress or merit without points of reference for the material produced and the property benchmarks established either from literature or industry. The reviewer is interested in understanding the potential cost savings of using corn compared to what is used commercially and requested that a perspective be provided on the relative cost of different biobased sources for creation of graphene, even if it is very general.

Reviewer 4

The reviewer remarked that there was no discussion on the technical process which was the focus of the project, and the project was difficult to review overall when comparing the objectives to what was reported. The reviewer commented that a key driver was cost reduction yet there was no indication of any cost analysis.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that great collaborations were formed with Johns Manville and Old Dominion Research Foundation and the presentation clearly mentioned the roles of each partner within this project. The reviewer concluded that the project seems well-coordinated and great partners were selected for this project.

Reviewer 2

The reviewer noted that the project PI is Climate Robotics; however, Johns Manville and Old Dominion University are the technical collaborators.

Reviewer 3

The reviewer expressed uncertainty about which project partners contributed to which part of the project.

Reviewer 4

The reviewer commented that the project partners fulfilled their roles within the scheduled time.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that at the time of the AMR, the project was very close to ending. Proposed future work regarding the approach to scale-up of the production process was discussed. The reviewer thinks the scale-up production of graphene is the most vital part of the future work and suggests confirming that high quality graphene should be produced prior to heavily investing in scale-up.

Reviewer 2

The reviewer commented that the project is completed.

Reviewer 3

The reviewer commented that nine unique conversion trials were run producing various Raman spectra D-band to G-and ratios between 1-1.24 and layers from 4-115. The reviewer acknowledged that the effect of phosphorous appears to be clear, but it is unclear from the other conditions evaluated what is driving these differences. The reviewer concluded that instead of scaling up, future work should also include refining the process parameters that affect conversion as well as gaining a better understanding of the sensitivity of graphene production to corn stover variability.

Reviewer 4

The reviewer stated that a plan should have been outlined to discuss process weaknesses that need to be addressed and further elaborated that there is no mention of cost models to determine competitiveness with current processes and no discussion of quality control or testing final products.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project supports the overall VTO Materials subprogram objectives and elaborated that graphene has many benefits to automotive composites. So, if the team can produce high quality graphene at low cost, then there are many applications for this material in the automotive industry in terms of lightweighting and multifunctionality.

Reviewer 2

The reviewer commented that the project is focused on fabrication using graphitization of corn stovers to produce polymer grafted nanoparticles , which support the VTO Materials subprogram objectives.

Reviewer 3

The reviewer remarked that graphene is expensive and using biobased sources appear to have immense potential to reduce the cost of these materials.

Reviewer 4

The reviewer noted that lower-cost, high-quality graphene that generates less carbon dioxide off-gas would help make these materials more competitive and useful for composite design supporting the VTO Materials subprogram, making the project objective very relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that the project is very close to ending so the funds are sufficient to achieve the remaining tasks.

Reviewer 2

The reviewer commented that the project has sufficient technical, equipment, and financial resources.

Reviewer 3

The reviewer noted that for the scope of work, the resources seem sufficient; however, increasing the budget to continue the work would enable a more thorough analysis of the sensitivity of graphene production on corn stover origin and composition.

Reviewer 4

The reviewer commented that the scope of the future work is very broad and includes process, product, and application development. The reviewer suggested developing a low-cost process that makes a product to match the quality of existing products.

Presentation Number: MAT280
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies
Principal Investigator: Amit Naskar, Oak Ridge National Laboratories

Presenter

Amit Naskar, Oak Ridge National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

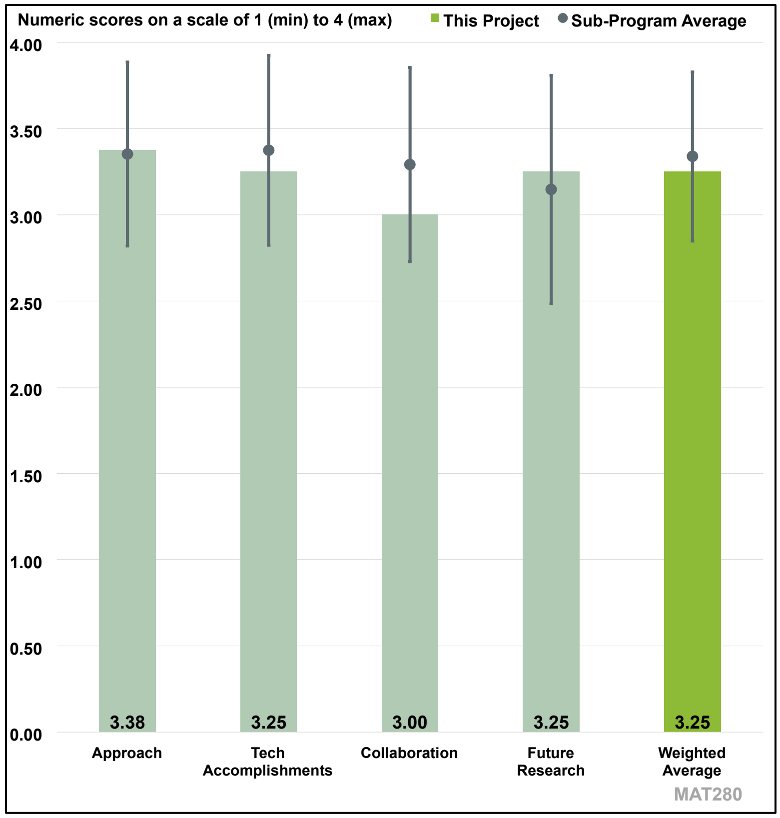

Figure 5-48. Presentation Number: MAT280 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies Principal Investigator: Amit Naskar, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the approach presented by the PIs appears adequate for achieving the project goal and further elaborated that this project is part of a larger effort made consisting of four thrusts, with this project being Thrust 1. Although the PI explained the contribution of this thrust area to the other thrust areas, the reviewer was not clear about the timelines by which the products from Thrust 1 must be delivered to Thrusts 2, 3, and 4. The reviewer expressed concern that the project is still in the early stages and only 15% of the work has been executed.

Reviewer 2

The reviewer remarked that the CCP 2.0 program is an ambitious undertaking. Breaking down the program into four primary thrust areas is well considered and allows for a broad range of activities crossing multiple technology areas. Thrust 1.0 was first reviewed at this AMR. This thrust area is subdivided into multiple projects; each with their own set of objectives, approach, accomplishments, and milestones. Evaluating these within the context of the PeerNet review system is much more challenging.

The reviewer noted that while the intention is to provide candid feedback, this task is made difficult by the breadth and diversity of the projects described under each thrust area. Technical barriers addressed by the presenters were relevant and included driving down the cost of high performance (e.g., 25Msi per 1.8g/cc specific modulus) fibers which is important and necessary to expand applications for fiber reinforced polymers in automotive components. One barrier speaks to supply chain reliability, but another barrier might suggest supply chain variability.

The reviewer further explained that high-performance fibers are highly, and most often, differentiated by supplier. A lack of standards for fiber reinforcement allows supply chain managers to build a broad base of qualified products with localized and global footprints which currently inhibit part manufacturers from making a transition to these materials because the risk of availability from a sole source of supply is too high to accept. The reviewer expressed interest in the DOE chairing an initiative to create relevant standards to qualify fiber suppliers.

Reviewer 3

The reviewer commented that the project aims to develop low-cost CF and alternative fibers from various sources and noted that the project is well designed, and the timeline is reasonable.

Reviewer 4

The reviewer commented that the aim of this project is to support the first pillar of the CCP 2.0 program, which focuses on developing low-cost fibers for composites. The reviewer explained that to achieve this goal, several comprehensive workstreams have been established and these workstreams are dedicated to the development of technology for several types of low-cost fibers including, polyolefins, carbon, UHMWPE, and natural fibers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that only 15% of the work has been completed and concluded that there is not much to report from a progress point of view.

Reviewer 2

The reviewer noted that this specific project encompasses six separate projects or tasks. Collectively, the research team is making fine progress on the objectives established for the thrust area. The reviewer explained that it is difficult to assess the progress wholly since each project can stand alone making it difficult to aggregate the accomplishments and evaluate the likely success of the final work product. The reviewer questioned if the objective for I.6.2 is to meet the same physical performance of CF equivalent specific properties of 25Msi per 1.8g/cc). The adoption of natural fibers to support sustainability goals may justify their use in many areas of commercial vehicles, but the fiber performance is unlikely to meet the CF equivalent metric. The reviewer concluded that making this clear would be useful and minimum performance metrics are needed to claim success.

Reviewer 3

The reviewer commented that although the project started only about six months ago, considerable progress has already been made.

Reviewer 4

The reviewer commented that considerable progress has been made on low-cost CFs, polyolefins, and UHMWPE fibers; however, work is still ongoing for natural fibers. The reviewer elaborated that a critical aspect missing in this task is the development of cost models to understand the expenses associated with producing these fibers using different methods.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that notable collaborators are PNNL and the University of Tennessee, Knoxville while acknowledging that the team has some unnamed industry partners. The reviewer concluded that this team appears to be adequate for executing the work.

Reviewer 2

The reviewer noted that the PI identified the collaborators in Thrust 1.0 and even identified the individual PI's working on each of the six subtasks but provided little detail about the role of each collaborator. The reviewer elaborated that this is less likely a weakness of the program and more a reflection of the challenges related to presenting such a wide range of activities in such a brief time making it difficult to describe each collaborator's role in the project. The reviewer concluded that it is of critical importance to include industrial partners in these efforts that can enable commercial viability and drive the adoption and implementation of these technologies.

Reviewer 3

The reviewer acknowledged that the project will be conducted in collaboration with the University of Tennessee, Knoxville, industry textile manufacturers and preform suppliers, ORNL, and PNNL. The specific industry members providing textile fiber precursors have not been specified. The reviewer noted that the project team previously reported significant delays due to a limited supply of fiber precursors and suggested developing a risk mitigation plan to prevent similar delays.

Reviewer 4

The reviewer praised the collaboration between this group and team members from the national laboratories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that only 15% of the work has been done and 85% percent remains to be executed. Not much can be said about future work now, except for the promised scope to be executed.

Reviewer 2

The reviewer explained that the future research work involves executing the work as described in the technical approach. However, there are specific future work elements that appear significant. The reviewer praised the CCP 2.0 goal to establish an industrial advisory board and acknowledged that this is highly recommended. The advisory board would have far more impact on project direction than the current AMR process and will be quite valuable. The reviewer noted that connecting with Tier 1 suppliers to facilitate technology transfer is significant. The reviewer suggested including details about costs and a path to scaleup in future work and noted this seems particularly relevant to the expansion of polymeric fibers and the polymer-fiber-reinforced polymers that hold much promise for high-rate production of lightweight materials.

Reviewer 3

The reviewer commented that the future work is well defined, and the targets are achievable.

Reviewer 4

The reviewer suggested that cost models be developed for each fiber system being manufactured in this project and further elaborated that, although the current process is focused on small-scale development, the cost models should be based on large-scale manufacturing. These models will help identify high-cost process steps and help refine the technology development.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project contributes to the production of affordable CF material for vehicle light weighting purposes.

Reviewer 2

The reviewer noted that the project's relevance cannot be questioned. Reducing cost, increasing availability, and scaling high performance reinforcements are critical steps toward expanding the use and applications in commercial automotive.

Reviewer 3

The reviewer stated that the project is highly relevant to the VTO Materials subprogram objectives.

Reviewer 4

The reviewer commented that the project is highly relevant as the United States goals to develop domestic technology for fiber production and acknowledged that fibers are currently manufactured outside the United States making the nation critically dependent on supply chain fluctuations and posing future safety risks.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that there is no indication that the allocated funds are insufficient or excessive considering the project is still in the initial stages of executing the work since only 15% of the work has been completed.

Reviewer 2

The reviewer remarked that $5.5 million to fund six projects at ~$300,000 per subtask per year appears low for the ambitious objectives identified. However, the reviewer would not like this statement to discourage the execution of this work. The reviewer suggested enlisting industrial partners where possible to support work such as inking processes as force multipliers for performing the work at the current funding level.

Reviewer 3

The reviewer commented that the project resources are sufficient.

Reviewer 4

The reviewer stated the resources proposed for the project are sufficient.

Presentation Number: MAT281
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures
Principal Investigator: Christopher Bowland, Oak Ridge National Laboratories

Presenter

Christopher Bowland, Oak Ridge National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

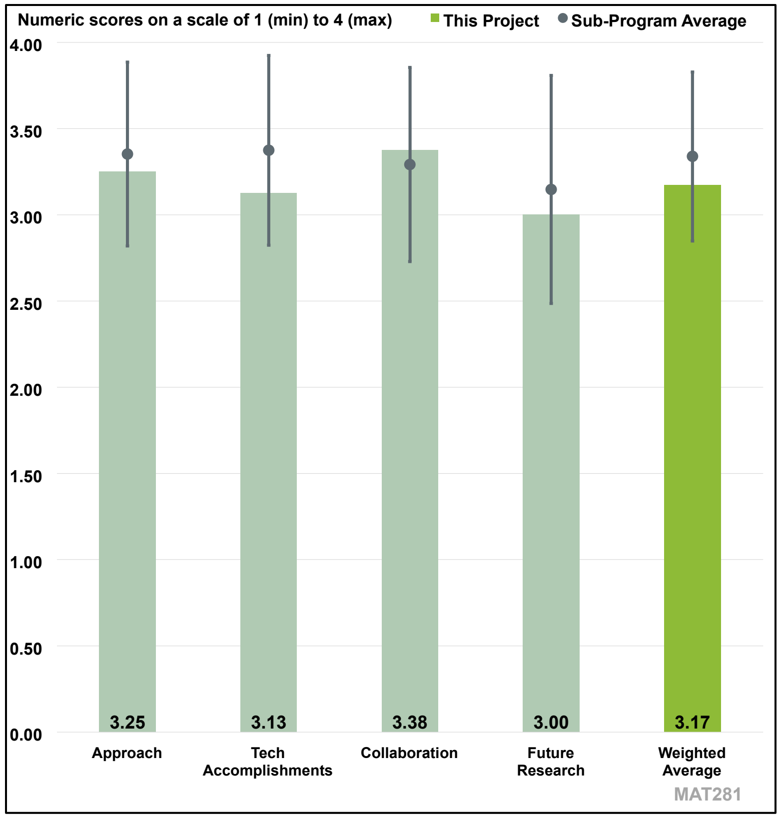

Figure 5-49. Presentation Number: MAT281 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures Principal Investigator: Christopher Bowland, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the primary objectives of the project are to enhance safety through SHM and damage detection or by increasing specific strength properties. This would suggest that the final composite materials developed would be integrated into the primary structure of future automobiles. The reviewer elaborated that there is no consideration for how vehicles are manufactured or the type of loads that are anticipated in service and this could result in a material system that fails to deliver on all appropriate material attributes. For this project to have a meaningful chance of success, the reviewer suggested that a fully defined pathway for how these materials will be implemented in practice, both by the Tier 1 supplier base and at the OEM should be developed.

Reviewer 2

The reviewer remarked that the approach is innovative and well planned because the program is attempting to develop multi-material systems such as NDE, life cycle monitoring, joining, assembling, inspection, painting, and processing of vehicles for improved manufacturing efficiency. The reviewer noted the focus is on six major tasks led by different PIs on the team.

Reviewer 3

The reviewer noted that the goal of each task was not clear in relation to the overall thrust goal because the project has six separate tasks. While it is understandable that there was not enough space to include all the information in the presentation, outlining the overarching goal and each deliverable would have been beneficial. The reviewer added that the topics, which were a mixture of highly exploratory and continuous efforts, were good and recommended soliciting industry feedback about each task to define the deliverable targets that will be impactful to industry. Some of the project task directions seemed to be decided based on researchers' intuition. The reviewer concluded that, for the technology developed in each task, it would be good to define the current state-of-the-art technologies as benchmarks and determine viable targets for each task (with industry feedback) to truly make an impact.

Reviewer 4

The reviewer remarked that the project is Thrust 2 for the CCP 2.0 program titled Multi-functional Materials and Structures and aims to develop technologies in several areas to make multifunctional composites. These areas are defined as (1) self-health monitoring, (2) embedded and over-molded electronics, (3) sensing and energy harvesting, (4) improved thermal management, and (5) improving the fatigue behavior. The reviewer concluded that the approaches developed in each of these areas are excellent.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the milestones are written without performance improvement targets, therefore, it is difficult to determine if the targeted percentage increase will have a meaningful impact on performance of the resulting parts. The same applies to the Go/No-Go Decision gateway for II.4. The reviewer remarked that the overall objective is to achieve a 30-50% mass saving for a load bearing fiber reinforced component; however, no quantitative metrics are included. The reviewer concluded that it is unclear how this goal will be achieved.

Reviewer 2

The reviewer remarked that the program appears to be on target to complete the major milestones considering the project started recently and only 5% of the work has been completed.

Reviewer 3

The reviewer commented that, considering this is a new project, the progress to date is decent. Although most of milestones are not SMART (not much measurable values), which makes it difficult to assess the progress, the milestones appear to be met. The reviewer also stated that it is difficult to assess the progress of each task.

Reviewer 4

The reviewer attributed great results for the damage characterization of composites and suggested developing a piece of equipment to demonstrate the technology effectively. Not much information was provided for over-molded electronics. The reviewer was curious about the plans for this development. Outlining the next steps and expected outcomes would be beneficial to better understand the direction and goals of this project. The sensing and energy harvesting work has been delayed and it would be desirable to provide more details on the reasons for the delay and the updated timeline for this work. Understanding these aspects would help in adjusting expectations and planning accordingly. Regarding the development of thermal capabilities, CNTs were proposed as a solution. In the results section, only the improvements in the strength and stiffness of the neat resin with embedded CNTs were provided. While these improvements are noteworthy, the electrical properties of the composite with CNTs are also very interesting and important. The current study focused only on neat resin; however, the composite properties, which combine the resin with reinforcing fibers, would likely provide more relevant and valuable insights. The reviewer wanted to know more about the plans to study the CNTs in the composite material and the proposed manufacturing process for embedding the CNTs in the composite. Understanding the methodology and approach will help in assessing the feasibility and potential impact of this development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that there appears to be a large network of companies and institutes that are listed as supporting the project; however, how communications are being coordinated across such a large team of contributors is unclear.

Reviewer 2

The reviewer commented that the assembled team consisting of national laboratories, universities, and industry partners is very strong and has the capabilities to complete the work.

Reviewer 3

The reviewer commented that some of the tasks have collaboration, while others do not. The reviewer remarked that having more industrial feedback would be good and acknowledged that once the advisory board is selected, this problem may be solved. Noting for some of the more mature concepts, particularly the continuous ones, the greater industry engagement is recommended so what is practically important and impactful can be properly assessed. .

Reviewer 4

The reviewer praised the excellent collaboration between the project teams.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project team could benefit from identifying a potential end use application to establish a more comprehensive list of performance requirements and noted identifying an end-use application would ensure all necessary requirements and constraints are considered not only in service needs but also in part production and vehicle assembly.

Reviewer 2

The reviewer observed that goals have been clearly identified; however, there is ambiguity about how all the six tasks will be integrated and demonstrated in one event or structure. Also, sensing work is very basic and will require much more effort than is currently planned. Testing will be done only at the coupon level which may not be able to encompass all the developments from the six tasks areas. The reviewer suggested that a more complex program structure could be targeted if time and budgets permit.

Reviewer 3

The reviewer commented that the future tasks that were listed are reasonable; however, the purpose of each future work is unclear. This comment is related to clearly defining the end goal. Since the end goal is not well defined, future work sounds more like incremental development, which may or may not be impactful for vehicle technology.

Reviewer 4

The reviewer suggested developing a piece of equipment to demonstrate the technology effectively. The reviewer further asked for the plans for the over-molded electronic circuit board development. CNTs were proposed for the development of thermal capabilities; however, only the improvements in the strength and stiffness of the neat resin with embedded CNTs were provided in the results section. While these improvements are noteworthy, the reviewer noted that the electrical properties of the composite with CNTs are also very interesting and important. The current study focused only on neat resin; however, the composite properties, which combine the resin with reinforcing fibers, would likely provide more relevant and valuable insights. The reviewer asked for the plans to study the CNTs in the composite material and the proposed manufacturing process for embedding the CNTs in the composite. Understanding the methodology and approach will help in assessing the feasibility and potential impact of this development.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the proposed research is aligned with the VTO mission statement.

Reviewer 2

The reviewer commented that the program directly targets multi-functional structures for vehicles that is a goal of VTO Materials subprogram.

Reviewer 3

The reviewer remarked that the project is relevant to lightweight materials; however, the targets and expected impacts should be more clearly defined.

Reviewer 4

The reviewer commented that the project is very relevant to support the VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that adequate resources appear to be deployed to complete the proposed work plan.

Reviewer 2

The reviewer remarked that the team comprised of national laboratories, a university, and industry who are well versed in the program areas.

Reviewer 3

The reviewer commented that the resources are sufficient.

Reviewer 4

The reviewer commented that the project has sufficient resources to complete the project tasks in a timely manner.

Presentation Number: MAT282
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

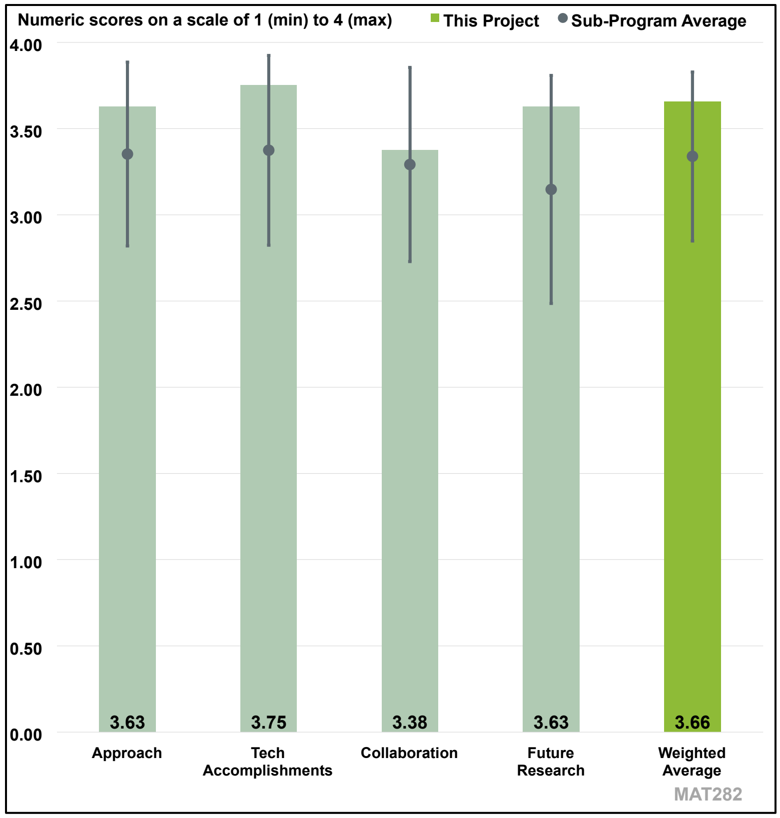

Figure 5-50. Presentation Number: MAT282 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project design and timeline are “Good!” as a response.

Reviewer 2

The reviewer concluded that the general target and topic of Thrust 3 is very important, which targets to address circularity and sustainability of polymer composites; however, because of lack of space and time for the presentation, various details were unclear. Each task should clearly define the target performance as a deliverable, especially as measurable SMART values. Showing milestones as percentages of completion is not necessarily good because that becomes relative to something, which may not be an actual standard or a comparable control value.

The reviewer pointed out for Task III.1 “Waste to Fiber,” that while the use of deconstructed PET waste as one of the building blocks is a good approach, the sustainability of the produced fibers is unclear. Octadecyl acrylamide co-polymer and polydiacetylene monomers are not waste-based, and they are the major component in the mass. The reviewer suggested a very quick LCA (and maybe

TEA) to roughly estimate GHG emission and energy inputs. Most likely the process is not so sustainable. The reviewer believes that targeting high molecular weight polymers is good and important for fiber spinning. The milestone of achieving 60% recovery of polydiacetylene is not clear because it may be referring to deconstructing the fiber again. If so, the total recovery of the monomer should be close to 100%. Also, polyaramid is an industrial grade fiber. The reviewer recommended some quick feedback from industry if this approach is truly attractive for making a significant impact.

The reviewer provided comments on “III. 2 Shredded Automotive Waste”. The reviewer deduced that the purpose of this task may be focusing on the separation of automotive wastes. Understanding the path and process for the separation of automotive waste is very important for the planned effort and makes sense. But then, the reviewer believes the project is targeting mechanical recycling or pyrolysis. Mechanical recycling must be able to separate a very clean waste feedstock; otherwise, it would become downcycling. Removal of halogen is important for pyrolysis, and the focus on removal of halogen makes sense. Pyrolysis can treat mixed waste, but energy inputs are generally high. The reviewer suggests performing a quick LCA on the process which is important to check if the pyrolysis process seems viable from a sustainable standpoint. As the process develops, other techniques should be considered for possibly treating mixed plastic wastes, which are assumed to be most of automotive wastes. The reviewer recommended investigating several recent technologies, especially in chemical recycling, which can address some of the mixed plastic waste challenges.

The reviewer provided insights for “III. 3 Bio-derived PECAN for Steel Replacement”. The task focuses on bio-based vitrimers developed by NREL during the CCP 1.0 phase and on mixing fiber compositions with natural fiber etc. Before going to Task 3 of manufacturing demonstration, the reviewer stated that the technology needs to meet the required mechanical properties, which are unclear as stated in the project scope (e.g., 75% of PECAN CFRP). PECAN CFRP by itself does not seem to meet the required mechanical properties needed to replace steel. While it highly depends on fiber loading and types of fibers, the reviewer suggests that this task needs to clearly define and understand the baseline of the current steel or CFRPs for the targeted car parts. Low mechanical strength composites may be useful for some of the interior parts, but structural parts will require much higher strength. Also, enhancing ductility is not necessary a good thing for most of car parts. Again, the reviewer reiterated that the researchers need to carefully check required mechanical properties of each of the car parts as well as their manufacturing process. The target values of the mechanical properties (e.g., tensile strength, tensile modulus, three-point bending strength, interlaminar shear strength, etc.) need to be clearly defined with a listing of the current mechanical properties of the relevant car parts.

The reviewer commented on task “III. 4 High-Throughput Recycling of Long CF from Cured Thermoset Composites”. The reviewer observed that the approach is to develop solvolysis technology for deconstructing epoxy thermoset to recover longer CFs. This is a great technology, and the reviewer believed this is a good task. One potential challenge is solvolysis in a high-temperature, high-pressure system. The reviewer suggested carefully designing the scalability of the technology, which is tricky due to the high-temperature, high-pressure process. The reviewer added that receiving feedback from industry is important and the approach should address industry’s needs.

The reviewer commented that the technical barriers addressed by this project are the ability for low-cost, high-volume manufacturing of CFs that are sustainable and recyclable. This addresses a VTO Materials subprogram goal with a metric to reclaim 85% of composites used in automobile body structures. The reviewer noted that the project is part of an overall effort entitled “Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites” that focuses on developing low-cost, low-carbon emission routes to reintegrate wastes into the composite materials supply chain and to realize a circular economy with polymeric products for applications of composite materials used in vehicles. The reviewer explained the approach is to produce and commercialize industrial-grade polymers and automotive composites from circular or renewable feedstocks with properties rivaling petroleum-derived materials while reducing manufacturing costs by $5/kg which aligns with the overall goal of the VTO Materials subprogram. This approach is targeting a reuse amount >95% of components, saving >50% manufacturing cost, and achieving >75% GHG emission reduction and >50% embodied energy reduction which meet or exceed the VTO Materials subprogram goals for composite materials.

The reviewer remarked that this project also relies on research being conducted in another area: “Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies” to complement the research over the period of this project; however, no project schedule was presented to show this relationship. The reviewer noted this approach supports a well-designed effort that can be accomplished within a reasonable timeline. Additionally, it offers new strategies to address sustainability through use of biobased and recycled materials and scalable manufacturing methods for low-cost, low-emission technologies to reintegrate waste and renewables into the composite materials supply chain while maintaining the required mechanical properties. The reviewer concluded that all efforts are consistent with the VTO Materials subprogram goals for composite materials.

Reviewer 3

The reviewer commented that the project was well designed with new strategies to address sustainability and offer scalable manufacturing solutions to achieving low-cost, high-volume manufacturing, low-cost carbon emission, sustainability, and recyclability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer questioned why only PET is mentioned in Task III and how the plastic sorting and collection for automobiles is put into the LCA database. The reviewer also questioned what technologies will be evaluated in relation to automobile plastics: the automobile shredder residue or automobile fluff, and/or the plastic sorting and technology. The reviewer expressed curiosity about the benefit of doing this work in terms of the LCA.

Reviewer 2

The reviewer commented that the project has demonstrated, substantial progress considering this is the first year noting the high molecular weight polyaramid was successfully synthesized. The reviewer questioned how the literature review for halogenated waste stream, tailoring the glass transition temperature, and designing the initial tests of hybrid composites with PECAN were conducted. Successful solvolysis of epoxy composites was also performed. The reviewer suggested that some of the target goals be carefully evaluated and early feedback from industry should be solicited because certain approaches may be irrelevant or off-target. The reviewer concluded that conducting an early-stage LCA or TEA to obtain ballpark estimates are important.

Reviewer 3

The reviewer commented that this project is in the initial stages and was only 10% complete as of the presentation at the 2024 VTO AMR. The technical accomplishments demonstrate early success toward meeting project goals by producing a copolymer synthesized in house from three components (TCl, polydiacetylene, and octadecyl acrylamide) that showed a molecular weight >10,000 grams per mole for the resulting poly(p-phenylene terephthalamide) and oxydiphthalic acid copolymer; publishing a report titled “Circular Economy for Automotive Shredder Reuse” on the circular economy for unwanted shredded automotive waste; conducting a techno-economic analysis and LCA on current resins got demonstrating a >40% reduction in GHG emissions resulting in an open literature publication; demonstrating that resin formulation can lead to high glass transition temperature materials which work with different reinforcements; and demonstrating a >70% reduction of embodied energy and a >75% reduction of GHG emissions relative to virgin fiber production. The reviewer noted that there was no project schedule presented that would define the project plan; however, the accomplishments are significant and consistent with the approach, project milestones, and VTO Materials subprogram goals.

Reviewer 4

The reviewer remarked that the project is on track. The team has demonstrated high molecular weight PET-derived copolymers, achieved a >70% reduction of embodied energy and a >75% reduction of GHG emissions for solvolysis recycling relative to virgin fiber production, demonstrated PECAN resin applicability and >20% reduction of first life GHG emissions through resin use alone. The reviewer praised the team for remarkable project results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer noted that, besides the Thrust 3 members, outside collaboration by the project team was unclear, and added that industry engagement, at least as in an advisory capacity, would be very important.

Reviewer 3

The reviewer highlighted the collaboration and coordination between three national laboratories: ORNL, PNNL, and NREL with no stated involvement by industry or academia and noted the appropriateness of the collaboration is likely due to the early-stage research being undertaken. The reviewer praised the coordination within the teams at the three national laboratories and within the overall Materials CCP (Thrust I support for Thrust III) and mentioned that there were no other areas identified requiring more collaboration.

Reviewer 4

The reviewer praised the collaboration between, PNNL, ORNL, and NREL and mentioned that, as the project progressed, industry partners may help with scale up.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer recommended evaluating the biodegradability of the bio-derivable and recyclable composites.

Reviewer 2

The reviewer commented that in terms of their current targets, the plans for future research seemed reasonable. However, the reviewer expressed uncertainty about how well certain approaches are truly addressing the path for circularity and sustainability. Most of the targets and target values appeared to be created based on the PIs' intuition without receiving inputs from industrial personnel. The reviewer suggested that the PIs carefully think through what truly successful outcomes would be after three years. In conclusion, the reviewer questioned whether industry would rapidly adopt the proposed technology if the PI achieved the current goals. In a sense, will industry adopt rapidly if PIs achieve the current goals?

Reviewer 3

The reviewer commented that the project presentation clearly defined the future research required to achieve the project targets and goals. The reviewer explained that there were six remaining challenges identified that would require future research: (1) conversion of high-performance polymers to fibers for composites applications, (2) high molecular weight of catalytic polymerizations from waste PET, (3) halogen materials separation, (4) ensuring resin compatibility with two different polymer matrices, (5) low throughput and equipment requirements for current solvolysis methods, and (6) interfacial strength of rCF with matrix resin for new composites. These challenges will be addressed by future research efforts to demonstrate circularity in aramid fibers, investigate catalytic amidation to produce high-value polymers, demonstrate CF and matrix resin recycling from cured thermoset composites under atmospheric pressure, develop analysis models for atmospheric pressure recycling scenarios, and evaluate sorting and separation technologies.,

The reviewer further detailed the project research focus areas which included identifying impacts of halogens in the waste stream and how to separate them, utilization of automotive shredder residue materials as feedstocks for composite formulation and the development of high performing recyclable and hybrid composites. Performance progress that demonstrates a >75% strength and a 50% more ductility for CFRCs analyses that concluded hybrid composites can result in first and second life benefits, and a 50+% reduction in the cost, energies, and GHG emissions for the first life of a composite, all reflect a well-planned effort that should result in achieving the project targets.

Reviewer 4

The reviewer commented that the proposed future research has clearly defined tasks for PNNL, ORNL, and NREL, and likely achieve the targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer commented that the circularity and sustainability of lightweight materials is highly relevant and very important research activity for future.

Reviewer 3

The reviewer commented that this project is directly relevant to the VTO Materials subprogram goals and metrics for CF and composites to achieve low-cost CF, reduced manufacturing costs, recyclability, and reduced carbon footprint.

Reviewer 4

The reviewer commented that the project is timely and would provide increased sustainability in opportunities to use biobased and reutilize existing materials, generate low-cost feedstocks from automotive shredder residue, and re-integration of these materials back into in-vehicle applications. The recyclable nature of these composites will enable 25+ wt.% reduction at <$5/lb weight savings. The reviewer explained the proposed technology has the potential to achieve >70% reduction in embodied energy and GHG emissions, >50% reduction in manufacturing cost while maintaining >90% mechanical properties for second life uses in automotive CFRPs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer noted that the project resources are sufficient.

Reviewer 3

The reviewer highlighted that this project has current and future funding of $1,350,000 per year over three years and is part of an overall effort under a thrust area titled "Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites". The reviewer explained that the project involves at least nine co-principal investigators and three national laboratories and use of their research facilities to conduct basic research on polymers and composite materials. The reviewer added that the funding and facilities for this project are considered sufficient to achieve the project objectives by the end of the performance period.

Reviewer 4

The reviewer commented that three national laboratories (PNNL, ORNL, and NREL) have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT283
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing
Principal Investigator: Vlastimil Kunc, Oak Ridge National Laboratories

Presenter

Vlastimil Kunc, Oak Ridge National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

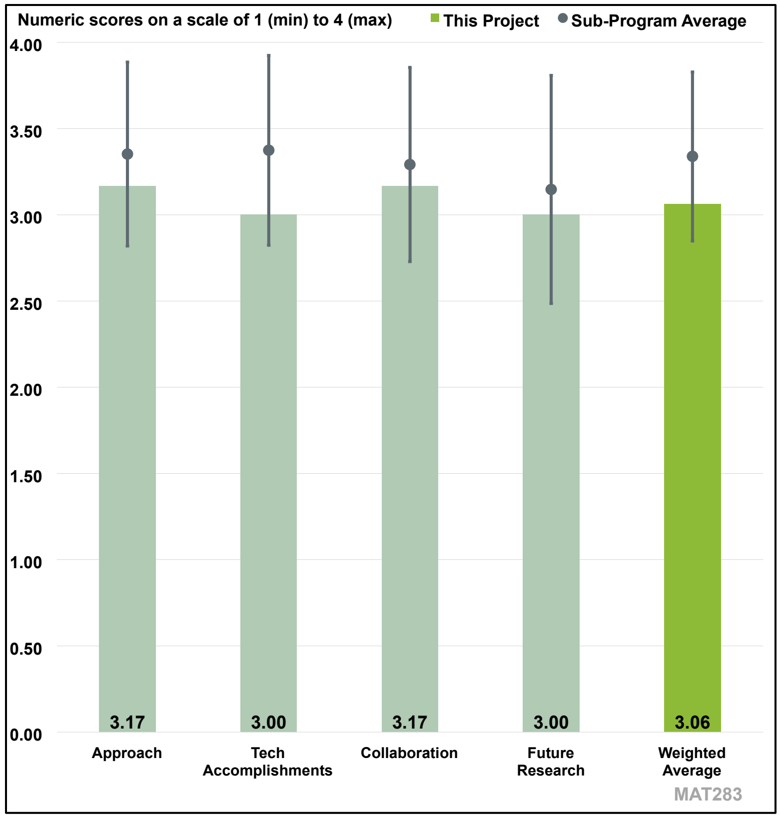

Figure 5-51. Presentation Number: MAT283 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing Principal Investigator: Vlastimil Kunc, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the AM compression molding has been demonstrated for laboratory scale parts, but the scope of work should include a verification step to ensure that the shape complexity can be achieved in conventional injection molding and maintained. The reviewer explained that, if more manufacturing constraints to part design are required, the adoption of the technology might be limited. The reviewer recommended that the project team consult with potential Tier 1 suppliers to determine what other obstacles my exist that would prevent implementation.

Reviewer 2

The reviewer commented that there can be no argument against the barriers stated by the PI to the wider adoption of high-performance composites in commercial automotive applications. The reviewer suggested that more emphasis be placed on the production challenges that impact high labor input, geometry control, labor content, capital expense (in tooling and manufacturing equipment), lack of standardization in the materials, etc. Nonetheless, the PI has done well to relate the current barriers to adoption (within such a broad set of project work).

The reviewer noted that the technical approach was difficult to evaluate amongst a broad set of project activities (i.e., five independent projects within the thrust area). The reviewer remarked that more effort in processing technologies to drive out cycle time is needed. Project IV.1 is a wonderful example of innovative technologies that hybridize multiple technologies (fused deposition modeling "printing" combined with continuous fiber compression molding). The reviewer commented that this technology would be more compelling if there were a more detailed definition of potential candidate parts to demonstrate part consolidation, potential weight reduction and ultimately cost/unit of weight saved. The reviewer suggested more details related to the potential of other AM technologies to meet cycle time or discussion of deposition rates that would allow one to infer cycle time based upon component mass is worthwhile. The reviewer concluded that establishing targets for the hierarchical materials may be worth considering.

Reviewer 3

The reviewer commented that AM of polymeric materials and composites is timely and of significant importance for the automotive industry to achieve light-weighting, multifunctionality, and deep decarbonization. The reviewer added that the project is well designed to address affordability, cycle time, predictability, light-weighting, and sustainability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the experimental investigations and corresponding simulation are based upon materials (e.g., glass fiber and acrylonitrile butadiene styrene) that are not commonly used for automotive structural parts, so the team should consider directing future work using materials that are appropriate for the target applications being proposed. The reviewer also suggested placing a stronger emphasis on the business case for implementation of each of the specific technologies under development.

Reviewer 2

The reviewer commented that it remains a challenge to review five projects and provide a detailed assessment of technical progress when the detail contained in the project presentation is insufficient. The reviewer explained that this is NOT the fault of the program or the reporting PI but a result of limited time available to report on such a wide range of activity. Regarding project evaluation, the reviewer remarked that the five projects presented for evaluation are highly disparate in their direction and technology. This left the reviewer questioning whether this is intentional or a result of the nature of the PI's leading each project. The reviewer expressed difficulty in determining a common thread between these efforts that would suggest they belong within a singular technology thrust area but praised the progress reported. The reviewer concluded that it is not clear how the identified targets will be measured and achieved or what the established baseline is to compare against because of the early stage of research for the CCP 2.0 program.

