4. Electrification

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 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 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, 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 4-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
elt094	Development and Demonstration of Medium-and Heavy-Duty Plug-In Hybrid Work Trucks	John Petras (Odyne Systems)	4-7	3.40	3.20	3.00	2.60	**3.15**
elt095	Vehicle-to-Grid Electric School Bus Commercialization Project	Adam Hunnell (Blue Bird Corp.)	4-12	3.50	3.13	3.63	3.13	**3.28**
elt158	Zero-Emission Cargo Transport II: San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project	Seungbum Ha (SCAQMD)	4-16	3.13	3.13	3.00	2.88	**3.08**
elt187	Comprehensive Assessment of On- and Off-Board, Vehicle-to-Grid Technology Performance and Impacts on Batteries and the Grid (SPIN System)	Sunil Chhaya (EPRI)	4-19	2.75	2.50	3.25	3.00	**2.72**
elt188	Bi-Directional Wireless Power Flow for Medium-Duty, Vehicle-to-Grid Connectivity	Omer Onar (CALSTART)	4-22	3.50	3.33	3.33	3.33	**3.38**
elt197	High Power and Dynamic Wireless Charging of Electric Vehicles	Veda Galigekere (ORNL)	4-25	3.38	3.50	3.38	2.88	**3.38**
elt198	Cybersecurity: Securing Vehicle Charging Infrastructure	Jay Johnson (SNL)	4-29	3.30	3.30	3.30	3.50	**3.33**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
elt199	Cybersecurity: Consequence-Driven Cybersecurity for High-Power Charging Infrastructure	Richard Carlson (INL)	4-35	3.63	3.63	3.75	3.50	**3.63**
elt201	Charging Infrastructure Technologies: Smart Vehicle-Grid Integration (ANL)	Keith Hardy (ANL)	4-39	3.50	3.67	3.50	3.50	**3.58**
elt202	Charging Infrastructure Technologies: Smart Electric Vehicle Charging for a Reliable and Resilient Grid (RECHARGE)	Jesse Bennett (NREL)	4-41	3.10	3.40	3.40	3.10	**3.29**
elt204	Charging Infrastructure Technologies: Development of a Multiport, >1 MegaWatt Charging System for Medium- and Heavy-Duty Electric Vehicles	Andrew Meintz (NREL)	4-45	3.13	3.25	3.25	3.38	**3.23**
elt205	Cybersecurity for Grid-Connected Extreme Fast Charging Station (CyberX)	David Coats (ABB)	4-48	3.17	3.17	3.17	3.17	**3.17**
elt206	Cybersecurity Platform and Certification Framework Development for Extreme Fast Charging, Integrated Charging, Infrastructure Ecosystem	Sunil Chhaya (EPRI)	4-50	3.33	3.50	3.50	3.17	**3.42**
elt207	Enabling Secure and Resilient Extreme Fast Charging: A Software/Hardware Security Co-Design Approach	Ryan Gerdes (Virginia Tech University)	4-53	3.67	3.17	3.33	3.17	**3.31**
elt208	Highly Integrated Power Module	Emre Gurpinar (ORNL)	4-55	3.25	3.33	3.25	3.17	**3.28**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
elt209	High-Voltage, High-Power Density Traction-Drive Inverter	Gui-Jia Su (ORNL)	4-59	3.14	3.07	3.14	3.07	**3.10**
elt210	Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain	Andrew Binder (SNL)	4-63	3.30	3.20	3.10	3.00	**3.19**
elt211	Power Electronics Thermal Management	Gilbert Moreno (NREL)	4-67	3.20	3.30	3.10	3.10	**3.23**
elt212	Non-Heavy Rare-Earth High-Speed Motors	Tsarafidy Raminosoa (ORNL)	4-71	2.88	3.25	3.38	3.13	**3.16**
elt214	Electric Motor Thermal Management	Kevin Bennion (NREL)	4-73	3.67	3.67	3.67	3.67	**3.67**
elt215	Permanent Magnets Without Critical Rare Earths to Enable Electric Drive Motors with Exceptional Power Density	Iver Anderson (Ames Laboratory)	4-76	3.50	3.50	3.25	3.13	**3.42**
elt216	Isotropic, Bottom-Up Soft Magnetic Composites for Rotating Machines	Todd Monson (SNL)	4-80	3.50	3.50	3.33	3.33	**3.46**
elt221	Integrated Electric Drive System	Shajjad Chowdhury (ORNL)	4-83	3.42	3.33	3.17	3.17	**3.31**
elt236	Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture	Watson Collins (EPRI)	4-87	3.50	3.33	3.83	3.17	**3.42**
elt237	Enabling Extreme Fast Charging with Energy Storage	Jonathan Kimball (Missouri S&T)	4-90	2.67	2.67	3.17	2.67	**2.73**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
elt238	Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State Direct-Current Protection	Srdjan Lukic (North Carolina State University)	4-93	3.33	3.33	3.33	3.17	**3.31**
elt239	High-Power Inductive Charging System Development and Integration for Mobility	Omer Onar (ORNL)	4-96	3.75	3.75	3.25	3.50	**3.66**
elt240	Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks)	Mike Masquelier (WAVE)	4-100	3.50	3.33	3.33	3.17	**3.35**
elt241	High-Efficiency, Medium-Voltage Input, Solid-State, Transformer-Based 400-kW/1000-V/400-A Extreme Fast Charger for Electric Vehicles	Charles Zhu (Delta Electronics)	4-103	3.25	3.33	3.50	3.00	**3.29**
elt257	Directed Electric Charging of Transportation Using eXtreme Fast Charging (XFC) (DIRECT XFC)	Tim Pennington (INL)	4-107	3.00	3.25	3.13	2.88	**3.13**
elt258	Grid-Enhanced, Mobility-Integrated Network Infrastructures for Extreme Fast Charging (GEMINI-XFC)	Andrew Meintz (NREL)	4-110	3.25	3.00	2.88	2.75	**3.02**
elt259	Development and Commercialization of Heavy-Duty Battery Electric Trucks Under Diverse Climate Conditions	Marcus Malinosky (Daimler Trucks North America)	4-113	3.20	3.60	3.20	3.20	**3.40**
elt260	Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management	Teresa Taylor (Volvo)	4-118	3.42	3.42	3.33	3.17	**3.38**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
elt261	High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter	Ben Marquart (Ricardo)	4-123	3.83	3.50	3.33	3.50	**3.56**
elt262	Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging	Brian Lindgren (Kenworth)	4-126	3.40	3.40	3.50	3.50	**3.43**
elt264	Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams	Joe Picarelli (Exelon/ Pepco Holdings Inc.)	4-130	3.25	3.33	3.50	3.25	**3.32**
elt265	A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale	Duncan Woodbury (Dream Team LLC)	4-135	3.00	2.70	2.80	2.90	**2.81**
elt266	ANL High Power Charging Charge Profiles	Dan Dobrzynski (ANL)	4-138	3.30	3.20	3.30	3.10	**3.23**
elt267	ORNL Resilient High Power Charging Facility	Madhu Chinthavali (ORNL)	4-142	3.00	3.17	3.00	2.83	**3.06**
elt274	eMosaic: Electrification Mosaic Platform for Grid-Informed Smart Charging Management	David Coats (ABB)	4-145	3.10	3.10	3.20	3.00	**3.10**
Overall Average				**3.29**	**3.29**	**3.28**	**3.14**	**3.27**

Presentation Number: elt094
Presentation Title: Development and Demonstration of Medium-and Heavy-Duty Plug-In Hybrid Work Trucks
Principal Investigator: John Petras (Odyne Systems)

Presenter

John Petras, Odyne 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. 60% of reviewers felt that the resources were sufficient, 20% 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.