Reviewer 3

The reviewer commented that the project, which started in January 2024, has all tasks on track and has already made considerable progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that this is a multi-laboratory project that includes collaborations with academic institutions as well as Nissan as an OEM and suggested the team consider Tier 1 supplier engagements to ensure the technologies under development align with future investment plans of automotive suppliers.

Reviewer 2

The reviewer commented that the collaborating entities are identified; however, the roles and responsibilities of the collaborating institutions are not clearly stated. The reviewer noted that this would be useful to specify and would aid in judging the teaming effectiveness and how interactions will be conducted, redundancy minimized, and technology transfer (if any) will be accomplished.

Reviewer 3

The reviewer praised the team collaboration which included: Nissan North America, Orbital Composites, University of California Berkley, University of Tennessee, University of North Texas, and University of Oklahoma each of which has specific tasks and deliverables.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the economics and manufacturing feasibility of 3D printing at high volume (>100,000 parts per year) should be an integral part of the program to ensure the business case can compete with other emerging technologies.

Reviewer 2

The reviewer commented that there is limited information provided and insufficient time allotted to describe five projects in a 20-minute period. The reviewer assume the technical activities outlined by the technical approach will be successfully executed and anticipates seeing the project results presented at future reviews or to participants of an external industrial advisory board.

Reviewer 3

The reviewer commented that the future research will follow planned tasks and coordinated tasks with collaborators to achieve the targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the work is aligned with the VTO Materials subprogram mission statement.

Reviewer 2

The reviewer commented that the relevance of Thrust IV with the broader CCP 2.0 program should not be questioned. The reviewer explained that more focus on specific applications would favorably impact the thrust area relevance; however, it is rather early in the project to suggest that opportunity does not exist. The reviewer noted the project could benefit from more industrial partners at all points in the value chain (material and equipment suppliers, tier ones, and OEM’s), however, there are many other opportunities within other VTO initiatives to engage those partners. The reviewer concluded that it might be interesting to see where the explored technologies in Thrust IV could be injected within active VTO programs or new initiatives that are competitively bid.

Reviewer 3

The reviewer noted that new sustainable feedstocks are needed for AM of automotive composites to reduce carbon intensity, energy consumption, and production costs while improving product performance,

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that there appears to be sufficient resources to complete the proposed work plan; however, it is not clear what TRL each of the technologies will achieve by the end of the project.

Reviewer 2

The reviewer commented that the total thrust area annual funding of $1.4 million means that each of the five projects are funded at less than $300,000 per year. The reviewer noted that these are ambitious efforts and funding seems limited, but this reviewer assessed that the appropriateness of the resources was sufficient based on technical progress reported in the budget period.

Reviewer 3

The reviewer commented that ORNL, Nissan North America, Orbital Composites, University of California Berkley, University of Tennessee, University of North Texas, and University of Oklahoma have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Acronyms and Abbreviations - MAT

Abbreviation	Definition
μm	Micrometer
3D	Three-dimensional
4M	4M Carbon Fiber Corporation (team member)
4XT	4X Technologies, LLC
A380	Designation for the most specified Al alloy that has the best combination of casting, mechanical, and thermal properties
ACMZ	Aluminum-copper-manganese-zirconium
AI	Artificial intelligence
AI/ML	Artificial intelligence/machine learning
Al	Aluminum
Al-MMC	Aluminum metal matrix composites
AM	Additive manufacturing
AM60B	A castable Mg alloy with excellent ductility, superior energy absorbing properties, and good strength and castability -
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AS4	A high strength, high strain, continuous carbon fiber made by Hexcel
AZ91D	A high-purity Mg cast alloy with excellent corrosion resistance, castablilty, and good strength
BEV	Battery electric vehicle
CALPHAD	CALculation of PHAse Diagrams (software by CompuTherm)
CANMET	Canadian Centre for Mineral and Energy Technology
CCF	Continuous carbon fiber
CCP	Composites Core Program
CCP 2.0	Phase 2 of the Composites Core Program
CF	Carbon fiber

Abbreviation	Definition
CFRC	Carbon fiber reinforced composites
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CNT	Carbon nanotube
Co	Cobalt
CRADA	Cooperative research and Development Agreement
Cu	Copper
DOE	U.S. Department of Energy
DRIVE	Driving Research and Innovation for Vehicle efficiency and Energy
EERE	Office of Energy Efficiency and Renewable Energy
e.g.	For example
EJOT	EJOT Group, supplier for engineered fasteners and joining technology
EJOWELD CFF®	Product name for a commercial friction welding process
EM	Electromagnetic
e-motor	Electric motor
EMI	Electromagnetic interference
etc.	et cetera (and so forth)
EV	Electric vehicle
Fe	Iron
Ford	Ford Motor Company
FSLW	Friction stir linear welding
FSP	Friction stir processing
F-SPR	Friction self-piercing rivet
FSW	Friction stir welding
FY	Fiscal year

Abbreviation	Definition
g/cc	Grams per cubic centimeter
G3-5M	A grade of cold-hardened nickel-based steel alloy with 5% molybdenum
GHG	Greenhouse gas
GM	General Motors
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
h	Hour
H11	Chromium-based steel alloy from the “H” family of steels with outstanding impact toughness
HiVe	High velocity
HPDC	High-pressure die-casting
HP-RTM	High-pressure resin transfer molding
HTC	High-temperature carbonization
HTC6 and HTC8	High-temperature carbonization trial number
ICME	Integrated computation materials engineering
I, II, III, IV	Roman numerals for 1, 2, 3, 4
IMC	Intermetallic compound
Inc.	Incorporated
in/min	Inches per minute
iPP-CF30	Designation used for a specific sample
JR	Company name JR Automation
kg	Kilogram
ksi	Kilopound per square inch
KUKA	Company name for Keller und Knappich Augsburg, manufacturer of industrial robots
kWh/lb.	Kilowatt hours per pound

Abbreviation	Definition
LCA	Life cycle analysis
LightMAT	Acronym for the Lightweight Materials Consortium
LLC	Limited liability corporation
LLDPE	Linear low-density polyethylene
LMCP	Lightweight Metals Core Program
LoukusTech	Loukus Technologies, Inc.
LTC	Low temperature carbonization
M	Million
MESC	Multifunctional Energy Storage Composites
Mg	Magnesium
ML	Machine learning
MMC	Metal matrix composites
Mn	Manganese
MoS_2	Molybdenum disulfide
MPa	Megapascal
MRD	Molecular Rebar® Design
MRL	Manufacturing readiness level
Msi	Megapound per square inch
MXene	The name for a new class of graphene like two-dimensional transition metal carbon (nitrogen) compounds
N/A	Not applicable
NDE	Nondestructive evaluation
Ni	Nickel
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory

Abbreviation	Definition
P1A	Project task within Thrust 1 of the LMCP
P1B	Project task within Thrust 1 of the LMCP
P1C	Project task within Thrust 1 of the LMCP
P1C1 and P1C2	Project task within Thrust 1 of the LMCP
P2A	Project task within Thrust 2 of the LMCP
P2B	Project task within Thrust 2 of the LMCP
P2C	Project task within Thrust 2 of the LMCP
P3A	Project task within Thrust 3 of the LMCP
P3B	Project task within Thrust 3 of the LMCP
PAN	Polyacrylonitrile
PECAN	Polyester Covalently Adaptable Network
PET	Polyethylene terephthalate
PI	Principal investigator
PMCP	Powertrain Materials Core Program
PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PVDF	Polyvinylidene fluoride
R&D	Research and development
rCF	Recycled carbon fiber
SBIR	Small Business Innovation Research
ShAPE™	Shear assisted processing and extrusion
SHM	Structural health monitoring
SLIC	Sustainable Lightweight Intelligent Composites
SMART	Specific, Measurable, Attainable, Relevant, Timely
SMC	Sheet molding compound

Abbreviation	Definition
Sn	Tin
SRNL	Savannah River National Laboratory
T6	Temper designation for Al that is heat-treated at a temperature between 325°F and 400°F to increase the strength
TCl	Terephthalolyl chloride
TEA	Techno-economic analysis
TiB_2	Titanium diboride
TPIC	Tillotson Pearson Incorporated Composites
TRA-C	Company name TRA-C Industrie, a FSW supplier
TRL	Technology readiness level
TuFF	Tailorable universal Feedstock for Forming
UCC	Ultra conductive copper
UHMWPE	Ultra-high molecular weight polyethylene
U.S.	United States of America
USW	Ultrasonic spot welding
VDA	Company name for Verband der Automobilindustrie, the German Association of the Automotive Industry
vs.	Versus
VTO	Vehicle Technologies Office
Zr	Zirconium

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6. Technology Integration

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well as innovations in connected infrastructure for significant systems-level energy efficiency improvement); combustion engines to reduce greenhouse gas (GHG) emissions; and technology deployment and integration at the local and state level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy and the U.S. Department of Energy (DOE), the VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

VTO's Technology Integration (TI) program supports a broad technology portfolio that includes alternative fuels, energy efficient mobility systems and technologies, and other efficient advanced technologies that can reduce transportation energy costs for businesses and consumers. The program provides objective, unbiased data and real-world lessons learned to inform future research needs and support local decision making. It also includes projects to disseminate data, information, and insight, as well as online tools and technology assistance to cities and regions working to implement alternative fuels and energy efficient mobility technologies and systems.

The TI goals are to strengthen national security through fuel diversity and the use of domestic fuel sources, reduce transportation energy costs for businesses and consumers, and enable energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 6-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaborations	EEEJ	Weighted Average
TI141	Integrated Fuel Cell Electric Powertrain Demonstration	Prateek Vaish (Cummins)	6-5	3.00	3.00	3.17	3.33	3.00	3.10
TI142	Field Demonstration of a Near-Zero Tier 5 Compliant Natural Gas Hybrid Line-Haul Locomotive	Bart Sowa (Gas Technology Institute)	6-9	3.20	3.40	3.20	3.60	2.80	3.24
TI144	Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program	Andrew Klock (Nation Fire Protection Association)	6-14	3.63	3.63	3.75	3.63	3.38	3.65
TI145	Electric Vehicle Market Stimulation in Divested Economies	Jenna Znamenak (Metropolitan Energy Center)	6-18	3.50	3.33	3.33	3.33	3.33	3.37
TI146	Rural Reimagined Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia	Pingen Chen (TN Tech)	6-21	3.75	3.63	3.63	3.88	3.75	3.69

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaborations	EEEJ	Weighted Average
TI147	Affordable Mobility Platform	Connor Herman (Forth Mobility)	6-25	3.63	3.50	3.13	3.50	3.63	3.39
TI148	Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network	Robert Blake (Native Sun Community Power Development)	6-29	3.50	3.25	3.25	3.50	3.88	3.39
TI153	Fleet Research Energy Data and Insights	Alicia Birky (National Renewable Energy Laboratory)	6-33	3.50	3.38	3.25	3.50	3.13	3.34
TI154	Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER)	Michael Graham (Columbia-Willamette Clean Cities Coalition)	6-37	3.50	3.20	3.10	3.10	2.90	3.18
TI155	Charge To Work USA	Jason Zimbler (CALSTART)	6-42	3.40	3.30	3.40	3.50	3.50	3.40
TI156	Leadership of Employers for Electrification Program (LEEP)	Prateek Suri (Forth)	6-47	3.38	3.38	3.00	3.25	3.25	3.20
TI157	Wasatch Front Multi-Modal Corridor Electrification Plan	Regan Zane (Utah State University)	6-51	3.88	3.50	3.38	3.88	3.50	3.56
TI158	East Coast Commercial Zero-Emissions Vehicle (ZEV) Corridor Planning Partnership	Michael Joseph (CALSTART)	6-55	3.63	3.13	3.00	3.38	3.50	3.24

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaborations	EEEJ	Weighted Average
TI159	First to Last Mile Creating an Integrated Goods Movement Charging Network Around the I-710 Corridor	Jack Symington (Los Angeles Cleantech Incubator)	6-59	3.75	3.25	2.88	3.25	3.38	3.21
TI160	Northeast Electric Highways Study	Brian Wilkie (National Grid USA Service Company Inc.)	6-63	3.88	3.75	3.25	3.63	3.13	3.50
TI161	MD-HD ZEV Infrastructure Planning with Focus on I-80 Midwest (IN-IL-OH) Corridor	Daniel O'Connor (Cummins Inc.)	6-67	3.50	3.40	3.00	3.50	2.80	3.21
TI162	San Francisco and Bay Area Regional Medium- and Heavy-Duty Electrification Roadmap	Dave Mullaney (Rocky Mountain Institute)	6-71	3.50	3.40	2.80	3.50	3.20	3.17
TI163	Houston to Los Angeles (H2LA)—Interstate 10 (I-10) Hydrogen Corridor Plan	Bart Sowa (Gas Technology Institute)	6-75	3.13	3.00	3.13	2.88	3.13	3.08
Overall Average				3.51	3.36	3.20	3.45	3.29	3.33

Presentation Number: TI141
Presentation Title: Integrated Fuel Cell Electric Powertrain Demonstration
Principal Investigator: Prateek Vaish, Cummins

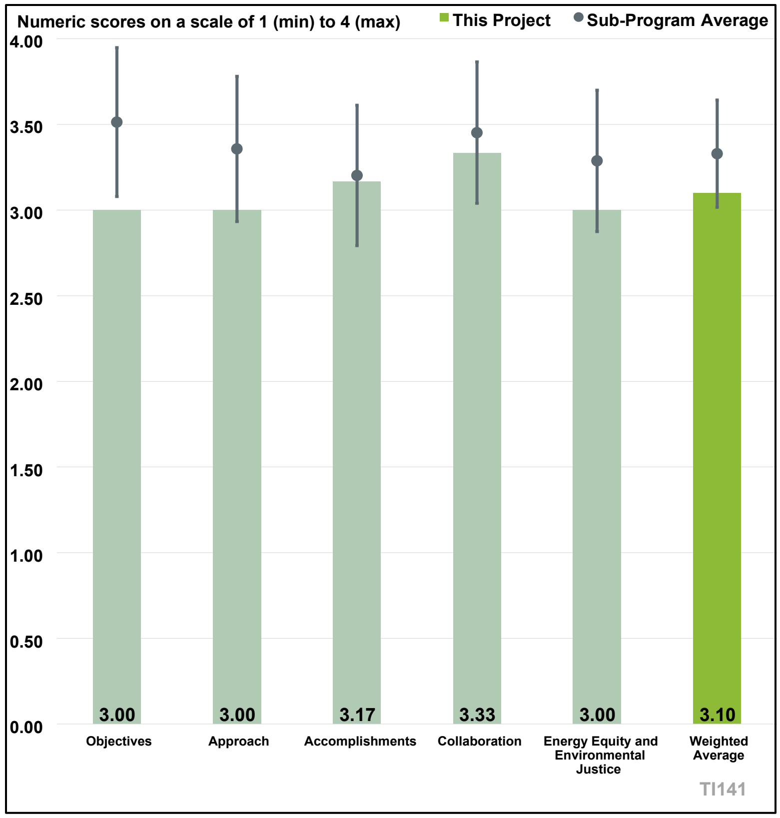

Figure 6-1. Presentation Number: TI141 Presentation Title: Integrated Fuel Cell Electric Powertrain Demonstration Principal Investigator: Prateek Vaish, Cummins

Presenter

Prateek Vaish, Cummins

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer stated that the project is focused on developing and demonstrating a modular, integrated fuel cell drivetrain for a heavy-duty (HD) truck (and originally, also a transit bus). HD trucks are a potential key application for fuel cells as batteries may not necessarily be fully applicable to the sector. Thus, this project is looking to develop an additional option for petroleum and emissions reductions from the HD sector.

Reviewer 2

The reviewer commented this project directly supports TI objectives through the development of a market-ready fuel cell electric powertrain with operational performance and total cost of ownership (TCO) that will support near-term, rapid, and substantial penetration of the commercial truck market, enhancing fuel diversity, bolstering local resilience, and diminishing GHG emissions that can be achieved by augmenting the use of alternative fuels and improving transportation efficiency.

Reviewer 3

The reviewer stated the project does somewhat address the objective of improving fuel diversity with the manufacture of a H_2 fuel cell powered Class 8 tractor. But if the project is assessed with the expectation and reasoning that improving fuel diversity requires building a tractor that is affordable and sought after/desirable in the marketplace, then the answer is clearly that the project has not built that equipment. $600,000 per unit at 1,000 units seems to be well beyond acceptable cost comparison. TCO should be evaluated, but the prototype cost alone is significantly higher than the cost of the diesel engine it is required to replace, and the fuel cost is another issue to consider, all of which makes it difficult to know what TCO will be.

The reviewer asked what the pathway is to \$5–\$6 per kilogram (kg) as was given in the presentation. There is no significant improvement in the equivalent miles per gallon (MPG) with H_2 fuel cells. The project is not responsible for the extremely high cost of H_2, but the project team should expect better mileage if the fuel diversity is to be expected to be adopted. This type of equipment and the fuel have to be comparable to equipment they are designed to replace if they are to be adopted in industry. It does not have to be the same as a diesel engine, but it has a long way to go to achieve an acceptable level of parity.

The reviewer stated a belief that the project has not solved for the equipment being extremely more expensive; the range is less; the vehicle is heavier, therefore less capacity, and if range goes up, carrying capacity goes down; no improvement in diesel gallon equivalent (DGE) MPG and the fuel is more expensive; and fueling infrastructure is more expensive. Although this is not in the scope of the project, building out a fuel that is more expensive and scarce does not drive adoption.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer noted that in Phase 1, the project team has designed a modular and scalable integrated fuel cell electric powertrain by leveraging existing fuel cell powertrains. The powertrain layouts and integration processes are also being refined to be manufacturable. A prototype fuel cell Class 8 truck will be constructed and commissioned. A Product Development and Manufacturing Plan will be developed, covering the overall powertrain cost, the high-volume system component cost, and the quantifying of high-volume production cost estimates; and the team will conduct high-volume TCO scenario analysis.

Reviewer 2

The reviewer highlighted that the key focus for the project is the 300-mile range. H_2 cost and availability are also still issues. The approach is focused on modular and scalable integrated powertrains to allow users to choose their specific components to meet their needs. The project is using a truck; however, the powertrain should also be applicable to transit buses (though plans for a transit bus under this project previously fell through). This project is also specifically focused on looking at TCO for this technology. The approach started with a discussion with partners to clearly drive design and metrics. Then the project moved on to design for build. Safety has been emphasized in the design of the truck. Reliability has also been a focus for the project approach, both for the truck as a whole as well as for individual components impacted by the move to a fuel cell such as brakes. They are working on improving fuel economy, acceleration, and gradeability. There is a concern on H_2 availability and cost (currently \$20/kg–\$40/kg), though they are working on a deal with Shell to provide full availability of the fuel. Right now, there is not a major focus on marketing and outreach to other potential fleets; the principal investigator (PI) is now considering that.

Reviewer 3

The reviewer stated that solving real world problems is building a piece of equipment that will be used in the market at a significant unit volume. The cost to build the unit does not support nor indicate there will be wide adoption. The presented cost of \$600,000 per unit at scale for a day cab application is not going to drive adoption. As an example, the reviewer recommended considering the use of a compressed natural gas (CNG) or liquid natural gas tractor. Although the differential on the equipment is 30%–40% of the diesel tractor, the end user will make that up in fuel cost savings without conceding range and cargo weight. The return on investment is achieved quickly. The fuel is easily delivered to the end user, on site, via existing pipeline infrastructure. TCO improvement is known.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer acknowledged that an integrated fuel cell electric powertrain design has been completed. The telematics data collection system has been installed. Powertrain module production, build, and assembly processes documents are complete. The prototype vehicle was assembled, commissioned, and validated in February 2024. Functional and performance validation is underway.

Reviewer 2

The reviewer noted that a truck has been built and 2,000 miles have been run on it. Another 8,000 miles will be run to complete validation and then the unit will be moved onto the fleet partner for demonstration (in Fontana, California) who expects to run the truck 75,000 miles over the year (300 miles/day). There are still some issues with cost. They will be using a public fueling station for operation, during which data will be collected and analyzed. The transit bus side of the project has been dropped since the project was unable to locate a bus original equipment manufacturing (OEM) partner. The current fuel cell tractor is about 8,000 pounds (lbs) more than a comparable diesel (22,000 lbs vs. 14,000 lbs), which means either lesser payload or the need for weight waivers.

Reviewer 3

The reviewer stated that progress has been achieved by building the one unit for the trucking logistics application. But the fact that no bus company was willing to participate is telling. The reviewer asked if it indicates that bus companies do not see a market for the equipment or a need. It was unclear if evaluation of more than the build of a H_2 fuel cell powered tractor was accomplished within the timeline.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer stated that collaboration appears to be a strong characteristic of this group. The team identified an OEM for the basis of the build and an end user committed to using the equipment as well as numerous vendors supplying necessary equipment. They should be commended for the collaboration.

Reviewer 2

The reviewer stated the project has assembled a strong team, led by Cummins and supported by CALSTART, Navistar, Long Beach Clean Cities, and Werner (the fleet). Cummins has been working closely with Navistar to integrate the powertrain into the truck. Outreach to additional fleets to learn about the demonstration unit would be an improvement.

Reviewer 3

The reviewer noted that Cummins Electrified Power North America (CEPNA) is the project lead, providing overall project management, task coordination, and administrative functions for the project. CEPNA is managing all technical tasks and working with Navistar to design the integrated fuel cell electric powertrain, and to build, commission, and test the prototype fuel cell vehicle. CEPNA will also provide service and support during the field demonstration at Werner Enterprises in Los

Angeles, California. CALSTART is assisting CEPNA with data collection and analysis, and supporting grant report deliverables (Performance Evaluation, Product Development and Manufacturing Plan, and Commercialization Pathway), Navistar is the OEM, providing the Class 8 truck and collaborating with CEPNA on the design of the integrated fuel cell electric powertrain. Long Beach Clean Cities is assisting CEPNA with project outreach. Southern California Gas Company is providing cost share to the project and providing feedback to the project team on the commercialization of fuel cell and H_2 technologies. South Coast Air Quality Management District is providing cost share to the project and providing feedback to the project team on the commercialization of fuel cell and H_2 technologies. Werner Enterprises is the fleet partner, conducting and operating the truck for a 12-month demonstration and facilitating driver education and safety training.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer noted that an estimated 15,000 gallons of diesel fuel per truck will be displaced annually. The H_2 fuel cell truck is estimated to reduce 335,700 lbs of carbon content annually compared to a diesel truck.

Reviewer 2

The reviewer conceded that energy equity and environmental justice (EEEJ) contributions are hard to measure, but the reviewer did not see the connection to improving how specific underserved and overburdened communities benefit from building H_2 fuel cell tractors. It is not the same as improving air quality in factories adjacent to underserved and overburdened communities.

Reviewer 3

The reviewer expressed the hope that if this technology can see cost reductions, it may be used to benefit Justice 40 Initiative (J40) communities. The presentation, however, did not appear to significantly address EEEJ issues.

Presentation Number: TI142
Presentation Title: Field Demonstration of a Near-Zero Tier 5 Compliant Natural Gas Hybrid Line-Haul Locomotive
Principal Investigator: Bart Sowa, Gas Technology Institute

Presenter

Bart Sowa, Gas Technology Institute

Reviewer Sample Size

A total of five reviewers evaluated this project.

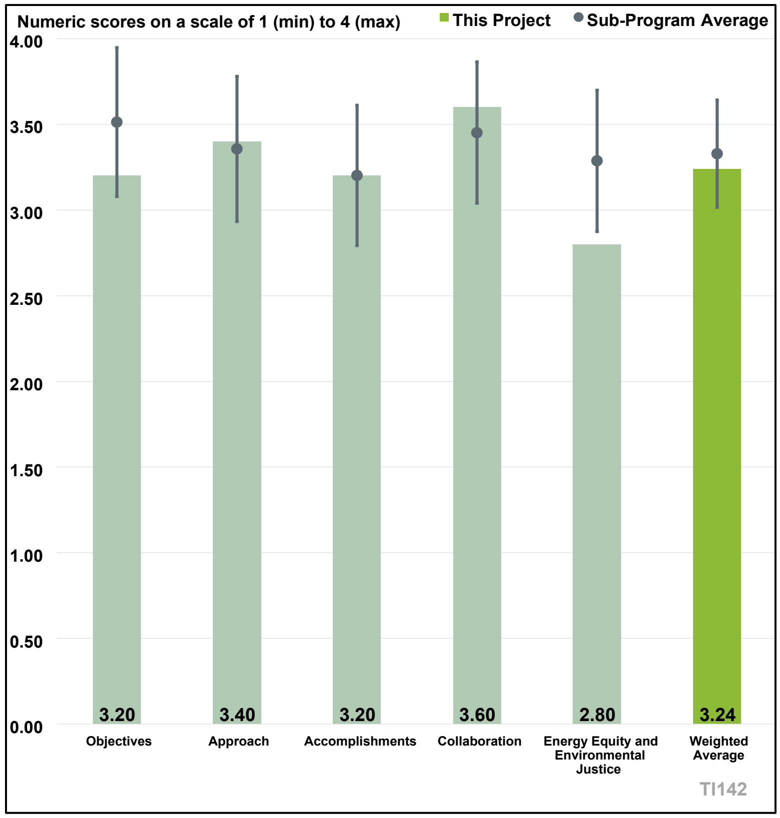

Figure 6-2. Presentation Number: TI142 Presentation Title: Field Demonstration of a Near-Zero Tier 5 Compliant Natural Gas Hybrid Line-Haul Locomotive Principal Investigator: Bart Sowa, Gas Technology Institute

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer noted a strength of the project is developing and demonstrating a locomotive that exceeds Tier 5 emissions (not yet in effect but are being pursued by California Air Resources Board [CARB]). This is well aligned with VTO goals and objectives.

Reviewer 2

The reviewer noted that the project improves the use of an alternative fuel in a hard to decarbonize application. The fuel is readily accessible, competitive to replacing diesel. The fuel reduces GHG emissions and is not burdened with costly, unavailable fuel. The engines selected to use the fuel are proven technology and will benefit from the application of the Cummins engine across the transportation sector.

Reviewer 3

The reviewer stated this project strongly supports overall TI and VTO objectives of fuel diversity and emissions reductions. CNG is currently half the cost of diesel fuel, and RNG can be significantly lower if carbon intensity is incorporated. Locomotive repowers are a significant market, with each costing up to $5 million and built to operate for as long as 50 years. This project also shows the potential for major emissions reductions for a sector known for high emissions, particularly in disadvantaged communities (DACs).

Reviewer 4

The reviewer commented that this project directly supports improved fuel diversity through the use of RNG and CNG, and H_2 in the future, in rail line haul operations. Local resiliency is improved with RNG and CNG infrastructure being reliable with locally produced fuels. The proposed technology will improve fuel efficiency and reduce GHG emissions while reducing criteria pollutants (oxides of nitrogen [NO_x], particulate matter [PM]).

Reviewer 5

The reviewer noted the objectives are not clearly defined. It should be stated within conventional fuel consumption reduction how much is due to the choice of fuel (i.e., carbon reduction with natural gas [NG]), how much is due to engine efficiency, and how much is due to the hybrid operation over an established baseline cycle. Data collected to dispel concerns of the industry should be defined so that proper baseline information can be compared to results. It was unclear what the actual impact of this project might be. The reviewer asked what the size is of the new locomotive market, and if it is realistic to assume the used market would implement this technology. The reviewer questioned if the technology is a true replacement to the diesel baseline.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer cited the approach as particularly strong since the project technology is a retrofittable solution for old locomotive stock. Another strength noted is that the project's modular engine pods are innovative as they can be moved around individually with a forklift for service and/or replacement. The opportunity to add fuel "tenders" to the train can cost-effectively extend range, which is a strength.

Reviewer 2

The reviewer acknowledged the application of module engine pods to re-power locomotives without the need for crane equipment improves application and location of use. It was stated in the presentation that the current infrastructure to deliver the fuel exists today. Use of RNG creates yet another market for the fuel. The engine and fuel pod and custom-built starter/generator solve for ease of adoption.

Reviewer 3

The reviewer stated that the approach for the project is solid and logical. The project has been developed to not only demonstrate alternative fuel in a hard sector to decarbonize, but also to exceed expected emissions regulations requirements. The original plan was for 4,300 horsepower (hp), but the project team found the need to have over 5,000 hp and adjusted the design accordingly. There were also supplier changes and supplier recommendations that changed design. The system is a completely modular construction, so units can be configured based upon the platform to be repowered.

Since the last Annual Merit Review (AMR), the engine was changed from the 12 L to the 15 L model, which is due out soon. These new engines are expected to be more efficient. The project team also included a custom 600 hp starter/generator. The current design is a pod arrangement, and the overall locomotive has 10 pods to reach the 5,100 hp level. Each pod can be lifted with a forklift and are based upon International Organization for Standardization hardware. The unit will be run at the Pueblo, Colorado, test center. The project worked to rely upon off-the-shelf components as much as possible.

There will be a 6-month testing period under a number of different duty cycles. The team does not yet appear to have an estimate for miles or hours of operation that will be run during the test period. An element the project has not looked at is if an individual engine is turned off, the engine across from it may also need to be turned off to balance vibration. Long haul locomotives typically have 2,000–5,000-gallon diesel tanks, so the team may expect to be at a range disadvantage for this unit. OptiFuel is looking at developing tenders over time.

Reviewer 4

The reviewer commented that the approach is minimally satisfactory. There needs to be a baseline duty cycle defined so that initial analysis work can be performed to justify the spending on engines, traction equipment, and batteries, and to gain confidence that the chosen fuel consumption reduction can be achieved. It was unclear to the reviewer how or why the battery size was reduced in the final round of powertrain choices. The approach for structuring the fuel consumption reduction needs to be improved. Perhaps it would be beneficial to have a waterfall chart that identifies the gains in efficiency in the locomotive.

Reviewer 5

The reviewer recognized that the project has developed a revised design based on the existing, widely used General Motors Electro-Motive Division SD90MAC locomotive platform, 80 ft long with two 3-axle trucks and with 5,100 hp continuous and 5,600 hp peak power. Energy storage employs a 380 kilowatt-hour (kWh) lithium iron phosphate battery and tractive effort is 175 kilopounds (klbs) continuous and 200 klbs starting. Onboard fuel storage is 2,000 DGE of NG in Type 4 tanks.

Activities in the first project phase included the engineering design of the near-zero locomotive, procurement of an existing vehicle for conversion, a production plan, and a system/Transportation Technology Center (TTC)/operational test plan. Advanced technology upgrades included 10 generator sets incorporating the latest X15N Cummins engines with efficiency improved up to 10% compared to the ISX12N, reduced battery pack size, RNG storage increased to 2,000 DGE, a custom 600 hp starter/generator to match the performance/dimension requirements and alternating current traction motors for improved adhesion over direct current traction.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer acknowledged that the project progress is on time. They have secured the test location with variable, real world terrain to evaluate the design. It should be recognized that the design managed the risk of unproven technology, the project adopted a conventional design that will allow for acceptance and replication, and it is utilizing "off-the-shelf components."

Reviewer 2

The reviewer noted the design is complete. The project team is waiting for Cummins to provide the new engines. Fuel storage is also modular at 1,000 DGE above and under the deck at 350 bar (also H_2-compatible, since the Cummins engine is H_2-compatible). Researchers expect to have everything put together in October 2024, if they receive the engines as planned, in order to have the full locomotive complete by end of December 2024. The team does not anticipate any significant issues with completing the project on time as long as they receive the engines on time.

Reviewer 3

The reviewer stated the locomotive design has been completed. The process of locating and procuring a used SD90MAC locomotive is underway. Major components are on order with deliveries expected in Quarters 2–3 (Q2–Q3) 2024. The production plan is complete with locomotive assembly to be conducted by RailServe in Longview, Texas. The test plan is complete with testing to start on January 2025 at the TTC testing facility in Pueblo, Colorado. Dynamic/static vehicle testing, performance, endurance, and component reliability testing will be conducted on a 50-mile, full-scale on-track testing, including a high tonnage loop. The locomotive procurement team is targeting delivery in Q3 2024, and production/assembly is scheduled for Q3–Q4 2024.

Reviewer 4

The reviewer cited a strength of the project is that COVID-19-related delays actually allowed time for important design enhancements and adjustments. One weakness is the availability of X15N Cummins engines needed for the project is unclear/uncertain. Another weakness is that the locomotive testing plan/test scenario details are not yet clear or known (important for knowing what range effects from using NG there will be on typical duty hauls).

Reviewer 5

The reviewer stated that it appears that most of the project is on track, except for the engine deliveries.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer cited a strong/good industry team and key collaboration with Federal Railroad Administration’s TTC as a project strength.

Reviewer 2

The reviewer acknowledged that GTI Energy Partners appeared to have selected the right project collaborators: VTO as funding agency; GTI Energy as prime recipient; OptiFuel as subcontractor and lead technology developer; Cummins, TMV Control Systems–Next Generation Locomotive Control Systems (TMV), FMW Solutions LLC, BAE Systems, DEF, Development Bank of Latin American and the Caribbean (CAF) as key technology providers; OptiFuel, OneGas, Utilization Technology Development (UTD) as industry stakeholders with cost share; RailServe as manufacturing and assembly services; and TTC for testing services. GTI Energy is an experienced VTO collaborator. The team has decades of experience in R&D, technology development, and the rail industry. GTI Energy has successfully collaborated in the past with OptiFuel, FMW, Cummins, and BAE.

Reviewer 3

The reviewer noted the project includes an experienced team, particularly OptiFuel, who has already demonstrated NG in a locomotive application. There are also several technical experts on the team to address specific areas of concern as well as key suppliers. The gas industry is also supporting the project.

Reviewer 4

The reviewer reported that GTI Energy is the project lead with overall responsibility for design, integration, testing, and reporting. OptiFuel is the lead technology developer. Cummins, TMV Controls, FMW, BAE, DEF, and CAF are key technology providers. OptiFuel, OneGas, and UTD are industry stakeholders providing cost share. RailServe provides manufacturing and assembly services. TTC provides testing services. GTI Energy is an experienced VTO collaborator. The team has decades of experience in R&D, technology development and the rail industry. GTI Energy has successfully collaborated in the past with OptiFuel, FMW, Cummins, and BAE.

Reviewer 5

The reviewer commented that a production plan is completed, however there is no mention of the product cost due to this technology. The reviewer asked if a production plan is necessary if the technology is not cost effective to the customer.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer commented that reducing pollutants in railyards that are often surrounded by underserved communities with continuous operations and engines under power will have an impact in improving air quality and noise reduction. If the replacement of the diesel engine is widely accepted, then the impact will be more rapid than improvements on emissions and will be more readily realized. The use of passenger transit applications will also improve air quality for riders, neighborhoods, and urban areas and will reduce noise.

Reviewer 2

The reviewer stated that at scale, the near-zero emission rail technology will contribute to EEEJ by reducing criteria pollutants from locomotives used in railyards and on the rail network across the entire United States. Railyards tend to be in areas where underserved populations have some of the poorest air quality. Similarly, when used in passenger transit applications, the technology will improve the air quality and reduce noise affecting the riders, operators, neighborhoods and urban areas.

Reviewer 3

The reviewer stated the project will not provide direct environmental justice (EJ) or equity benefits. However, if commercially developed, the project technology would offer significant emissions savings at rail yards and ports which are typically located in or near DACs, which was noted as a strength by the reviewer.

Reviewer 4

The reviewer commented that this is really a one-off demonstration, and the impact will be if the technology is adopted at scale since many railyards are in challenged communities as well as passenger rail operation is often in Justice 40 (J40) communities.

Reviewer 5

The reviewer noted the level of criteria pollutant emissions was never discussed. Only a reduction in fuel economy is mentioned. The project target is to “exceed” Tier 5 emissions. The reviewer questioned higher emissions. The reviewer also questioned if the intention is to be certified at Tier 5. Perhaps relevant railyard emissions at a site could be listed, and the impact of this technology on improving emissions could be compared for that site. There are no detailed plans for the Energy Environmental Justice Action Plan (EEJ) work.

Presentation Number: TI144
Presentation Title: Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program
Principal Investigator: Andrew Klock, Nation Fire Protection Association

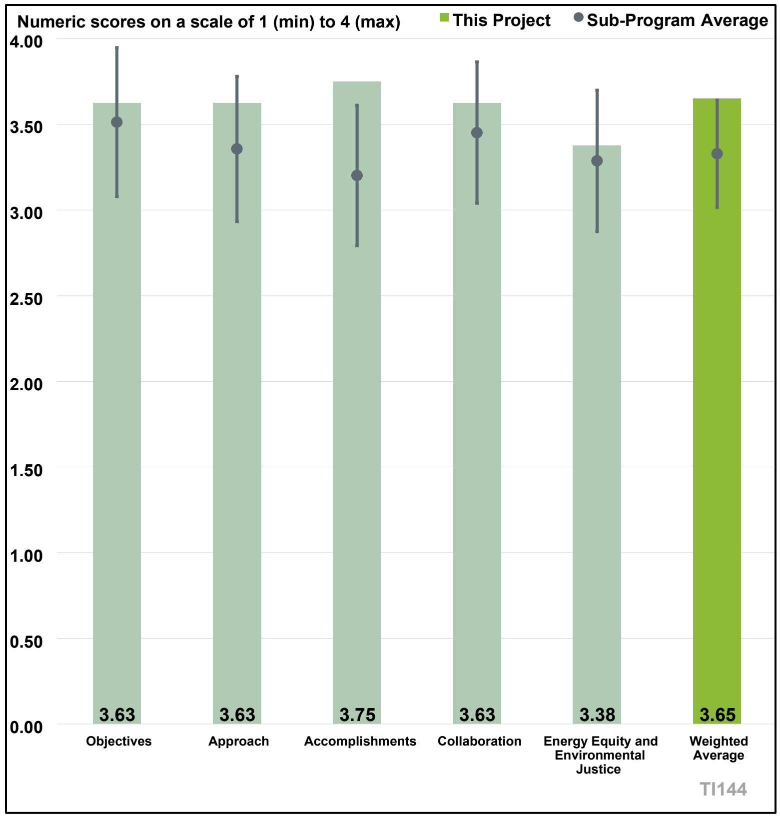

Figure 6-3. Presentation Number: TI144 Presentation Title: Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program Principal Investigator: Andrew Klock, Nation Fire Protection Association

Presenter

Andrew Klock, Nation Fire Protection Association

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer stated belief that this question does not apply as written to the project but may be addressed the next time around. This is a much-needed project and the leader has met the overall listed objective: gather the latest DERST research and data and conduct field testing, gleaning best practices using latest distributed energy resource (DER) equipment (EV, energy storage system [ESS], solar) in controlled fire incidents. Update and modularize our existing train-the-trainer programs for emergency responders (ESS, photovoltaic, EV/electric vehicle supply equipment [EVSE]) and distribute those across the country. Create a multi-user, scenario-based serious gaming platform for fire departments to train on interactive, real-world DERs in structures. Develop and deploy nationwide a DER field evolution and props guide for conducting DERST tactics training at fire academy or outdoor training centers. The reviewer reported having supported three trainings on first responder training and recognized the value of the structure put in place to keep this training relevant and current.

Reviewer 2

The reviewer noted one of the current concerns to the driving public (perceived) is for EV battery fires. The National Fire Protection Association (NFPA) has provided a training manual that fire departments can use to train fire fighters so when the public shows a concern, the departments have proof they are trained in the rare case of a fire.

Reviewer 3

The reviewer acknowledged the project focuses on training fire professionals to handle fires from alternative energy devices, primarily related to electric/hybrid vehicle batteries and charging equipment and household solar energy related energy storage and equipment. Household fires from alternative energy could be a potential barrier to deployment, so education of fire fighters and homeowners is one component to addressing these barriers.

Reviewer 4

The reviewer stated this project addresses a critical need that crosses boundaries from automotive EV applications to distributed energy systems in garages and commercial buildings, all having lithium-ion batteries in common. Fires involving these types of batteries cannot be extinguished effectively using traditional firefighting tactics, so educating firefighters in the latest methods is important. This project will increase local resiliency, boost consumer confidence in the safety of lithium-ion batteries and dispel some of the negative stereotypes that exist about EV fires.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer noted there is a high demand for this training from first responders; fire response teams, hired and volunteer; tow truck operators; building developers; property owners; and EV owners. There is likely more myth around EV related fires, but that has to be dealt with.

Reviewer 2

The reviewer stated this training will give fire departments advanced fire training specific to DERs and EVs. This training document appears to have been researched to address a very specific issue related to this type of fire.

Reviewer 3

The reviewer commented that the project has developed an online "multi-player" training tool that is widely accessible, requiring only a computer and internet connection. The training is based on actual burn tests and data analysis collected under the project.

Reviewer 4

The reviewer stated this project presents training in an approachable and relatable way through a gaming platform. Lifelike scenarios are easy to comprehend, and lessons are reinforced by actually performing simulated incident responses. There may be a learning curve for the gaming interface with older participants who are not used to playing video games, and younger trainees may find the keyboard interface a little archaic vs. a handheld game controller or a virtual reality headset apparatus.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer stated the majority of milestones have been completed with just a few items to be reviewed and the vast majority of the training document and training module complete. Budget Period (BP) 1 and 2 are complete.

Reviewer 2

The reviewer stated the project has made excellent progress on all tasks.

Reviewer 3

The reviewer acknowledged most of the project objectives have been met and others appear to be ahead of schedule. The hardest work has already been done and the training is already benefiting first responders.

Reviewer 4

Per the presentation timeline presented, the reviewer noted the project is on schedule. But with less than six months remaining, there is much to do.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer acknowledged the level of collaboration and team members selected to participate appears to benefit the project extremely well. The bi-weekly meetings and the benefits listed in the presentation seem appropriate and a value add, focusing on firefighter best practices, communicating lessons and training development, and effective deployment methods, which will consume the last six months of the project.

Reviewer 2

The reviewer commented that this project has a very specific program to be developed, and the team that was brought in to work on the project was very appropriate. Particularly, the North American Fire Training Directors (NAFTD) association that has specific skills in developing fire training was appropriate, because not just any training expert understands the nature of the vast members of the fire departments across the United States. NFPA was a very appropriate group to take on this task.

Reviewer 3

The reviewer noted that NFPA obviously has the experience and expert knowledge to craft this type of training program. The University of Texas, Argonne National Laboratory, NAFTD, and GHD Digital all bring relevant experience to the project. The team is right sized with an effective number of participating organizations, and each participant has a clear-cut role to play. Coordinating a real-world fire training incident to gather information specific to the training was an excellent idea.

Reviewer 4

The reviewer stated that collaboration and coordination within the project team partners seemed to be good. It is not clear how much external collaboration has been performed outside the team. For example, it is not clear how outreach on the training is being performed, such as from which groups and how feedback on the training will be collected.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer noted that from the presentation, the takeaway is that the project leaders have thought through the dissemination of the information to make it available to all communities regardless of socio-economic status. Through this project, NFPA is developing DER educational offerings that increase awareness, knowledge, and best practices for the fire service across the country. The DER stakeholders, regardless of the community's socio-economic status, should be able to implement and use DERs with the assurance that the responder community is familiar with and has the training to handle incidents. NFPA has taken steps to ensure these materials are accessible to U.S. first responders and do not create undue burden.

Reviewer 2

The reviewer noted the project team has identified three ways that EJ communities will be served by this training without overburdened cost to the community.

Reviewer 3

The reviewer acknowledged the project specifically designed the training course to be web-based and work on any computer connected to the internet. The goal was to eliminate the need for special training equipment and its associated costs that would be burdensome to underserved and small fire departments.

Reviewer 4

The reviewer noted that while NFPA provides its online training programs for free, making them widely accessible, there may be issues where firehouses or first responders without reliable internet access may be hindered or unable to use the training. Understandably, there are costs involved with creating hard compact disc or digital video disc copies of the training scenario, even in small numbers, but some accommodation might have been warranted to make the program more universally available.

Presentation Number: TI145
Presentation Title: Electric Vehicle Market Stimulation in Divested Economies
Principal Investigator: Jenna Znamenak, Metropolitan Energy Center

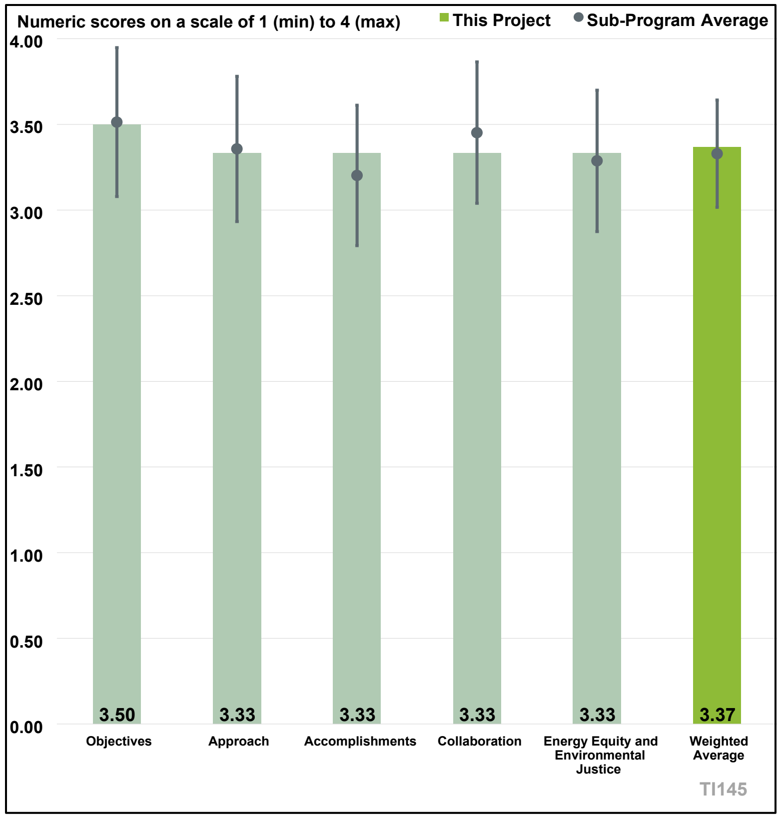

Figure 6-4. Presentation Number: TI145 Presentation Title: Electric Vehicle Market Stimulation in Divested Economies Principal Investigator: Jenna Znamenak, Metropolitan Energy Center

Presenter

Kelly Gilbert, Metropolitan Energy Center

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer noted the project, which increases access to EVs in underserved markets, directly supports TI objectives of national security through increasing fuel diversification, and the objective of affordability through saving money by use of existing infrastructure.

Reviewer 2

The reviewer stated the deployment of EV tractors in four locations and five medium-duty (MD) EVs at another meets the objectives related to fuel diversity and GHG reduction. At this stage in the project, the local resiliency and alternative fuel use have not been fully realized. Data from utilization of the 10 EVSEs in one community and future deployments in additional communities will determine the extent of impact on local resiliency and GHG reductions. The investment is focused on the EVSE deployment with a critical assumption that, "Availability of EVSE will necessarily increase demand from individual and fleet consumers." (Slide 19). An additional approach to further the TI objectives is to provide access to EVs within the communities where the EVSE are located.

Reviewer 3

The reviewer stated this project will address and support the overall TI objectives by increasing fuel diversity, improving local resiliency and reducing GHG emissions. Introducing plug-in electric vehicles (PEVs) of various sizes and missions into these communities covers a lot of bases in terms of visibility and demonstrated capability, while installing EVSE in underserved areas enhances access to clean energy and promotes the adoption of PEVs.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer stated the approach follows best practice of conducting meaningful community engagement that has direct effects on programmatic decision making, specifically through directing site selection for deployment. Additionally, using insights from this work will help to create methods and evaluation frameworks that are transferable to other regions.

Reviewer 2

The reviewer noted the project's critical assumption that "Availability of EVSE will necessarily increase demand from individual and fleet consumers" (Slide 19) leaves potential that EV adoption does not occur or occurs much slower than anticipated. An additional approach to further the TI objectives is to provide access to EVs within the communities where the EVSE are located. However, the deployment of several HD and MD vehicles in the region has been successful, indicating success in the notion that higher match rates for industry can help offset some of the challenges of meeting local match in divested communities.

Reviewer 3

The reviewer believed this approach has a chance for great success by replacing a significant number of higher-polluting vehicles with PEVs. Deploying PEVs in municipal fleets demonstrates to community members and city employees the capability of EVs and showcases the community being pro-active in reducing its carbon footprint as an example for others.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer commented that this project is making good progress and appears to be nearly on schedule: 53% of tasks are complete with almost two years left in the timeline. Zero-emission HD vehicles have already been deployed and are at work improving air quality and showcasing the capability of these types of vehicles.

Reviewer 2

The reviewer noted the project has conducted community engagement, deployed HD vehicles, deployed light-duty work trucks, and installed EVSE.

Reviewer 3

The reviewer acknowledged the deployment delays experienced were caused by factors outside of the project lead's control (supply chain issues with the Ford F-150 Lightning). The project team showed resiliency by pivoting some partners to a different EV model that also met the partners' mission. There is demonstrable success in the completion of six community events.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer noted the project has collaborated with a number of local entities including industry, municipal government, and transportation officials.

Reviewer 2

The reviewer noted that completion of six community events indicates successful partner collaboration. The ability to pivot to a different type of vehicle when the Ford F-150 Lightnings were delayed also shows willingness to work together toward the end goal. The community education aspect of BP 2 seems a little behind but it is in progress.

Reviewer 3

The reviewer commented that the presentation and supporting document did not give an adequate picture of the team makeup and duties, nor any kind of schedule for team meetings. It appears that there is a prime recipient, some partners tasked with outreach, and other partners who will deploy vehicles within their company or municipality. On the surface, it appears that the right mix of partners have joined the project, and there are vehicle deployments to show for their efforts.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer noted the project is utilizing meaningful community engagement to inform decision making regarding the siting of infrastructure as well as focusing investments in zero-emissions heavy equipment in DACs, ensuring that the benefits of electric transportation accrue to DACs.

Reviewer 2

The reviewer acknowledged that deployment of EVSE in divested communities will improve the perception of EV driving and availability of charging. All the chargers will be in such communities and the deployment of EV tractors and MD vehicles within the same communities will have significant air quality impacts. One additional approach to further the TI objectives is to provide access to EVs within the communities where the EVSE are located, not just to chargers themselves.

Reviewer 3

The reviewer quoted, “Placement of charging stations in underserved communities by providing access to small grants at reduced cost-share rates will spur adoption of EVs in these markets.” This is a solid plan and involving community leaders in the site selection will give them reason to feel invested, encouraging the community’s continued support for EVSE after project completion. The project will also use data collected and lessons learned to create a strategic plan for other cities looking to deploy EVSE with a community-led process in underserved areas.

Presentation Number: TI146
Presentation Title: Rural Reimagined Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia
Principal Investigator: Pingen Chen, TN Tech

Presenter

Pingen Chen, TN Tech

Reviewer Sample Size

A total of four reviewers evaluated this project.

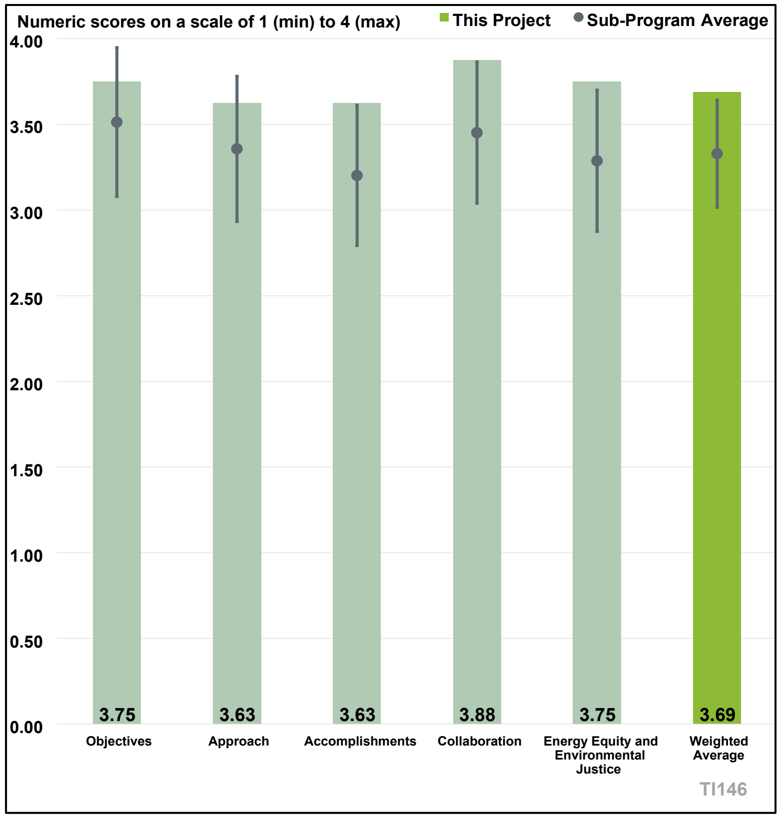

Figure 6-5. Presentation Number: TI146 Presentation Title: Rural Reimagined Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia Principal Investigator: Pingen Chen, TN Tech

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer noted a strength is that the project specially addresses the particularly tough challenge of rural applicant EV adoption and associated issues. This is supportive of and well aligned with VTO goals and objectives. A potential weakness is that direct current fast chargers (DCFCs) are not Federal Highway Administration (FHWA)-compliant (62 kWh)--maybe this is a good thing though? The reviewer suggested the project may address/incorporate Level 1 charging into the project plan.

Reviewer 2

The reviewer stated the project objectives are clearly defined, ambitious, and well aligned with TI objectives including national security; affordability; reliability and resilience; and, uniquely, economic growth. The last of the goals addressed by this project is one way that it stands out above the rest, particularly focusing that growth on a historically underserved region of the United States.

Reviewer 3

The reviewer noted that ambitious goal statements are in line with TI objectives. EVs introduce fuel diversity, which is enhanced by knowledge transfer. Equipping rural road routes with EV charging increases resiliency for consumers and small businesses, which is enhanced by job awareness. EVs reduce GHG by increasing alternative fuel use.

Reviewer 4

The reviewer commented that this is an ambitious and well-rounded program that includes workforce development for PEV technicians and EVSE installers/electricians, both positions of great need. Including ride and drive demos as well as short-term vehicle loans to individuals and fleets is a good strategy to encourage PEV purchases. The project is targeting areas of critical need in terms of geography and economy. The project is well researched and the presentation and supporting documents are thorough and complete.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer noted the approach does a good job of achieving the project's objectives of improving the region's charging network through the installation of a large number of charging stations throughout a very large region. Another way that the project achieves its objectives is through EV demonstrations that have been shown to change the opinions of potential EV drivers that might be skeptical of the technology. An important component of the project approach that contributes to economic growth is through workforce development and training, which is essential for ensuring that the benefits of transportation electrification are widespread and go beyond simply those with the opportunity to drive EVs.

Reviewer 2

The reviewer stated the live presentation was immensely helpful to understanding the approaches being used and their relationship to real-world challenges. Installation of charging stations is a necessary step toward supporting EV adoptions in economically distressed areas. Demonstrating reliability with local fleet deployments is a successful real-world tactic. Long test drives with consumers is evidently (based on Accomplishments numbers) a highly successful experiential educational tool.

Reviewer 3

The reviewer noted that by taking a holistic approach to creating a green economy and an EV ecosystem, this project has the potential to make a transformative impact on the underserved rural communities that goes well beyond simply introducing PEVs and installing charging infrastructure. This project will provide the means to sustain and grow the demand for clean transportation options.

Reviewer 4

The reviewer designated a strength of the project is that the approach leverages other programs and funding sources to buy down incremental EVSE cost to $0. Another strength is the project builds on and expands prior rural electrification testbed projects that concluded in 2022. A weakness is the charger site selection seems to be somewhat arbitrary and not really based on gap analysis.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer noted the project has delivered 25 of 30 EVs. The project team has contacted 126 potential charging station site hosts, with 31 currently being installed and 13 already installed. The team has conducted 166 EV test drives. These are impressive figures with much more work still promised.

Reviewer 2

The reviewer noted that this project appears to be on schedule to reach its goals and a significant portion of the PEV deployments and EVSE installations have already been accomplished. A large number of community engagement events have already been held. While attendance was sparse at some, the number of communities exposed to the program is bound to have an impact and leave a lasting impression.

Reviewer 3

The reviewer stated that extraordinary participation rates in the consumer test drive program are the biggest indicator of the project’s potential for achievement of its overall goals. This aspect seems quite replicable and very effective. While the project purchased 62.5 kW DCFC, which is the least powerful version available and not compatible with the National Electric Vehicle Infrastructure (NEVI) and FHWA Alt Fuel Corridor specifications, the justification of cost and electric service capacity is reasonable for purposes of this project. The reviewer recommended more information regarding the site selection process for EVSE be provided, specifically for Level 2 (L2) community charging. An unclear aspect of the project is the update to National Alternative Fuels Training Consortium (NAFTC) hybrid/EV training course and its relationship to Tennessee Tech’s training courses. Also unclear is NAFTC’s role in the project, and the scope and replicability of the workforce outreach and/or training. Perhaps this will become clear in future work.

Reviewer 4

The reviewer cited the 2-week test ride program, which is very popular to date, with a high positive review rate (85%) as a strength. A weakness is that the charger installations are later in the project (unplanned), which reduces the appeal/effectiveness of vehicle demos.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer stated the project team is strong and led by a PI with significant experience in this project space. The project is supported by a wide range of key public and private partners and numerous Clean Cities and Communities (CC&C) coalitions.

Reviewer 2

The reviewer acknowledged that the ambitious nature of this project requires a great deal of collaboration, which the team has demonstrated. The list of partners is exhaustive, both in geographic scope as well as in type of entity engaged.

Reviewer 3

The reviewer commented that the project has a tidy organizational structure with clearly defined roles for all partners. The member organizations have a good track record of success in their areas of expertise, particularly the NAFTC with curriculum development.

Reviewer 4

The reviewer recognized that the project has an astonishing number of cooperators. Accomplishments seem to indicate that the coordination among the team is very effective. While some target accomplishments are lagging, it does not seem to be due to any weakness in the collaboration. That said, the presentation did not indicate the methods and purposes of communication that make the project successful; that information would be useful to other projects.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer stated a strength of the project is that it includes a substantive workforce development effort targeting those residing within DACs. There is also a scalable train-the-trainer component to increase reach to DACs across Appalachia. Another strength is that the project is entirely focused on providing underserved rural communities with access to EVs, EV infrastructure, and EV education.

Reviewer 2

The reviewer acknowledged that the project focuses on expanding the charging network as well as the associated green economy of EVs. The project does so in an historically underserved region.

Reviewer 3

The reviewer stated this project is highly targeted to benefit rural underserved populations, and participation rates seem to indicate it is, so far, successful in reaching them. The reviewer would like to see more about self-determination or local leadership with decision making. The lack of such information does not necessarily indicate it is missing from the project implementation. Cost-sharing projects are notoriously difficult to deploy without causing additional burdens on already overburdened communities. The project team has brought in cost-sharing partners and directly taken on costs to alleviate many of these burdens from their target beneficiaries. Sustaining these costs long term on their behalf is a concern for future success/sustainability of outcomes. The test drive program is very interesting, and future results regarding participants may tell us more about the real-world impact of this project on the target rural underserved communities.

Reviewer 4

The reviewer noted that the target areas of this project are some of the most distressed and at-risk communities in the country. Focusing on workforce development as a key component of the project will bring many positive and attainable clean energy opportunities to these areas.

Presentation Number: TI147
Presentation Title: Affordable Mobility Platform
Principal Investigator: Connor Herman, Forth Mobility

Presenter

Connor Herman, Forth Mobility

Reviewer Sample Size

A total of four reviewers evaluated this project.

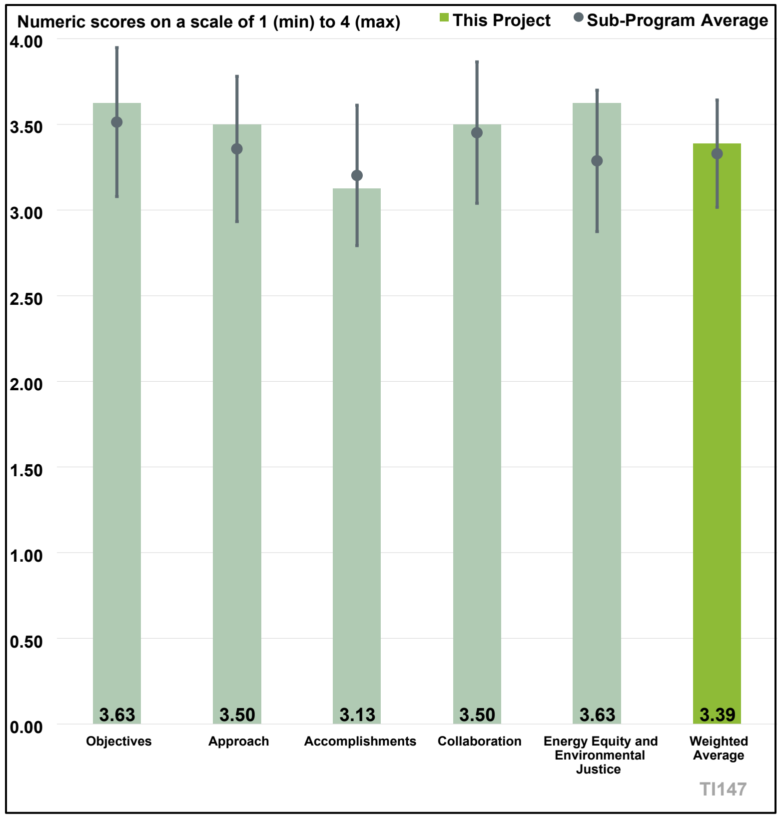

Figure 6-6. Presentation Number: TI147 Presentation Title: Affordable Mobility Platform Principal Investigator: Connor Herman, Forth Mobility

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer stated the project supports TI objectives of improving fuel diversity by providing a means to access electric transportation for low-income residents of affordable housing through the use of car sharing. This also supports the TI objective of increasing local resiliency as a more diverse mix of fuels is utilized by shared vehicles. Replacing other automotive trips with EV trips will contribute to the TI objective of reducing GHG emissions.

Reviewer 2

The reviewer appreciated the project overall. The project met the go/no go milestone for BP 1 and appears to be making steady progress on the milestone for BP 2. The reviewer stated anticipation for some of the use data coming out of the project to verify impact.

Reviewer 3

The reviewer stated that project objectives clearly align with TI objectives. EVs improve fuel diversity, which is strengthened by providing positive experiential access to EVs by target populations. Car sharing increases local resiliency by providing reliable and convenient transportation for urban dwellers in affordable-housing complexes. Both EVs and car sharing decrease GHG emissions. All objectives are designed to be replicable within specific market segments.

Reviewer 4

The reviewer commended the project's stated objectives, which, when completed, would definitely support TI goals to improve fuel diversity and provide access to clean transportation for the communities. The project has a wide geographic footprint, targeting many different areas of the country, giving it visibility and exposure. The car-share component of the project is well conceived and works well in reality. The multifamily housing part of the project looks to be more difficult to realize, due to the number of known stumbling blocks inherent in projects like this, namely charging infrastructure is slow to reach underserved, lower income areas with a higher density of multifamily properties and the overall EV adoption rate in historically underserved communities and communities of color is disproportionately low.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer commented that the union of electric shared vehicles, publicly accessible charging infrastructure, and affordable housing is efficient, equitable, and clever. This is an excellent approach to addressing multiple issues within a single program in a way that is still relatively simple.

Reviewer 2

The reviewer noted that recent research out of University of California Berkeley demonstrates EV car sharing is an effective way to improve air quality in DACs. This project will provide related relevant data about its use across many geographic areas. The approach supports decarbonization, transportation equity, and aims to help resolve sustainable funding challenges.

Reviewer 3

The reviewer stated that the overall approach is comprehensive. However, the planning timeline for launching a new service in new markets seems very ambitious. Parameters for selecting cities for participation and for selecting target residences are sound, with particular benefit to underserved population groups. The user experience for the car-sharing app provides options for people without smart phones. A keystone approach is not stated in the Approach section. The reviewer suggested the approach include the identification of one or more champions or ambassadors for the car-sharing program from within the resident population of each deployment site. Peer leadership and self-determination are strong indicators of future success.

Reviewer 4

The reviewer stated that car sharing with PEVs allows consumers to experience these types of vehicles affordably and without sales or time pressure. Targeting affordable-housing developments is an obvious way, in theory, to reach the desired population for this project. However, making this part of the project work in reality will be difficult as exhibited by the delays already happening.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer noted that gauging the actual progress against the scheduled timeline was difficult using the presentation and slides. The team has accomplished an impressive amount, it seems, and still has a lot to do.

Reviewer 2

The reviewer affirmed the project is moving forward and has accomplished the go/no go milestone for BP 1. The delays in securing host site agreements, vehicles, and installing EVSE appear to be due to executing contracts with city partners, supply chain issues, and permitting challenges. Such challenges probably could have been foreseen but the team showed limited ability to change their approach to mitigate them.

Reviewer 3

The reviewer noted the project appears to be behind schedule in some critical areas, such as the deployment of vehicles and EVSE for both the rideshare program and the housing development portion, as well as some of the administrative and training tasks. The reviewer cited an example in the Affordable Mobility Platform rideshare program near Seattle, Washington, which is well configured and easy to use, but stated there is a lot of work left to do in order to get this project over the finish line successfully and to have a meaningful impact.

Reviewer 4

The reviewer remarked that it appears that the delay in the transportation needs assessment (TNA) and selection of site hosts is impacting the accomplishment of some project tasks. However, it takes time to do these activities appropriately, particularly with overburdened populations. Per the live presentation, the delays represent good progress toward accomplishments that will underpin success in the remainder of the project objectives. The TNAs are available online, and the reviewer stated anticipation for learning more about how TNAs were conducted and for their various results. The reviewer noted confusion after the presentation whether TNAs were conducted with local participation or solely with modeled Census and other locally- and nationally- sourced data. The project team is conducting continuous engagement with the residents of the affordable housing complexes that host the car-sharing programs. The reviewer noted staff at the complexes are not using the cars at notable rates, but residents are using the cars. The car-sharing program design is attractive and replicable. However, it is unclear at this point in the project whether the outcomes will be sustainable beyond the project period, given there is not a profitability model for privately-run car-sharing programs at this time. Government, foundation, or other support funds for post-project operations have not yet been identified, though the operator is set up as a non-profit organization specifically for the identified need to attract such partnerships and funding.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer affirmed that the project has a well-rounded team of contributors with solid credentials in their areas of expertise and a track record of success. Communication and coordination among team members appears to be excellent.

Reviewer 2

The reviewer commented that the ambitious nature of the project requires a great deal of collaboration across the entire country, and the project team has included key partners like CC&C coalitions, metropolitan planning organizations, research institutions, deployment hosts, and subject matter experts.

Reviewer 3

The reviewer stated Forth, Mobility Development, Argonne National Laboratory, and Portland State University are well known in this arena and provide strong expertise in their fields. Trying to coordinate with 40 host sites would be challenging for any group of partners; however, the project has been largely successful in engaging the vast majority.

Reviewer 4

The reviewer remarked that the collaborative is carefully designed to include all the partners necessary for technical success. The planned coordination among the project team is exemplary, with regular communication planned to mitigate project risks of all kinds. The weakness raised by the reviewer was that collaboration with the beneficiary audience is not well defined.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer expressed that the design of the program excellently achieves EEEJ through extending the benefits of transportation electrification to low-income and underserved populations by focusing on affordable housing developments.

Reviewer 2

The reviewer noted that this project maximizes benefits to underserved and overburdened communities by listening to the needs in the initial TNA, deploying EVSE in neighborhoods, giving them access to use those vehicles, which will expand their reach to jobs, schools, and other services that can improve quality of life. The project is engaging many communities in need across the country, not just a single community in one area.

Reviewer 3

The reviewer reiterated that the project is targeting specific geographic areas and housing developments that are disadvantaged and in most need of assistance. The TNA conducted for this project was very thorough and gave it a good basis for deciding where to focus project resources.

Reviewer 4

The reviewer stated this project is sharply focused on EEEJ objectives and outcomes. However, the project plan does not leave much room for collaboration with and leadership from within the target EJ communities. The objectives for BP 2 to train (paid or unpaid is unclear) on-site ambassadors from the resident community, as well as co-design outreach materials (see Diversity, Equity, Inclusion, and Accessibility [DEIA] milestones, slide 17 of presentation), looks promising. The benefits to the community are potential at this time and rely heavily on the fiscal and social sustainability of the program beyond the project term. The project team would do well to prepare the beneficiary populations for advocacy on their own behalf to decision makers and to build a compelling argument (a case statement) to potential future funders who might help make up the up to 75% gap between rider-generated revenue and full operational cost.

Presentation Number: TI148
Presentation Title: Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network
Principal Investigator: Robert Blake, Native Sun Community Power Development

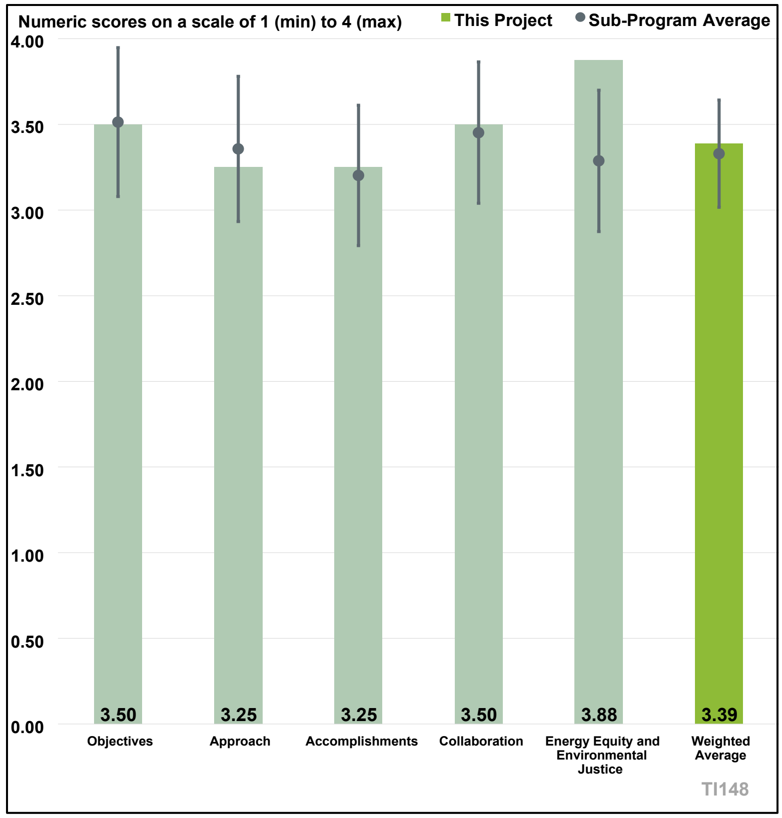

Figure 6-7. Presentation Number: TI148 Presentation Title: Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network Principal Investigator: Robert Blake, Native Sun Community Power Development

Presenter

Robert Blake, Native Sun Community Power Development

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer reiterated that the TI objectives addressed in this project include fuel diversity, local resiliency, and GHG emissions reduction. This is achieved by providing PEV and EV vehicles to replace or supplement traditionally fueled vehicles utilized in an historically underserved region in the upper Midwest.

Reviewer 2

The reviewer noted that this project's objectives align seamlessly with TI objectives. Its focus on and leadership from vastly underserved tribal lands and communities, along with coordination of utilities, meets local resiliency objectives. Its focus on understanding fossil fuel use before replacement with PEVs improves fuel diversity. Its focus on deploying EV and EVSE contribute to GHG emission reductions.

Reviewer 3

The reviewer stated it was a little difficult to assess overall how the project is meeting VTO objectives and follow progress in the slides provided. The goals are clearly outlined on Slide 4; however, the number of chargers and vehicles operating on the ground are confusing on Slide 10. Slide 4 indicates there will be three MD vehicles: one transit shuttle and two electric school buses. Slide 10 indicates five transit shuttles were purchased. The reasons why the changes were made are not clearly laid out. Slide 4 states 60 L2 chargers will be deployed, slide 7 identifies six priority L2 sites, and Slide 10 lists 14 L2 locations, but no information is given on the number of chargers per site.

Reviewer 4

The reviewer commented that project objectives are aimed directly at supporting all of the listed TI goals and the project uses a formula similar to many other ongoing projects around the country. The reviewer remarked that the installation of a significant number of EVSE along major travel routes will be the most effective result of this project by increasing access to EV charging, which will in turn spur interest in the purchase of EVs among these populations.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer stated the project approach is reasonable and straight forward. It improves the landscape for EV adoption by technology demonstration and infrastructure deployment.

Reviewer 2

The reviewer commented that the project approach includes evaluation of sites for suitability but does not indicate whether/how the communities were engaged to assess their needs. If such engagement was conducted prior to siting and purchasing the equipment, the information should be presented more clearly. There were successes in procuring vehicles, installing EVSE, and deploying data loggers to begin data collection and analysis.

Reviewer 3

The reviewer noted it is difficult to separate the approach from the accomplishments, based on the slides and on the live presentation. However, reviewing the approach based on the milestones presented, it appears to include adequate planning for a successful community need-based site selection process as well as excellent partnerships for technical success. The approach among native nations toward knowledge sharing and interconnectedness, as described in the live presentation, bodes well for replicability.

Reviewer 4

The reviewer commented that installing EVSE along travel routes linking tribal lands directly addresses the energy inequities experienced by these communities. Placing EVs in these communities as service and demo vehicles will expose residents to these clean energy transportation options, and the additional vehicles will certainly be appreciated by the community. The reviewer expressed that the number of vehicles being allocated for such a large geographic area is a bit low and expected a higher ratio of MD group transport vehicles like buses and vans, rather than personal-use-sized light-duty vehicles. The reviewer felt that engaging 10,000 people through in-person events is optimistic and stated curiosity to see the actual numbers for the 52 planned events. Three of the participating sites, presumably for EVSE installation, are casinos. The reviewer expressed concern that subsidizing or incentivizing access to gambling establishments for EV owners may not be in the best interest of the poorer members of these communities, nor is it the best use of DOE funding, at least optically.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer reiterated that the project reports delivery of 15 EVs and two chargers. The project team has conducted the leg work to establish charger locations with agreements with site hosts in place. The project team has also contributed by providing dealership training, in hopes of extending the impact on EV adoption outside of the vehicles purchased directly for this project.

Reviewer 2

The reviewer noted that it appears that this project has met many of its critical milestone targets and that the hard work has been done: EVSE have been installed in many locations and vehicles have been ordered, with some already in service. Ongoing activities such as data gathering need to be completed before some end-of-project materials can be generated, as is the case with many such projects.

Reviewer 3

The reviewer noted considerable progress appears to have been made, but it is challenging to understand exactly what has been completed since the vehicle counts by type and station descriptions do not align.

Reviewer 4

The reviewer commented that site host legal agreements are often a headache for scatter-site EVSE projects, so having those signed at this stage is a terrific accomplishment. Continuous engagement with tribal nations and local communities where deployments and EV charging opportunities are taking place is critical to success. Data loggers allow the participant nations to continually evaluate vehicles for EV replacement feasibility. Consumer and fleet test drive questionnaires show a very great improvement in acceptance of EVs similar to those shown in the rural Appalachia project. The need throughout this project to allow for individuated needs and decisions by sovereign nation tribes presents a unique potential issue (and learning opportunity) with interoperability of travel corridor outcomes.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer noted the project has engaged many important partners including tribal nations, CC&C coalitions, government agencies, industry, and transit agencies.

Reviewer 2

The reviewer stated that the partners appear to be collaborating well and making progress on the project delivery efforts. The inclusion of unique components, such as the solar trailers for pow-wows, demonstrate cultural understanding and opportunity to address a need.

Reviewer 3

The reviewer remarked that this looks like how a successful project should be administered. The working partners all bring excellent credentials to the project. All parties knew their assignments and did their share of the work.

Reviewer 4

The reviewer commented that coordination appears to be effective based on accomplishments. A comprehensive list of cooperating partnerships includes tribal leadership, administrative support and expertise from CC&C coalitions, cost sharing and technical support from utilities, and community partners from various tribal institutions. A description of how the various categories of cooperators work and collaborate would be helpful for others wishing to learn from this project.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer stated that the focus on tribal nations and the vision to unite geographically disparate nations through electric transportation is inspirational and exciting.

Reviewer 2

The reviewer observed that the project is investing in community resources at 13+ locations that are in underserved communities. It includes workforce development opportunities and lowers transportation costs for residents. It is creating a clean mobility system across rural Minnesota, North Dakota, and South Dakota, which improves access to long-distance destinations and new job opportunities.

Reviewer 3

The reviewer noted that clear leadership from within tribe-led organizations means this project is starting from a place of excellence. Its objectives to connect numerous tribal nations to critical services on EV travel corridors and provide personalized community needs speaks to energy equity outcomes and easing of existing community burdens. Replication planning provides additional EJ benefits.

Reviewer 4

The reviewer commented that tribal nations are traditionally underserved and underrepresented in the clean energy/clean transportation areas, and this project directly addresses these types of communities by giving them access to more community service vehicles and by adding EVSE to serve the community directly as well as incentivize travelers to stop and spend time in the communities while charging.

Presentation Number: TI153
Presentation Title: Fleet Research Energy Data and Insights
Principal Investigator: Alicia Birky, National Renewable Energy Laboratory

Presenter

Alicia Birky, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

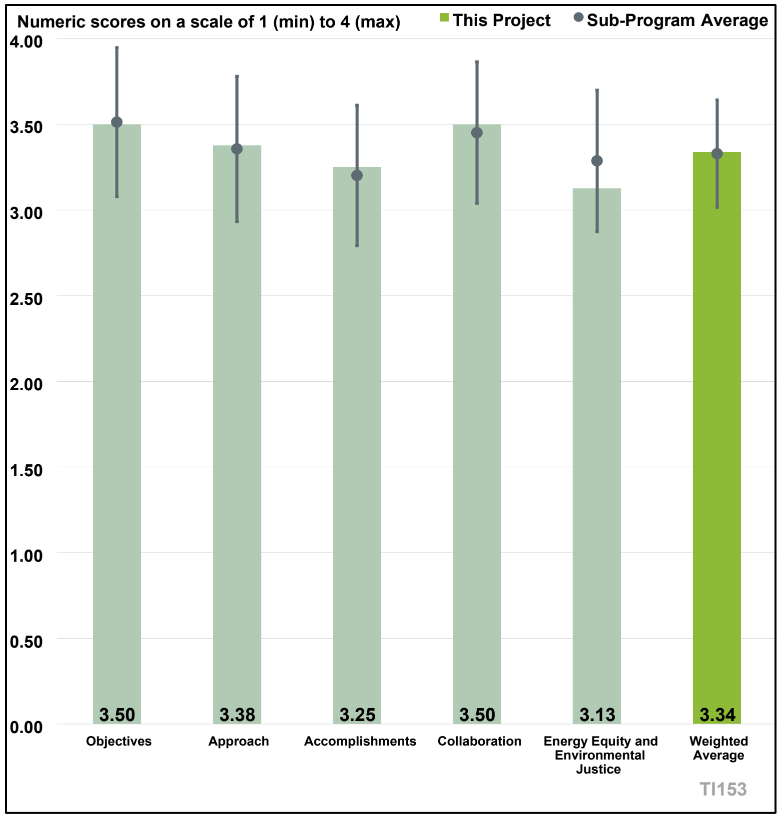

Figure 6-8. Presentation Number: TI153 Presentation Title: Fleet Research Energy Data and Insights Principal Investigator: Alicia Birky, National Renewable Energy Laboratory

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer noted that this project matches TI objectives by providing the latest data available for the benefit of stakeholders and vehicle analysis.

Reviewer 2

The reviewer commented that this project is focused on data gap analysis, data collection, and data analytics to support commercial vehicle (including both conventional vehicles and EVs) RDD&D to achieve decarbonization. This project substantially supports the GHG emission reduction, increase of alternative fuel use, and increasing transportation efficiency, for the commercial vehicle sector.