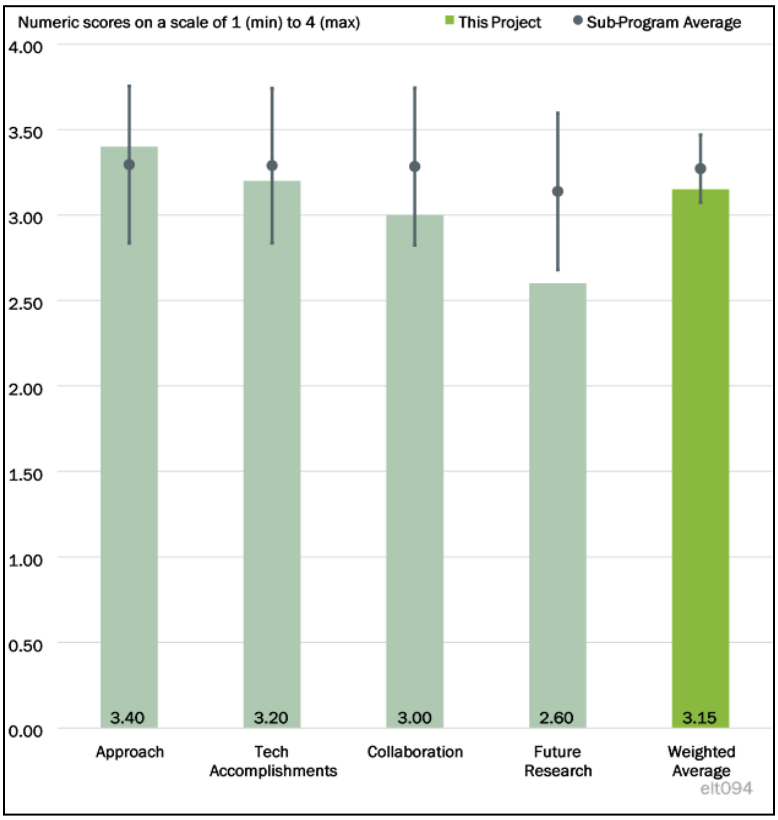

Figure 4-1 - Presentation Number: elt094 Presentation Title: Development and Demonstration of Medium-and Heavy-Duty Plug-In Hybrid Work Trucks Principal Investigator: John Petras (Odyne Systems)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that, fundamentally, this is a very strong project. It has a solid, quantified objective to develop and demonstrate an advanced plug-in hybrid electric vehicle (PHEV) medium-duty (MD and heavy-duty (HD) work truck with greater than 50% reduction in fuel consumption compared to a conventional diesel vehicle baseline.

The reviewer stated that the project's approach is excellent by combining a standard hybrid powertrain, a stock transmission, and an electric motor connected through the power take-off (PTO), along with a modular design. This approach is minimally intrusion, requires no changes to the base powertrain, while retaining the powertrain warranty. It provides ample hydraulic/pneumatic power, exportable power, and applies to multiple original equipment manufacturer (OEM) and application platforms. This modularity and flexibility are key. In addition, this project covers largely new ground with regard to improving the fuel economy and emissions of non-traditional stationary, work truck vocational applications.

The overall project is well designed, feasible, and ultimately will be successful as the applications are demonstrated, the return on investment (ROI) steadily improves as the cost of batteries comes down, and further technology, design simplifications, and cost savings opportunities are implemented.

Reviewer 2:

The reviewer indicated that the approach to performing the work is considered to be excellent. This a straightforward application of electrification using standard architecture to apply electrification to the auxiliary systems of the vehicle rather than using a "running" engine. It is intended to utilize existing PTO technology to run a generating motor. It is clear that the approach is intended to minimize the disruption of operator activity.

The reviewer indicated that the approach seems to be directed at geographic markets that will require that vehicles not continuously idle during the stationary activities, thus making cost a lesser factor. What is not clear is what the cost parameters may have been to identify the potential for adoption across all markets. The reviewer suggested that this is a shortcoming that should be studied and reported on in future presentations.

Reviewer 3:

The reviewer liked the approach to performing the work. General goals were established, and then when users commented—for example, that the project team did not need 15 kilowatts (kW) of power, but only 12 kW—the goal for exportable power was re-adjusted.

Reviewer 4:

The reviewer referenced 2018 project presentation Slide 3, which indicates the objective of targeted ROI of less than or equal to 5 years. The reviewer was not sure if any of the results have been shared already. Considering the continuous reduction in battery cost, the reviewer suggested that it might be helpful to revisit the results of such a study on a yearly basis to discuss if such an objective is still within scope or to explain why it is being excluded.

Reviewer 5:

The reviewer noted that the overall approach is comprehensive. However, the biggest gap in the work seems to be the definition of the Stationary Fuel Use profile. The team acknowledges limited work in this area, so the experimental dynamometer data from the National Renewable Energy Laboratory (NREL) related to this is good to see and seems promising. Nonetheless, a clearer approach to how this fuel use profile is determined should be presented because this represents a major fuel consumption use of the vehicle.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project has achieved a number of impressive technical accomplishments. This includes the use of Oak Ridge National Laboratory (ORNL) simulation and hardware-in-the-loop (HIL) analyses to refine driving strategies to optimize fuel economy over the driving and stationary cycles of operation. A number of features have been identified to improve fuel economy up to 34%-50% over a baseline diesel vehicle. The design and integration of the test truck has been completed. The test truck has been tested on the dynamometer at the NREL Renewable Fuels and Lubricants Laboratory (ReFUEL), where the mild strategy yielded a 9.5%-23% fuel economy improvement and the aggressive strategy yielded a 69%-75% improvement in fuel economy. In addition, over the stationary work cycle, the test truck yielded an 80%-99% improvement in fuel economy and emissions.

Reviewer 2:

The reviewer observed very good stationary cycle test results. The reviewer expected further definition and validation of this fuel use cycle with real-world scenarios from participating utility companies in the future. Additionally, the comment about TCO is also important for eventual vehicle adoption and should be clarified in future technical updates.

Reviewer 3:

This reviewer referred to 2019 project presentation Slide 5, which reflects a Fleet Data Collection, Analysis, and Summary by November 2020. The reviewer inquired about the outcome of this target, and the new timeline for fleet build and data collection if not already met.

Reviewer 4:

The reviewer remarked that modular configuration of the PTO and main powertrain allows for deployment on different platforms. The goal of acquiring a lower cost battery needs work, and if it is beyond the scope of this effort, it should be so stated.

Reviewer 5:

The reviewer stated that the progress can be considered to be good, and the schedule has generally been met. However, the reviewer pointed out that there is a severe shortcoming in that the report states that there is not a cooperating demonstration partner identified and it seems to be that this may be a reason that the project may not be completed.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that this project exhibits outstanding collaboration and coordination through an impressive number of strong project partners covering all bases including modeling and simulation, technology development and integration, testing and validation in the laboratory and fleets, as well as procurement.

Reviewer 2:

The reviewer indicated that the coordination between project team members appears well thought out and executed.

Reviewer 3:

The reviewer stated that the collaborations have been good with the original list of cooperating partners. The exception is the identification and confirmation of the demonstration partner. This is a major shortcoming of the program and places the final outcome in jeopardy. Since no time was allowed for in-depth questioning, the lack of a demonstration partner was not clarified.

Reviewer 4:

The reviewer was extremely disappointed that absolutely no utility fleets, non-utility fleets, or other fleets were identified as partners for demonstrating the developed prototypes. The Principal Investigator (PI) should have at least identified the fleets that the project team had conversations with and the potential fleets that the project team will attempt to contact. The pandemic is no excuse for failure to talk.

Reviewer 5:

Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the project's intention to complete a full year of simulation of truck fuel savings based on NREL driving and stationary test results, continue to optimize and refine the system to minimize fuel consumption and improve ROI, and perform 1-year real-world demonstrations with utility partners is logical and appropriate.

The reviewer indicated that the presentation indicates the challenge of getting utilities to participate and contribute capital equipment and mentioned revising the program plan to allow a depreciation cost-share rather than full equipment. The reviewer asked some questions about and suggested some ideas for the challenges faced. What other approaches might encourage utility participation? Is it possible to consider reducing the number of demonstration vehicles initially from, for example, 10 total to 6 total while still achieving statistically valid and credible results? In short, this could potentially reduce the utility capital equipment burden upfront with additional demonstration vehicles added in the future as they become available. Additionally, is it possible to explore bulk battery purchases in collaboration with other entities or applications to drive down battery costs initially? The presentation mentioned Ricardo as the lead for procurement.

Reviewer 2:

The reviewer commented that the future work is considered to be on a sensible path regarding the function of the system being built. There was a high degree of confidence that it will work. The reviewer wanted to know the cost in comparison to legacy systems and identified finding and confirming a demonstration partner(s) as a critical element.

Reviewer 3:

The reviewer indicated that Slide 9 appears to be missing timelines for identified Budget Periods (BP) 2 and 3.

Reviewer 4:

The reviewer suggested that further clarification on the type of utility partners being considered and their relevance in terms of meeting the fuel use goal demonstrations was needed. The presenter mentioned there are many candidate partners, but limited information on their specific use cases and relevance to the project goals was given.

Reviewer 5:

The reviewer commented that there was no slide identifying proposed or suggested additional research needed or items for consideration for future research.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer confirmed the support of overall U.S. Department of Energy (DOE) objectives by saying the stationary fuel use scenario is a critical use case that should be considered to significantly further energy independence and greenhouse gas reduction (GHG). This project is perfectly in line with those goals.

Reviewer 2:

The reviewer stated that this project clearly supports DOE objectives to reduce petroleum consumption and emissions, as results already indicate the feasibility of achieving greater than 50% improvement in full duty-cycle fuel economy and more than an 80% reduction in stationary emissions. Given the modular nature of the project's technology approach, successful development will enable many pathways to expand implementation throughout MD and HD vehicle vocational applications.

Reviewer 3:

The reviewer attested and affirmed the substantial need for improving the fuel efficiency of MD trucks and work trucks (used for PTO).

Reviewer 4:

The reviewer confirmed this project does support DOE objectives of reducing GHCs and local air pollution through elimination of running engines during stationary activities of vehicle use. The reviewer raised the concern that it is not clear at what cost this may be achieved.

Reviewer 5:

Not applicable was indicated by this reviewer.

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

Reviewer 1:

The reviewer stated that the resources appear sufficient to achieve the project goals.

Reviewer 2:

The reviewer commented that sufficient resources have been provided to achieve project objectives to date, and this project has a strong contractor cost-share percentage of 58%.

Reviewer 3:

The reviewer stated that the resources not adequate. The project needs a demonstration partner.

Reviewer 4:

The reviewer thought the amounts of funds designated for Federally Funded Research and Development Centers (FFRDC) (NREL and ORNL) were excessive.

Reviewer 5:

Not applicable was indicated by this reviewer.

Presentation Number: elt095
Presentation Title: Vehicle-to-Grid Electric School Bus Commercialization Project
Principal Investigator: Adam Hunnell (Blue Bird Corp.)

Presenter

Adam Hunnell, Blue Bird Corp.

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.

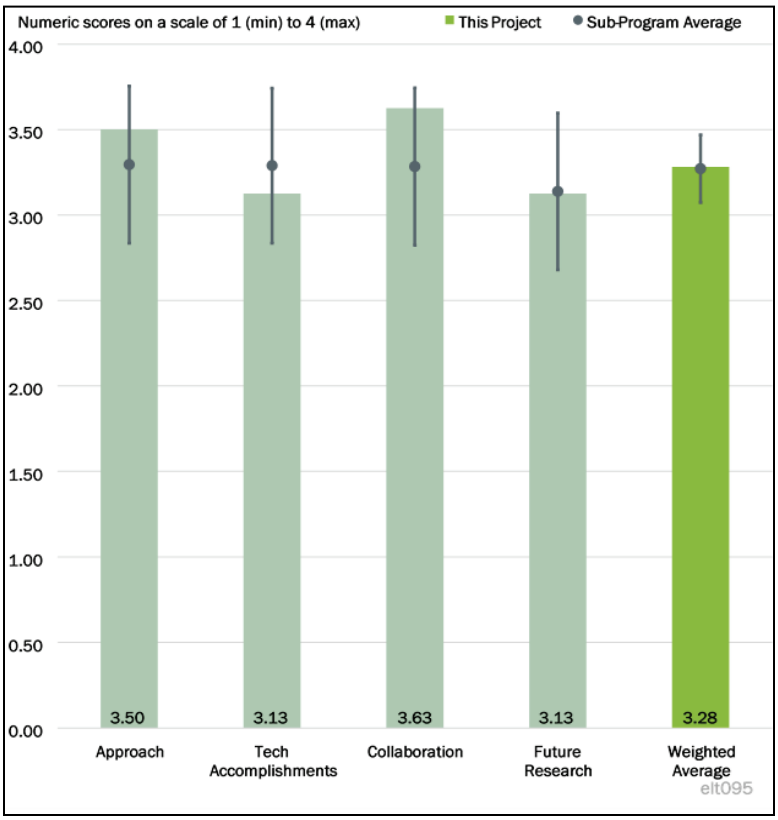

Figure 4-2 - Presentation Number: elt095 Presentation Title: Vehicle-to-Grid Electric School Bus Commercialization Project Principal Investigator: Adam Hunnell (Blue Bird Corp.)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer opined that this project was well thought out and happens to be a niche solution that fits a niche problem at the right time and place. The partners and collaborators were also a perfect fit.