Reviewer 3

The reviewer observed that the lack of usable data, structured to deliver concrete outcomes needed for TI objectives, is a real barrier to effective action. FleetREDI not only gathers data, but also deploys that data to create useful tools available to industry in a way that ensures privacy of the user and applicability at scale.

Reviewer 4

The reviewer noted that the project's objective is to create a nationally representative set of fleet data that can be used by researchers.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer commented that this project developed a standardized operational data processing pipeline which enables the population of data from various sources to support the project objectives, which is very impressive. Since data are collected from different sources, achieving consistency in planning, collecting, and presenting efficiently will be a challenge. The project team is working on the development of a data logger to improve the process.

Reviewer 2

The reviewer stated the approach is well crafted and planned. The PI noted that a future solution for data storage will need to be defined. Additionally, there was discussion surrounding the best way to provide stakeholders with confidence that their data is protected, limited, and anonymized. That process may still need some development.

Reviewer 3

The reviewer stated that the project idea is sound and much of the analyses being done in FleetREDI are quite innovative. The reviewer appreciated the broad partnership across a number of different stakeholders and the goal of connecting into a variety of tools. Many such tools are emerging, and maintaining cohesion and quality in that ecosystem will be important. The reviewer recommended evaluating different data ingestion mechanisms. Logging individual vehicles as the primary means for data acquisition is inefficient. Vehicle OEMs and a few commercial providers already collect much of this data. Figuring out how to collaborate with those data owners would be a more efficient data acquisition approach and could resolve concerns about data representativeness. That is not necessarily an easy task, but one that is probably worthwhile.

Reviewer 4

The reviewer acknowledged that the approach to this project is directly addressing the technical barriers. The development and use of the "data-driven methodology to assess data coverage and sufficiency" in targeting future datasets and fleets is noted as a great example of focusing the limited resources on the most critical data gaps.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer said the project is on track with progress and accomplishments. In fact, other analysis projects have already begun to use the data collected.

Reviewer 2

The reviewer observed it is still early days for this project (20% complete), but some of the tools and analyses developed are promising. The website with dashboard was welcome and has some useful data. The reviewer remarked that it may not be well known that it exists or what it can do. Figuring out how to generate more user awareness and uptake could be valuable.

Reviewer 3

The reviewer stated that the project team has made impressive progress, including identifying data availabilities and assessing data gaps as well as development of a public-facing website to visualize the information contained in the data. The project team also realized the challenges associated with the security and consistency of data sharing from OEM and fleet partners. The project team has been working on addressing these issues. The reviewer recommended the project team emphasize the alternative fuel technology vehicles that support the decarbonization goal in the presentation.

Reviewer 4

The reviewer noted the team has made very good progress on the technical aspects of the project. One technical item that was mentioned as a potential issue was ensuring consistency of data from third party data providers. The project team seems to be addressing this through the development of data logging and ingestion standards. However, one issue related to progress is that most of the project's data collection has been related to the diesel fleet. The reviewer recommended that to better meet some of the overall TI objectives related to improving fuel diversity and reducing GHG emissions, the project should continue to try to collect data from alternative fuel fleets.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer noted that the project team has been partnering with the other stakeholders to leverage various decarbonization projects across DOE and beyond. Strong collaboration with the existing projects and broad stakeholders is documented in this project.

Reviewer 2

The reviewer stated that the collaborations listed in the opening slide are the right ones. Working with OEMs, regulators, non-profits, other Federal government agencies, and local projects displayed a strong collaborative focus with a broad ecosystem. This will be key for success and is an area where the researchers are encouraged to double down. FleetREDI has high potential but will only reach that potential if it is broadly used by an array of decision makers. The project team is off to a strong start and further effort is encouraged.

Reviewer 3

The reviewer applauded the project team for doing an excellent job collaborating with DOE Livewire data platform and third-party data providers. Collaboration with OEMs seems to be more challenging, but the team appears to continue working with OEMs to share data. The project team and data resources are supporting 25+ projects.

Reviewer 4

The reviewer questioned what the main project team members are contributing and accomplishing beyond the plan. The reviewer wondered if a few private industry stakeholders could be employed (OEM, Geotab, etc.).

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer stated the project is using a data driven approach to fill gaps in data availability. This will assist in making sure that the data being collected is representative of all parts of the country including overburdened and underserved communities.

Reviewer 2

The reviewer suggested that the ability to overlay DAC scores with datasets would be beneficial. The ease of obtaining this information would benefit the EEEJ plan since it would be easily available in any future analysis work.

Reviewer 3

The reviewer noted that the project team focused on data pipe map matching and geospatial data fusion to include DAC scores in the datasets, However, it is important to connect to the fleet owners from DACs and inform them how to utilize the platform developed in this project and make informed decisions towards adoption of low-GHG emission vehicles.

Reviewer 4

The reviewer commented that like all research-focused projects, the connection to EEEJ outcomes really depends on how the research is used. It is difficult to evaluate, at this point, how the FleetREDI capabilities will be deployed in EEEJ contexts. The reviewer suggested a more focused approach on EEEJ related outreach and tool uptake by decisions makers could strengthen these aspects of the project.

Presentation Number: TI154
Presentation Title: Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER)
Principal Investigator: Michael Graham, Columbia-Willamette Clean Cities Coalition

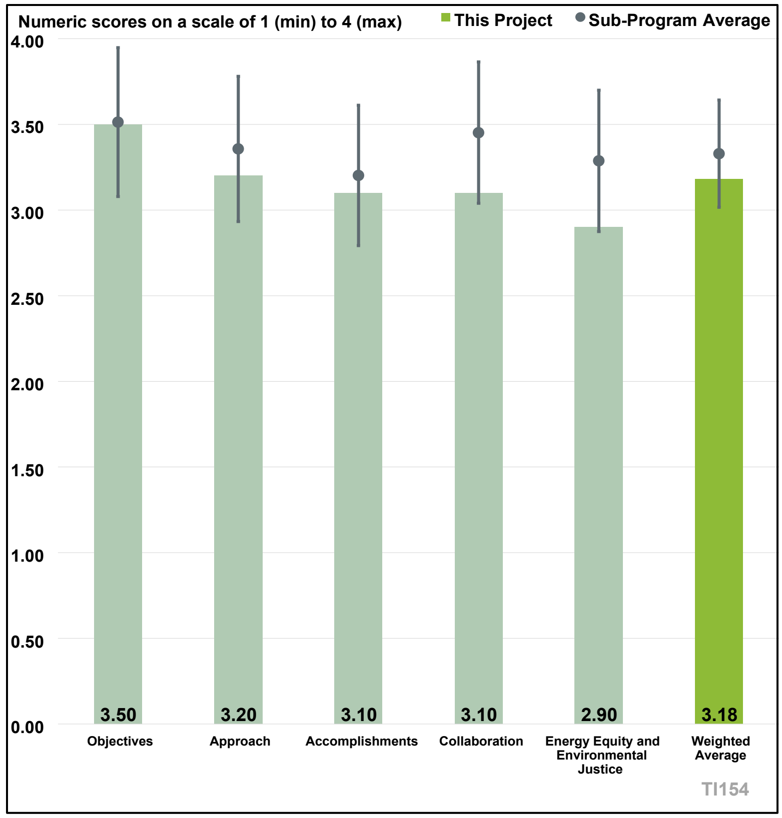

Figure 6-9. Presentation Number: TI154 Presentation Title: Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER) Principal Investigator: Michael Graham, Columbia-Willamette Clean Cities Coalition

Presenter

Michael Graham, Columbia-Willamette Clean Cities Coalition

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer commented that the project objective and overview slides describe the project's specific objectives and barriers addressed, as well as how the project supports the VTO objectives of improving fuel diversity, increasing local resiliency, and reducing GHG emissions by accelerating interest and support for workplace charging to advance EV adoption by working with 30 CC&C coalitions across the country. The project objectives appear to be effective and substantially support TI objectives.

Reviewer 2

The reviewer noted that the project team has reached out to a large number of workplaces and has involved a large number of CC&C coalitions and communities, which puts this program in touch with VTO's objectives.

Reviewer 3

The reviewer noted the project is focused on addressing reliable charging through workplace charging, particularly for those without home charging. Technical information for employers and training for on-site EVSE management are also key elements, which are sorely needed. These objectives are important for expanding the market for EVs, thus improving fuel diversity and reducing GHG emissions through increased use of alternative fuel (electricity).

Reviewer 4

The reviewer observed this project strongly supports the overall TI objectives of improving fuel diversity, increasing local resiliency, and reducing GHG emissions. Workplace charging will provide access to charging for those employees who may not have the ability to charge at home, will reduce the impact of peak EV charging demand on utilities, and will encourage the purchase of PEVs.

Reviewer 5

The reviewer stated that workplace charging is an important element of the solution space for transportation electrification in light-duty vehicles. Workplace charging takes on barriers like workplace engagement, and some elements of capacity development in terms of providing resources and trainings. It only partially addressed the barrier of lack of access to home charging. It is not clear how well access to workplace charging correlates to access to home charging. It would be good to know if the workplaces engaged are providing an extra option for people with home charging, which is nice, or an option to charge to people who previously had none, which is far more impactful. An understanding of the cost and value propositions of workplace charging is also a barrier which would be good to see addressed. The reviewer questioned if the companies make money or lose money on workplace charging and how much. The reviewer asked if money lost is recovered through other pathways like improved worker satisfaction and retention. These are questions that will be important to motivate many workplaces but that are not well understood.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer stated the project website is accomplished and a good resource for workplaces.

Reviewer 2

The reviewer observed the project has used extensive feedback from project partners to develop resources and training, based upon real-world issues. The project is now planning to focus on increasing marketing efforts to employers during the final BP, to work to increase commitments and EVSE ports. If successful, this project should contribute to key solutions in this deployment area.

Reviewer 3

The reviewer commented this project includes some unique and innovative approaches to outreach and education. The project has created a library of handout materials aimed at educating businesses and communities on the benefits of workplace charging and has launched the landing page for an informational website. The project incentivizes participation by recognizing businesses that pledge and install EVSE with an "EV Friendly Workplace" certificate and mention on the project website.

Reviewer 4

The reviewer stated a belief that overall, this project takes on two important elements of getting charging installed at workplaces: supporting workplaces with knowledge resources and training and providing recognition of successes. The reviewer suggested that adding some views of how much it costs to install workplace charging, how those costs could be mitigated, what revenue or non-monetary benefits such charging could provide, etc., would strengthen the project. At this moment, the only incentive is recognition, which may be of limited value. The reviewer appreciated the idea of the utility working group and would have liked to see more content on what this group does and how findings from this group could be more broadly publicized and understood. The amount of outreach carried out in this program was appreciated as sometimes getting the word out is of under-appreciated value.

Reviewer 5

The reviewer noted the project approach section provides a satisfactory methodology to accomplishing the project objectives and supporting the integration of advanced transportation technologies and practices. The project approach is divided into three project periods (planning and preparing, implementation of outreach, and succession planning and wrap-up), each containing associated tasks. The milestone slide appears to only display a subset of the total project milestones. More details related to all the project's milestones, as well as activities/tasks under each BP would have provided more details on the entire project scope.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer noted that the project appears to be on track to meet its goals. It has engaged over 3,300 workplaces and received 221 commitments, although EVSE installations are just getting started, with 25 ports installed of the planned 3,500.

Reviewer 2

The reviewer commented that the project is nearly complete with go/no-go for end of BP 2, completing all BP 2 milestones. The project has completed an EEEJ action plan to direct at least 40% of funds/benefits to DACs. The team kicked off the outreach of BP 2 in advance of schedule. They have engaged more workplaces than planned, but only 34% of pledges at time of presentation development; the update is closer to 50% now. 250 EVSE ports have been installed to date (roughly 8% of goal). The biggest issues have been funding for EVSE plus the number of decisions needed within employers/facilities. The project started the EMPOWER Recognition Program during BP 2. The project has created a number of resources (one-pagers and handouts) in response to needs identified. The project has recently developed a tracking dashboard available on the website, identifying organizations involved in the project.

Reviewer 3

The reviewer cited significant outreach, which is a prerequisite for success. Converting engagement to pledges to installations will be where the project ultimately succeeds or fails. The reviewer noted it is still early to know how collecting pledges is going. The reviewer commented that only 25 ports (presumably L2) seems like a low number, but that may be a function of timing lag from engagement to pledge to infrastructure deployment. More details on how that process looks and whether installation numbers are troubling or expected would be valuable. Also, some estimate of causality would be valuable. The reviewer asked if the workplaces that pledged to install would have done so without this program and if the recognition provided by this project was a meaningful motivation to install chargers. The reviewer questioned if the resources and technical support provided enhanced decision making. The reviewer suggested a survey gauging motivations and incremental benefit would help understand those types of questions.

Reviewer 4

The reviewer acknowledged that good progress has been made towards achieving project goals. The project has made progress on several key activities: (1) 3,300 workplace engagements vs. the project goal of 2,000, (2) 124% of the pledged workplaces meet Justice40 metrics, and (3) launch of the workplace charging resource center landing page (www.workplacecharging.com), which contains a number of project resources. Goals related to EVSE ports installed appear to be behind schedule with only 1% installed.

Reviewer 5

The reviewer noted that the project team missed the mark of installing a large number of EVSEs in workplaces which defeats the purpose of providing an alternative to employees who are garage orphans, (EV owners with no garage or driveway). They have developed nice recognition certificates but have failed to define exceptional commitment in a workplace.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer stated the project includes a significant team of partners, including 30 CC&C coalitions. The project appears to have specific roles for all team members with a clear project management hierarchy.

Reviewer 2

The reviewer commented that project team members are well chosen and have significant experience in their areas of expertise. The project partners include CC&C coalitions from around the country and regional captains have been identified to oversee operations at a localized level.

Reviewer 3

The reviewer noted the broad geographic scope of partners in states of different levels of EV and EVSE deployment and the mobilization of expertise like Smart Electric Power Alliance, American Lung Association, and others was valuable and creates strong opportunities for learning and knowledge sharing. It was not clear, however, how deep that knowledge sharing went and how it ultimately made it to end users. The reviewer understood that there was a training by CC&C implementation partners on workplace charging issues, but it was difficult to understand how effective that was. More information on how that training was carried out, how CC&C partners used the information provided and whether those implementing partners found that it ultimately led to workplace action would be valuable for future merit reviews.

Reviewer 4

The reviewer cited an effective project team including Columbia-Willamette Clean Cities (prime), and 30 CC&C coalition partners across the country, as well as numerous other key partners, were assembled to carry out this project and provide an appropriate mix of expertise among team members. Beyond just listing the project partners, the collaboration and coordination slide would have benefited from some details related to the frequency and purpose of project team meetings/interactions.

Reviewer 5

The reviewer noted that while the researchers have listed the partners in this project, their roles to accomplish the project goals are not clear. It has been suggested that dealerships be included in their workplaces to contact as they are also employers.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer commented that this project will provide greater opportunities for underserved communities by expanding EV options and providing workforce development training for careers in the clean mobility field. The percentage of pledged workplaces that meet Energy and Environmental Justice Metrics has exceeded projections, and the project's incentive program also includes recognition of businesses for meeting EEEJ criteria.

Reviewer 2

The reviewer stated a belief that EEEJ was potentially an important part of providing charging access to low to middle income communities, especially residents of multifamily housing without access to home charging. That energy equity (EE) benefit could be substantial but is highly dependent on what types of workplaces are being engaged and ultimately making commitments. More details on categories of workplace engaged and the type of employee for whom those workplaces are seeking to provide charging would be valuable. For example, a warehouse providing charging may provide considerably more EE benefit than an office park or tech campus.

Reviewer 3

The reviewer acknowledged that the project has good potential to contribute to EEEJ goals by reducing GHG emissions by accelerating interest and support for workplace charging. The project contains a goal on the number of pledged workplaces meeting project EEJ metrics and by including in the EMPOWER Recognition Program a category (Level 3) to recognize "exceptional commitment to expanding access to EVs for their employees, especially when meeting EMPOWER's EEJ metrics as an EEJ Workplace." Given the large geographic footprint of this project, it would have benefited from including more community-based organizations, to help provide local priorities for this project and ensuring the connection between the workplaces and their surrounding communities. Finally, until the deployment of the project is up and running at full capacity and the anticipated results are documented, it is difficult to evaluate the significance of the project benefits.

Reviewer 4

The reviewer noted that the project is specifically focused on ensuring that at least 40% of funds/benefits are applied to underserved communities through EVSE expansion. This is important, though, overall, the project team does not appear to be emphasizing EEEJ elements, at least in the presentation.

Reviewer 5

The reviewer stated it is not clear how this project will have served EJ communities. The team does have an action plan but did not explain what that is.

Presentation Number: TI155
Presentation Title: Charge To Work USA
Principal Investigator: Jason Zimbler, CALSTART

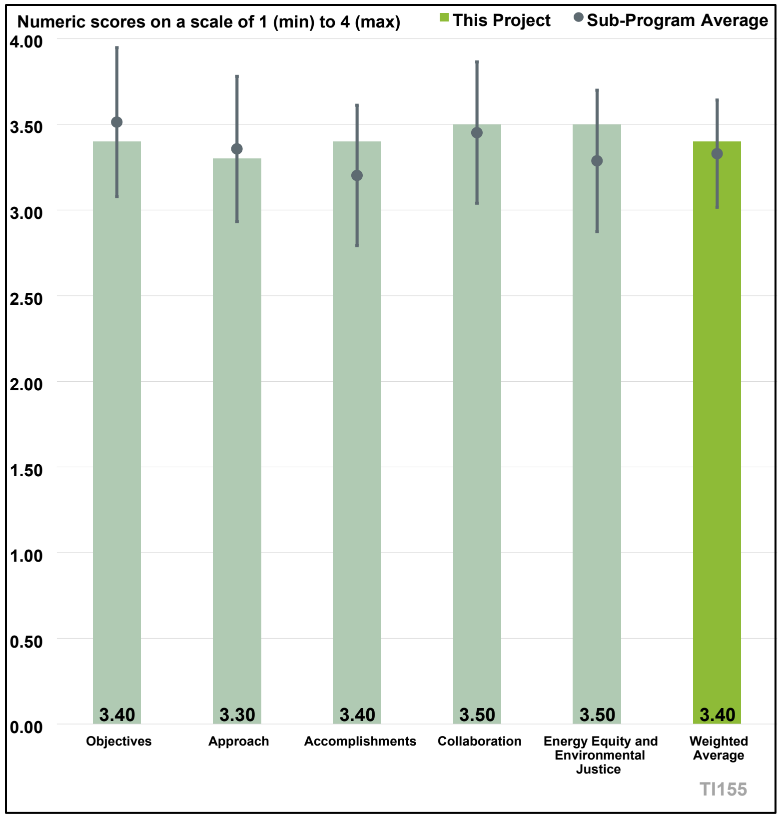

Figure 6-10. Presentation Number: TI155 Presentation Title: Charge To Work USA Principal Investigator: Jason Zimbler, CALSTART

Presenter

Jason Zimbler, CALSTART

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

This reviewer said that this project strongly supports the TI objectives of improving fuel diversity, increasing local resiliency and reducing GHG emissions. The reviewer believed that the project's objective of fostering a large-scale workplace charging initiative will increase the coverage of charging infrastructure, increasing consumer confidence and reduce range anxiety. In addition, the reviewer noted that the project is targeting sites in DACs, so that employees who do not have the means to charge at home will have access to convenient charging at work. The reviewer admired the project's goal of installing at least 100,000 charge ports.

Reviewer 2

The reviewer acknowledged that the project objective and overview slides described the project's specific objectives and barriers addressed. The reviewer also said that the project supports the VTO objectives of increasing local resiliency and reducing GHG emissions by creating a self-sustaining market for workplace charging. The reviewer appreciated that the project objectives appear to be effective and substantially support TI objectives.

Reviewer 3

This reviewer found that the project is focused on improving access to workplace charging for EV owners by expanding charging capacity at key locations. The reviewer remarked that this project supports TI objectives by allowing EV owners additional opportunities for charging their vehicles, particularly those who may not have charging options at home. The reviewer believes that this is a critical element for expanding the ability for drivers to adopt cleaner technologies that result in petroleum displacement.

Reviewer 4

This reviewer noted that the PI laid out a clear plan with specific numbers as to the type of employers to reach out to.

Reviewer 5

This reviewer stated that the objectives of this project supported the overall TI objectives. The reviewer appreciated the objective of spurring a marketplace for adoption of workplace for EV charging, though the reviewer was unclear how that objective was being carried out in practice. The reviewer recommended more information on approaches and lessons learned in marketplace development be included in future iterations.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

This reviewer acknowledged that this project has a well-rounded approach, shows a thorough understanding of the barriers that stand in the way of workplace charging commitments, and offers effective solutions, like a Project Builder Tool and a project website, to educate business owners and alleviate any concerns the owners may have. The reviewer remarked that the project has effectively used search engine data to identify business owners that may be predisposed to installing EVSE and highlighted the fact that the project team has prioritized healthcare facilities and higher education organizations as targets with a high probability for success. The reviewer also noted that the project team has recruited community officials to help encourage local businesses to sign up for the charging initiative. The reviewer noticed that the co-primes on this project are also co-primes on the very similar Leadership of Employers for Electrification Program (LEEP) project (TI156) and believe that this overlap in leadership will serve to strengthen both projects.

Reviewer 2

This reviewer had generally favorable comments for this project. The reviewer found that all project approaches for workplace charging were analogous, focusing on technical capacity development and commitment generation. The reviewer felt that the approach to capacity building and tools provided in this project were stronger than many projects, and that commitment generation appeared to be on course with the project plan.

Reviewer 3

This reviewer noted that reaching out to specific, different sized employers has made obtaining workplace charging pledges easier to obtain, showing similarly sized companies' examples and enabling those employers to see what similar companies are doing in the EVSE world.

Reviewer 4

The reviewer mentioned that this project is focused on putting charging infrastructure where people work to enable deployment of EVs. The reviewer found that the project provided technical assistance and information to help employers deploy EVSE for workplace charging and that the project specifically looks at how to develop a self-sustaining workplace charging model. The reviewer noted that a unique aspect of this project's approach was to incorporate outreach to public officials to help multiply the message, as well as the inclusion of a workplace resource center and portal. The project team is also working carefully to focus future efforts toward employers who may be closer to considering workplace charging. The reviewer cautioned that the project goal of 100,000 charging ports appears to be overly ambitious and may not match completely with numbers of employers targeted under this project.

Reviewer 5

The reviewer found that the project approach section provided a satisfactory methodology to accomplishing the project objectives and supporting the integration of advanced transportation technologies and practices. The reviewer noted that the project approach is divided by three project periods (Lay the Foundation for Workplace Charging Nationwide, Gain Momentum in Workplace Charging Implementation, and Create a Self-Sustaining Market for Workplace Charging), each containing associated tasks. Additionally, the review found that the Milestone slides provided significant detail with regards to the planned tasks per Budget Periods and progress-to-date. The reviewer noted that the project goal of contributing to at least 100,000 EVSE port installations may be unrealistic, given this project would contribute 20% of the ports needed to reach President Biden's 500,000 charging port goal.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

This reviewer admired the project website and the project evaluation tool, stating that the tools were unique. The reviewer also appreciated that the website linked directly to the Electric Vehicle Adoption Leadership (EVAL) certification tool. The reviewer noted that the project team's commitments were on track with all established goals. The reviewer suggested that the project would benefit from the discussion of a plan for marketplace creation/support and the discussion of what role the tool/website plays in that.

Reviewer 2

This reviewer noted that good progress has been made towards achieving project goals. The reviewer found that the project has made progress on several key activities, notably launching the Charge@Work webpage and Project Builder tool, obtaining 10+ pledges from large employers and 100+ from small/medium sized employers to commit to workplace charging implementation, and hosting nearly 40 programmatic events across the nation via webinars, conferences, and automotive shows. However, the reviewer stated that progress to the "1,000 site assessments" or the "100,000 ports" goals were not covered on the presentation slides.

Reviewer 3

The reviewer noted that the project team clearly listed the types of public events and appearances involved in this project (Employee Recruitment) and that the team developed a workplace charging resource center.

Reviewer 4

The reviewer remarked that the project hit an issue with availability of chargers (particularly in DACs) as well as demonstrated a difficult economic/business case for workplace charging. The reviewer noted that the project developed tools and resources needed by employers and built relationships with public officials and employers. The person found that the project has a clear path forward for meeting the overall and BP 2 metrics concerning public official and employer commitments, and that the team is particularly close on large employer commitments for BP 2. The reviewer noted that the team has achieved over 200 pledges from employers and over 50 from elected officials, while the overall plan calls for 100,000 chargers. The reviewer remarked that this goal is quite large.

Reviewer 5

The reviewer found that the project's groundwork tasks from BP 1 have been completed. The Charge@Work website and Project Builder tool have been demonstrated, and some community engagement events and webinars have been held, but the reviewer found that many tasks are still in progress near the end of BP 2. The reviewer also noted that at the time of this project's presentation, the project was well short of gaining commitments from 450 businesses and 100 public officials.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer mentioned that the project team has a clearly defined structure and schedule for routine communication among team members. The reviewer appreciated that the team co-primes have a strong track record of success in EVSE development and installation, and that the project team recruited officials in many communities to act as ambassadors and liaise with local businesses, encouraging them to sign on for the charge at work program.

Reviewer 2

The reviewer found it helpful that the project team clearly defined their collaboration cadence, including how often the project staff meets as a both group and one-on-one.

Reviewer 3

The reviewer noted that the project team of CALSTART (prime), five CC&C coalition partners across the country, and numerous other key partners was effectively assembled to carry out this project and provide an appropriate mix of expertise among team members. The reviewer also stated that collaboration and communication among project partners was appropriate for the project scope.

Reviewer 4

This reviewer expressed that project coordination appeared to be strong and well organized. The reviewer appreciated the attempts to link to another project's certification scheme, demonstrating inter-project collaboration. The reviewer recommended more discussion about how energy, equity, and inclusion (EEI) fit into the bigger picture, as well as the national grid, and the reviewer felt that utilities were an underappreciated element of the workplace charging equation. The reviewer believes that the project would benefit from insight about how previous commitments were being engaged to support workplace charging development, what lessons exist for utilities beyond NG, and how EEI could facilitate utility learning.

Reviewer 5

This reviewer noted that the project team is collaborating closely with the related Forth workplace charging project every few weeks. The person found that the project team includes advocates and implementers, as well as utilities and CC&C coalitions. There are monthly calls with subrecipients (partners). The reviewer encouraged the project team to focus on improving outreach to high value audiences but praised the project's overall plan which identifies clear roles for each member.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

This reviewer appreciated the project survey that assessed the energy equity impacts of this work. The reviewer compared the project to other projects that assume work charging would benefit those who did not have home charging. The reviewer admired that the project team collected information about where chargers were located and the associated equity implications. This reviewer recommended further investigation of what types of businesses were installing chargers and whether users did or did not have access to home charging. The person acknowledged that location is only a high-level equity indicator and that follow-on surveys could make the impact evaluation more robust.

Reviewer 2

The reviewer mentioned that the project has potential to contribute to EEEJ goals by reducing GHG emissions via accelerating interest and support for workplace charging. The reviewer pointed out that the EEEJ presentation slide provided a number of project metrics to demonstrate the commitment to J40 goals. The reviewer also suggested that the project would benefit from including more community-based organizations in each coalition location, to help provide local priorities for this project.

Reviewer 3

This reviewer noted that the listing of specific percentages in the EEJ communities and events shows a major commitment to these communities.

Reviewer 4

The reviewer found that the project's commitment to EEEJ is demonstrated primarily through six targets, which constitute a thoughtful and inclusive plan for considering diversity, equity, and inclusion (DEI) in the project management plan. These targets include: 60% of employer pledges adjacent or within J40 communities, 30% of employer sites located in underserved areas, 25% of workplace charging stations in underserved areas, 40% of Ride and Drives in underserved areas, 30% of business certifications in DEI areas, and 30% of budget to minority- or women-owned business enterprises (MBWE).

Reviewer 5

This reviewer praised the project team for going beyond their goals for many EEEJ metrics, as over 60% of sites pledges are adjacent to or within J40 communities. The project team has found that the project's message can remain consistent among all J40 communities. The reviewer noted that the feedback provided to the project team from communities is largely the same as other communities, in that employees appreciate workplace charging. This reviewer indicated that putting a charger at an employer in an J40 location does not necessarily benefit the community, and that dual use has largely been for fleet vehicles and employee vehicles. The reviewer suggested that the project team explore opportunities for sharing chargers at certain types of employers (like grocery stores), which the team has explored slightly.

Presentation Number: TI156
Presentation Title: Leadership of Employers for Electrification Program (LEEP)
Principal Investigator: Prateek Suri, Forth Mobility

Presenter

Prateek Suri, Forth Mobility

Reviewer Sample Size

A total of four reviewers evaluated this project.

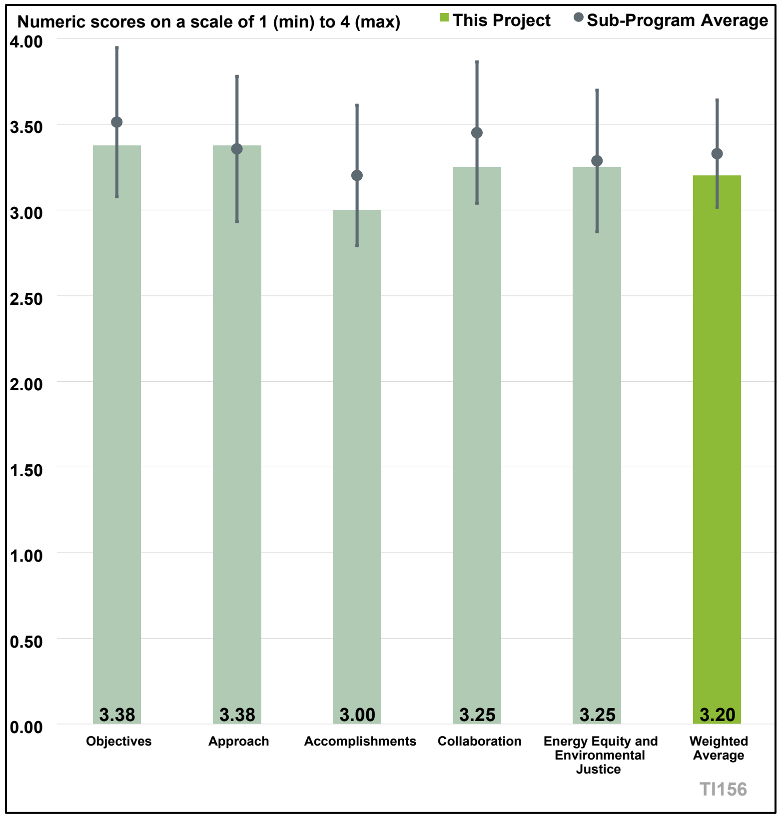

Figure 6-11. Presentation Number: TI156 Presentation Title: Leadership of Employers for Electrification Program (LEEP) Principal Investigator: Prateek Suri, Forth Mobility

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

This reviewer found that the objectives of this project can meet the stated TI objectives but acknowledged that their success depends heavily on implementation specifics. The reviewer stated that TI objectives would be marginal if workplace charging is another option for people with access to home charging. However, the impact would be substantial if it is providing access to charging to people without other charging options. The reviewer suggested dedicating a presentation slide to specifically target the latter use cases to enhance alignment with TI's objectives.

Reviewer 2

This reviewer stated that communicating to workplaces about EVSE for employees is a positive step for VTO.

Reviewer 3

The reviewer confirmed that this project strongly supports the TI goals of improving fuel diversity, increasing local resiliency and reducing GHG emissions by promoting and enabling increased use of PEVs. The reviewer indicated that the project directly targets three distinct barriers: lack of technical knowledge related to the implementation of charging infrastructure, lack of access to electric mobility and charging solutions, and lack of organizational capacity to pursue workplace charging solutions. The reviewer noted that the project team's goal of 2,500+ workplace commitments and 20,000 EVSE port installations is quite high, but it represents a fraction of the total charge ports needed to create an effective national EV charging network, noting that charging at work makes the best sense for most drivers.

Reviewer 4

The reviewer found that the project objective and overview slides describe the project's specific objectives and barriers addressed, as well as how the project supports the VTO objectives of increasing local resiliency and reducing GHG emissions by creating a nationwide workplace charging program comprised of education, outreach and technical assistance activities. The person noted that the project objectives appear to be effective and substantially support TI objectives.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

This reviewer found that the project approach was good and had a more mature plan than many AMR projects. In particular this reviewer appreciated the project website that was developed, along with the high-quality resources on the website. The reviewer also admired the tracking of employer types engaged and the preparation of user surveys.

Reviewer 2

This reviewer praised the project approach section's methodology to accomplishing the project objectives and supporting the integration of advanced transportation technologies and practices. The project approach is divided into three project periods (Platform Design and Distribution Plan, Cohort Launch and Data Collection, and National Campaign Launch), each containing associated tasks and applicable go/no-go decision points. The reviewer noted that the Milestone slide provided appropriate detail with regards to the planned tasks per Budget Periods and progress-to-date.

Reviewer 3

This reviewer found that the presentation lacked clarity of how communication to employers is happening. The project team identified robust numbers but did not specify how the team intended to achieve them.

Reviewer 4

This reviewer found it innovative and unique how the project team is incentivizing employers to commit to the program through recognition/certification by the EVAL certification. The reviewer also noted that encouraging the installation of dual-use chargers, open to the public at times when employees are not using them, adds benefit to the local communities. The reviewer highlighted that the overlap in leadership between this project and Charge@Work project (TI155) will serve to strengthen both projects.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

This reviewer found the project website to be well executed and containing valuable information. However, the reviewer also found it difficult to assess progress towards both engagement and installation goals, namely the 20,000 EVSE installation goal, and requested updates to the progress of those goals in in future reviews.

Reviewer 2

The reviewer acknowledged that the team has made satisfactory progress towards achieving project goals, including: 1) completing the buildout of the EVAL website, including public-facing pages, 2) completing numerous outreach and marketing activities, and 3) hosting nearly 40 programmatic events across the nation via webinars, conferences, and automotive shows. The reviewer noted that progress to the “5000+ employer worksite registrations on the EVAL platform” goal appears to be behind schedule, and that progress to the “2,500+ employer commitments” or the “20,000+ port installations” goals were not covered.

Reviewer 3

The reviewer noted that the project team has a series of “in Progress” sections and urged the team to move along with this project.

Reviewer 4

This reviewer writes that the project did not produce many tangible results. For instance, EVSE have been installed at workplaces, but most of the education/outreach groundwork and project planning has been done. The reviewer noted a lack of updates on the number of employer commitments received or projections relative to reaching the 2,500 workplaces and 20,000 EVSE goals. The reviewer pointed out the potential for a site’s Leadership in Energy and Environmental Design rating to be adversely affected by the extra power consumption of installed EVSE, highlighting the project team’s awareness of the issue.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

This reviewer found that the project mobilized a strong team of both primes and subs as well as implementation partners, and that the overall collaboration plan was well documented and effectively implemented. The reviewer also felt as though communication and collaboration between three similar workplace charging projects would have been desirable.

Reviewer 2

The reviewer highlighted that the project team of Forth (prime), CC&C coalition partners across the country, and numerous other key partners, was effectively assembled to carry out this project and provide an appropriate mix of expertise among team members. The reviewer noted that collaboration and communication among project partners was appropriate for the scope of the project.

Reviewer 3

The reviewer noted this project’s large number of sub-recipients, most of whom are local implementation partners. The reviewer also praised the project team’s strong background in EVSE infrastructure planning and deployment, clearly defined organizational structure, and effective communication plan.

Reviewer 4

The reviewer found that the project’s collaboration and coordination chart lacked specifics as to what each team member is responsible for.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

This reviewer found that the project has strong potential to contribute to EEEJ goals by bringing outreach, education and resources on EVs and charging access to employers and workers of all demographics. The reviewer acknowledged that the Energy Equity and EJ presentation slides provided project metrics that demonstrate commitment to J40 goals and project benefits.

Reviewer 2

This reviewer noted that this project's ability to meaningfully impact energy equity will rely on the provision of charging to people without the option to home charge. The reviewer suggested including evidence of who is using workplace charging or whether the types of businesses collaborating with this project could reasonably be expected to employ a high number of people without other access to charging.

Reviewer 3

The reviewer appreciated the project's robust written plan but found that the project lacked clarity of how it would be implemented.

Reviewer 4

This reviewer acknowledged that workplace charging provides access to electric mobility and charging solutions for those who may not have the means or facility to charge at home, therefore this project has the potential to accelerate PEV adoption among a large segment of the population. This reviewer also highlighted that this project is prioritizing opportunities for MBWE to perform the EVSE installations and admired that the project team is convening a focus group to ensure that DEI principles are integrated into its project management plan.

Presentation Number: TI157
Presentation Title: Wasatch Front Multi-Modal Corridor Electrification Plan
Principal Investigator: Regan Zane, Utah State University

Presenter

Dustin Maughan, Utah State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

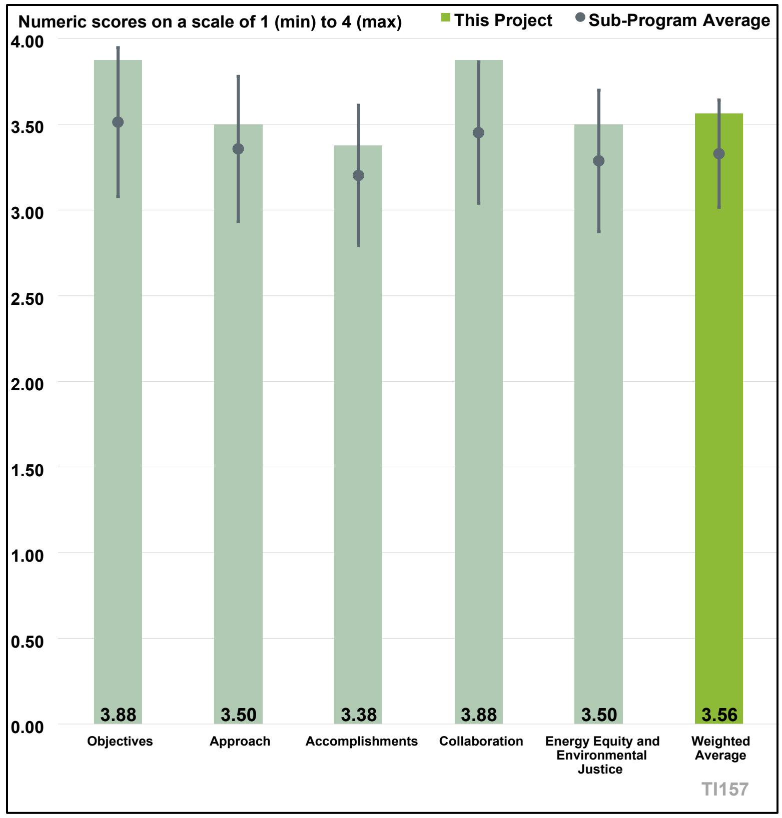

Figure 6-12. Presentation Number: TI157 Presentation Title: Wasatch Front Multi-Modal Corridor Electrification Plan Principal Investigator: Regan Zane, Utah State University

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

This reviewer believed that this project's largest strength is that the team is developing a multi-modal plan that supports electrification of freight and people movement, which is strongly relevant to VTO objectives.

Reviewer 2

The person noted that the project's multi-modal approach for reducing emissions aligns well with DOE goals.

Reviewer 3

The reviewer appreciated that the project team was investigating the impact of corridor transportation emissions on low-income communities, particularly for freight travel, as it is a crucial issue to solve, especially in this area of Utah (UT).

Reviewer 4

This reviewer praised the project team's discussion of transportation alternatives, especially the team's mention of light rail/train as an option and the discussion of using analysis tools to establish the best electrification opportunities. The reviewer noted that the project's goals of assisting communities, especially low-income communities, will be met with support from the UT Clean Cities coalition. The reviewer also appreciated that the project focused on small fleets, which are often overlooked.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

This reviewer admires the community planning aspect of this study, the fact that the project includes UT inland ports, and that the project team is exploring multiple scenarios and meeting so often.

Reviewer 2

This reviewer found that the variety of approaches used in this project are useful and well-thought out to reduce emissions in the corridor, and there seems to be a commonsense approach to the prioritization of solutions. Transit, freight, and utility models will be studied via scenarios to understand the cost and importance of each solution type.

Reviewer 3

The reviewer appreciated the technological aspect of this work combined with the community outreach and looks forward to the project's community-forward case study. The reviewer believed that it is interesting to see how medium- and heavy-duty (MD/HD) charging is combined with community charging or electrifying transit, even though many communities are not fully involved in the HD shipping that is a part of this corridor. The reviewer noted that the transit would be difficult, as many residents work jobs that require commuting in the middle of the night when transit is not running. Additionally, among other long-term questions, this reviewer questioned if the study plans to do anything to offset community electric loads or focus on charging during off-peak times. The reviewer recalled the PI noting that attention to the systematic investment plan would be included in the project's annual plans, and that on-site storage would be a temporary solution along with DER.

Reviewer 4

This reviewer pointed out that the project has a strong degree of community engagement and input into the plan development process. The reviewer also noted that the project team's scope is too large to the point where it is unclear what the team's main priorities are among the various components. The reviewer also noted that the degree of coordination/focus on interstate connections to the port are not very clear.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

This reviewer identified two particular project strengths: 1) the fact that the team has accomplished a reasonable amount of data collection and modeling development work during the performance period, and 2) that the project supports an adjacently funded 5-year effort.

Reviewer 2

The reviewer found that the project deadlines for the Inland Port plan are being impacted by changes to UT's Inland Port vision. Data collection and modeling appeared to be detailed from the high-level presentation, although parts of this study have been modeled in recent years already. This reviewer appreciated the project's new, and more holistic, modeling view.

Reviewer 3

This reviewer admired the team's work collecting lots of data. This reviewer enjoyed the presentation on the models that have been developed and the "infrastructure optimizer" and looks forward to the models and tools being further refined. However, this reviewer had difficulty following some of charts that were used.

Reviewer 4

This reviewer acknowledged the project's large scope, cautioning the project team about running out of time and resources to complete tasks for the transit, freight and utility studies, along with an understanding of the impact on emissions. The reviewer also suggested that the team be more transparent with data analysis regarding the model of energy consumption, transportation costs, and emissions for future electrification scenarios, including discussing how decisions will be made. The reviewer recommended the National Renewable Energy Laboratory's (NREL) scenario analysis tool for classifying Mobility, Energy, and Productivity of land use, which may make analysis easier.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer had high praise of the project plan for collaboration and stakeholder input, hoping that input can be efficiently garnered, and that proper communication of scenario outputs can be completed, given the number of stakeholders, advisory boards and partner members.

Reviewer 2

This reviewer found that the project had good coordination with the UT Inland Port Authority and admired that the project lead (Advancing Sustainability through Powered Infrastructure for Roadway Electrification [ASPIRE] Center) is a state congressionally directed entity.

Reviewer 3

The reviewer found that this study will be extremely useful to other areas of UT as well as other communities nationally if the Advisory Board Team/committee partners engage positively with the project. The project's state funding and the UT Inland Port initiative, combined with this DOE funding, guarantee the attention of the committee members. The reviewer cautioned the project team, saying that care will be needed to balance out the political desires of the state funding with the technical solutions and recommendations from the modeling, as well as the community feedback.

Reviewer 4

This reviewer appreciated the project team's time commitment and bi-weekly team meeting schedule, predicting that the team will achieve the project goals without much issue.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

This reviewer praised the team's focus on EEJ, as well as the team's focus on communities that have the poorest air quality, and the largest health risks associated with diesel PM and vehicle emissions. The reviewer also appreciated that the project team is offering/studying solutions that will allow low-income DACs access to more affordable transportation alternatives.

Reviewer 2

This reviewer admired that the project directly targets long-term air quality improvement among DACs impacted by freight transport, through MD/HD electrification planning, as well as electrified transit planning.

Reviewer 3

This reviewer suggested that the project team include more details on this project's EJ involvement, as the project is moving into the community engagement stage. The reviewer noted that community engagement for this project has been combined with larger community engagement efforts conducted by ASPIRE in the impacted community over the past several years. This reviewer praised the project's ability to build trust but cautioned the team to not allow community engagement to be outweighed by the non-community representatives of the Advisory Board.

Reviewer 4

This reviewer would have appreciated additional discussion of the transit and freight emissions impact on the EJ communities and the cost weighed versus health cost on the population. The project team could address this by re-thinking the market impact assessment. This reviewer thought it was unclear if the project team had an understanding of the baseline emissions within the region.

Presentation Number: TI158
Presentation Title: East Coast Commercial Zero-Emissions Vehicle (ZEV) Corridor Planning Partnership
Principal Investigator: Michael Joseph, CALSTART

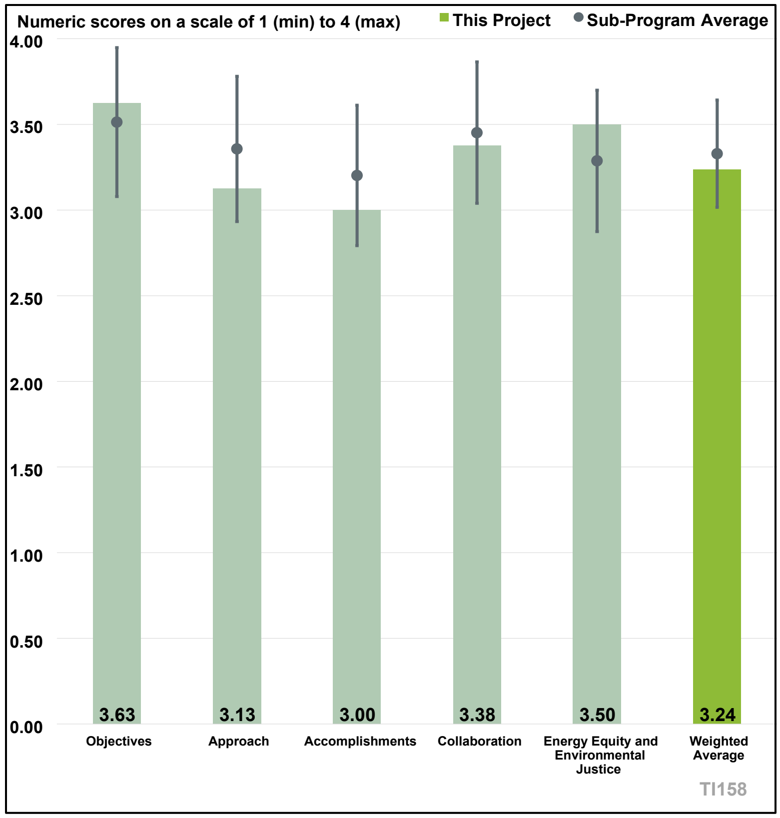

Figure 6-13. Presentation Number: TI158 Presentation Title: East Coast Commercial Zero-Emissions Vehicle (ZEV) Corridor Planning Partnership Principal Investigator: Michael Joseph, CALSTART

Presenter

Annie Lee, CALSTART

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

This reviewer admired that the project would produce and publish a plan identifying specific site/node recommendations for zero-emission vehicle (ZEV) infrastructure development along I-95 across 7 states, aligning closely with VTO goals and objectives. Additionally, this reviewer saw it as a strength that there is much existing East Coast ZEV corridor work that this project can leverage.

Reviewer 2

This reviewer noted the large scope of this project and its involvement with multiple important stakeholders, thought this reviewer would like to have seen what one of the working group roadmaps looks like to understand the planning process. The reviewer had high praise for the project strategy approach in aligning utilities, financing models, site configurations, and ensuring investment in identified areas, but the reviewer did not understand how the approach would be accomplished.

Reviewer 3

Assuming that this project successfully meets the stated goals, then this reviewer believes that it will contribute to the TI objectives, though more information is needed about the electricity generation grid mix along the corridor, as well as where any proposed H_2 fuel would be shipped in from.

Reviewer 4

This reviewer believed that the two fuels discussed in this project (battery/utility electricity and H_2 fuel cell electric) will add to the diversity of fuels available on the I-95 Corridor. This reviewer admired the project team and their work toward meeting TI objectives and "Community First" focus. However, the reviewer felt that the project is moving slowly due to the large number of project partners.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

This reviewer did not see analysis of today's baseline GHG emissions for HD freight within the corridor and hopes that the project team will include that in future presentations.

Reviewer 2

This reviewer noted the project's wide array of stakeholders with their own regional concerns and believes that the team's coordination efforts to create a functional and replicable model for ZEV deployment will be a challenge. As much of the effort relies on CC&C coalitions to coordinate local efforts, this reviewer wondered how this project will ensure that coalitions are prioritizing this particular effort in their short time frame. The reviewer commented that much of this project involves planning, and that none of the partners (aside from utility partners and some Industry Working Group members) are deploying EV or H_2 stations. The reviewer cautioned the project team about avoiding scope creep and prioritizing the right partners, suggesting that existing work should be leveraged to fill in the gaps for something new.

Reviewer 3

The reviewer pointed out that the goals of this project may be difficult to achieve. Additionally, this reviewer found that the presentation included too many details and not enough graphics. The reviewer suggested including fleets as a part of the industry team, as it appears that the team consists mostly of suppliers of vehicles and infrastructure. This reviewer warned that it may be difficult to meet the zero emissions standards due to lack of available MD/HD vehicles at this time.

Reviewer 4

This reviewer did not see how H_2 was included in the current work or partner coordination, even though it is included in the project scope. The reviewer also suggested that the project team consider truck parking as a key aspect of the plan.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

This reviewer praised the project team for forming and standing-up an industry working group and utilizing a well-scoped survey to assess their statuses along the I-95 corridor, however the project's milestone progress is slightly behind schedule.

Reviewer 2

Due to the project's size and scope, this reviewer had difficulty judging the project's progress. This reviewer found that the project has a good start but could easily fall behind quickly. It appears that the size of the project budget is justified for year two to continue the pace of progress, but the reviewer suggested looking into NREL's mobility planning tool which may be beneficial to project work.

Reviewer 3

It was difficult for this reviewer to understand how the project team interacts with different groups on the project (Community, Industry, Infrastructure). The reviewer encouraged the team to communicate often between groups, as it will be critical to developing and deploying the necessary infrastructure. Additionally, the reviewer suggested that the team should focus more on projects that can be easily replicated.

Reviewer 4

This reviewer noted that the project accomplishments in Q1 2023 and Q2 2024 are closer to ancillary accomplishments to highlight the project, rather than actual milestones. This reviewer is concerned that, nine months into the project, the project team 1) has not guaranteed involvement from all the relevant ports along this freight corridor, 2) has not secured all their State Energy Office partners, 3) has no plan to coordinate with the Appalachian Hydrogen Hub, and 4) the Industry Working Group is largely OEMs and not shipping companies such as Old Dominion. This project is also not looking at light duty vehicle traffic, though it may be valuable to leverage each state's NEVI planning efforts to learn what EEJ efforts, modeling, and outreach have been done to date. This review highlighted that EV freight corridors may be nominated as part of the open FHWA Alternative Fuel Corridor Request for Nominations.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer noted that the working group and advisory boards are quite complete, other than missing HD truck fleets. The industry advisory board only has a few small truck fleets. This reviewer suggested that the project team work with large partners like Walmart, Saia, or Old Dominion that regularly use I-95.

Reviewer 2

This reviewer found that the project roles among identified partners are well defined, however the team has not engaged many fleet partners yet and the degree of engagement with the ports is unclear.

Reviewer 3

The reviewer appreciated that the team's monthly meetings and weekly office hours allowed for a great communication flow, but requested more detail on how CALSTART is holding those partners accountable for a large portion of this work, including working group creation.

Reviewer 4

This reviewer praised the project's progress but suggested that the PI state how often project team member meetings occur. The reviewer also recommends incorporating more fleets and fleet managers into the mixture of team members, perhaps some of the larger state fleets who will be using the planned infrastructure involved.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

This reviewer strongly approved of the project plan outline for 2024 and 2025.

Reviewer 2

The reviewer highly praised the project team that will carry out the EJ portion of this project, claiming that the team members are all experts and have a long history of successful projects with their stakeholders. This reviewer suggested providing the results of the community outreach in more detail, including what metrics work and/or require improvement.

Reviewer 3

The reviewer noted that infrastructure sites and locations will be prioritized in terms of DAC benefits.

Reviewer 4

This reviewer commented that many of the EEJ components have not begun, other than project spending. The CC&C partners have been given language and asks to take to the local community representatives, but no information is available yet on the success of that task. The reviewer noted that the goal of the project is to create a replicable model, but when looking at a multistate corridor, it is unclear who the real target is to use this model. The reviewer referred to the presentation that stated, "the project....tasks stakeholders with disseminating the planning process itself beyond the project" but questioned if this means stakeholders will offer free support from the stakeholders to EEJ communities along the freight corridors, or simply provide the report.

Presentation Number: TI159
Presentation Title: First to Last Mile Creating an Integrated Goods Movement Charging Network Around the I-710 Corridor
Principal Investigator: Jack Symington, Los Angeles Cleantech Incubator

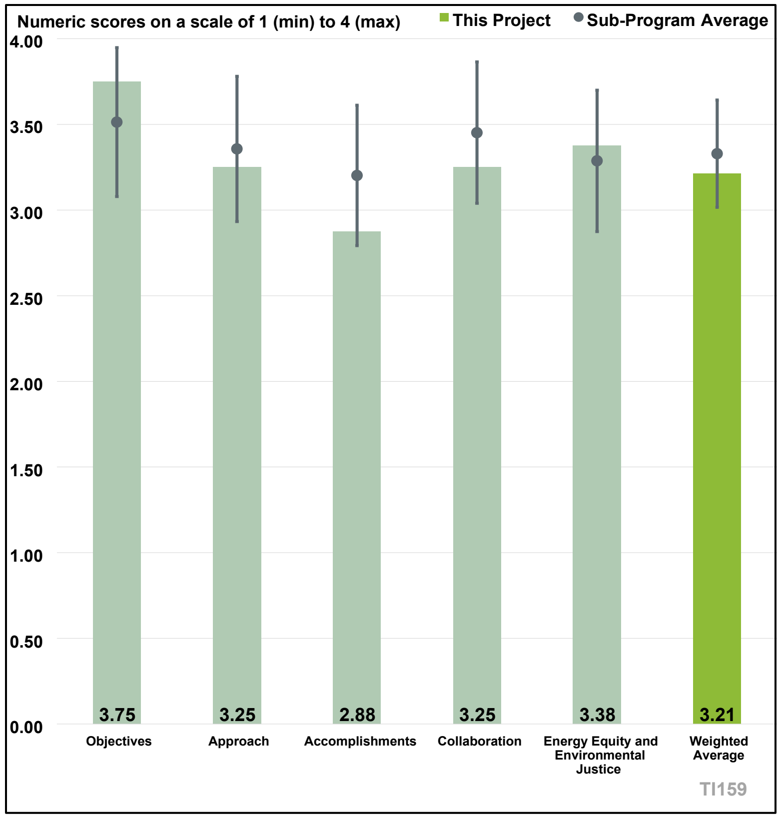

Figure 6-14. Presentation Number: TI159 Presentation Title: First to Last Mile Creating an Integrated Goods Movement Charging Network Around the I-710 Corridor Principal Investigator: Jack Symington, Los Angeles Cleantech Incubator

Presenter

Jack Symington, Los Angeles Cleantech Incubator

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

This reviewer believed that the project is a good match to help support VTO objectives.

Reviewer 2

This reviewer noted that the shared charging model, particularly for MD/HD fleets, is a crucial model needed for the industry as a whole. This reviewer praised the project for being ahead of other VTO TI corridor projects, in that the stations already exist yet are underutilized. The reviewer suggested that finding best practices for sharing these stations, increasing MD/HD EV deployment, and not experiencing power failures, would benefit all freight corridors nationally. The reviewer also mentioned that unique electricity grid generation and distribution in this region demands more intricate modeling than other parts of the country.

Reviewer 3

This reviewer assigned this project a high score as it touched on multiple technologies, and it was extremely focused, much smaller, and more concentrated than other larger projects. This reviewer also approved of the project's partners and team members.

Reviewer 4

This reviewer stated that the project's focus on MD/HD first- and last-mile travel aligns well with VTO's objectives.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

This reviewer liked the project team's approach but noted that the project seems to be behind schedule. This reviewer praised the team's wireless charging approach and use of graphics to show where trucks have 30+ minutes of dwell time.

Reviewer 2

The reviewer admired the project's telematics data, traffic map, and building off previous corridor work, noting their assistance in contributing to the project objectives, but mentioned that the presentation had too much of an emphasis on streamlining permitting. The reviewer suggested that the presenter look into California Code 65850.7 and 65850.71, which are working to advance permitting processes in California, and rank city and county permitting procedures publicly if the team is complying with permitting criteria as outlined by state law. The reviewer also recommended that the project team reach out to the California Governor's Office of Business and Economic Development (GO-Biz) to accelerate this permitting stage, and outline if there are different priorities needed for MD/HD EV charger permitting.

Reviewer 3

This reviewer highlighted the necessity of engagement to understand the communities' needs in order for successful implementation. The reviewer acknowledged that the project appears to capture community engagement by developing a scope of engagement under data collection and the benefits assessment. The project team's use of data loggers to capture how trucks currently move through the area was praised by the reviewer, who stated that it will provide a valuable resource for understanding behavior and help identify opportunities for efficiency.

Reviewer 4

The reviewer requested that the project team identify the specific modeling and evaluation strategies that will be used for MD/HD operational and financial distributed charge solutions. The reviewer suggested that the MD/HD infrastructure plan should not be the last step in the process, but instead should begin as soon as possible so that at least one revision of the final plan can be completed. This reviewer recommended prioritizing other areas of the project to ensure the project finishes on time, as opposed to focusing on truck operational data gathering. Finally, this reviewer recommended having a backup plan for the port areas if the wireless charging solution is not ready by its deadline.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

This reviewer mentioned that the team may want to prioritize other areas of the project, such as identification of potential charge locations and the prioritization of which cities can be of the best support, as the reviewer suspected that all 29 cities are not a good match. Additionally, this reviewer wondered why historical data from some of the many projects that have been completed for I-710 was not used.

Reviewer 2

The reviewer noted that the project timeline is 42% complete, yet statement of project objectives (SOPO) percentage completion is only at 25%. This reviewer also suggested that efficiencies could be gained by working with GO-Biz for EV charger permitting, under California law.

Reviewer 3

This reviewer acknowledged that the project has met some of the goals, but that there will need to be acceleration of the project to ensure it is completed in the time frame stated. One of the project's great accomplishments was trying to utilize existing properties and keeping charging costs low.

Reviewer 4

This reviewer found it concerning that Los Angeles Cleantech Incubator is nearly 1-year into the project, though the project is only 25% complete. The person noted that the presentation did not adequately establish the project timeline by BP, so it was difficult to know whether this was anticipated or what was causing the delays.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

This reviewer praised the project team, mentioning the team's history of successful deployment studies in the region. The reviewer suggested the team involving GO-Biz and the California Energy Commission more in the project work, leveraging California streamlined permitting efforts and laws.

Reviewer 2

The reviewer also praised the project team but would have appreciated more discussion on how the team keeps in communication with each other. The reviewer anticipates that the project will achieve the community and municipal goals as their input will be vital to the project's success or failure.

Reviewer 3

This reviewer found it unclear how the project team is operating or if the advisory group has been beneficial.

Reviewer 4

The reviewer pointed out that the core team seems to be collaborating well, but the presentation did not detail how the advisory group participants were being engaged. Additionally, the reviewer was not sure as to why the presentation did not list California Energy Commission and Caltrans, two major state agencies coordinating roll out of the state's national EV infrastructure plan. The reviewer also highlighted that the project's limited progress after nearly a full year indicated some challenges with partnering.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer praised the project team's awareness of the project's impact on local EEJ communities, evident by the discussion of keeping ratepayer cost low, reducing pollution burden, and addressing community concerns about the increased weight of EVs. This reviewer noted that this project could adapt into a case study, provided there is additional discussion with the project's utility partners about Olympic electrical grid planning, and the impact additional corridor electrification would have on the local communities. The reviewer was also interested to see if any creative solutions are proposed to avoid placing the financial burden of increased road repair on the most burdened communities.

Reviewer 2

The reviewer approved of the project plan.

Reviewer 3

This reviewer predicted that the project score will go up by the next AMR, as the Community/EJ process is well stated in the objectives section, but the process has not yet started.

Reviewer 4

This reviewer referred to the energy equity slide, which highlighted three areas of benefit for DACs. However, the engagement scope was not presented in detail, making it difficult for this reviewer to assess the degree to which the project is engaging directly with communities regarding community prioritization for goods movement land use investment. This information would have been helpful to better understand how the project is ensuring benefits accrue for underserved communities.

Presentation Number: TI160
Presentation Title: Northeast Electric Highways Study
Principal Investigator: Brian Wilkie, National Grid USA Service Company Inc.

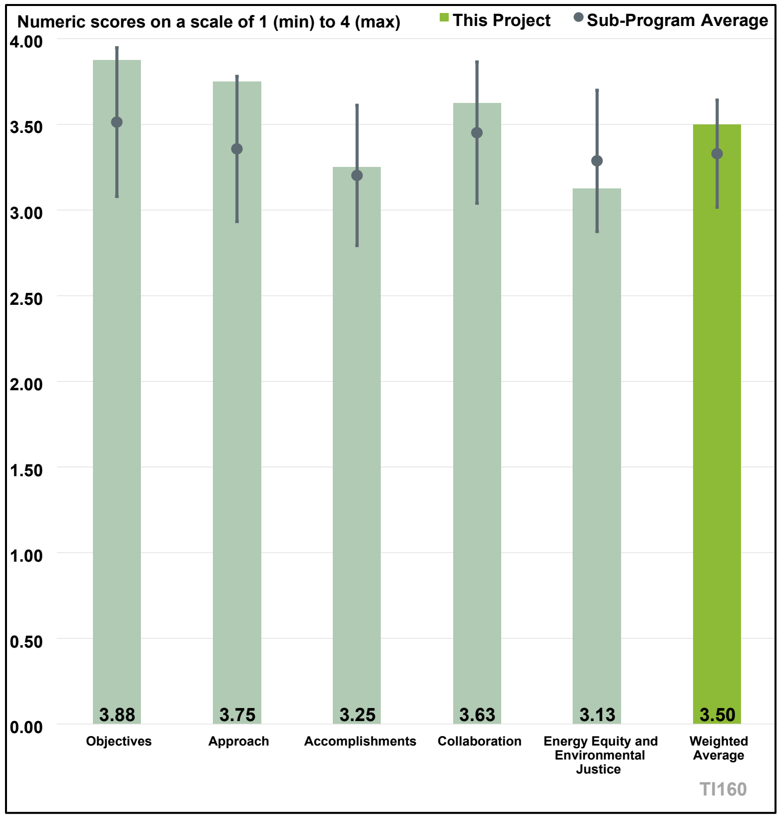

Figure 6-15. Presentation Number: TI160 Presentation Title: Northeast Electric Highways Study Principal Investigator: Brian Wilkie, National Grid USA Service Company Inc.

Presenter

Pedro Jardim, National Grid USA Service Company Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer commented that a project strength is that the project is conducting a high-quality MD/HD ZEV infrastructure study, that is modeling load curves and estimating costs for over 120 station sites across 3,000 miles of pre-defined freight corridors within a dense multi-state Northeast region. This is highly relevant to VTO goals and objectives.

Reviewer 2

The reviewer stated that this was a very good match for VTO objectives.

Reviewer 3

The reviewer noted that the project objective and overview slides describe the project's specific objectives and impact, as well as how the project supports the VTO objectives of improving fuel diversity and reducing GHG emissions by developing an innovative study approach to forecast electric charging demand at critical sites on freight corridors across the Northeast. The project objectives appear to be effective and substantially support VTO objectives.

Reviewer 4

The reviewer said that providing a clear plan for locating EV infrastructure in the northeast region for MD/HD freight is very much needed for the states in the region.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer noted that a project strength is that it relies on site-specific site assessment rather than modeling-only effort. Utility and partners (including state agencies) will select the sites to examine vs. letting a model do all of it. An additional strength is that the effort is well coordinated with state agencies involved in EV corridor planning and existing NEVI plans. Another strength is that the effort is targeting 30 mile-spacing between stations, exceeding NEVI standard.

Reviewer 2

The reviewer commented that working with utilities across the region is a very positive step to getting a project of this nature off the ground.

Reviewer 3

The reviewer stated that the project approach section provides an excellent methodology to accomplishing the project objectives and supporting the integration of advanced transportation technologies and practices. The project approach is divided into three project periods (Technical Analysis, Engage Stakeholders, and Develop Regional Plan), each containing associated tasks and applicable go/no-go decision points. The Milestone Slide provides a detailed description of the planned tasks per BP and progress to date.

Reviewer 4

The reviewer noted that it is a good project approach, although what is the specific process for down selection of the necessary charge sites? More fleet stakeholders are necessary to gain understanding of the cost and requirements for site locations. Is one monthly core project team meeting sufficient to drive progress? The PIs agree that the individual partner meeting is also a good idea, though the PIs do not think that using California Advanced Clean Truck (ACT) rules to estimate number of trucks is sufficient for the Northeast states and would suggest that something more novel may be required.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer commented that identifying locations in all the northeast states to eventually providing electrical load information for is a very positive step for states to use to provide the infrastructure needed to head to a clean transportation sector.

Reviewer 2

The reviewer commented that good progress has been made towards achieving project goals. The project has made progress on several key activities: (1) finalized list of 120+ sites to be studied that have been vetted by state DOTs and utilities, (2) stood up 3 stakeholder advisory committees (Utility, State Agency and EJ) with 38 different organizations, companies and agencies across 9 states represented, and (3) held the Project Kickoff Event in Brooklyn, in collaboration with the CALSTART project, which had over 100 stakeholders in attendance, demonstrating significant stakeholder interest in the study

Reviewer 3

The reviewer commented that it was unclear how close to the project schedule the progress has been so far.

Reviewer 4

The reviewer commented that while progress has been mostly steady, there are some large technical tasks remaining. The reviewer viewed this as a weakness.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer stated that the project substantially benefits from being utility-led and that the project demonstrates a strong degree of project team coordination.

Reviewer 2

The reviewer stated that putting together an advisory team is an excellent way to get a project of this nature off the ground.

Reviewer 3

The reviewer noted the project had an effective team including National Grid (prime) and numerous other key partners, who are assembled to carry out this project and provide an appropriate mix of expertise among team members. Collaboration/ communication among project partners appears to be appropriate for the scope of this project. While the Clean Communities of Central New York is named as a project partner, the role of other CC&C coalitions in the nine states covered by this project is unclear.

Reviewer 4

The reviewer stated that there is a good stakeholder plan, and the regional states seem to have high interest. The reviewer believed the project needs more fleet truck information (both operational and financial). Whether adding fleets to the advisory board or discussing with fleets in an ad hoc way, more needs done here.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer commented that while the project will not provide direct EEJ benefits it will develop a plan for broad MD/HD freight electrification across the Northeast including within and through many DACs, which are now disproportionately impact by freight emissions.

Reviewer 2

The reviewer said it was a good plan.

Reviewer 3

The reviewer commented that the project has good potential to contribute to EEEJ goals by identifying and convening of EJ groups within the communities impacted by the freight corridors studied to form the Environmental Justice Advisory Committee. The Environmental Justice Advisory Committee will include possible EJ impacts as part of the regional roadmap, and integrate community group recommendations into the project's regional plan.

Reviewer 4

The reviewer commented that most MD/HD freight haulers get their loads in primarily in EJ communities so providing a plan for EV infrastructure will go a long way to clean up emissions in the future in EJ communities.

Presentation Number: TI161
Presentation Title: MD-HD ZEV Infrastructure Planning with Focus on I-80 Midwest (IN-IL-OH) Corridor
Principal Investigator: Daniel O'Connor, Cummins Inc.

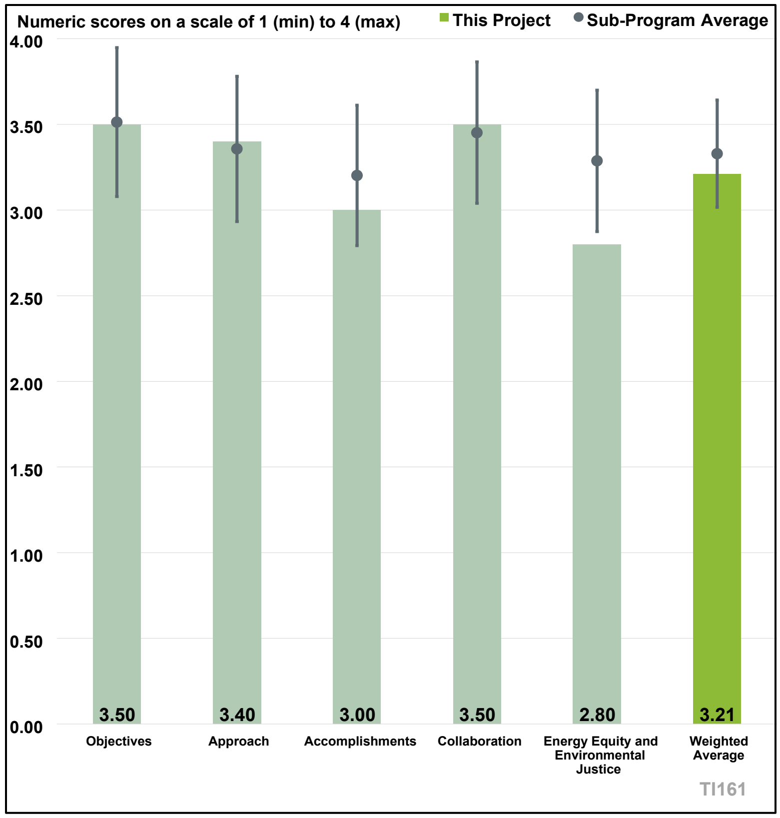

Figure 6-16. Presentation Number: TI161 Presentation Title: MD-HD ZEV Infrastructure Planning with Focus on I-80 Midwest (IN-IL-OH) Corridor Principal Investigator: Daniel O'Connor, Cummins Inc.

Presenter

John Kresse, Cummins Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer commented that the project is tackling the challenge of MD/HD corridor electrification planning and assessment in the Midwest. This closely supports VTO goals and objectives.

Reviewer 2

The reviewer that the project objectives directly support the analysis gaps needed to develop clean corridors and reduce GHGs emissions.

Reviewer 3

The reviewer said it was very nice to see a H_2 and EV corridor project that is coordinating with the H_2 Hubs and evaluating technology such as DER, megawatt charging, and wireless charging. This reviewer would have marked a higher score, but it was stated that H_2 combustion engines are ZEVs, which is not true. The presenter did note that fuel cell electric vehicles (FCEVs) and H_2 combustion engines could be modeled separately, and this would make a great case study from this project—using grey H_2 and not green H_2. The confusion about the difference between FCEVs and H2 combustion engines is developing, so messaging should be clear about these differences as well as the difference in H_2 types.

Reviewer 4

The reviewer stated that this is the best potential study/project that the reviewer has had the opportunity to review. The project has a solid SOPO with inclusion of potential H_2 infrastructure and a great team of CC&C groups, university, national laboratories and manufacturers. The reviewer wishes the team good luck on this project addressing a heavily travelled corridor.

Reviewer 5

The reviewer stated that the project shows support for most DOE objectives; however, the reviewer did not see any analysis planning for what the GHG reduction will ultimately be and how this project will improve the business-as-usual approach.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer commented that the project is leveraging and building upon existing national laboratory tools (i.e., expanding POLARIS to incorporate wireless inductive charging).

Reviewer 2

The reviewer noted that while a good approach is formed using model projections for a phase 1 and phase 2 using vehicle TCO and vehicle volume, there are no EVSE partners identified to aid in the placement of chargers. And there is only one utility partner, leaving the reviewer to wonder how the Illinois (IL) and Ohio (OH) portions of the corridor will be studied. The reviewer would have liked to see a sample of what POLARIS information is and how that data can be used for informing decisions. The reviewer suggested the same for the NREL Projection HD Tool information—even if it were added to the reviewer only slides.

Reviewer 3

The reviewer stated that the use of both Argonne and NREL tools in new ways (including weather modeling) and with new data is straightforward, replicable, and easily available to the public after this project. Overcoming the lack of depot-level charging is crucial, and it appears that the right project partners are lined up to support this. The use of Purdue graduate students and then high schools in Disadvantaged Business Enterprise areas is a really interesting approach, hopefully helping spur interest in this research field in the next workforce generation.

Reviewer 4

The reviewer was happy to see both H_2 and wireless charging being studied, considering this important as there will certainly be areas without adequate infrastructure to support battery electric vehicle (BEV) infrastructure. The reviewer also wants to congratulate the project team for taking advantage of an existing DOE tool (POLARIS) and working to better integrate it into the real world. The reviewer encouraged the project team to do a lot of education and outreach to low-income communities adjacent to the corridor.

Reviewer 5

The reviewer commented that the project is leveraging and building upon existing NREL tools (i.e., expanding POLARIS to incorporate wireless inductive charging). The reviewer saw it as a weakness that the project seems to over-focus on Northwest Indiana (IN); whereas it is a three-state corridor project (OH in particular tends to be out of the loop on activities).

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer commented that it appears to be a very realistic schedule; and the project has some outstanding partners. They like the idea of doing the project in two phases.

Reviewer 2

The reviewer stated that the project is at the beginning, but it has a clear approach and objectives. It is noteworthy that it will explore advanced technologies in Phase 2. They will be very interested to see how the Phase I baseline compares to the Phase 2 results.

Reviewer 3

The reviewer stated that the presentation noted being behind on the project in several areas (contracting, stakeholder summary report, utility data collection, POLARIS calibrations, etc.). Engagement and data collection from small utilities would be a great place to support this project, particularly with their noted issues of grid interconnection challenge understanding.

Reviewer 4

The reviewer commented that it appears to be a very realistic schedule; and the project has some outstanding partners. They like the idea of doing the project in two phases.

Reviewer 5

The reviewer commented that while it is not specifically stated, it appears that the project will miss the completion date for the first two objectives.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer noted that the effort includes a good overall team of key public and private partners. Adding that some additional utility partners from IL and OH would be beneficial.

Reviewer 2

The reviewer commented that there is a great project team with no weakness. Having a truck stop is huge.

Reviewer 3

The reviewer commented that the assembled team covers all the needed components for this work, aside from the high school to be identified at a later time. Coordinating to receive data from 60 small utilities is always going to be a challenge, and a case study or lessons learned debrief would be extremely helpful for other electrification projects. The reviewer was very interested to see what comes out of the H_2 Working Group and what can be utilized by the two H_2 Hubs located on this corridor. The in-depth interconnection study at the Pilot location in northern IN Public Service Company territory is another example of a potential case study from the project team.

Reviewer 4

The reviewer was glad to see the motor truck association and Purdue University involved. Long term this project could be replicable in other parts of the country.

Reviewer 5

The reviewer commented that although many applicable partners are listed with the project, it is unclear who are partners and who are valuable stakeholders. Additionally, it is unclear what the project communication/management plan is with this variety of partners and who is responsible for what.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer noted that the project indirectly provides EJ benefits by developing freight electrification plans along urban Midwest corridors that transect numerous DACs where emission impacts are high.

Reviewer 2

The reviewer noted that much of the EEJ work will come later from the underserved high school to be determined in IN once a sponsor is found, as well as from outreach from Drive Clean Indiana. The technical education plan that is to be developed from this work could lead to a great workforce development component for EEJ communities

Reviewer 3

The reviewer asked what the eight specific milestones are within the EJ plan. Perhaps this could be added on the reviewer only slides. Additionally, the reviewer asked what the technical education plan is and how this plan serves the EJ communities of the corridor. The reviewer also asked if the EJ communities of the corridor are identified.

Reviewer 4

The reviewer would have liked to hear more about community outreach, especially environmental benefits for local residents and economic opportunities to be employed by, or to support the charging hubs. Perhaps the project could add an element to the Purdue team to identify potential employment opportunities.

Reviewer 5

The reviewer stated that the project is analysis of corridors that are surrounded by DACs, but the specifics of how the communities will be engaged and specific benefits are lacking.

Presentation Number: TI162
Presentation Title: San Francisco and Bay Area Regional Medium- and Heavy-Duty Electrification Roadmap
Principal Investigator: Dave Mullaney, Rocky Mountain Institute

Presenter

Dave Mullaney, Rocky Mountain Institute

Reviewer Sample Size

A total of five reviewers evaluated this project.

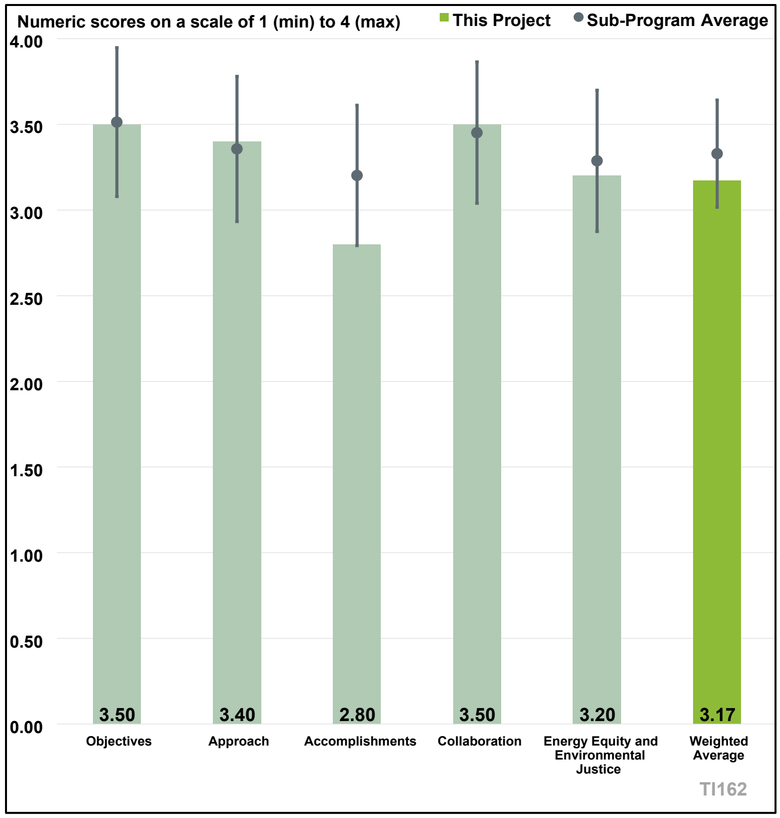

Figure 6-17. Presentation Number: TI162 Presentation Title: San Francisco and Bay Area Regional Medium- and Heavy-Duty Electrification Roadmap Principal Investigator: Dave Mullaney, Rocky Mountain Institute

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer stated that the project was a great match of objectives to DOE needs.

Reviewer 2

The reviewer commented that the impact to the grid is a massive barrier to electrification, particularly the coming MD/HD electrification, so this work is highly relevant to advancing TI's objectives. This being more of a hub-and-spoke modeling versus a corridor modeling presents a new aspect to supporting TI objectives and aiding other hubs nationally.

Reviewer 3

The reviewer noted that the project's objectives are well aligned with the goals of VTO and DOE. Zero emission drayage trucks are an important challenge that needs to be solved.

Reviewer 4

The reviewer said the project's focus on anticipating growing demand for fleet electrification and the need to align the grid investments to support the transition aligns well with the VTO's objectives.