Reviewer 2:

The reviewer stated the fundamental assumption that a competitive TCO for an electric school bus can be achieved through optimization of three parameters (bus capital cost, bus operating cost, and revenue generation from grid integration) appears sound. The broad approach targeting technical (at the vehicle and electric vehicle supply equipment [EVSE] level), regulatory, and metering challenges is appropriate as progress in all three areas is mandatory to achieve viability for MD and HD EV vehicle-to-grid (V2G) applications.

The reviewer further commented that this project is working to address a broad range of barriers to V2G integration including technical and non-technical barriers including vehicle and EVSE level improvements, regulatory (interconnection and tariffs), and metering. Specific objectives for this period include specification and procurement of high-power bidirectional EVSEs, interconnection contracting for EV-based distributed energy resources (DERs), and metering and tariffs to support service provision on utility and recovery time objective (RTO) networks.

Reviewer 3:

The reviewer observed that the goals appear to be appropriately targeted.

Reviewer 4:

The reviewer remarked that was good to see the change of direction from alternating current (AC) to direct current (DC) bi-directional charging.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed that there have been broad, strong project accomplishments across the technical, regulatory, standards certification, and metering spaces in the last 2 years. The primary technical accomplishments the last 2 years have concerned charging and grid integration including modeling of the revenue generation opportunity from grid services; building the high-power bidirectional charging and communications chain; and developing protocols for a school bus DER to function as a node on a utility distribution circuit. Fiscal Year (FY) 2021 and FY 2022 milestones appear on track including the build and test of on-board circuits to allow high-power charging and discharging and prototype 3 (P3) prototype build and commissioning.

The reviewer observed that steady progress has been made including improving fuel efficiency by 9% (but still short of the target of 1.32 kilowatt-hours [kWh] per mile) through lower rolling resistance tires, more aggressive regenerative braking, and lightweighting.

The reviewer noted that modeling of potential revenue generation through provision of V2G services leverages several earlier projects to inform its approach and results. Superficially, the revenue generating potential looks promising; however, key assumptions such as the potential reduction of monthly demand charges and tariff levels are not clearly defined, lending doubt to the credibility of the total cost of ownership (TCO) analyses at this time.

The reviewer acknowledged that progress has been made with ground-breaking efforts on the regulatory front including interconnection, metering, and tariff proposal for presentation to the California Public Utilities Commission (CPUC).

Reviewer 2:

The technical accomplishments and progress are what the reviewer had expected as measured against performance indicators.

Reviewer 3:

The reviewer observed that TCO results represents a $55,755 advantage over 15 years considering a $246,062 credit for electric vehicle (EV) grid services. It would be helpful to have the breakdown for the grid services credit to assess the business case strength.

Reviewer 4:

The reviewer acknowledged that it is a hard problem to solve and bumps on the road are expected. The reviewer also wondered about risk mitigation strategies.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the project maintains strong, diverse project collaborators across its technical, regulatory, and procurement elements. This activity also benefits from cross-fertilization leveraging other projects including Southern California Edison (SCE)‘s V2G Integration Project (2021-2023) funded by the California Energy Commission (CEC), and the “Make-Ready” elements of the Rialto Unified School District

(USD) charging infrastructure through SCE. These collaborations permit leveraging of technology, knowledge, and resources—always a good thing to see.

Reviewer 2:
The reviewer remarked that it seems like all parties are engaged.

Reviewer 3:
The reviewer suggested that perhaps a more urban school district than Rialto (a very exurban or suburban school district) would have been a better partner because it would have imposed a less rigorous requirement on the school buses (for example, less range and thus less battery capacity for energy storage and thus lower battery weight). The reviewer added that all the other partners are excellent.

Reviewer 4:
Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:
The reviewer stated that the project identifies the remaining challenges and barriers as achieving energy efficiency objectives and completing arrangements for Rialto USD's electric school bus fleet to function as a DER including an interconnection agreement and establishing terms of DER participation within SCE's distribution grid.

The reviewer commented that a definitive conclusion about the project's potential V2G economic contributions cannot be made until contract and regulatory arrangements have been established. It would be very beneficial to comprehensively frame the value proposition of this V2G application from a best case to worst case TCO perspective regarding regulatory and tariff scenarios. In this way, a truly objective assessment could be established, and specific target parameters (regarding demand charge reduction and tariffs) could be established mitigating any potential ambiguity as to the value proposition of electric school bus V2G applications.

The reviewer asked if it would it be beneficial to explore the opportunity to potentially reduce battery costs through volume purchases? In addition, the reviewer wanted to know about the potential of conducting an analysis of the steady progression in battery cost reduction in recent years and where battery costs are likely to be in the near future and subsequently using this information to inform estimates of future ROI.

Reviewer 2:
The reviewer highlighted that the listed future research "DER term negotiation" is an essential step for validation commercialization options.

Reviewer 3:
The reviewer suggested that there is more work needed to reduce weight of the school buses and to improve energy-storage density of the electric batteries. Also, the reviewer indicated that more work is needed on the cost modeling for electric school buses to serve as DERs during peak periods. The reviewer suggested replacing or comparing gasoline-powered school buses instead of diesel-powered school buses. Also, the reviewer did not think it is fair to compare the 15-year lifespan to a 15-year diesel or gasoline-powered school bus. The lifespan of diesel and gasoline vehicles is over 20-30 years (for example, look at dump trucks).

Reviewer 4:

The reviewer indicated that there is lots to clean up. The reviewer wondered about the grid services $250,000 benefit, and how that one was calculated.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer indicated that having this deployment project is essential to test the technology readiness level.

Reviewer 2:

The reviewer liked the idea of using electric school buses to serve as DERs during peak periods of electric energy use and re-charging the school buses during non-peak periods of electric energy use. The time of use of school buses and the range of school bus routes fit nicely for "peak-shaving."

Reviewer 3:

The reviewer noted that the project addresses a core Vehicle Technologies Office (VTO) objective to reduce the cost of plug-in electric vehicles (PEVs) and understand the potential impacts of EV charging on the nation's electric grid by pioneering V2G technology in MD and HD vehicles.

Reviewer 4:

Not applicable was indicated by this reviewer.

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

Reviewer 1:

The reviewer remarked that the project appears to be on track.

Reviewer 2:

The reviewer stated that sufficient resources have been provided to achieve targeted objectives to date and the project has a strong 50% contractor cost share.

Reviewer 3:

The reviewer had no comments.

Reviewer 4:

Not applicable was indicated by this reviewer.

Presentation Number: elt158
Presentation Title: Zero-Emission Cargo Transport II: San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project
Principal Investigator: Seungbum Ha (South Coast Air Quality Management District)

Presenter

Seungbum Ha, South Coast Air Quality Management District

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.

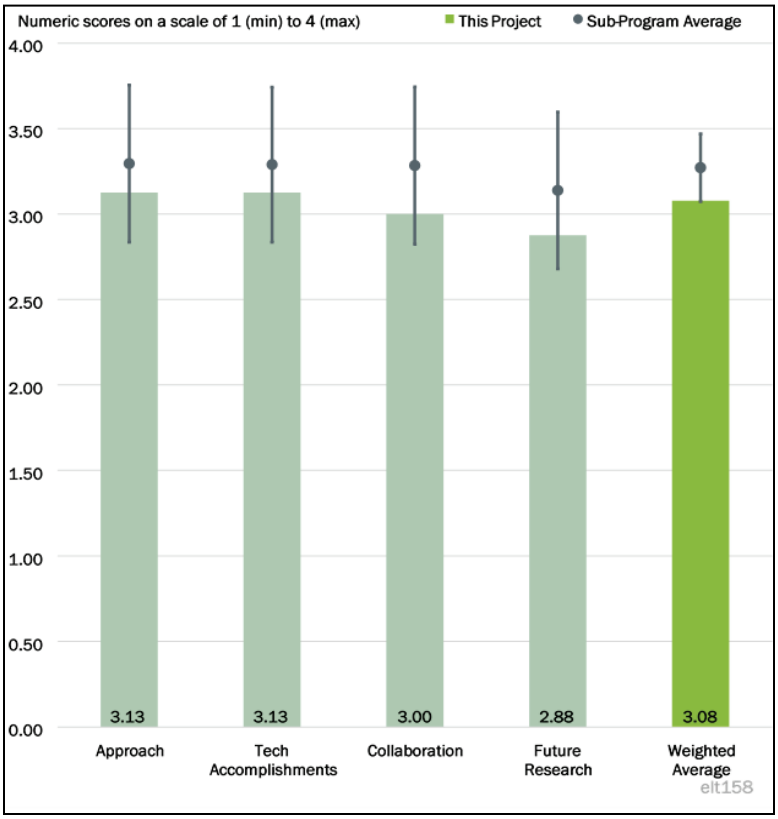

Figure 4-3 - Presentation Number: elt158 Presentation Title: Zero-Emission Cargo Transport II: San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project Principal Investigator: Seungbum Ha (South Coast Air Quality Management District)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the project is well planned and, given that it is near the end, expects that it will be completed. There is not a great deal of evidence in the budget details corresponding to deliverables and outcomes.

Reviewer 2:

The reviewer expressed the belief that the U.S. Government has to be a main resource of funds for research and development (R&D) of a high-risk, high-cost technology such as hydrogen fuel-cell HD trucks. The reviewer indicated that it was not necessary to fund the effort on compressed natural gas (CNG) or hybrids since such technology was mature 4-5 years ago. Even the speaker admitted that the partners wanted the PI to shift focus from data collection and analysis to more intensive deployment. Additionally, the reviewer highlighted that this project has profound implications for improving the air quality of the low-income, minority neighborhoods surrounding the Ports of Los Angeles and Long Beach in California.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked that the project provided good metrics against plans, and it is a long program comparing differing solutions. The reviewer called it a good job.

Reviewer 2:

The reviewer remarked that the overall progress was good when measured against performance indicators and goals. There definitely could have been much more average daily use of the hydrogen fuel-cell demonstration trucks. It was not clear to the reviewer what the "hold-up" was. The reviewer suggested that the PI should have listed the components in the hydrogen fuel-cell power train and electronics that need standardization so that a standards committee with DOE support could work on them.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

Although there always could be more, the reviewer observed a good job in sharing results with key stakeholders.

Reviewer 2:

The reviewer emphatically remarked that it was disappointing not to see the Port of Los Angeles and Port of Long Beach listed as formal partners on the project team. U.S. DOT had worked with the Ports and secured their cooperation for the safety of alternative fuel trucks (both hydrogen and natural gas) operating in their jurisdictions. The U.S. Department of Transportation (DOT) even provided training on hydrogen fuel safety for the Total Transportation Services Inc. (TTSI) truck drivers.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer observed that the standardization of hydrogen components and electronics is definitely needed. Also, research is needed to determine what can be done to bring down the cost and to commercialize hydrogen-fuel-cell engines and powertrains.

Reviewer 2:

The reviewer remarked that the program is basically done.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer remarked that, yes, this project is needed to attain zero-emissions in an area classified as a non-attainment zone. In addition, the reviewer commented that there is a social or environmental justice issue.

Reviewer 2:

The reviewer said that, yes, this project did support the overall DOE objectives.

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

Reviewer 1:

The reviewer said that, yes, resources are sufficient.

Reviewer 2:

The reviewer remarked that the funds for the CNG-hybrid part of this project should be moved over to the hydrogen and fuel cell part of this project to address studies on standardization and commercialization of hydrogen fuel-cell engine and electronic components as described above. The CNG-hybrid work is not necessary as described above.

Presentation Number: elt187
Presentation Title: Comprehensive Assessment of On- and Off-Board, Vehicle-to-Grid Technology Performance and Impacts on Batteries and the Grid (SPIN System)
Principal Investigator: Sunil Chhaya (Electric Power Research Institute)

Presenter

Sunil Chhaya, Electric Power Research Institute

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.

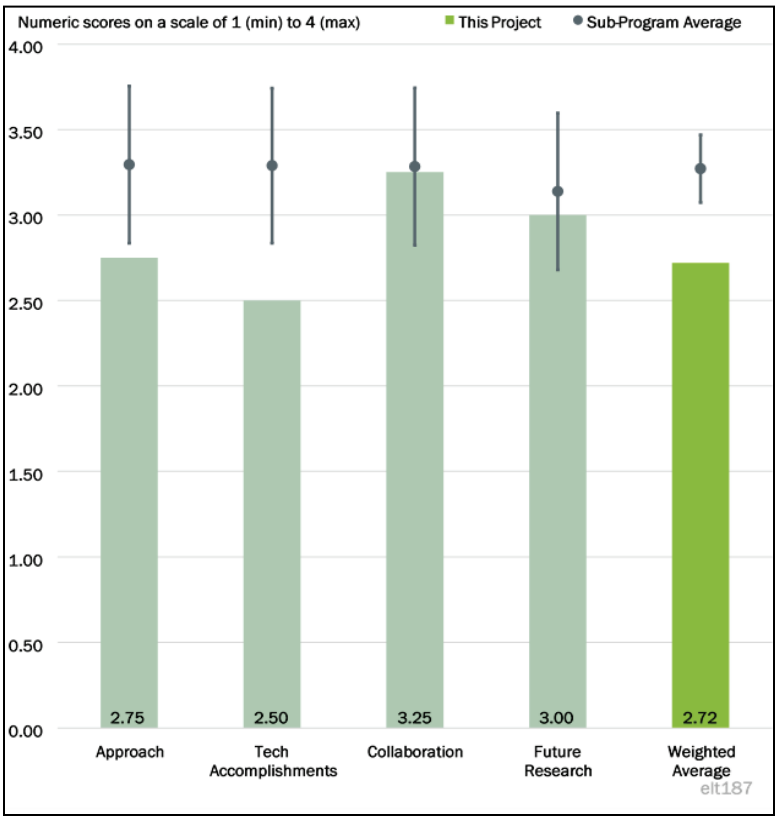

Figure 4-4 - Presentation Number: elt187 Presentation Title: Comprehensive Assessment of On- and Off-Board, Vehicle-to-Grid Technology Performance and Impacts on Batteries and the Grid (SPIN System) Principal Investigator: Sunil Chhaya (Electric Power Research Institute)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer observed that the approach is relatively basic. It is interesting that the idea was to work on a unit targeted toward multi-unit dwellings. The project also focused on both AC and DC charging, while many programs have tended to ignore AC for V2G. The project also looked outside of just EV batteries for input. Overall, the approach seems reasoned and appropriate.