Reviewer 5

The reviewer commented that the objectives are very good; but scored the project low as it has just gotten started. They look forward to learning more in the near future.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer stated that the project is using data and simulation to map out and understand freight and truck movements, which are quite different from personal vehicles. The results will help determine where and what kind of electric charging infrastructure is needed to support truck electrification. Thoughtful truck charging deployment will help freight fleet operators have more confidence in electrification while also supporting local resiliency and environmental benefits.

Reviewer 2

The reviewer noted that this is a national problem, and while this solution will be customized to the Bay Area, it should have several lessons learned, methodologies, and dashboards available for other transportation hubs to replicate this work. The active combination of partners as utility, telematics data, CC&C, Caltrans, and Lawrence Berkeley National Laboratory is fantastic. This combination should help them to accelerate their efforts moving forward. Modeling at the pace of California's regulations is fantastic as it would be considered aggressive for the rest of the nation yet should be realistic for California. It would be scope creep, but if they can address what could potentially be a H_2 technology in their modeling, therefore less electrification would be needed, it would really enhance this study. It could be a great case study to see how much electricity is needed to convert MD/HD vehicles to electric, see if the grid can support that, then make an argument for implementing some H_2 vehicles if the grid capacity is unattainable.

Reviewer 3

That reviewer commented that it is a very impressive project team; and that they are glad to see that the team included Caltrans. There is a very good focus on EJ communities that will potentially benefit and should be included in the project.

Reviewer 4

A reviewer commented that the approach is well defined and appears to have been sized correctly and also relates to historical work. The only negative aspect they find is the drayage market aspect. Drayage typically refers to port related haulage. The reviewer believes the project would be better served and more applicable to a broader stakeholder set if the drayage market was replaced by short regional haul, i.e., haulage within 250 miles per day. This would add vehicle volume to the project plans.

Reviewer 5

The reviewer commented that the project's narrow aperture of only considering BEVs for drayage in the Port of Oakland is limiting. BEVs will clearly be an important solution in the drayage market, but assuming a 100% market capture is not warranted at this time. The Port of Oakland is a member of the Alliance for Renewable Clean Hydrogen Energy Systems Hub. This feels like a missed opportunity for collaboration.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer commented that the project is just at the beginning, but it has a clear approach and objectives. Initial data presented is compelling. The reviewer is looking forward to hearing future updates.

Reviewer 2

The reviewer commented that the completion rate was at 10%, when the team should be one-third of the way through their project. The milestone slide did not have SOPO deadlines, so it is hard to determine where exactly they have fallen behind. Getting drayage and long-haul partners on board should be an immediate goal for this summer.

Reviewer 3

The reviewer noted that they scored this project low due to the length of time it has taken to get the project under contract. Hopefully at the next review there will be meaningful progress.

Reviewer 4

The reviewer noted that it is concerning that Rocky Mountain Institute is nearly 1-year into the project period of performance and only 10% complete. The presenter explained the delays are primarily due to contracting. There was little discussion on how this is being addressed and whether activities will pick up enough to help cover the delay.

Reviewer 5

The reviewer noted a good start but added that it appears the initial contracting delay has the risk to delay portions of the project. There is a need to catch up.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer stated that it is an excellent team with substantial analytical skills. Having a utility in Pacific Gas and Electric Inc., as project partner is a huge benefit.

Reviewer 2

The reviewer commented that this is a very strong partner team, as well as advisory board team. The project team itself has all the right partners—many of which can become typically a barrier to a project like this, if they are not actively included. A number of feedback mechanisms were noted, but they need to start collaborating more to bring the project timeline back on track. This was the only freight study to mention working with small owner/operator fleets that might not be able to afford their own private chargers.

Reviewer 3

The reviewer stated that the project team made progress by having team meetings. Good job in putting team members together, this should be a great collaborative effort.

Reviewer 4

The reviewer commented that the partners listed along with their roles in Slide 12 provide good coverage of all areas of expertise and engagement needed. Having the utility as a partner is critical given it will be the primary entity responsible for grid expansion to support growing fleet electrification.

Reviewer 5

The reviewer commented that the team is well formed, and responsibilities are identified. One missing partner they see is truck fleets. A few large private fleets would be a valuable addition to the project advisory board.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer said that the project addressed an important problem with a positive benefit to the surrounding community.

Reviewer 2

The reviewer stated that the project will absolutely support EEJ for local communities along these freight routes and by the ports. The community involvement will be more reactionary to modeling however, with potentially more to be decided in the future. It would be great to hear some of the early community concerns. They asked if road ownership could be built into the model, so that the results do not suggest increasing wear and tear on roads that the local community has to pay for.

Reviewer 3

The reviewer commented that they have reviewed many projects, and they are impressed that the project team got EJ input very early on for this study. The reviewer is looking forward to the project team's success and a lot more progress by next year.

Reviewer 4

The reviewer stated that the project leverages the East Bay Clean Cities Coalition for local engagement plus other community-based organizations (Slide 8). They are tasked with coordinating and capturing community listening sessions to gather feedback in multiple project phases. The project is also creating a dashboard and roadmap that "allows exploration of recommended charging deployment in Justice40 communities."

Reviewer 5

The reviewer commented that the project team was a reasonable and apparently qualified set of partners who are enlisted to support the EEEJ activity. The reviewer did not see a plan to quantify the EEEJ local emissions reductions or total GHG savings of the project.

Presentation Number: TI163
Presentation Title: Houston to Los Angeles (H2LA)—Interstate 10 (I-10) Hydrogen Corridor Plan
Principal Investigator: Bart Sowa, Gas Technology Institute

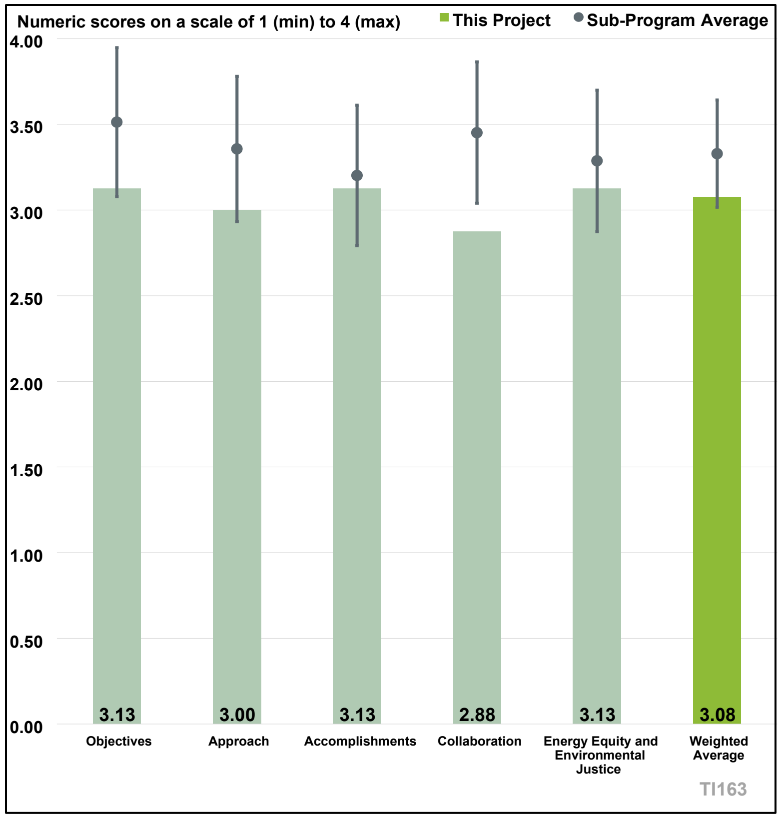

Figure 6-18. Presentation Number: TI163 Presentation Title: Houston to Los Angeles (H2LA)—Interstate 10 (I-10) Hydrogen Corridor Plan Principal Investigator: Bart Sowa, Gas Technology Institute

Presenter

Bart Sowa, Gas Technology Institute

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1

The reviewer stated that the project aligned is closely with the TI objectives of improving fuel diversity, increasing alternative fuel use and local resiliency.

Reviewer 2

The reviewer noted the project objective and overview slides describe the project's specific objectives and impact, as well as how the project supports the VTO objectives of improving fuel diversity, improving local resiliency, and reducing GHG emissions by developing a model of a H_2 -powered freight corridor, to inform the feasibility of investment, in the Texas Triangle and I-10 corridor between Houston and Los Angeles. The project objectives appear to be effective and substantially support TI objectives, as well as supporting the National Zero-Emission Freight Corridor Strategy.

Reviewer 3

The reviewer stated the project has assembled a great team; they hope that they are all contributing. The objectives as stated are clear; what may be missing is a discussion of the potential economic impact of using H_2 as a fuel. The team is doing a good job of getting community input.

Reviewer 4

The reviewer commented that the list of project/technology barriers is stated and written in an incomplete fashion. The potential reductions in criteria pollutants and GHG emissions are not quantified, and they see no approach for performing this activity in the project. The manner of H_2 production is not mentioned—is this green or brown H_2? The identification of technology cost, fuel cost and infrastructure cost are not addressed to the degree that is required so that stakeholders can make an informed decision on the customer and societal costs of this project.

Question 2: Please comment on the project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1

The reviewer said that the project took a comprehensive approach to solving real world challenges by doing extensive community listening sessions and working closely with technology and industry partners to explore innovative deployment solutions.

Reviewer 2

The reviewer stated that the project approach section provides a satisfactory methodology to accomplishing the project objectives and supporting the integration of advanced transportation technologies and practices. The project approach is divided into two project tasks (Model Construction and DEIA Efforts, and Scenario Analysis/Risk Assessment), each containing associated tasks/activities. The Milestone slide provides a description of the project milestones and progress to date.

Reviewer 3

The reviewer stated that the project has assembled a powerful team and asked if all team members contributing? They did not see much input from Exxon and Walmart in the presentation; it would be good to have their input included from the beginning of the project.

Reviewer 4

The reviewer noted that the potential reductions in criteria pollutants and GHG emissions are not quantified and sees no approach for performing this activity in the project. The manner of H_2 production is not mentioned—is this green or brown H_2? The identification of technology cost, fuel cost and infrastructure cost are not addressed to the degree that is required so that stakeholders can make an informed decision on the customer and societal costs of this project.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1

The reviewer noted that most of the project tasks appear on track and there is an informative listing of model interactions on Slide 9.

Reviewer 2

The reviewer stated that satisfactory progress has been made towards achieving project goals. The project has made progress on several key activities: (1) formed Local Project Advisory Groups, (2) a significant portion of the modeling work is underway and/or completed, and (3) kicked off the Community Benefits Team planning.

Reviewer 3

The reviewer said that this project seems to be on track. They are impressed that the team is using some existing studies/projects and existing tools, which is good for keeping costs down and also for replicability. The project team made a good choice in using their local CC&C for outreach.

Reviewer 4

The reviewer noted that the project achieved significant milestones including building a refining a mobility and freight network energy demand model, developing a vehicle dynamics and weather impact model, and developing a national implementation blueprint.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1

The reviewer commented that there were positive and significant collaborations within the project team, including from Oak Ridge National Laboratory, University of Texas at Austin and from key industry stakeholders such as Exxon and Walmart.

Reviewer 2

The reviewer said it was an effective project team including GTI (prime) and numerous other key partners which were assembled to carry out this project and provide an appropriate mix of expertise among team members. Collaboration/communication among project partners appears to be appropriate for the scope of this project. Beyond the three CC&C coalition partners, the project team may benefit from local community groups.

Reviewer 3

The reviewer offered congratulations on getting the bi-weekly meetings going; adding this will be critical as the project moves forward. They would like to see evidence that Exxon/Mobil and Walmart are contributing as they are critical to the success of the study.

Reviewer 4

The reviewer felt it would have been beneficial to have some results from the first advisory group meeting, perhaps on reviewer only slides. It is unclear how well collaboration is proceeding since Slide 16 simply restates the listing of project partners.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1

The reviewer noted that the project team closely engaged community stakeholders to examine impacts and economic and environmental benefits. Input gathered from the community indicated particular concern about the introduction of a relatively unknown new fuel technology. However, implementing the technology will significantly reduce GHG and criteria pollutants from on-road transportation.

Reviewer 2

The reviewer said that the project has a satisfactory potential to contribute to EEEJ goals. Due to its analytical nature, this project is expected to contribute to Community Benefits and EEEJ by applying lessons learned to modeling and planning efforts for the H_2 corridor, ultimately impacting future investments. Until the modeling and planning are completed and the anticipated results are documented, it is difficult to evaluate the significance of the project benefits at this time.

Reviewer 3

The reviewer felt it is a great choice of team members. This part of the project will be difficult to explain as H_2 as a fuel is still in its infancy in the U.S. Continue to make progress and hold more meetings with local EJ groups and residents.

Reviewer 4

The reviewer said it was a good listing of project deliverables for the EEEJ plan and asked where the overburdened communities are within the corridor. They only saw information for Texas and did not see a plan for quantifying emission benefits (relative to today) within the EEEJ communities.

Acronyms and Abbreviations – TI

Abbreviation	Definition
ACT	California Advanced Clean Truck rule
AMR	Annual Merit Review
ASPIRE	Advancing Sustainability through Powered Infrastructure for Roadway Electrification
BAE	BAE Systems Inc.
BEV	Battery electric vehicle
BP	Budget Period
CAF	Development Bank of Latin American and the Caribbean
CC&C	Clean Cities and Communities
CEPNA	Cummins Electrified Power North America
CNG	Compressed natural gas
DAC	Disadvantaged community
DCFC	Direct current fast charger
DEI	Diversity, equity, and inclusion
DEIA	Diversity, Equity, Inclusion, and Accessibility
DER	Distributed energy resource(s)
DERST	NFPA Distributed Energy Resources Safety Training (DERST) Program
DGE	Diesel gallon equivalent
DOE	U.S. Department of Energy
EE	Energy Equity
EEEJ	Energy equity and environmental justice
EEI	Energy, Equity and Inclusion
EEJ	Energy Environmental Justice Action Plan
EJ	Environmental Justice
EMPOWER	Equitable Mobility Powering Opportunities for Workplace Electrification Readiness
ESS	Energy storage system
EV	Electric vehicle

Abbreviation	Definition
EVAL	Electric Vehicle Adoption Leadership
EVSE	Electric vehicle supply equipment
FCEV	Fuel cell electric vehicle
FHWA	Federal Highway Administration
FMW	FMW Solutions LLC
GHG	Greenhouse gas
GO	California Governor's Office of Business and Economic Development, or GO-Biz
GTI	GTI Energy Partners
H_2	Hydrogen
HD	Heavy-duty
Hp	Horsepower
IL	Illinois
IN	Indiana
J40	Justice 40 Initiative
kg	Kilogram
klbs	Kilopounds
kWh	Kilowatt-Hour
L2	Level 2
Lbs	Pounds
LEEP	Leadership of Employers for Electrification Program
MBWE	Minority- or women-owned business enterprises
MD	Medium-duty
MD/HD	Medium-duty/heavy-duty
MPG	Miles per Gallon
NAFTC	National Alternative Fuels Training Consortium
NAFTD	North American Fire Training Directors
NEVI	National Electric Vehicle Infrastructure
NFPA	National Fire Protection Association

Abbreviation	Definition
NG	Natural gas
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
OH	Ohio
PEV	Plug-in Electric Vehicle
PI	Principal Investigator
PM	Particulate matter
Q1/Q2/Q3/Q4	Quarter
RDD&D	Research, development, demonstration, and deployment
RNG	Renewable natural gas
SOPO	Statement of Project Objectives
TCO	Total cost of ownership
TI	VTO Technology Integration subprogram
TMV	TMV Control Systems–Next Generation Locomotive Control Systems
TNA	Transportation needs assessment
TTC	Transportation Technology Center
UT	Utah
UTD	Utilization Technology Development
VTO	Vehicle Technologies Office
ZEV	Zero Emission Vehicle

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7. Vehicle Analysis

The Vehicle Technologies Office (VTO) has a comprehensive portfolio of early-stage research to enable industry to accelerate the development and widespread deployment of a variety of promising sustainable transportation technologies. The research focus areas include fuel diversification, vehicle efficiency, energy storage, and mobility energy productivity that can improve the overall energy efficiency and efficacy of the transportation or mobility system. VTO leverages the unique capabilities and world-class expertise of the national laboratory system to develop innovations in electrification, including advanced battery technologies; advanced combustion engines and fuels, including co-optimized systems; advanced materials for lighter-weight vehicle structures; and energy efficient mobility systems. VTO is uniquely positioned to address early-stage challenges due to strategic public-private research partnerships with industry (e.g., U.S. DRIVE, 21st Century Truck Partnership) that leverage relevant expertise. These partnerships prevent duplication of effort, focus DOE research on critical research and development (R&D) barriers, and accelerate progress. VTO focuses on research that industry does not have the technical capability to undertake on its own, usually due to a high degree of scientific or technical uncertainty, or that is too far from market realization to merit industry resources.

The VTO Analysis (VAN) subprogram supports the planning and execution of technology, economic, policy, and interdisciplinary analyses to inform and prioritize VTO research portfolio planning, including activities such as research target-setting and impacts estimation. VAN supports vehicle data, modeling and simulation, and integrated and applied analysis activities using the unique capabilities, analytical tools, and expertise resident in the U.S. Department of Energy's (DOE) national laboratory system. These activities explore advancements in vehicles and transportation systems and resulting energy impacts to inform early-stage R&D and offer analytical direction for potential and future research investments.

Project Feedback

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, and numeric score responses (on a scale of 1.0 to 4.0). 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 table presenting the average numeric score for each question for each project is presented below.

Table 7-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
VAN016	Transportation Data Programs	Stacy Davis (Oak Ridge National Laboratory)	7-4	3.50	3.50	3.38	3.50	3.48
VAN017	ANL VTO Analysis Modeling Program	Michael Wang (Argonne National Laboratory)	7-9	3.67	3.67	3.67	3.83	3.69
VAN021	Transportation Energy Evolution Modeling (TEEM) Program	Ruixiao Sun (Oak Ridge National Laboratory)	7-13	3.50	3.00	3.50	3.25	3.22
VAN023	Assessing Energy and Cost Impact of Advanced Vehicle Technologies	Ram Vijayagopal (Argonne National Laboratory)	7-16	3.50	3.50	3.50	3.50	3.50
VAN032	Tracking the Evolution of Electric Vehicles and New Mobility Technology	Joann Zhou (Argonne National Laboratory)	7-18	3.50	3.33	3.17	3.50	3.38
VAN045	Analysis of Electric Heavy-Duty Driving and Infrastructure Requirements Within A Regional Area	Marcus Alexander (EPRI)	7-22	3.50	3.50	3.25	N/A	3.46
VAN047	Integrated Modeling and Technoeconomic Assessment of Electric Vehicle Community Charging Hubs	Eleftheria Kontou (University of Illinois)	7-24	3.00	3.33	3.00	3.33	3.21

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
VAN059	Deploying Charging Infrastructure to Catalyze Market Adoption of Electric Vehicles and Improve Mobility Health and Economic Outcomes in Disadvantaged Communities	Corey Harper (Carnegie Mellon University)	7-28	2.33	2.67	3.17	3.00	2.69
VAN060	Quantifying New and Used Plug-in Electric Vehicle Market Dynamics in Disadvantaged Communities	John Helveston (George Washington University)	7-31	3.50	3.50	3.33	3.67	3.50
VAN061	Transportation Electrification Impact Study	Eric Wood (National Renewable Energy Laboratory)	7-34	3.63	3.75	3.75	3.38	3.67
Overall Average				3.36	3.38	3.37	3.44	3.38

Presentation Number: VAN016
Presentation Title: Transportation Data Programs
Principal Investigator: Stacy Davis, Oak Ridge National Laboratory

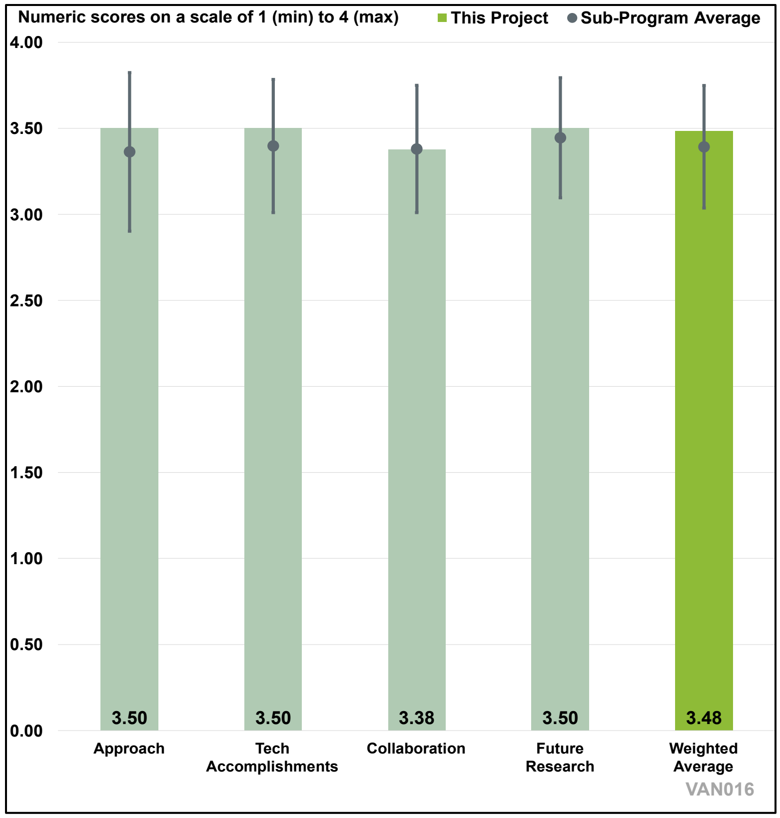

Figure 7-1. Presentation Number: VAN016 Presentation Title: Transportation Data Programs Principal Investigator: Stacy Davis, Oak Ridge National Laboratory

Presenter

Stacy Davis, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project provides a valuable platform to gather and consolidate data that can support research, technology development, and decision making on transportation. The project is designed well with a reasonable timeline. It would be nice to see more outreach efforts on promoting the Transportation Energy Data Book (TEDB) and Fact of the Week outside of DOE/national laboratories. It would be nice to gather user feedback on the format of the TEDB, as the over 400-page PDF is less likely to be the way most people utilize the tool and may potentially prevent an individual data table to be updated at an ad-hoc and timely fashion. Considering most users may rely heavily on the search function to find a data table from specific topics, exploring a more interactive online interface may be more user-friendly.

Reviewer 2

The TEDB is a tried and true approach and there is no need to change. The Fact of the Week (FOTW) is a great way to spread VTO Analysis and there is no reason to change the current approach. Regarding additional medium- and heavy-duty vehicle (MHDV) analysis, investigating the potential for updated and new data is important. The approach, which includes, literature review, Experian, and 2021 Vehicle Inventory and Use Survey (VIUS) data, is reasonable.

Reviewer 3

The bulk of the project funding and work is to update the TEDB. Having a consistent data source that is used across DOE (and other federal agencies?) is useful to eliminate duplicate work and inconsistencies in analysis findings. The approach and process has been refined over 41 editions. Improving the data and outputs to include visualizations/dashboarding and application programming interface (API) is a good addition. Though as mentioned in comments, updating the data more frequently seems necessary in today's environment. The work on medium/heavy truck usage and scrappage is interesting and useful. The reviewer wondered if the work is duplicated, or done differently, by other federal agencies (Energy Information Administration, U.S. Department of Transportation [DOT]/National Highway Traffic Safety Administration) to where the analysis and results are inconsistent across the government.

Reviewer 4

The technical barriers are unclear but appear in the Multi-Year Program Plan 2011–2015; Section 2.6 Outreach, Deployment and Analysis A, B, C; and Section 3.2 Program Analysis. No other reference to these barriers was found in the Annual Merit Review (AMR) presentation or the TEDB Edition 40. However, a precise match for the text was located in a 2010 DOE/EERE report from the Vehicle Technologies Program, titled Multi-Year Program Plan 2011 – 2015. The reviewer assumed that the TEDB will be released on schedule (that is good) and sees from the response to reviewer comments from the previous year that improving the API was cited as an area of improvement and that work continues (that is also good).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

This project has a long history with a proven record of accomplishments. It is nice to see that improvements are continuously being implemented, and future implementation of API function will be a great addition.

Reviewer 2

The reviewer stated that it was great to hear that the backend of the TEDB is getting a bit of an overhaul, and that some new user-facing features are being worked on. FOTW is a boon to VTO as an organization and amazing that over half of VTO site visits were through FOTW. The reviewer found the analysis "shorts" to be thought-provoking as well. The reviewer was happy to hear that the laboratories collaborated on the additional MHDV analysis and jumped into the new VIUS dataset with most of the basic/initial analysis (relevant to many of us modelers) being completed.

Reviewer 3

The reviewer stated that the FOTW seems to be a good path to get new users/laypeople to the VTO webpage which seems to be a significant reason for its use and also a key output of this work. The work on medium/heavy truck usage and scrappage is interesting and useful. The reviewer thought it was understandable that not enough data to quantify scrappage were available. The 2021 VIUS data analysis study will be interesting and provide useful knowledge updates that have been lacking since 2002.

Reviewer 4

In-lieu on an explicit description of specific technical barriers to overcome, the reviewer made a few guesses. It can be seen from the Responses to Previous Reviewer Comments section (on Slide 13) that automating the data book API was identified as a potential area for improvement during the

2023 AMR. Based upon Technical Accomplishments presented on Slide 8, the reviewer assumed that some of this work was accomplished. From the Approach – Description on Slide 5 of the presentation, there was insufficient data in the past to develop scrappage rates for trucks and that TEDB Edition 41 will include such scrappage rates, based upon a University of Tennessee study. An understanding of scrappage rates are critical to fleet turnover, and fleet turnover fosters the transition to cleaner transportation. This contribution could be important.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project shows great collaboration within the project team. This work requires a lot of effort coordinating with data sources, and the team seems to do a good job. Transportation has always been intertwined with other sectors, such as urban planning and socioeconomics, so it may be beneficial to include some of the relevant entities/data sources that may be useful for transportation energy related research.

Reviewer 2

This work is inherently collaborative; TEDB requires working with a myriad of federal agencies and other organizations to compile and update data. FOTW requires working with VTO leadership and the folks who completed the highlighted individual analyses. The collaboration with the National Renewable Energy Laboratory (NREL) is unique in that Oak Ridge National Laboratory (ORNL) was able to leverage intra-DOE freight truck expertise to maximize value-add for the new VIUS (and explore other potentially valuable datasets).

Reviewer 3

The TEBD is ORNL only. The medium-/heavy-duty truck collaboration between ORNL and NREL on this project seems to be working well. Argonne National Laboratory (ANL) is an unfunded partner and provides data to ORNL for this work.

Reviewer 4

Collaboration seems to have been limited to NREL ($40,000) and ANL; perhaps this is all that is required. Additional collaboration might be warranted with academic researchers, the United States Government (USG) such as DOT, the Environmental Protection Agency (EPA), etc., and other national laboratories (Lawrence Berkeley National Laboratory [LBNL] for heavy-duty trucks, for instance). Such collaboration and coordination can help to harmonize USG messaging on such topics.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Future work is clearly defined and achievable. The reviewer would also like to encourage the team to consider making improvement on the user interface of TEDB, with the amount of data in the collection, it can be overwhelming for users, especially general public, who want to find quick facts and data that is relevant to them. The reviewer said it may be nice to have more filtering/categorization function on the web interface to help the user navigate the data without going through hundreds of pages or browsing a laundry list of tables. The reviewer also said it may be beneficial to move the official TEDB from a gigantic PDF publication to more user friendly, interactive dashboard/table web interface in the future.

Reviewer 2

The reviewer had nothing further to add here other than to continue updating and publishing the TEDB! VTO should find ways to push this into the public, whether that is on social media (LinkedIn, Twitter/X) or elsewhere.

Reviewer 3

The reviewer believes that future research to continue the TEDB is clear. The other aspects of future research were more vague.

Reviewer 4

The bulk of this future work involves regularly publishing transportation data which does occur on a timely basis. As such, the reviewer assumed that the project is clearly defined. As noted in the previous year's reviewer comments, API development is important and the reviewer suspects that it will continue to merit ongoing effort and funding. Fostering academic research that makes use of and/or leverages the TEDB could be of future value (the reviewer thought of the recent University of Tennessee vehicle scrappage analysis by Green and Leard in this context).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is highly relevant to the mission of DOE and VTO. The reviewer commented that it is very valuable to support research and making policies for transportation energy at VTO.

Reviewer 2

"Create and maintain a strong foundation of data" is clearly addressed by this project.

Reviewer 3

The work to provide a consistent data source that is used across DOE (and other federal agencies?) is useful to eliminate duplicate work and inconsistencies in analysis findings. With so many data sources available that is produced/updated more frequently and likely in more or different detail, it would be interesting for the project to do a user workshop to understand how/if people use the data, what data users feel is missing/could be improved, and what other data sources they use instead of/in addition to the TEDB data.

Reviewer 4

Public awareness of the Transportation Fact of the Week is important and indirectly supports the overall VTO mission. The TEDB is also useful in this regard. The reviewer suspects that researchers (from VTO and elsewhere) that are in need of such data are likely to obtain it directly from other USG sources. With that said, researchers do reach for the TEDB when a quick, off-the-cuff energy statistic is required.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resource seems adequate to accomplish milestones in a timely fashion.

Reviewer 2

The resources are sufficient. A good bang-for-the-buck for VTO.

Reviewer 3

The TEDB funding is sufficient, but perhaps too high. The reviewer would expect data access and automation would decrease the effort and cost compared to previous years. But it is not clear to the reviewer how much manual work is required to interact with the many sources (likely with changing staff and data practices). The medium-/heavy-duty truck work funding is sufficient, but could likely be expanded given the complexity in the truck market.

Reviewer 4

The reviewer presumed that the TEDB has been and will be released on schedule, so the resources are adequate. Funding for API development is important and should be continued. Funding directed towards the incorporation of new analysis, such as scrappage rates from the University of Tennessee study, is also important and should be continued, possibly increased, should the need be found to exist. Likewise, collaboration with NREL on medium- and heavy-duty truck data and analysis is important and may need to be funded at rates greater than $40,000. LBNL is also engaged in important heavy-duty truck-related research that may be of value. Also, consider funding to expand the data offerings from Wards Auto, J.D. Power, Experian, etc. While much of this data is generally prohibited from unregulated public circulation, it should be possible to aggregate the data in a manner that is still useful to the general public, while maintaining business confidentiality. This data would be of great value internally to researchers that may produce derivative data products that can be made public.

Presentation Number: VAN017
Presentation Title: ANL VTO Analysis Modeling Program
Principal Investigator: Michael Wang, Argonne National Laboratory

Presenter

Michael Wang, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

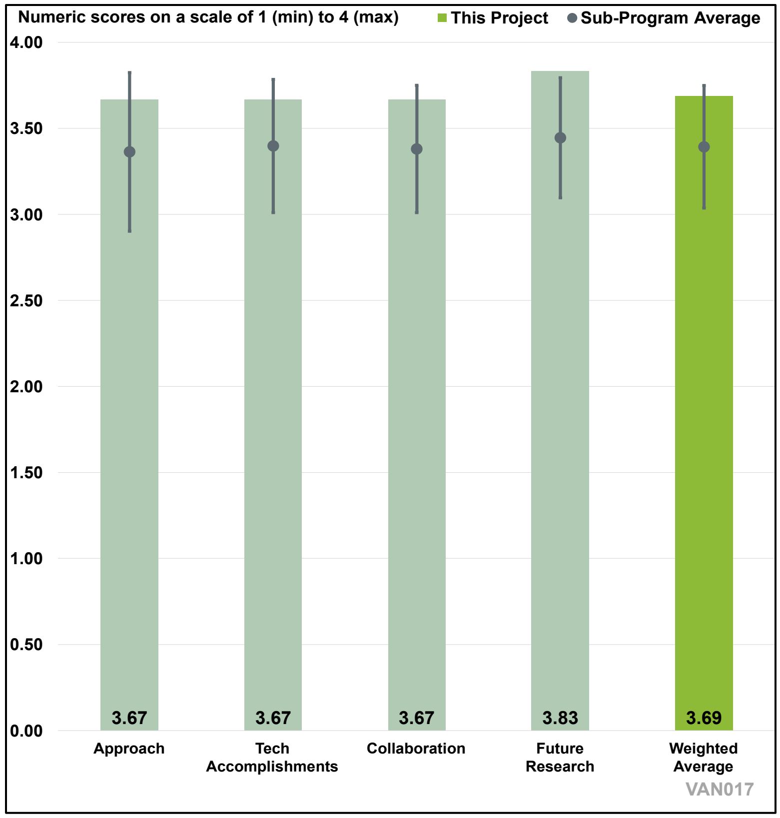

Figure 7-2. Presentation Number: VAN017 Presentation Title: ANL VTO Analysis Modeling Program Principal Investigator: Michael Wang, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the first two barriers are very broad and all of the work presented, addresses them to some degree. There was not any discussion on whether the chosen pathways to whittle away at these barriers (Tasks 1-4) were selected due to their being priorities, or low-hanging fruit, or both. Regarding Task 1, the reviewer is not versed in different sources for "non-CO_2 GHG pollutants," but using EPA MOtor Vehicle Emission Simulator (MOVES) and literature review seems reasonable. The reviewer thought streamlining and automating data pipelines is always a win. For Task 2, the general approach seems reasonable to push Autonomie inputs through the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model to dump out greenhouse gases (GHGs). The reviewer thought Task 3 was a great idea and expanding the grid mix options and leaning on National Energy Modelling System (NEMS) outputs (Annual Energy Outlook [AEO]) is a good use of resources (openly available and heavily vetted). The reviewer also thought Task 4 was a good idea and had a good approach. The presentation needs to "connect the dots" a little better. For instance, it is unclear how "developing transparent models" helps to "overcome inconsistent data and methodologies." The presentation just states what GREET is and that emerging technology/mobility options will be added and does not talk about overcoming inconsistent data and methodologies (Slide 3).

Reviewer 2

One of the barriers that the project mentions that it is addressing is “overcoming inconsistent data, assumptions, and guidelines,” which does not seem like a “barrier” but rather a motivation for this work. The reviewer commented that it would have been nice to have seen an example of how GREET resolved an inconsistency. The project is like a machine now, adding new capabilities and automating tasks. The reviewer thought it would also have been nice to have described in more detail the “new methodology to automate annual updates of fuel economy.” There were a number of publication references, and the reviewer hopes one of those papers has more details. The reviewer also said it was nice to see a very practical exercise of using GREET to inform policy incentives (Task 4).

Reviewer 3

Dr. Wang and his research team have continuously and consistently overcome *so* many technical barriers throughout the decades-long development of GREET. Watching the evolution of GREET throughout the decades has been a real treat. Graduate students, future researchers, and young environmentalists cut their teeth on this model, starting in the mid-nineties, and many of these people are now career local, state, and national policymakers that make regular and important use of GREET. The current iteration of GREET is no different insofar as it successfully overcomes technical barriers, such as the incorporation of alternative electric power sector generation mixes and medium- and heavy-duty cradle-to-grave (C2G) analysis.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Regarding non-CO_2 GHG pollutants in Task 1, it is not clear to the reviewer what the old source was and how much of a change resulted from the update. Additionally, on the data automation methodology, no details were given, just pictures of spreadsheets. The reviewer commented it would be helpful to know what the old methodology was, what the new methodology is, and how much time it saves. For Task 2, the reviewer would have liked to have seen an uncertainty analysis. The reviewer said it would have been helpful to know how wide the assumptions were allowed to vary in the final results to account for uncertainties. After accounting for the uncertainties in a reasonable way, the reviewer would have liked to have known if the results were significant. For Task 3, there is a good spread of grid mixes, but the reviewer commented that the sensitivity could have been accomplished with far less; 4-5 cases would have covered the whole range with far less complexity. For Task 4, the model is useful for exploring different sensitivities.

Reviewer 2

The reviewer gave the project kudos as each task had significant accomplishments.

Reviewer 3

The task-specific objectives have been dealt with very successfully. The inclusion of the Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA)-related incentives into the Heavy-Duty Battery Electric Vehicle Infrastructure Scenario Analysis Model (HEVISAM) is particularly noteworthy and relevant, as is the streamlining of data integration. The potential complexity and time-intensiveness of such data integration efforts is often not fully appreciated by many outside of the small circle of people directly involved in the process. Developing such a large and complex model that is internally consistent is hard work. The integration of other models from DOE and national laboratories, such as Autonomie, the Battery Performance and Cost (BatPaC) model, HEVISAM, and EverBatt, etc., provides a robust, powerful, and defensible suite of modeling tools, the value of which (for regulators, at least) would be difficult to overstate. The expansion of electricity mix options to include additional AEO scenarios, regional fidelities, and decarbonization initiatives is relevant. The reviewer said it would be of great value to see this expansion include harmonization with EPA data and modeling efforts beyond the Emissions & Generation Resource Integrated Database (eGRID), such as EPA's Power Sector Modeling Platform using the Integrated Planning Model (IPM), used to support EPA's stationary and now, mobile source rulemakings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that there seems like a good amount of collaboration: industry (U.S. DRIVE, Aluminum Association, and American Iron and Steel Institute), national laboratories (ANL, NREL, ORNL), and academia (University of Michigan). But it is unclear whether any of this was actual collaboration versus citation. Grid mixes from NREL were used, but the reviewer questions if the team worked with NREL or just downloaded the publicly available data/projections. The reviewer had the same concern with ORNL and U.S. DRIVE (embedded into Autonomie outputs).

Reviewer 2

The lab work is coordinated well, not just within ANL and other laboratories but also within multiple offices at DOE. This is commendable. However, since GREET uses some aspects of EPA's MOVES4 model, the reviewer said it was peculiar to see no engagement/collaboration with EPA.

Reviewer 3

The interactions with other VTO projects and models are readily apparent and is one of the greatest accomplishments of the GREET suite of tools. Collaboration and coordination appear strong, particularly with other national laboratories. The reviewer commented that it would have been useful to have a better understanding of these interactions with original equipment manufacturers (OEMs) and, particularly, energy companies.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Non-CO_2 pollutants for hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) needs more work. The review was not sure it is worth spending resources on expanding "new mobility options" in GREET as there is enough uncertainty to iron out in the modes currently covered by GREET.

Reviewer 2

Slide 19 does a good job of laying out future work. In particular, the impact of criteria pollutants is of increasing concern for communities as there is a more direct impact to human health. The reviewer suggested that expanding the future work to more broadly evaluate criteria pollutants be of greater priority.

Reviewer 3

The expansion of electricity mix options to include additional AEO scenarios, regional fidelities, and decarbonization initiatives is relevant and important. In that same vein, the reviewer said it would be of even greater value to see the expansion of GREET include harmonization not only with EPA's eGRID, but to also expand GREET to include electricity mix options from EPA's Power Sector Modeling Platform using IPM, an economic dispatch model which is used to support EPA's stationary and now, mobile source rulemakings.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project primarily supports the following objectives but lends support to the "foundation of data" objective as well: build, maintain, and exercise relevant analytical models; execute insightful integrated analyses that provide greater understanding of critical transportation energy problems.

Reviewer 2

The reviewer commented that the project is absolutely relevant.

Reviewer 3

GREET, in conjunction with Autonomie, BatPaC, HEVISAM, EverBatt, etc., clearly supports many VTO subprogram objectives. In addition to being DOE's flagship life cycle analysis (LCA) model, GREET may very well be the best example of a VTO project that cuts across multiple subprograms.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resource allocation is sufficient to complete the task list along with the regular model maintenance and "cog-turning" that is required for such a large model.

Reviewer 2

The reviewer commented that there were sufficient resources.

Reviewer 3

Continued GREET development is critical for ongoing LCA research and policymaking purposes domestically and abroad. While the reviewer is aware that every dollar spent on GREET is one less dollar that DOE can spend on other valuable transportation-related projects, the reviewer highly encourages GREET's continued funding and development and looks forward to new releases. To this end, it is the reviewer's understanding that EPA is considering providing additional financial support to DOE to facilitate harmonization of GREET with EPA electric power sector dispatch modeling tools.