Reviewer 2:

The reviewer commented that the project Relevance is presented as "Viability of V2G as DER resource and cost/benefit to consumer and utilities. Technical progress (viability) has been made even with the impact of coronavirus disease 2019 (COVID-19). However, no progress is apparent on the benefit of V2G, and only battery life is being examined as a cost of V2G. Several barriers are listed corresponding to cost-benefit that would have been apparent at the beginning of the project. The reviewer asserted that without a clear cost-benefit, it is difficult to see a future for the technical achievements of the project.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that it appears that all planned activities have been completed, while pointing to a direction for future efforts. Testing and validation were completed over the past several months, as was integration of the Smart Power Integrated Node (SPIN) unit. It should be noted that this project has been extended from June 2020 to June 2021, at least partially due to delays due to COVID-19. In particular, these delays impacted DC testing.

Reviewer 2:

The reviewer asserted that as earlier discussed, no progress has been made on the cost benefit of V2G, nor the power and energy requirements for DER applications. Without a cost benefit to V2G, the standards and hardware developed in this project are of little use.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer noted that the team was led by the Electric Power Research Institute (EPRI) and also included an EVSE manufacturer, an integrator, and an EV manufacturer. The project also collaborated with NREL, ORNL, and the Society of Automotive Engineers (SAE). The team appears to have made good use of its partners for the specific capabilities, as well as the labs (for testing and technical input) and SAE for technical outreach and coordination. The reviewer observed that it was a bit surprising there was not a utility on the team, though (upon questioning) the PI did indicate that might be an element of future work. It was good to see that the AC work led to a collaboration by several of the team members for SCE to define interconnection requirements for OEMs and EVSE manufacturers to include in the permitting process.

Reviewer 2:

The reviewer commented that it is a bit confusing why barriers include insufficient data on DER applications and insufficient value of V2G integration as a DER asset when EPRI is the prime. The reviewer thought there would be excellent access within EPRI to past utility data as well as thoughts on the value of V2G as a DER asset.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer noted that the current project is nearly complete, though there are some key elements still to complete. The project team appeared to indicate that there will be continuing work on application and integration work, including potentially more testing work from Fiat Chrysler Automobiles (FCA) and NREL. It also appears there is also additional work needed focused on certifications, integration with solar and utility operation, and more in-use verification.

Reviewer 2:

The reviewer said that the project has reached scheduled end data and is wrapping up current work.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the project is focused upon evaluation of V2G systems, both for AC and DC charging. A greater understanding of the technical requirements and impacts of V2G is needed for future EV penetration scenarios, as there may be opportunities for improved financial performance through V2G.

Reviewer 2:

The reviewer indicated that understanding the value of V2G as a DER asset is important to overall DOE objectives. However, the greatest challenges to making V2G valuable are not technical. Developing application-specific costs, commercial issues (including warranties), pricing, and availability/reliability are issues that must be solved. Future projects should be much more commercially focused than technically focused.

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

Reviewer 1:

The reviewer said that the resources appear sufficient to achieve the originally planned work, which is nearly complete.

Reviewer 2:

The reviewer stated that the resources were not sufficient to resolve barriers concerning insufficient data on DER applications and the value of V2G integration as a DER asset.

Presentation Number: elt188
Presentation Title: Bi-Directional Wireless Power Flow for Medium-Duty, Vehicle-to-Grid Connectivity
Principal Investigator: Omer Onar (CALSTART)

Presenter

Omer Onar, CALSTART

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.

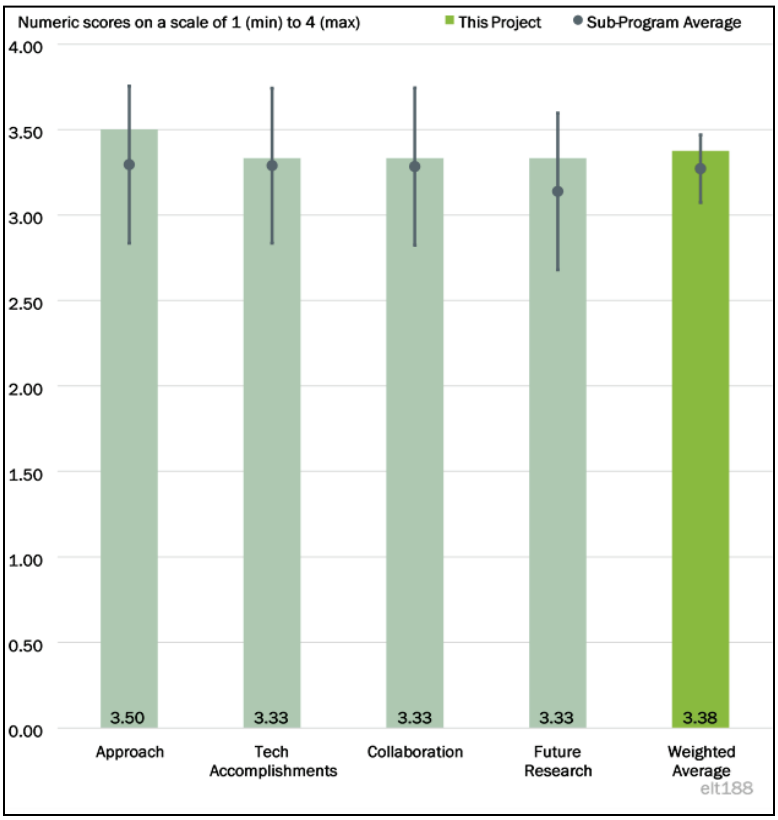

Figure 4-5 - Presentation Number: elt188 Presentation Title: Bi-Directional Wireless Power Flow for Medium-Duty, Vehicle-to-Grid Connectivity Principal Investigator: Omer Onar (CALSTART)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

According to the reviewer, the approach is good and systematic. It involves simulation, building and testing components, and finally integrating and testing the full system.

Reviewer 2:

The reviewer observed an outstanding approach and also raised some technical questions for the project team. Why was an inductor–capacitor–capacitor (LCC) compensation network selected? What are other options? Should the project team go for LCC for all wireless charging applications?

The reviewer remarked that it seems like the DC link capacitors look different as some of them are black, some of them are silver. They are also placed in an interleaved way. Is the project team using two different types of DC link capacitors? Is there any consideration the project team should be made aware of?

The reviewer noted that the 20-kW charger will make people think it is a single-phase charger, but in this project, three-phase is used, which can go to much higher power. Why was 20 kW picked for this project?

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed that the work the team has carried out so far is tremendous, and the reviewer highly recognized the great efforts and achievements the team had made. However, it seems the majority of the work presented in this year's review had already been completed before February 2020. The reviewer highly appreciated the nice revisit of the previous content but also expected to see some updated slides as compared to the 2020 review to highlight the hard work that the team has done between February 2020 and June 2021. If the reviewer were to rate the whole project, the reviewer would go for outstanding.

Reviewer 2:

The reviewer commented that the progress made is good, but the pending testing of the full system will provide a better verification of the performance.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that there has been good collaboration across the project team, and this will become more evident when the system is tested in the actual vehicle.

Reviewer 2:

The reviewer commented that the collaboration and coordination between ORNL, United Parcel Service (UPS), and Workhorse is great. The only reason that it is not "outstanding" is because the reviewer did not see much involvement from the project lead CALSTART. Maybe CALSTART will be involved more in the next budget period, so this could be outstanding next time.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer commented that the proposed future research is outstanding. The final deployment and 6-month data collection in real-life applications would be the most interesting part. The reviewer asked what type of data are being collected? Will efficiency, vehicle battery usage, charging and discharging power be collected?

In addition, the business case of this bidirectional wireless charging system is the key. Bidirectional wireless charging has always been a question for the reviewer. If the reviewer understood it correctly, the presenter mentioned the application being the UPS vehicles coming back to the depot with about 30%-40% state of charge (SOC) leftover after the day of the work and can output power to compensate for the other vehicles' charging loads that added on to the building loads. This is equivalent to peak shaving or demand charge mitigation. This sounds like the vehicle battery pack could be further optimized, and a stationary battery pack could be placed at the building to offer more help with higher efficiency and may be lower cost. The reviewer agreed that the bidirectional wireless technology should be looked into, but if the business case could be justified, this would definitely be outstanding.

This reviewer expressed interest in seeing how convenient the wireless charger is versus the conductive in this bidirectional case. It would be fantastic if it could be quantified—how much additional loss/cost versus how much time it can save the driver to plug in. How much economic benefit could the fleet gain by participating into the ancillary services market, as compared to putting less margin on the vehicle? How much economic benefit could the fleet gain by moving the unused 30% battery capacity to stationary energy storage (more

efficient being conductive and less weight on the fleet vehicle, and less expensive being that battery is stationary rather than automotive qualified)?

Reviewer 2:

The reviewer commented that the testing of the full system that was simulated in the actual system is a logical step for verification.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that the project is relevant to DOE objectives.

Reviewer 2:

The reviewer remarked that the maturing wireless charging technology, especially for MD and HD vehicles, supports the DOE objectives. It would have been helpful if the performance targets and more details about the targeted application had been provided.

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

Reviewer 1:

The reviewer indicated that the resources are sufficient.

Reviewer 2:

The reviewer thought that the resources are sufficient. Every organization has unique expertise and great collaboration. The reviewer is looking forward to seeing CALSTART contributing to the business case and economic analysis.

Presentation Number: elt197
Presentation Title: High Power and Dynamic Wireless Charging of Electric Vehicles
Principal Investigator: Veda Galigekere (Oak Ridge National Laboratory)

Presenter

Veda Galigekere, 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.

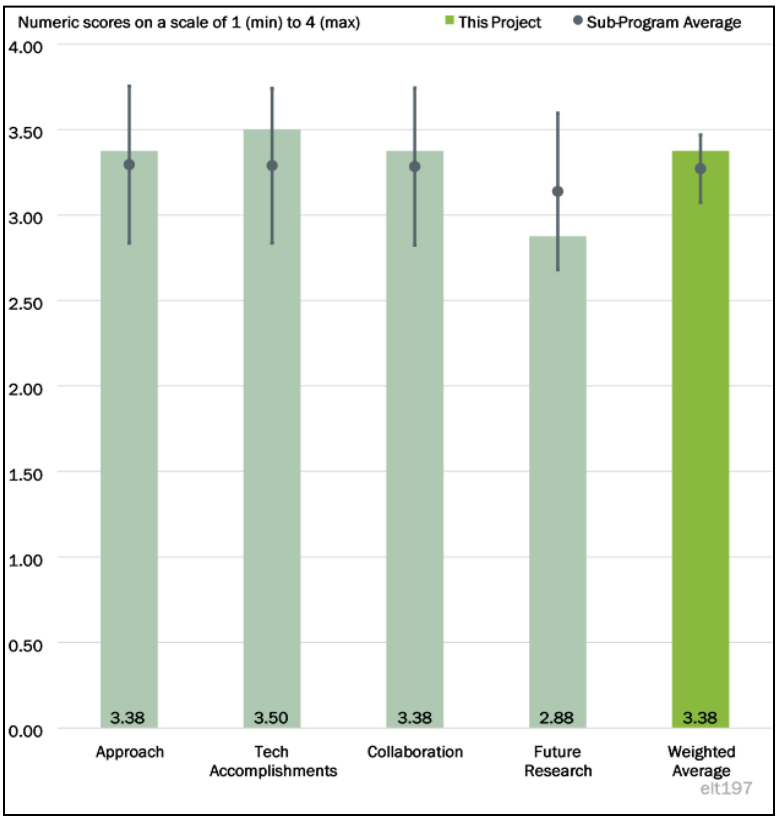

Figure 4-6 - Presentation Number: elt197 Presentation Title: High Power and Dynamic Wireless Charging of Electric Vehicles Principal Investigator: Veda Galigekere (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that the work is very well planned and executed projected. All milestones are very clearly defined and explained.

Reviewer 2:

The reviewer commented that this project sought to address efficiency (90% or better), power density, and controllability barriers related to dynamic wireless charging. This team's approach included studies and analysis, followed by laboratory validation and finally real-world validation of an integrated system. Thus far, the approach appears to be working well as the team successfully completed their go/no-go decision point last year.

Reviewer 3:

The reviewer remarked that the project team presented a good and systematic approach. It would have been helpful to compare the proposed approach to the state of the art.

Reviewer 4:

While the overall efficiency target of 90% has not yet been demonstrated in a moving vehicle, this reviewer observed simulation results that appear to indicate the project is moving in the right direction. Regarding

identifying Class 8 EV models, the reviewer agreed that perhaps the biggest benefit of dynamic wireless power transmission (DWPT) may be derived by Class 8 trucks, if the on-board battery size can be sufficiently reduced. Because this reviewer did not believe there are any Class 8 EVs in production, is there a process to quantify the benefit derived from DWPT in a real-world scenario, without relying exclusively on simulation?

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer noted that there appear to be a significant number of accomplishments on this project made by each of the project partners. From benchtop characterization of couplers to validation of power electronics, the team has made good progress. The real-world conditions site was identified, which drives the team closer to the validation of an integrated system under real-world conditions.

Reviewer 2:

The reviewer stated that the team has demonstrated a working lab prototype, which demonstrates the potential of this work as well as prepared this team well for a field test.

Reviewer 3:

This reviewer reported that all 2021 milestones have been met so far, and the other milestones are on target to be met.