Presentation Number: VAN021
Presentation Title: Transportation Energy Evolution Modeling (TEEM) Program
Principal Investigator: Ruixiao Sun, Oak Ridge National Laboratory

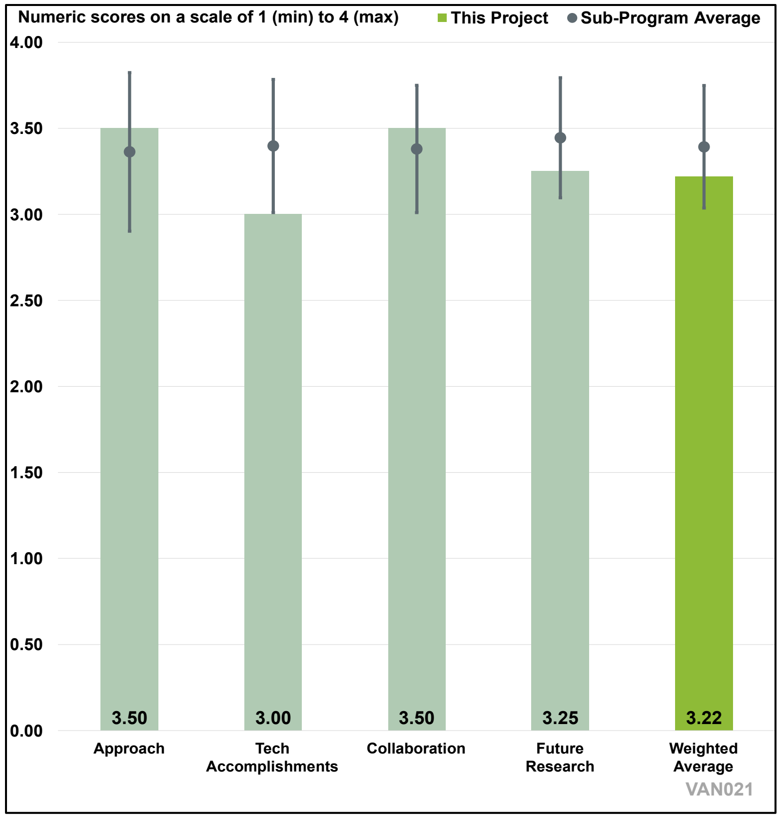

Figure 7-3. Presentation Number: VAN021 Presentation Title: Transportation Energy Evolution Modeling (TEEM) Program Principal Investigator: Ruixiao Sun, Oak Ridge National Laboratory

Presenter

Ruixiao Sun, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The Market Acceptance of Advanced Automotive Technologies (MA3T) is an important model for VTO and a number of stakeholders. Keeping it up to date and rebuilding/re-estimating different components are both valuable to VTO. MA3T seems like a good option for implementing methodology to estimate the impact of IRA tax credits. Capturing more of the scrappage/survival behavior, beyond simple overall national averages, is vital to fully understanding the impacts of regulations. Implementing more detailed scrappage in MA3T will greatly improve the model’s ability to estimate policy impacts.

Reviewer 2

The project is an interesting look across a range of scenario cases and seems to assume that electrification is the only path to net-zero emissions. Low-carbon liquid fuels should also be considered as a complement to electrification and represented by “+P1” or “+P2” cases where liquid fuels are lower in carbon intensity but higher in price.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the work on scrappage was fascinating (Greene/Leard) and was curious how the recent surge in insurance-totaled vehicles (due to increase cost-to-repair) might reverse some of this trend. The sales/stock results from Slides 8-9 could use a little more explanation. The reviewer said it was not clear what was meant by “Adv” or “Base” under battery and charging. Those assumptions (battery prices and charging infrastructure rollout) should have been explicitly noted in the presentation. The results themselves are also difficult to interpret. For instance, the reviewer questioned if the IRA added 5-10 million new vehicle sales per year in the late 2020s. The reviewer thought the change in total stock was odd as well. The reviewer questioned if the used vehicle market was not a zero-sum change., i.e., if it results in less scrappage overall rather than less battery electric vehicle (BEV) scrappage, and more internal combustion engine (ICE) scrappage. The reviewer thought it odd that the total stock grows much more in the higher BEV cases. The reviewer assumed travel demand is not changing, so all of these vehicles are being added to the fleet, and the total mileage per vehicle drops considerably (e.g., in BI+IRA1E there are over 50 million more vehicles on the road in 2050 versus Ref). The reviewer was not sure if these results were ready to be shown. Additionally, the International Council on Clean Transportation’s (ICCT’s) low IRA case assumes no BEVs qualify for the foreign entity of concern (FEOC) limitation, meaning, there should be no tax credit impact after 2025 (when critical mineral FEOC constraint comes into play—battery components FEOC constraint started in 2024). In other words, BI+IRA1 should not have a BEV ramp up into 2031.

Reviewer 2

The reviewer noted that there is still work to do on tuning the model and understood that the results shown were preliminary. The reviewer was also surprised by the variation in size of 2050 light-duty vehicle (LDV) stock over a range of scenarios (EIA’s Annual Energy Outlook has 2050 stock at 294 million).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

MA3T, like any large model, requires a number of data inputs from a range of sources. The reviewer said it would have been helpful for the presentation to differentiate between these sources and active direct collaborations with other organizations, rather than bunching it all together.

Reviewer 2

The reviewer commented that there was collaboration across multiple teams.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The future work aligns with the project goals (project ends in September 2024).

Reviewer 2

The reviewer questioned if there was value in aligning the model to new EPA GHG standards. The reviewer commented that it might be more interesting to run the model based on various incentives and assumptions and assess alignment with EPA compliance cases.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project directly supports all three objectives.

Reviewer 2

The reviewer commented that the work is highly relevant and should prove useful in assessing policy measures.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Resources seem well-aligned with the expertise and effort required to complete the project.

Reviewer 2

The reviewer noted that this project may need more time and/or budget for thorough model development and scenario runs.

Presentation Number: VAN023
Presentation Title: Assessing Energy and Cost Impact of Advanced Vehicle Technologies
Principal Investigator: Ram Vijayagopal, Argonne National Laboratory

Presenter

Michel Alhajjar, Argonne National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

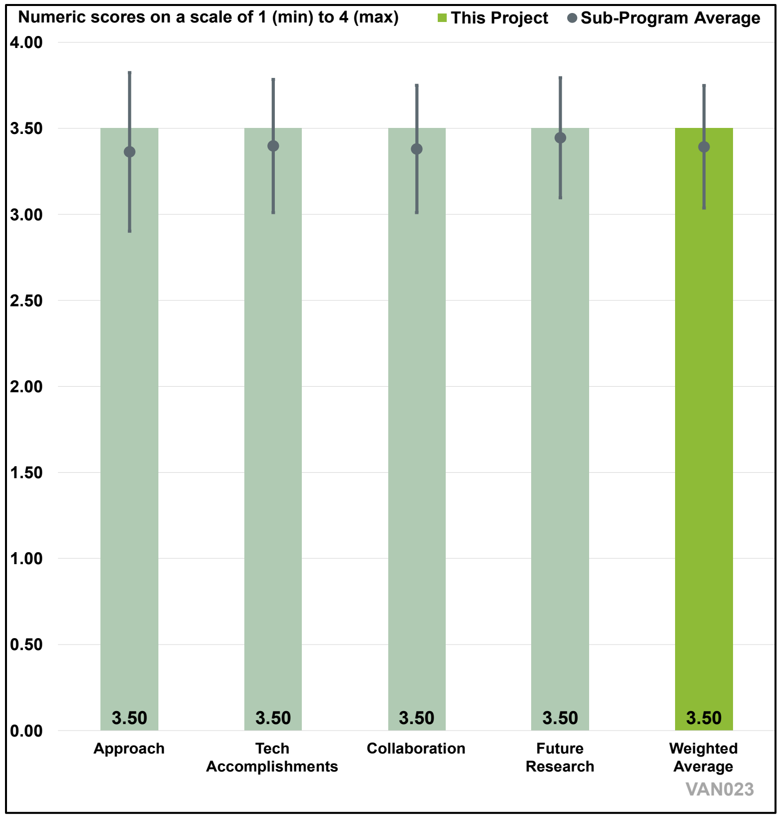

Figure 7-4. Presentation Number: VAN023 Presentation Title: Assessing Energy and Cost Impact of Advanced Vehicle Technologies Principal Investigator: Ram Vijayagopal, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The approach to analyzing vehicle technologies is sound and well accepted by outside stakeholders.

Reviewer 2

The reviewer said the team is doing a good job at integrating a wide array of data sets and models.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Progress appears to have been on track through the period of performance. This was likely very challenging considering the need for ANL to support government-wide analyses over the past 2 years.

Reviewer 2

The reviewer commented that the project seems to be on track for timely completion.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

Work appears to be well coordinated with other national laboratories, with DOE, and with other federal agencies.

Reviewer 2

The team has responded to multiple stakeholders in expanding scope and capabilities over time.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer would recommend that a greater variety of sources of cost data be incorporated, in particular, additional sources of component and vehicle teardown data.

Reviewer 2

The reviewer is looking forward to battery recycling database integration and the desktop version of TechScape.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

Autonomie continues to be a key tool for evaluating VTO vehicle technology programs.

Reviewer 2

The project will be useful as a starting point for newer electric vehicle adopters in assessing costs and capabilities.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that no indication was provided that funding was insufficient for near-term and future goals.

Reviewer 2

The reviewer commented that the project seems on track to complete planned work within the project timeframe.

Presentation Number: VAN032
Presentation Title: Tracking the Evolution of Electric Vehicles and New Mobility Technology
Principal Investigator: Joann Zhou, Argonne National Laboratory

Presenter

Joann Zhou, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

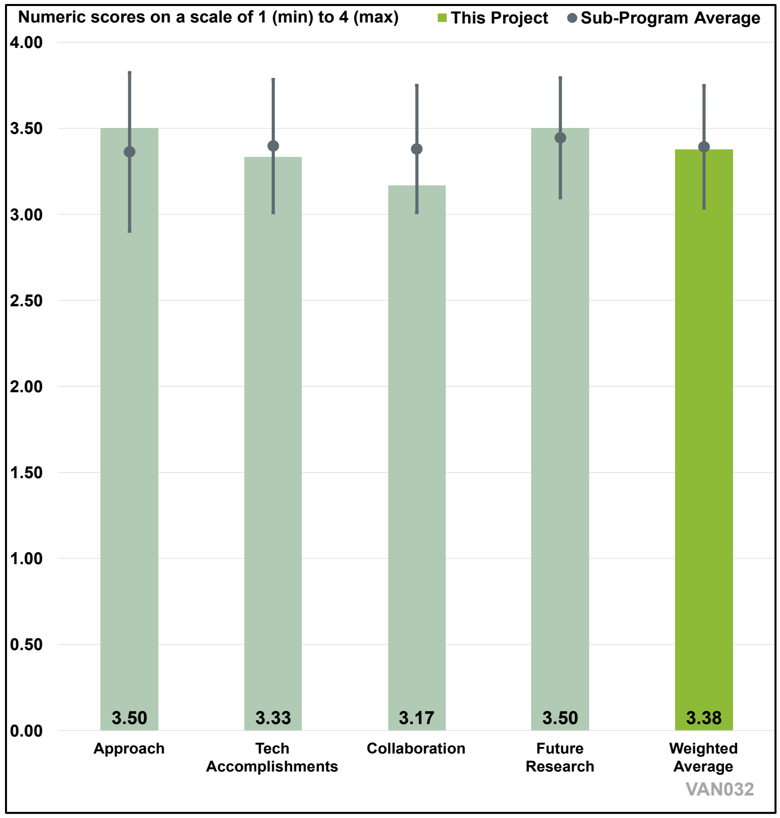

Figure 7-5. Presentation Number: VAN032 Presentation Title: Tracking the Evolution of Electric Vehicles and New Mobility Technology Principal Investigator: Joann Zhou, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the work approach is good, although there were some weaknesses due to data limitations (Experian stock data is quite different from S&P/Polk, and Ward's sales data does not align perfectly into EPA car/light truck categories). There are ways to solve the data issues, but they are either too expensive for this project (Polk) or are not publicly available (EPA official production numbers by car/light truck and nameplate). Additionally, the approach should be to develop estimates with uncertainties, rather than single values. This is particularly relevant for the counterfactuals required to estimate GHG reduction, gasoline consumption reduction, and fuel cost savings.

Reviewer 2

Information on markets (e.g., vehicle registrations) and commodity flows is well presented and highly useful. Results on fuel cost savings and total cost of ownership seem somewhat at odds with other analyses. Rather than general claims in this area, the reviewer said it might be useful to select several "tracking model pairs" consisting of a new electric vehicle (EV) vs. new ICE vehicle or new HEV and compare the 5-year ownership cost while detailing general and regional assumptions. HEV options, particularly in cases where gasoline prices are high, may compete more favorably than the baseline ICE vehicle and make a stronger showing against the EV option. The reviewer said it would have been nice to see annotations where/when disruptions in data trends are observed. For example, the reviewer questioned if there were changes in policy or issues in supply. The reviewer also questioned if these were short-term blips or the first signs of fundamental shifts in the market.

Reviewer 3

The battery manufacturing and planned battery plant investment research is of tremendous national and international value and was heavily cited by EPA in its recent light-, medium-, and heavy-duty rulemakings. The battery manufacturing and battery plant investment research are very important and, depending upon DOE's available funding, may even have been strong enough to stand on its own (that is, independent of the research on EV market trends and usage of mobility technology as a function of household income). This latter research on EV market trends and usage of mobility technology as a function of household income is more basic and still developing and the reviewer is confident that it will have increasing importance in the future.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The team has produced several great pieces of analysis. Recent sales trends, including both the number of units as well as sales-weighted attributes, are very important for VTO to understand the U.S. LDV market as it evolves. The manufacturing and battery production flows (Slide 9) are particularly helpful as other modelers attempt to estimate the potential eligibility for the IRA clean vehicle credits (CVC). The gasoline displacement analysis needs to include caveats and uncertainties if published and should present ranges and not single values due to the enormous uncertainty of the counterfactual fuel economy and vehicle miles traveled (VMT). BEV VMT is around 15% lower than that of non-BEVs, not because of the powertrain but because they are luxury vehicles; and luxury vehicles are driven less miles than mass-market vehicles. More importantly, though, the analysis assumes a counterfactual case that likely does not meet Corporate Average Fuel Economy (CAFE) or EPA GHG. ICE vehicles in a no-BEV world would be much more efficient to comply with CAFE. Local fuel use and GHG emission reductions should have included HEVs, which are clearly the preferred manufacturer non-plug-in vehicle (PEV) compliance option, and an option that consumers have widespread access to across most size classes. The same goes for the "public-facing EV fact page," HEVs should be included in the total cost of ownership (TCO) calculations.

Reviewer 2

The reviewer would have liked to have seen more rigor and detail on the total cost of ownership analysis.

Reviewer 3

The technical accomplishments associated with the battery manufacturing and planned battery plant investment research are great and fill an important gap in our understanding and the reviewer encourages the funding of this work. The technical accomplishments of the non-battery-related research are also significant and will take additional time and funding to fully bear fruit. However, this work remains important and the reviewer encourages its support.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that there does not appear to be much direct collaboration on project work aside from working with regional agencies on mobility usage data. Other laboratories, academia, and industry (and government agencies) are all thinking about these market dynamics and would likely have a lot to contribute (whether via review of ANL work and assumptions or directly developing analyses with ANL).

Reviewer 2

The reviewer stated that the collaboration with NREL and ORNL seems about right, as is the outreach with regional agencies, Clean Cities, and the City of Chicago. The reviewer suggested reaching out to EPA’s Transportation and Climate Division (TCD), in the Office of Transportation and Air Quality (OTAQ), with regards to the EV market trends and usage of mobility technology as a function of household income as this work lines-up nicely with their portfolio. Regarding the battery-specific research, the reviewer suggests reaching out to EPA’s Assessment and Standards Division (ASD), also in OTAQ.

Reviewer 3

The reviewer did not have any specific comments.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said maintaining publication of current reports and analyses is good. The supply chain component is valuable, and it would be helpful for ANL to maintain a live database (even just an Excel file updated monthly) to account for the inevitable new announcements and delays over the coming years. The reviewer does not think this warrants another project with more funding, just posting the already regularly internally updated spreadsheet as a resource. This reviewer referenced prior comments for a few ideas on future work. Future work could include a more detailed assessment of the counterfactuals for the gasoline consumption and emissions reduction analyses. The reviewer also recommends adding HEVs to all “BEV v. ICE” analyses (emissions, TCO), because consumers are not operating in an ICE vehicle vs. BEV dichotomy.

Reviewer 2

In looking at regional emissions impacts, the reviewer thought it might be useful to also consider consumer choices around clean electricity. Even where electric power grids are still coal-heavy, EV buyers have options around clean electricity procurement ranging from home solar to utility-sponsored programs to renewable energy credit (REC) purchases. The reviewer expects that where consumer choice of an EV is motivated, at least in part by the desire to reduce GHG emissions, there will also be actions taken on clean electricity. The reviewer commented that it would be interesting to know if data supports this (i.e., are EVs serving to accelerate the growth of clean energy in the power grid).

Reviewer 3

The reviewer stated that continuing to document battery manufacturing and planned battery plant investments will be of great importance into the future and the reviewer urges DOE to continue funding such research. Likewise, the reviewer urges DOE to consider funding more basic research, such as the non-battery-related aspects of this project. The reviewer suspects that these aspects will likely have increased importance in the future. This is one downside of collecting basic statistics on newer, not-well-established projects, like those presented here. An early finding that high-income households in Chicago are more likely to use high-tech gizmos, such as transportation network companies (TNCs), e-bike, and e-scooter services, it is not particularly surprising or illuminating. However, a finding (in a hypothetical future) that low- and medium-income households in Chicago are starting to adopt the use of TNCs, e-bike, and e-scooter services would be of great relevance, for it would suggest the mainstreaming of vehicle electrification. And before such a historic transition can be divined from the data, much historical data will need to be gathered.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project supports both of the following VTO Analysis objectives: create and maintain a strong foundation of data; and execute insightful integrated analyses that provide greater understanding of critical transportation energy problems.

Reviewer 2

The reviewer did not have any specific comments.

Reviewer 3

The battery-specific research presented herein clearly supports the objectives of several important VTO subprograms, such as Analysis, Batteries, Electrification, Materials, etc. This research is very relevant and of great immediate value. Aspects of the non-battery-specific research (e.g., transportation electrification as a function of household income) are also important, but perhaps in the longer term. The reviewer questions if it would be beneficial for some sort of closer alignment of these aspects of the presented research with the Energy Efficient Mobility Systems subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that resources were sufficient to achieve the stated milestones.

Reviewer 2

Funding for the battery-only portions of this project (battery manufacturing and planned battery plant investments) is well, well-worth the $250,000 spent on it in fiscal year (FY) 2023 and all of the rest of the research, the remaining six or so accomplishments, only serve to make this research a better deal for the U.S. taxpayer. (Put more crudely, it could be said that the battery-only research “pays” for or justifies the remaining research). And while the data gathered for this nascent non-battery research may not yet be earthshaking, there will come a time when it will be, and it is vital that this transition be well-documented so that the associated lessons can be learned. The reviewer suggests increasing the funding for this research so that it can continue and, ideally, suggests increasing the funding so that these researchers can purchase other vital automotive datasets to augment the existing Wards Auto and Experian Automotive data.

Reviewer 3

The reviewer did not have any specific comments.

Presentation Number: VAN045
Presentation Title: Analysis of Electric Heavy-Duty Driving and Infrastructure Requirements Within A Regional Area
Principal Investigator: Marcus Alexander, EPRI

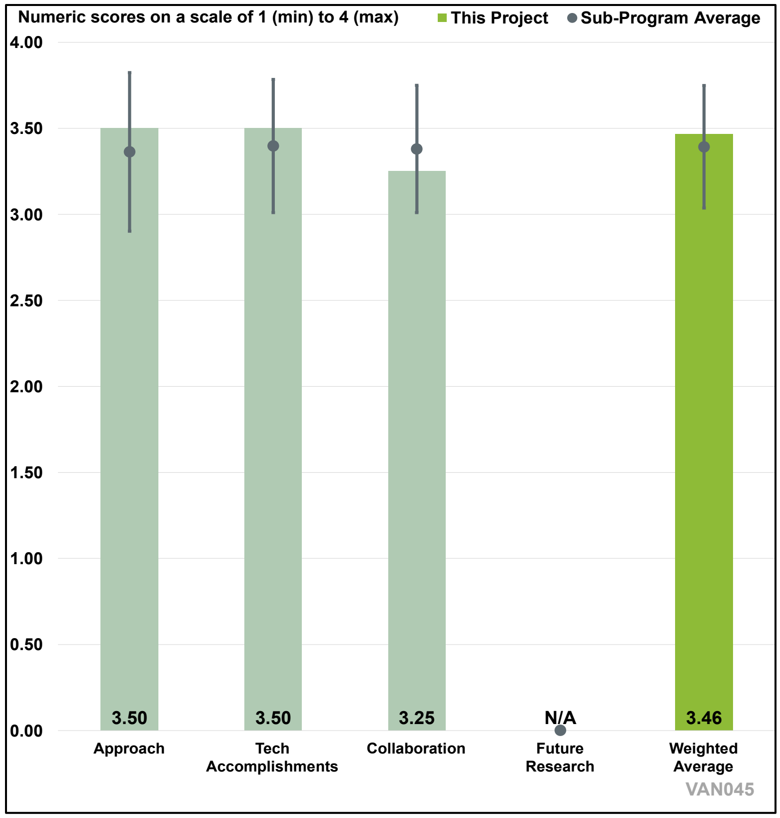

Figure 7-6. Presentation Number: VAN045 Presentation Title: Analysis of Electric Heavy-Duty Driving and Infrastructure Requirements Within A Regional Area Principal Investigator: Marcus Alexander, EPRI

Presenter

Marcus Alexander, EPRI

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The approach is somewhat similar to the broader DOE Transportation Electrification Impact Study (TEIS) and the results appear to be complementary to that study.

Reviewer 2

The project team’s expertise aided the project approach, which leveraged existing data, tools, and models. The overall approach to evaluate high-power charging for truck fleets is a broad area, but the focus on specific examples was good. The project was able to pull broad insights and location-specific insights on constraints/options to minimize grid upgrades to serve the load. The overall approach to model truck fleets that would/may use the charging sites was good to determine the need. Using that data with utility data/insights to understand location-specific options and costs was good.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project appears to have been completed on time and on budget.

Reviewer 2

The project developed charging load profiles for known (depot)/anticipated (truck stop) trucks and used real-world utility data to understand current usage/limitations and determined installation cost estimates to meet the new power demand. The evaluation and comparison of several cost minimization approaches for local distribution grid upgrades was good and showed how they each can solve the challenge, but at sometimes large cost differences.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The scope of the distribution-level analysis appears to have been fairly limited. The reviewer would have liked to have seen more utilities involved representing a larger geographic area and demographic/geographic diversity.

Reviewer 2

The project team structure with the Electric Power Research Institute (EPRI) as lead and performing utility modeling, NREL focused on core competency vehicle modeling, and utilities providing real-world data was a very good team and usage of team qualifications.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The project has ended. The reviewer would recommend to DOE that they limit AMR to projects with ongoing research so that the reviews can still impact the progress of a particular project.

Reviewer 2

The project is over, but EPRI mentioned their current EVs2Scale2030 project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This is obviously very relevant due to the potential distribution-level impacts of heavy-duty (HD) direct current fast charging (DCFC).

Reviewer 2

The project is a clear fit for vehicle and systems analysis to better understand the real-world operation of vehicles and grid, develop cost estimates, and mitigation approaches with results comparison is a clear industry need (utilities, commercial/municipal fleets, and truck stop operators)

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said no indication was provided that funding was insufficient.

Reviewer 2

The reviewer commented that funding was sufficient for a 3.5-year modeling project that included national laboratory resources.

Presentation Number: VAN047
Presentation Title: Integrated Modeling and Technoeconomic Assessment of Electric Vehicle Community Charging Hubs
Principal Investigator: Eleftheria Kontou, University of Illinois

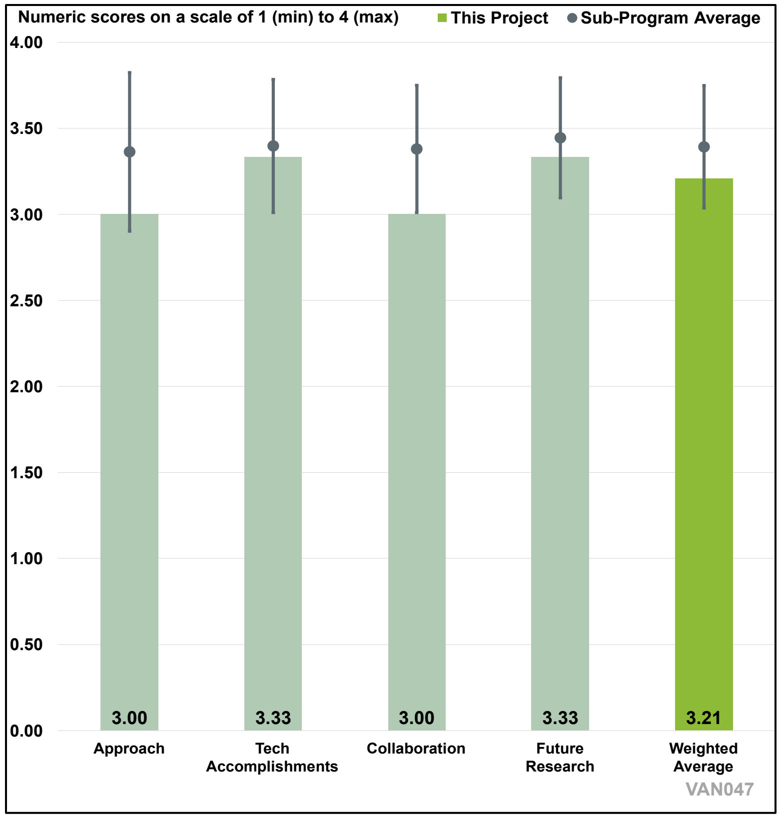

Figure 7-7. Presentation Number: VAN047 Presentation Title: Integrated Modeling and Technoeconomic Assessment of Electric Vehicle Community Charging Hubs Principal Investigator: Eleftheria Kontou, University of Illinois

Presenter

Ruolin Zhang, University of Illinois

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project takes an interesting approach to explore an economical deployment of chargers at multi-unit dwellings (MUDs). The general approach is adequate with a reasonable timeline. However, the reviewer questioned the usage of charging station data but not vehicle data from EVWATTS to develop the logit model for the driver's decision of charging location.

Reviewer 2

The reviewer would have liked to see more emphasis on overall economics. It is not clear what the assumed costs for parking and/or charging that make investments attractive were. It was also not clear if there are significant stress points from a tenant/user/system operator perspective.

Reviewer 3

Technical barriers are well-described and addressed via multiple agents (parker, garage owner, EV owner vs. ICE vehicle owner). The challenges presented by misallocation of parking spots are discussed up-front. Approach, inputs, variables, and methods are identified and described clearly. The timeline extension (a year, i.e., 50% of the originally scheduled project duration) seems significant but understood re: COVID-19 impacts. Some of the challenges with interconnection and make-ready costs might be important to include with the techno-economic assessment, i.e., how tools like those developed as part of this research can assist with forecasting nearer-term payback periods (thereby encouraging development of more charging facilities and make EV adoption an easier choice for consumers).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project seems to make good progress toward its completion, and results are clearly presented with its technical contribution.

Reviewer 2

The project may need some form of pilot operation to validate that this really works for all stakeholders.

Reviewer 3

The exploration of the different factors motivating drivers/parkers was well-structured, isolated, and parameterized to achieve key insights. Comparison of several different approaches was well-formatted to unpack the impacts of the research, via charts on optimization, utilization, matchings, and revenue. There are clear advances to be made in terms of spatial visualization of impacts; there were a bit more challenging to comprehend, and a graphic user interface (GUI), as described in the outstanding deliverables, will greatly improve that issue.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project seems to form a strong collaboration between national laboratories and transportation agencies. However, the review stated that it can be improved by having inputs from MUD property owners and housing agencies about implementation factors/constraints to be considered.

Reviewer 2

The reviewer suggested reaching out to several charging network providers and MUD property managers for active engagement.

Reviewer 3

Community engagement as a key deliverable seems to be an important takeaway. Developing relationships with end users will produce important insights for future work. The scope of collaboration with the Alliance for Clean Transportation and the Illinois DOT is not clear.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The proposed future work is clearly defined and appropriate for concluding the project, which will allow the project to achieve its targets.

Reviewer 2

The reviewer suggested trial and validation before proceeding with further analysis cases (e.g., curbside charging).

Reviewer 3

Looking into other non-household electric vehicle supply equipment (EVSE) applications seems to be a clear next step. Understanding the economics in greater detail, as well as the jurisdictional nuances of curbside charging facilities (who builds them, where, by what authority, through what funding and payback mechanisms, etc.) will be essential. Just because a location appears to be suitable does not necessarily mean that a charging facility can/will be built, given cost and payback structures that vary by jurisdiction.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is relevant and supportive of VTO subprogram objectives. MUD charging is an important challenge to address to allow the US to achieve its transportation electrification goal.

Reviewer 2

The question of MUD EV charging is highly relevant and will become important by the end of the decade as EV stock ramps up.

Reviewer 3

This research supports a key mechanic for transportation electrification. While many drivers will leverage home charging facilities, those cannot be taken for granted in a future with significantly higher degrees of transportation electrification. Further, en-route charging (away from where a vehicle is primarily domiciled) can not only benefit customers but may also create benefits for utilities by incentivizing more flexible charging, given that those en-route chargers present additional opportunities for charging that may not otherwise be available to drivers. Essentially, utilities and customers will have additional, flexible options for charging with more ports deployed in more places, all of which will benefit from some level of incentives to increase utilization. There is also an important equity component, whereby public charging experiences need to be dramatically more efficient and higher quality to facilitate more straightforward transportation electrification experiences for consumers, regardless of whether they own property on which they can charge their vehicle.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources for this project are sufficient and appropriate for achieving milestones in a timely fashion.

Reviewer 2

The reviewer said there were sufficient resources for the initial analysis phase but would like to see more work on economics (levelized cost of charging and business models) as well as pilot demonstrations as future steps.

Reviewer 3

Resources were not described at length, either in the read-ahead, or the presentation itself, so making a judgement call here is challenging. It appears that adding staff/advisors from utilities, or with additional electric utility-facing experience, may create additional value for this project, in terms of understanding more practically how parking spot electrification is planned, funded, and accomplished. Integrating concepts like rate design, interconnection, return on investment/payback periods, and load forecasting/diversity may serve to paint a clearer picture about the potential benefits offered by integrating this research into parking systems.

Presentation Number: VAN059
Presentation Title: Deploying Charging Infrastructure to Catalyze Market Adoption of Electric Vehicles and Improve Mobility Health and Economic Outcomes in Disadvantaged Communities
Principal Investigator: Corey Harper, Carnegie Mellon University

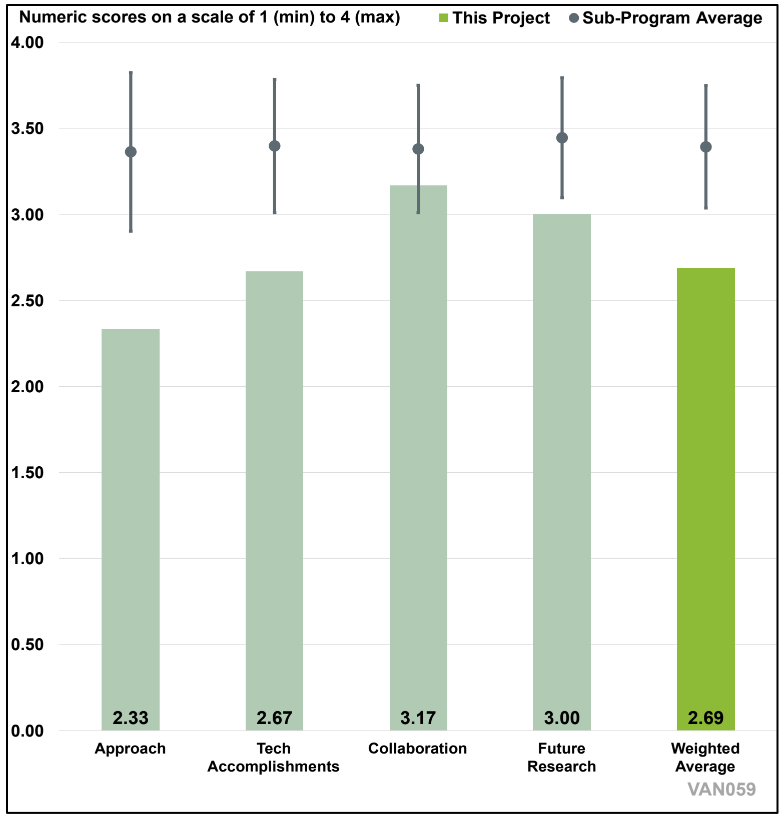

Figure 7-8. Presentation Number: VAN059 Presentation Title: Deploying Charging Infrastructure to Catalyze Market Adoption of Electric Vehicles and Improve Mobility Health and Economic Outcomes in Disadvantaged Communities Principal Investigator: Corey Harper, Carnegie Mellon University

Presenter

Corey Harper, Carnegie Mellon University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

It is unclear to the reviewer how this project may address its goals, especially when the model does not seem to consider the cost of deployment and cost of EV ownership. The timeline is reasonable.

Reviewer 2

The project seems to have several very different focuses that the reviewer does not think will work. The focus on improving EV adoption in low-income/minority population is good, but seems the primary reasons are known to be more of vehicle cost and new vs. used in many cases, rather than available EVSE being the limitation. The project goals (Slide 6) are very specific like this was an implementation project, not equity modeling focused. The reviewer does not see how the (upcoming) distribution grid analysis will help answer the main questions. The reviewer thought it seemed unnecessarily too detailed for this work.

Reviewer 3

The project has a very good initial question and good integration of a number of models.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

Considering the short time period of execution, the project is still at an early exploration stage, and the progress so far is satisfactory.

Reviewer 2

The reviewer acknowledged that the project started recently and has only spent 10% of the budget. Initial modeling work is underway and incorporates factors for low income and minority populations to determine location and proximity to current and future potential modelled EVSE. The Kuse factor needing to be forced to 205 (extremely high) seemed to indicate the underlying assumptions/algorithm needs to be refined.

Reviewer 3

The review commented there had been reasonable progress for only a half-year of work.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The project seems to have a good team with university, national laboratories, and local agencies. The reviewer said it would be good to see how local agencies and communities contribute to the project, especially on how to accommodate mobility needs of communities with different demographic and geographic conditions/limitations.

Reviewer 2

The team and roles were described, but the current work was all Carnegie Mellon University (CMU) so team coordination was not highlighted since the project is not yet at the stage where NREL and UVM will be active in the project.

Reviewer 3

The reviewer commented that the project had good collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The immediate future work seems to be a reasonable next step based on current progress, but it is unclear to the reviewer how this project may address its goals with proposed future work. For example, while charging infrastructure plays a crucial role in EV adoption, total cost of ownership remains the dominate reason especially for the disadvantaged communities that are more sensitive to cost. However, it is not clear to the reviewer how cost is being considered in the future project scope.

Reviewer 2

The reviewer stated that the next step of the usage modeling was described, but specific roles and work for NREL and UVM were not described.

Reviewer 3

The reviewer was concerned with how generalizable/scalable the results would be outside of Pittsburgh (the study area).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The project is relevant to VTO objectives and supports them.

Reviewer 2

The reviewer said the project is relevant but needs to be more focused to address a targeted relevant question and not try to do too much in one project. The reviewer also said this project should reevaluate the relevance for some of the work (e.g., distribution network analysis).

Reviewer 3

The reviewer commented that the project is highly relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The review stated that the resources were appropriate for the project to meet milestones in a timely fashion.

Reviewer 2

The reviewer commented that the resources of the project were sufficient.

Reviewer 3

The reviewer said the resources were sufficient, but likely excessive if/when the project scope evaluation is complete, e.g., distribution analysis and determining how to meet specific metrics (e.g., increase EV adoption in disadvantaged communities [DACs], decreased travel cost/time, decrease grid upgrade costs, determining how many EVSE are needed in a specific area).

Presentation Number: VAN060
Presentation Title: Quantifying New and Used Plug-in Electric Vehicle Market Dynamics in Disadvantaged Communities
Principal Investigator: John Helveston, George Washington University

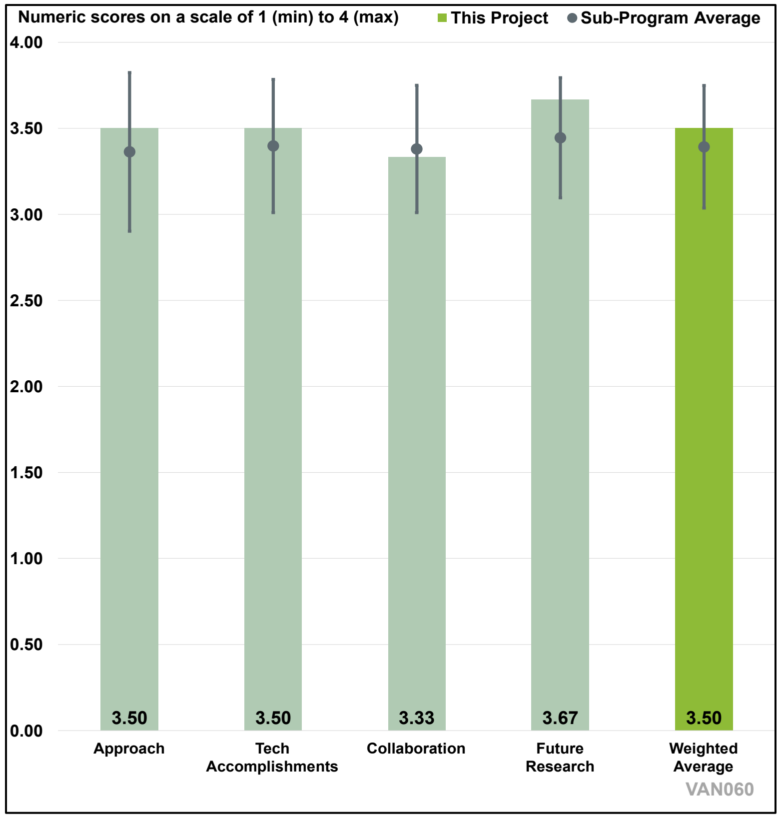

Figure 7-9. Presentation Number: VAN060 Presentation Title: Quantifying New and Used Plug-in Electric Vehicle Market Dynamics in Disadvantaged Communities Principal Investigator: John Helveston, George Washington University

Presenter

John Helveston, George Washington University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This project has a good structure to understand PEV market dynamics and study consumer preference in DACs, and the timeline is reasonably planned. One suggestion for Thrust 1 is to consider how the insight may be used to evaluate total cost of ownership for new and used electric vehicle buyers, and how cost parity may vary between the new and used car market.

Reviewer 2

The reviewer said the approach was interesting and innovative.

Reviewer 3

The study is well designed and will address the barriers listed for exploration. The timeline for the project is reasonable and achievable. The study will help identify some interesting observations about how to make EV ownership more equitable by understanding some of the root causes. The reviewer said it is an important topic, was glad to see it funded, and was looking forward to the project results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The project shows good progress toward the project plan. While the dataset used in the study has its challenges and certainly not perfect, it allows informative and insightful analysis to been done. The idea of using social media platforms for the survey is interesting, but potential data quality issues and sampling bias should be addressed.

Reviewer 2

The reviewer commented that the initial results were intriguing.

Reviewer 3

The project started a few months ago and it seems to be progressing well. The George Washington University team and NREL partnership seems to be working well. The reviewer said it is a relatively low dollar project but an important project. Equity is important and hopefully the results will help develop better policies.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The collaboration with the national lab and the plan to integrate its tools seem reasonable, however, how it will be implemented is unclear to the reviewer. The reviewer commented that it may be beneficial to collaborate with disadvantaged communities to get some qualitative feedback rather than purely relying on quantitative survey data.

Reviewer 2

The reviewer said the project was a good example of academia/university collaboration.

Reviewer 3

The project is still in the early stages and the collaboration/coordination seems to be going well. The reviewer stated it would have been beneficial to have some local community groups and neighborhood associations as partners or identified in the work streams.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Future work is defined and it is appropriate for achieving project goals. Potential future scope could include modeling the total cost of ownership for new and used EV owners, and how cost parity may vary between the new and used EV market.

Reviewer 2

The project is likely to develop insights for the research community and VTO.

Reviewer 3

The project has well-defined future work and seems achievable. Based on the current performance and achievements, the likelihood of achieving results/deliverables is very high. The reviewer is looking forward to hearing more about it in the next AMR.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

This project is highly relevant to VTO subprogram objectives and is addressing an important question about affordability and EV adoption in the disadvantage community.

Reviewer 2

The reviewer said the project is highly relevant.

Reviewer 3

Equity is a very important part of policy development. This study will point to some results that will help with better delivery of policies for DACs. DACs stand to benefit a lot from adoption of EVs and it is important to understand how to increase EV uptake in DACs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

Resources are appropriate for the scope of this project and its timeline and milestones.

Reviewer 2

The reviewer commented that there were sufficient resources for an analytical project.

Reviewer 3

The reviewer said hopefully, the future work that will be needed after this study is completed will be funded. This is an important topic and should be supported.

Presentation Number: VAN061
Presentation Title: Transportation Electrification Impact Study
Principal Investigator: Eric Wood, National Renewable Energy Laboratory

Presenter

Eric Wood/ Bin Wang, National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

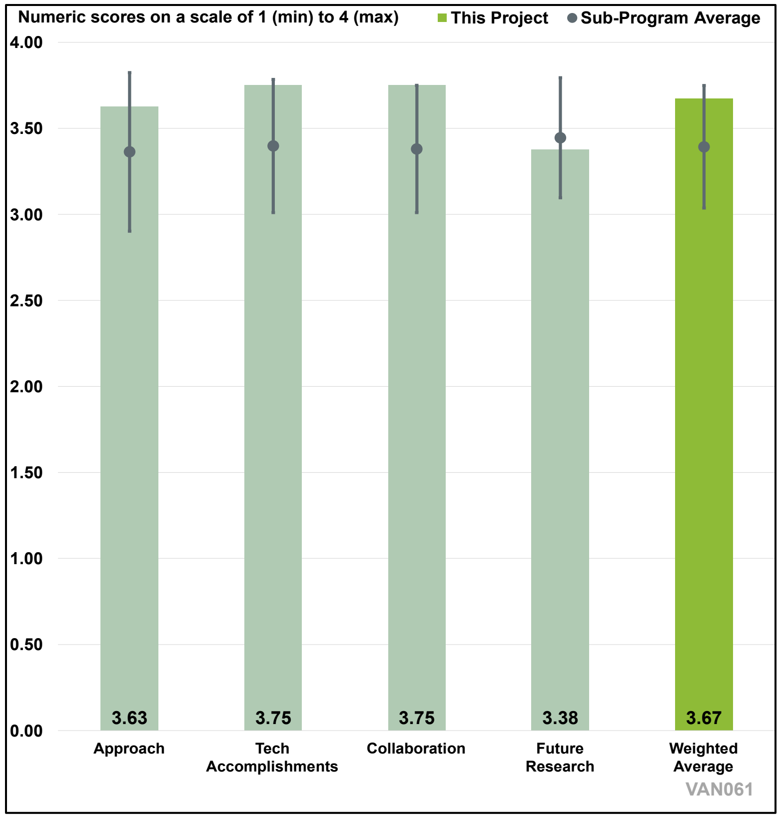

Figure 7-10. Presentation Number: VAN061 Presentation Title: Transportation Electrification Impact Study Principal Investigator: Eric Wood, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

This is a unique project in terms of timeline, a “sprint.” The team developed a reasonable approach, merging several suites of pre-developed models from NREL (EVI-X modeling suite), LBNL (HEVI-LOAD), and Kevala (grid-side) to try and get a better feel for the scale and impact of EV charging infrastructure installation and operation in a “high-EV” future. Limiting the scope to incremental rather than absolute limits the overall value of the work. The reviewer said it would have been more valuable to determine the feasibility and cost to achieve EPA’s assumed No Action BEV adoption pathway (from an infrastructure perspective). But the approach provides exactly what was needed for EPA’s policymaking purposes, which was the goal. The LDV approach was also narrowed sufficiently to ensure all tasks could be completed (two analysis years, predetermined EV adoption scenarios, specific geographies, relatively simple “managed vs. unmanaged” scenarios). Heavy-duty is a different animal altogether, but the team designed a logical approach to estimate charging infrastructure impacts and costs in the allocated timeline.

Reviewer 2

Work was well executed given the condensed timing. The reviewer was not sure comparing infrastructure capital investment ($12 billion) to net benefits ($33 billion) was entirely relevant. The reviewer assumed that infrastructure costs, or at least a portion of those costs, are already reflected in the net benefits calculation in the form of electricity pricing. If the extent of infrastructure capital investment leads to near-term jumps in electricity prices, then that would be worth addressing as a separate summary topic.

Reviewer 3

The reviewer commented that this was a very ambitious project with a clear focus on determining the potential estimated distribution cost increase from a proposed EPA rulemaking that would increase PEVs. The project focused only on the incremental PEVs. The reviewer said there was a good and logical teaming approach to leverage qualifications and developed models (all partners) to do the work. Several modeling steps were needed to move from projected sales (by county) to electric demand, to determine available capacity, new capacity required, and cost estimate of distribution system upgrades to support the policy case. The project evaluated different options/aspects including managed charging as ways to efficiently use existing infrastructure/minimize new infrastructure needs. The modeling included travel demand which is especially useful for supporting freight movement. The principal investigators mentioned hydrogen fueling infrastructure, but it was not focused on a very big problem, but a logical approach and teaming.

Reviewer 4

The reviewer said the project is well designed, in particular being able to reallocate resources for a “sprint.”

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The team appears set to complete all milestones on time and has already completed the “sprint” segment (in the finalized EPA regulation). The findings are fascinating and will be valuable for those maintaining and updating integrated energy models that need to better represent PEV charging infrastructure. The reviewer commented that there should be more focus on the uncertainties. The number of knobs and levers that were set based on expert judgement need to be explicitly stated, and ideally the team should make everything openly available so that the results can be reproduced by other researchers.

Reviewer 2

The reviewer said the full report should be made public.

Reviewer 3

The project performed modeling of county level zero emission vehicle (ZEV) projections (all counties it seems), also determining state and national ZEV averages that inform the later distribution needs analysis/costing, which is impressive. The project looked at ZEV sales/stock and power/energy demand projected at county, state, and national levels. The modeling results confirm the highly local impacts on grid demand and distribution system capacity/needs. Kevala’s work quantified the peak load and total energy increases resulting from the proposed EPA action. The work also modeled the positive impact of managed charging (fleet and home). The results also showed a relatively small increase in kilowatt-hours and kilowatts. The reviewer also said the distribution system improvement needs analysis regarding charging stations, infrastructure components, and cost for unmanaged/managed was great and highlights the overall investment scale and potential savings from managed charging.

Reviewer 4

The reviewer said a multi-state charging infrastructure cost assessment was a significant achievement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This was clearly a highly collaborative effort. Data and findings were passed between multiple national laboratories (NREL/LBNL), government agencies (DOE/EPA), and industry (Kevala).

Reviewer 2

The reviewer stated there was good coordination across multiple teams, especially in spanning light-duty and medium- and heavy-duty, and also working with power distribution experts.

Reviewer 3

The team included the needed relevant qualifications and staff. The coordination and collaboration between the different laboratories (NREL as lead, LBNL) and Kevala seemed to be well-designed and worked well. The role and coordination of others listed as partners (EPA, California Energy Commission, Joint Office of Energy and Transportation, etc.) was not well-described but the reviewer expects they served as industry advisors which is appropriate for including the required perspectives, understandings, and corrections when needed.

Reviewer 4

The reviewer said there was good collaboration between NREL, LBNL, EPA, DOE, and the private sector.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the future research all seems like it would be valuable, with the purpose generally being “improve understanding of PEV impacts on the grid.”

Reviewer 2

The reviewer commented that it was important to include the evolution of grid mix before drilling down into more detailed analysis. Recommended actions, for example, on where and when to charge EVs, should comprehend the decoupling of the grid from fossil fuels. This may change the picture considerably and will likely complicate the analysis, but it is important to look beyond the current grid which is still 60% fossil-based and not aligned with the current administration’s 2030 and 2050 GHG emissions reduction targets.

Reviewer 3

The planned future work for this project is appropriate and near-term work focus is on important topics to understand how distribution infrastructure hardware manufacturing ramp up needed to support the near-term needs.

Reviewer 4

The reviewer stated to continue the good work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this project firmly supports all VTO Analysis objectives: data, analysis, and modeling.

Reviewer 2

The reviewer stated the project was highly relevant, especially in terms of grid readiness and the benefits of managed charging.

Reviewer 3

The project has a clear and direct relevance to understanding the projected PEV population and grid charging demands and in determining what grid investments are needed to support the successful PEV deployment.

Reviewer 4

The reviewer commented that the project is highly relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The resources have proven to be sufficient (the project is basically complete).

Reviewer 2

The project report is complete.

Reviewer 3

The budget is very high for a modeling/simulation project, but there was a lot of work being done concurrently which requires a lot of staffing. One hour to describe a project of this scale and pace was not enough, so the review suspects there were a lot of project elements that were not described. The funding level is likely accurate.

Reviewer 4

The reviewer said resources were sufficient.

Acronyms and Abbreviations – VAN

Abbreviation	Definition
AEO	Annual Energy Outlook
AMR	Annual Merit Review
ANL	Argonne National Laboratory
API	Application programming interface
ASD	EPA's Assessment and Standards Division
BatPaC	Battery Performance and Cost Model
BEV	Battery electric vehicle
BIL	Bipartisan Infrastructure Law
C2G	Cradle-to-grave
CAFE	Corporate Average Fuel Economy
CMU	Carnegie Mellon University
CO_2	Carbon dioxide
CVC	Clean vehicle credits
DAC	Disadvantaged community
DCFC	Direct current fast charging
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
eGRID	Emissions & Generation Resource Integrated Database
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FEOC	Foreign entity of concern

Abbreviation	Definition
FOTW	Fact of the Week
FY	Fiscal year
GHG	Greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation model
GUI	Graphic user interface
HD	Heavy-duty
HEV	Hybrid electric vehicle
HEVISAM	Heavy-Duty Battery Electric Vehicle Infrastructure Scenario Analysis Model
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
IPM	EPA's Integrated Planning Model
IRA	Inflation Reduction Act
LBNL	Lawrence Berkeley National Laboratory
LCA	Life cycle analysis
LDV	Light-duty vehicle
MA3T	Market Acceptance of Advanced Automotive Technologies
MOVES	EPA's MOtor Vehicle Emission Simulator
MUD	Multi-unit dwelling
NEMS	National Energy Modelling System
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
OTAQ	EPA's Office of Transportation and Air Quality
PEV	Plug-in electric vehicle

Abbreviation	Definition
PHEV	Plug-in hybrid electric vehicle
REC	Renewable energy credit
TCD	EPA's Transportation and Climate Division
TCO	Total cost of ownership
TEDB	Transportation Energy Data Book
TEEM	Transportation Energy Evolution Modeling
TEIS	U.S. Department of Energy's Transportation Electrification Impact Study
TNC	Transportation network company
US DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability
USG	U.S. government
UVM	University of Vermont
VAN	U.S. Department of Energy's VTO Analysis (VAN) subprogram
VIUS	Vehicle Inventory and Use Survey
VMT	Vehicle miles traveled
VTO	Vehicle Technologies Office
ZEV	Zero emission vehicle

8. Acronyms and Abbreviations

Abbreviation	Definition
µL/mg-S	Microliter per milligrams sulfide
µm	Micrometer
0D	Zero-dimensional
1 Å –10 cm	Angstroms to centimeters scale
1 s – 1 yr	Seconds to year scale
1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
4M	4M Carbon Fiber Corporation (team member)
4XT	4X Technologies, LLC
A380	Designation for the most specified Al alloy that has the best combination of casting, mechanical, and thermal properties
AAM	American Axle and Manufacturing
AC	Alternating current
ACC	Adaptive cruise control
ACMZ	Aluminum-copper-manganese-zirconium
ACT	California Advanced Clean Truck rule
AD	Additives type
ADS	Automated driving system
ADT	Articulated dump truck
AE	Activation energy
AEO	Annual Energy Outlook
AFE	Active Front End
AFM	Atomic force microscopy

Abbreviation	Definition
AFR	Air-fuel ratio
AFRL	Air Force Research Laboratory
Ag	Silver
Ah	Ampere-hour
AI	Artificial intelligence
AI/ML	Artificial intelligence/machine learning
AIMD	Ab initio molecular dynamics
AIR7357	SAE International MegaWatt and Extreme Fast Charging for Aircraft
Al	Aluminum
Al_2O_3	Aluminum oxide
Al-MMC	Aluminum metal matrix composites
AM	Additive manufacturing
AM60B	A castable Mg alloy with excellent ductility, superior energy absorbing properties, and good strength and castability
AMP	Colorado-based recycling technology vendor AMP (formerly Amp Robotics)
AMR	Annual Merit Review
AN	Ammonium nitrate
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
APaCK-V	Argonne Perception and Connectivity Kit - Vehicle
API	Application programming interface
APS	Advanced Photon Source
ARC	Accelerating rate calorimetry
ARC	Army Research Combustor
ARL	Army Research Laboratory

Abbreviation	Definition
AS4	A high strength, high strain, continuous carbon fiber made by Hexcel
ASCENT	Aviation Sustainability Center
ASD	EPA's Assessment and Standards Division
ASPIRE	Advancing Sustainability through Powered Infrastructure for Roadway Electrification
ASR	Double-loop DC drive system, speed loop (ASR)
ASTM	ASTM International, formerly known as American Society for Testing and Materials
AT	Aftertreatment
Atm	Standard atmospheric pressure unit
ATSPM-E	Automated Traffic Signal Performance Measures-Energy
AV	Autonomous vehicle
AVL	Company name
AZ91D	A high-purity Mg cast alloy with excellent corrosion resistance, castablilty, and good strength
B100	100% biodiesel
B_2S_3	Boron Sulfide
B_2S_3-Li_2S	Boron Sulfide and Lithium Sulfide
B500	Battery 500 Consortium
BAE	BAE Systems Inc.
BatPaC	Battery Performance and Cost Model
BEAM CORE	Behavior, Energy, Autonomy, Mobility Comprehensive Regional Evaluator
BESS	Battery energy storage system
BEV	Battery electric vehicle
BIL	Bipartisan Infrastructure Law
BMS	Battery management system

Abbreviation	Definition
BNL	Brookhaven National Laboratory
BP	Budget Period
BPT	Bidirectional Power Transfer
BTE	Brake thermal efficiency
BTM	Behind the meter
BTMS	Behind-the-meter energy storage
C/S	Carbon/sulfur
C2G	Cradle-to-grave
CA	Conductive additive
CAF	Development Bank of Latin American and the Caribbean
CAFE	Corporate Average Fuel Economy
CALPHAD	CALculation of PHAse Diagrams (software by CompuTherm)
CAM	Cathode active materials
CANMET	Canadian Centre for Mineral and Energy Technology
CARB	California Air Resources Board
CAT	Caterpillar
CAV	Connected and automated vehicle
CC&C	Clean Cities and Communities
CCF	Continuous carbon fiber
CCP	Composites Core Program
CCP 2.0	Phase 2 of the Composites Core Program
CCS	Combined Charging System
CCV	Closed crankcase ventilation
CDA	Cooperative driving automation
CE	Coulombic efficiency

Abbreviation	Definition
CEI	Cathode electrolyte interphase
CEPNA	Cummins Electrified Power North America
CERPMs	Chip-Enabled Raised Pavement Marker(s)
CF	Carbon fiber
CFD	Computational fluid dynamics
CFM	Carbon framework material
CFRC	Carbon fiber reinforced composites
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CH_4	Methane
CHA	Chabazite
CI	Compression ignition
CMC-SBR	Sodium carboxymethyl cellulose (CMC) and Styrene butadiene rubber (SBR)
CMU	Carnegie Mellon University
CNG	Compressed natural gas
CNT	Carbon nanotube
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
CPE	Composite polymer electrolyte
CPS	Cyber-Physical Security
CR	Compression ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council

Abbreviation	Definition
CRC	Cyclic redundancy check
CRF	Sandia National Laboratories’ Combustion Research Facility
CS-SPAN	Carbon Supported Sulfurized polyacrylonitrile
Cu	Copper
CV	Cyclic voltammetry
CV	Connected vehicle
C-V2X	Cellular-vehicle-to-everything
CVC	Clean vehicle credits
DAC	Disadvantaged community
DC	Direct current
DCaaS	Data Center as a Service
DCFC	Direct current fast charger
DEC	Diethyl carbonate
DEE	1,2-diethoxyethane
DEF	Diesel exhaust fluid
DEI	Diversity, equity, and inclusion
DEIA	Diversity, Equity, Inclusion, and Accessibility
DEMS	Differential electrochemical mass spectrometry
DER	Distributed energy resource(s)
DERST	NFPA Distributed Energy Resources Safety Training (DERST) Program
DFI	Ducted fuel injection
DFT	Density functional theory
DFT-MD	Density functional theory molecular dynamics
DGE	Diesel gallon equivalent
DGMARL	Decentralized graph-based multi-agent reinforcement learning algorithm

Abbreviation	Definition
DI	Direct injection
DME	1,2-Dimethoxyethane
DME	Dimethyl ether
DNN	Deep neural network
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DOE	U.S. Department of Energy
DOL	Electrolyte solvent 1,3-dioxolane
DORMA	VTO Decarbonization of Off-Road, Rail, Marine, and Aviation subprogram
DOT	U.S. Department of Transportation
DPA	Diphenylamine
DPF	Diesel particulate filter
DR	Demand response
DRIFTS	Diffuse reflectance infrared Fourier transform spectroscopy
DRIVE	Driving Research and Innovation for Vehicle efficiency and Energy
DRX	Disordered rock salt
DSC	Differential scanning calorimetry
DSO	Distribution system operator
e.g.	For example
E/S ratio	Electrolyte/Sulfur ratio
E98	98% ethanol/2% gasoline
EAS	Exhaust aftertreatment system
EC	Ethylene Carbonate
ECO_PI	Ecological Performance Index

Abbreviation	Definition
Eco-ATCS	Ecological Adaptive Traffic Control System
ECU	Engine control unit
EDS	Energy-dispersive X-ray spectroscopy
EE	Energy Equity
EEEJ	Energy equity and environmental justice
EEI	Energy, Equity and Inclusion
EEJ	Energy Environmental Justice Action Plan
EELS	In situ Electron Energy Loss Spectroscopy
EEMS	VTO Energy Efficient Mobility Systems subprogram
EERE	Office of Energy Efficiency and Renewable Energy
EF	Electric field
EGR	Exhaust gas recirculation
eGRID	Emissions & Generation Resource Integrated Database
EIA	U.S. Energy Information Administration
EIS	Electrochemical impedance spectroscopy
EJ	Environmental Justice
EJOT	EJOT Group, supplier for engineered fasteners and joining technology
EJOWELD CFF®	Product name for a commercial friction welding process
ELT	VTO Electrification Technologies subprogram
EM	Electromagnetic
EMC	Ethyl methyl carbonate
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
e-motor	Electric motor

Abbreviation	Definition
EMPOWER	Equitable Mobility Powering Opportunities for Workplace Electrification Readiness
EMS	Ethyl methyl sulfone-based electrolytes
EPA	U.S. Environmental Protection Agency
EPR	Electron paramagnetic resonance
EPRI	Electric Power Research Institute
EQCM	Electrochemical quartz crystal microbalance
Er	Erbium
ESS	Energy storage system
etc.	et cetera (and so forth)
ETFE	Ethylene tetrafluoroethylene
EtOH	Ethanol
EV	Electric vehicle
EVAL	Electric Vehicle Adoption Leadership
EVSE	Electric vehicle supply equipment
F2DEM	bis(2-fluoroethoxy)methane
F5DEE	2-[2-(2,2-Difluoroethoxy)ethoxy]-1,1,1-Trifluoroethane
FAA	Federal Aviation Administration
FCEV	Fuel cell electric vehicle
FDMB	Fluoro-dimethoxylbutane
Fe	Iron
FEC	Fluoroethylene carbonate
FEOC	Foreign entity of concern
FFC	Federal Communications Commission
FGS	Functionally graded scaffold

Abbreviation	Definition
FHWA	Federal Highway Administration
FIXS	Flexible interface for XIL simulation
FMW	FMW Solutions LLC
FOA	Funding opportunity announcement
FODS	Freight Origin-Destination Synthesis
Ford	Ford Motor Company
FOTW	Fact of the Week
FPT	Fiat Powertrain
FSLW	Friction stir linear welding
FSP	Friction stir processing
F-SPR	Friction self-piercing rivet
FSU	Florida State University
FSW	Friction stir welding
FTA	Federal Transit Administration
FTIR	Fourier transform infrared spectroscopy
FUSE	Flexible charging to Unify the grid and transportation Sectors for EVs at scale
FY	Fiscal year
FZ	FZ Jülich-Company Name
g/cc	Grams per cubic centimeter
g/kWh	grams per kilowatt-hour
G3-5M	A grade of cold-hardened nickel-based steel alloy with 5% molybdenum
GC	Gas chromatography
GDI	Gasoline direct injection
GE	General Electric, Inc.

Abbreviation	Definition
Gen	Generation
GER	Global equivalence ratio
GHG	Greenhouse gas
GM	General Motors
GO	California Governor's Office of Business and Economic Development, or GO-Biz
GPU	Graphic processing units
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies model
GSA	General Services Administration
GTI	GTI Energy Partners
GTT	Geospatial Transportation Typology
GUI	Graphic user interface
H	Hour
H11	Chromium-based steel alloy from the "H" family of steels with outstanding impact toughness
H_2	Hydrogen
HB	Handbook
HC	Hydrocarbon
HD	Heavy-duty
HEFA	Hydroprocessed esters and fatty acids
HEV	Hybrid electric vehicle
HEVISAM	Heavy-Duty Battery Electric Vehicle Infrastructure Scenario Analysis Model
HFMP	1,1,1,3,3,3-hexafluoro-2-methoxypropane
HiVe	High velocity
Hp	Horsepower

Abbreviation	Definition
HPC	High power charger
HPDC	High-pressure die-casting
HP-RTM	High-pressure resin transfer molding
HRE	Heavy rare earth
HTC	High-temperature carbonization
HTC6 and HTC8	High-temperature carbonization trial number
HV	Human-driven vehicle(s)
HyREX	Optimized Low Carbon Fuel Range Extender
I, II, III, IV	Roman numerals for 1, 2, 3, 4
I_2	Iodine
ICAO	International Civil Aviation Organization
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
ICME	Integrated computation materials engineering
ID	Identification
IDT	Ignition delay time
IEEE	Institute of Electrical and Electronics Engineers
IEK	IEK-9 - Company Name
IL	Illinois
IMC	Intermetallic compound
IMEP	Indicated mean effective pressure
IMT	Intake manifold temperature
In	Indium
IN	Indiana

Abbreviation	Definition
in/min	Inches per minute
Inc.	Incorporated
INL	Idaho National Laboratory
IOO	Infrastructure Owner Operator
IPK	Iso-paraffinic kerosene
IPM	EPA's Integrated Planning Model
iPP-CF30	Designation used for a specific sample
IRA	Inflation Reduction Act
ISO	Independent system operator
J/m2	Joules per meters squared
J2954	SAE International standard for Wireless Power Transfer (WPT) for EVs
J3271	SAE International standard for Megawatt Charging System for Electric Vehicles
J3400	SAE International standard charging connector
J40	Justice 40 Initiative
JR	Company name JR Automation
Kg	Kilogram
Klbs	Kilopounds
Koura	Koura - Company name
ksi	Kilopound per square inch
KUKA	Company name for Keller und Knappich Augsburg, manufacturer of industrial robots
KW	Kilowatt
kWh	Kilowatt-hour
kWh/lb	Kilowatt hours per pound
L	Liter

Abbreviation	Definition
L2	Level 2
LATP	Li1.3Al0.3Ti1.7(PO4)3, a potential solid-state electrolyte
LBNL	Lawrence Berkeley National Laboratory
LBO	Lean blow-out
LBS	Lithium thioborates
lbs	Pounds
LCA	Life cycle analysis
LCLF	Low carbon liquid fuel
LD	Light-duty
LDV	Light-duty vehicle
LEEP	Leadership of Employers for Electrification Program
LES	Large eddy simulation
LFP	Lithium iron phosphate
LG	LG Energy Solution Ltd.
LHCE	localized high-concentration electrolyte
Li	Lithium
Li CE	Lithium coulombic efficiency
Li nm	Lithium and nanometers
Li NMC	Lithium nickel manganese cobalt oxides
Li SPAN	Lithium sulfurized polyacrylonitrile
Li/Ni	Lithium/nickel
Li_2O	Lithium oxide
Li_2O/LiF	Lithium oxide per lithium fluoride
Li_2S	Lithium Sulfide
Li_2S_2	Lithium disulfide

Abbreviation	Definition
Li_2S-B_2S_3	Lithium Sulfide and Boron Sulfide
Li_2S_x	Lithium Sulfide type
Li_2ZrCl_6	Lithium zirconium chloride
$Li_5B_7S_{13}$	Lithium boron sulfide
LIBs	Lithium-ion battery(ies)
LIC	Li3InCl6
$LiCoO_2$	Lithium cobalt oxide
LiF	Lithium fluoride
LiFSI	Lithium bis(fluorosulfonyl)imide
LightMAT	Acronym for the Lightweight Materials Consortium
Li-ion	Lithium-ion
$LiNiO_2$	Li−Ni−O compound
$LiNO_3$	Lithium nitrate
LiOH	Lithium Hydroxide
$LiPF_6$	Lithium hexafluorophosphate
LiPS	Lithium polysulfide
Li-S	Lithium Sulfur
LiTFSI	Lithium bis(trifluoromethanesulfonyl)imide
Li_xNiO_2	Lithium nickel oxide cathode with variable lithium content
LLC	Limited liability corporation
LLCF	Low-lifecycle-carbon-fuels
LLDPE	Linear low-density polyethylene
LLNL	Lawrence Livermore National Laboratory
LLTO	Lithium lanthanum titanate
LLZO	Lithium lanthanum zirconate

Abbreviation	Definition
LLZTO	Garnet-type fast lithium-ion conductor Li6.75La3Zr1.75Ta0.25O12
LMB	Lithium metal batteries
LMCP	Lightweight Metals Core Program
LMR	Lithium manganese-rich
LNO	LiNiO2
LoukusTech	Loukus Technologies, Inc.
LPP	Lean premixed prevaporized
LPSC	Li_6PS_5Cl
LPSCl	Lithium phosphorus sulfide chloride
LSV	Linear sweep voltammetry
LTC	Low temperature carbonization
LTO	Lithium titanium oxide
LYC	Li3YCl6 (LYC)
M	Million
m^2/V-s	meters squared per volt seconds
MA	An (undefined) electrolyte additive
MA3T	Market Acceptance of Advanced Automotive Technologies
mAh	Milliampere-hour
mAh/g	milliampere-hours per gram
mAh/g or mAh g^{-1}	Specific capacity [mAh/g] refers to the amount of electric charge [mAh] a material can deliver per gram of that material.
MBWE	Minority- or women-owned business enterprises
MCCI	Mixing-controlled compression ignition
MCS	Megawatt charging system
MD	Medium-duty

Abbreviation	Definition
MD/HD	Medium-duty/heavy-duty
MeOH	Methanol
MEP	Mobility energy productivity
MERF	Materials Engineering Research Facility
MESC	Multifunctional Energy Storage Composites
MG	Motor-generator
Mg	Magnesium
mg/cm^2	milligrams per square centimeter
MIT	Main injection timing
MITIE	Micromobility-Integrated Transit and Infrastructure for Efficiency
ML	Machine learning
MLPs	Machine learning interatomic potentials
MMC	Metal matrix composites
Mn	Manganese
MNC	Li1.2Mn0.54Ni0.13Co0.13O2 a lithium manganese compound
MOF	Type of electrolyte
MoS_2	Molybdenum disulfide
MOSFET	Metal–oxide–semiconductor field-effect transistor
MOVES	EPA's MOtor Vehicle Emission Simulator
MPa	Megapascal
MPG	Miles per Gallon
MRD	Molecular Rebar® Design
MRL	Manufacturing readiness level
mS/cm	Millisiemens per centimeter
Msi	Megapound per square inch

Abbreviation	Definition
MTF	Type of electrolyte
MUD	Multi-unit dwelling
MV	Megavolt
MW	Megawatt
MWC	Megawatt charging
MWCNT	Multi-walled carbon nanotubes
MXene	The name for a new class of graphene like two-dimensional transition metal carbon (nitrogen) compounds
N/P ratio	Negative-to-positive electrode capacity ratio
N_2O	Nitrous oxide
NA	Not Applicable
NACS	North American Charging Standard
NAFTC	National Alternative Fuels Training Consortium
NAFTD	North American Fire Training Directors
NASA	National Aeronautics and Space Administration
Nb	Niobium
NCM	Lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC)
NDE	Nondestructive evaluation
NEMS	National Energy Modelling System
NEVI	National Electric Vehicle Infrastructure
NFPA	National Fire Protection Association
NG	Natural gas
NGP	Next Generation Profile(s)
NH_3	Ammonia
NHTSA	National Highway Traffic Safety Administration

Abbreviation	Definition
Ni	Nickel
NiO_2	Nickel (II) oxide
NJFCP	National Jet Fuel Combustion Program
NM	Nickel manganese oxides
Nm	Nanometers
NM9505	$LiNi_{0.95}Mn_{0.05}O_2$
NMC	Nickel manganese cobalt oxide
NMC/Li	Battery system with a nickel manganese cobalt oxide cathode and a lithium metal anode
NMC622	cathode type with 60% nickel, 20% manganese, and 20% cobalt
NMC811	cathode type with 80% nickel, 10% manganese, and 10% cobalt
NMOG	Non-methane organic gas
NMR	Nuclear magnetic resonance spectroscopy
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NSLSII	National Synchrotron Light Source II
OCV	Open circuit voltage
OEM	Original equipment manufacturer
OH	Ohio
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
OTAQ	EPA’s Office of Transportation and Air Quality
P1A	Project task within Thrust 1 of the LMCP

Abbreviation	Definition
P1B	Project task within Thrust 1 of the LMCP
P1C	Project task within Thrust 1 of the LMCP
P1C1 and P1C2	Project task within Thrust 1 of the LMCP
P2030.13	Draft guide for creating a functional specification for electric vehicle (EV) fast charging stations
P2A	Project task within Thrust 2 of the LMCP
P2B	Project task within Thrust 2 of the LMCP
P2C	Project task within Thrust 2 of the LMCP
P3A	Project task within Thrust 3 of the LMCP
P3B	Project task within Thrust 3 of the LMCP
PAA	Polyacrylic acid
PACCAR	Successor company to the Pacific Car and Foundry Company
PAH	Polycyclic aromatic hydrocarbon
PAN	Polyacrylonitrile
pCAM	Precursor cathode active material
PC-MCC	Prechambered enabled mixing-controlled combustion
Pd	Palladium
PDF	Pair distribution function
PE	Polyethylene separator
PECAN	Polyester Covalently Adaptable Network
PECVD	Plasma-enhanced chemical vapor deposition
PeleLMeX	PeleLMeX is the non-subcycling version of PeleLM, an adaptive-mesh low Mach number hydrodynamics code for reacting flows
PEO	Poly(ethylene) oxide
PET	Polyethylene terephthalate

Abbreviation	Definition
PEV	Plug-in electric vehicle
PF5	Phosphorus pentafluoride anion
PF6	Hexafluorophosphate anion
PFG1	Partially-fluorinated glymes type
PFGs	Partially-fluorinated glymes
PFI	Port fuel injection
PFT	Pulse Fourier transformation
PGM	Platinum group metals
PHEV	Plug-in hybrid electric vehicle
P-HIL	Power Hardware-in-the-Loop
PI	Principal investigator
PIV	Particle image velocimetry
PM	Permanent magnet
PM	Particulate matter
PMCP	Powertrain Materials Core Program
PNNL	Pacific Northwest National Laboratory
PPM	Polymer poly(pentyl malonate)
PQC	Post-Quantum Cryptography
PR	Pooled rideshare
PS	Polysulfide
Psi	Pound per square inch
Pt	Platinum
PVDF	Polyvinylidene fluoride
Q1	Quarter 1/Quarter 2
Q1/Q2/Q3/Q4	Quarter

Abbreviation	Definition
Q3/Q4	Quarter 3/Quarter 4
QA	Quality assurance
R&D	Research and development
R2	Modeled circuit resistor 2
RANS	Reynolds-averaged Navier-Stokes
ratio of B/S/Li	ratio of Boron per Sulfur per Lithium
rCF	Recycled carbon fiber
RCM	Rapid compression machine
RDD&D	Research, development, demonstration, and deployment
RE	Rare earth
REC	Renewable energy credit
RFP	Request for proposal
RHC	Reduction half cycle
RNG	Renewable natural gas
RR(s)	Radar retro-reflector(s)
RRC	Rolling resistance characterization
RT14	Particle Type
S	Sulfur
S/cm	Siemens per centimeter
S8	Octasulfur
SAE	SAE International, formerly Society of Automotive Engineers
SAF	Sustainable aviation fuel
SBIR	Small Business Innovation Research
SBR	Styrene–butadiene rubber
SCM	Smart charge management

Abbreviation	Definition
SCO	Selective catalytic oxidation
SCP	Silicon consortium project
SCR	Selective catalytic reduction
SE	Solid electrolyte
SEI	Solid-electrolyte interphase
SEM	Scanning electron microscopy
SEMs	Scanning electron microscopies
SEMS	Site energy management system
ShAPE™	Shear assisted processing and extrusion
SHM	Structural health monitoring
SI	Spark ignition
SIC	Single-ion-conducting
SiC	Silicon carbide
SiOx	Silicon Oxide Type
SLAC	SLAC National Accelerator Laboratory
SLIC	Sustainable Lightweight Intelligent Composites
SLP	Single-layer pouch
SMART	Specific, Measurable, Attainable, Realistic, and Timely [milestones]
SMART	Systems and Modeling for Accelerated Research in Transportation
SMC	Sheet molding compound
Sn	Tin
SNL	Sandia National Laboratories
SOA	State of the art
SOC	State of charge
SOPO	Statement of Project Objectives

Abbreviation	Definition
SoS	System of System(s)
SpaciMS	Spatially resolved capillary inlet mass spectrometer
SPAN	Sulfurized polyacrylonitrile
SPaT	Signal phase and timing
SPE	Solid polymer electrolyte
SPK	Synthetic paraffinic kerosene
SPS	Spark plasma sintering
SRNL	Savannah River National Laboratory
SSE	Solid-state electrolyte
S-SPAN	Sulfur – sulfurized polyacrylonitrile
SSRL	Stanford Synchrotron Radiation Light Source (SSRL) is a general user facility supported by the DOE Office of Science
SST	Solid-state transformer
ST1/ST2	SuperTruck 1/SuperTruck 2
STEM	Science, Technology, Engineering, Mathematics
SUNY	State University of New York
SVF	Soot volume fraction
SWNT	Single-wall carbon nanotubes
SwRI	Southwest Research Institute
T3CO	Transportation, Technology, and Cost of Ownership
T6	Temper designation for Al that is heat-treated at a temperature between 325°F and 400°F to increase the strength
TAT	Traffic analysis tool
TCD	EPA's Transportation and Climate Division
TCl	Terephthalolyl chloride
TCO	Total cost of ownership

Abbreviation	Definition
TEA	Techno-economic analysis
TEDB	Transportation Energy Data Book
TEEM	Transportation Energy Evolution Modeling
TEIS	U.S. Department of Energy's Transportation Electrification Impact Study
TEM	Transmission electron microscopy
TEMPO	Transportation Energy and Mobility Pathway Options
TFEM	Time-frequency electromagnetic method
TFHRC	Turner-Fairbank Highway Research Center
TFSI	Bis(trifluoromethanesulfonyl)imide (TFSI), [(CF3SO2)2N]−
TFTFE	1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl ether
TI	VTO Technology Integration subprogram
TiB2	Titanium diboride
TM	Transition metal
TMB	Trimethylbenzene
TMR	Tunnel magnetoresistance
TMV	TMV Control Systems–Next Generation Locomotive Control Systems
TNA	Transportation needs assessment
TNC	Transportation network company
TOF	SIMS Time-of-flight secondary ion mass spectrometry
TofF SIMS	Time-of flight secondary ion mass spectrometry
TOU	Time-of-Use
TPIC	Tillotson Pearson Incorporated Composites
TRA-C	Company name TRA-C Industrie, a FSW supplier
TRL	Technology readiness level
TTC	Transportation Technology Center

Abbreviation	Definition
TTE	1,1,2,2-tetrafluoroethyl-2,2,3,3-tetrafluoropropyl ether
TTS	Traffic Technology Services
TuFF	Tailorable universal Feedstock for Forming
TWC	Three-way catalyst
TXM	Transmission X-ray microscopy
U.S.	United States of America
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability DOE partnership
UC	University of California
UCB	University of California, Berkeley
UCC	Ultra conductive copper
UCI	University of California, Irvine
UCSD	University of California-San Diego
UDRI	University of Dayton Research Institute
UHMWPE	Ultra-high molecular weight polyethylene
uL/mg	micro liters per milligram
ULI	NASA University Leadership Initiative
ULSD	Ultra-low sulfur diesel
UPER	Universal power electronics regulator
US	United States
US DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability
USG	U.S. government
USW	Ultrasonic spot welding
UT	University of Texas
UT	Utah

Abbreviation	Definition
UTD	Utilization Technology Development
UVM	University of Vermont
UW	University of Washington
UW	University of Wisconsin
V	Volts
V1G	Unidirectional smart charging
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything
VAN	U.S. Department of Energy's VTO Analysis (VAN) subprogram
VDA	Company name for Verband der Automobilindustrie, the German Association of the Automotive Industry
VDC	Volts direct current
VECTOR	Visual-Enhanced Cooperative Traffic Operations
VGI	Vehicle grid integration
ViL/VIL	Vehicles-in-the-loop
VISSIM	PTV VISSIM – Traffic Simulation Software
VIUS	Vehicle Inventory and Use Survey
VMS	Variable message sign
VMT	Vehicle miles traveled
VNL	Volvo VNL heavy-duty truck
VoFLE	Volume of Fluid and Lagrangian Eulerian
VOICES	Virtual Open Innovation Collaborative Environment for Safety

Abbreviation	Definition
VRU(s)	Vulnerable road user(s)
vs.	Versus
V-SCR	Vanadia-based selective catalytic reduction
VTO	Vehicle Technologies Office
VTOL	Vertical take-off and landing
VVT	Variable valve timing
WBG	Wide bandgap
WE	Working Electrode
Wh/kg	Watt hours per kilogram
Wh/L	Watt hours per liter
WMLES	Wall-modeled LES
WPT	Wireless power transfer
WRLES	Wall-resolved LES
WSU	Washington State University
WVU	West Virginia University
XANES	X-ray absorption near edge structure spectroscopy
XAS	X-ray absorption spectroscopy
XFC	Extreme fast charge
XIL	Everything-in-the-loop
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRF	X-ray fluorescence
ZEV(s)	Zero emission vehicle(s)
Zr	Zirconium
ZT	Zero Trust (ZT) Architecture

U.S. Department of
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& Renewable Energy

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energy.gov/eere/vehicles

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