Reviewer 4:

The reviewer indicated that the project team showed good progress but verifying the dynamic performance is very critical.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the project is well coordinated among ORNL, NREL, and Idaho National Laboratory (INL).

Reviewer 2:

The reviewer remarked that this project brought to bear three different national laboratories to address the challenge, as well as an OEM, a test facility, and a university institute. Each of laboratories had clear tasks and contributions to the project.

Reviewer 3:

The reviewer indicated that there is good collaboration across project team. Verification in actual vehicles is critical.

Reviewer 4:

The reviewer noted collaboration with an OEM (Hyundai) to integrate the DWPT system in a real vehicle, and with ACM for DWPT demonstration. This is a good way to go because the knowledge of these organizations will allow faster project completion and improve the chances of success.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the future work proposed looks logical, testing out the piece parts in controlled environments before testing of the integrated systems on a test course.

Reviewer 2:
The reviewer asserted that the proposed research is logical. Verifying the dynamic performance and real- life verification are critical milestones.

Reviewer 3:
The reviewer commented that the project's next steps are field demonstration, which is logical; however, the project team may not have enough time to execute this fully.

Reviewer 4:
One critical question identified by this reviewer that has to be answered is the impact on infrastructure and the grid. If a large number of vehicles that are on the road in Atlanta are going to be driving in a charge-sustaining manner, what kind of power requirements does it impose on the overall DWPT system and the power grid? What would it take for the grid to be capable of supporting this level of wireless charging? Is there a trade-off between the percentage of roadway that is electrified and the overall system cost?

The reviewer also inquired about what happens with the freeze-thaw cycles that occur during the winter and pot holes that show up on the roads. Perhaps this is not as much of a problem in Atlanta as it may be further up north.

Lastly, this reviewer referenced mention of optimizing the geometry to remove thermal hot spots. Would the extreme temperatures that are being faced across the western United States present a challenge for the cooling requirements?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:
The reviewer stated that the project is relevant because it is working on drivetrain technology that will reduce GHGs and perhaps make vehicle batteries smaller for commercial trucks.

Reviewer 2:
The reviewer said, yes, this project supports the DOE objectives for climate goals and full electric transportation.

Reviewer 3:
The reviewer observed that the project is relevant because the dynamic wireless power transfer can help reduce the on-board battery requirement as well as potentially reducing range anxiety.

Reviewer 4:
This reviewer remarked that successful implementation of DWPT should improve acceptance of EVs and make a large number of them more efficient because of smaller battery packs.

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

Reviewer 1:
The reviewer said that the resources are sufficient.

Reviewer 2:
Sufficient resources were observed by this reviewer.

Reviewer 3:
The reviewer stated that the project funding is sufficient for the project tasks.

Reviewer 4:

The reviewer commented that the project has a short time left to completion compared to its deliverables.

Presentation Number: elt198
Presentation Title: Cybersecurity: Securing Vehicle Charging Infrastructure
Principal Investigator: Jay Johnson (Sandia National Laboratories)

Presenter

Jay Johnson, 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. 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.

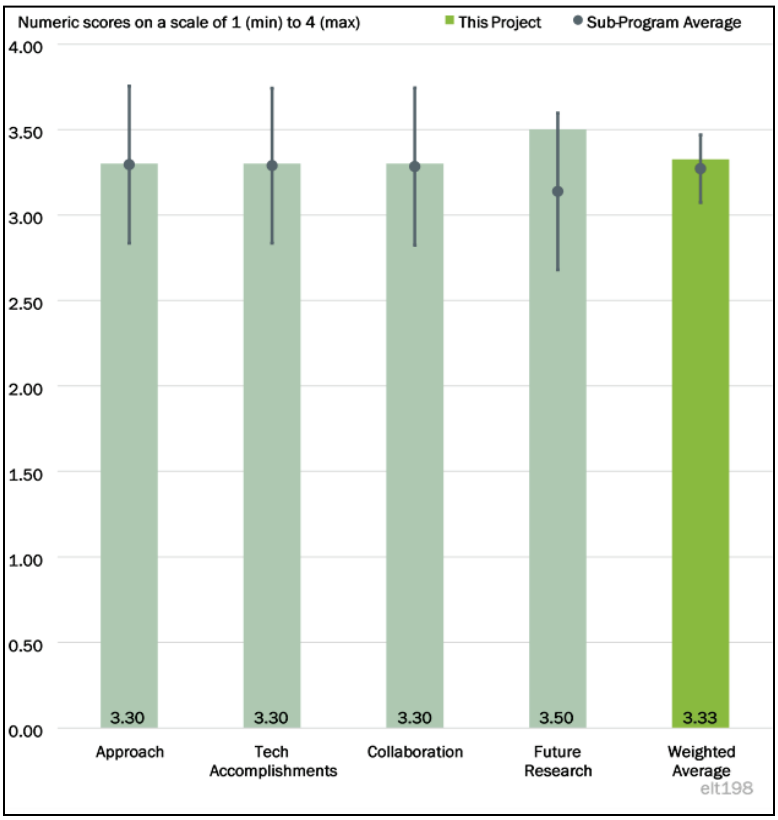

Figure 4-7 - Presentation Number: elt198 Presentation Title: Cybersecurity: Securing Vehicle Charging Infrastructure Principal Investigator: Jay Johnson (Sandia National Laboratories)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that, overall, the project has identified and implemented a very strong approach with a logical sequence of goals, milestones, and project deliverables. In short, the project approach has been to develop comprehensive EV/EVSE vulnerability assessments/threat models, investigate and quantify potential grid consequences of cybersecurity breeches, and subsequently develop a risk matrix and prioritize mitigation strategies. In addition, the project approach has been to develop a hardening guide to mitigate threats and work with standards development organizations to develop a new public key infrastructure (PKI) standard and testing system for use in EVSE ecosystems. The reviewer stated that the project presented overall, a very solid approach at this stage of the game.

The reviewer offered that the project approach has largely been a bottoms-up effort looking at vulnerabilities and threats to specific EVSE and their backend systems and how this could radiate throughout the EV ecosystem. At this point, it may be good to start considering top-down cybersecurity elements. For example, where breeches may occur at the cloud, grid, or other level and how EV/EVSE systems could be used as pathways to widely propagate these breeches and their impacts. At this point, what is the right cybersecurity strategy moving forward—a bottoms up approach, or a combination of bottoms-up and top-down approaches and how and where do they intersect both technically and temporally to maximize the overall effectiveness of cybersecurity protection throughout the EV ecosystem?

Reviewer 2:
The reviewer commented that, unfortunately, audio was lost on this presentation for quite some time. Some of the reviewer's comments come only from slide review and not the from presentation because of these audio outages.

The reviewer noted the overall approach of focusing on a portion of the National Institute of Standards and Technology (NIST) Cybersecurity Framework (labeled Risk Assessment under Identify) is sound. Actually, it is the same basic path an adversary seeking compromise would take, which is like walking in an attacker's footsteps to understand their likely methods, discoveries, and eventual exploitation.

However, the reviewer questioned accepting Pacific Northwest National Laboratory's (PNNL's) assertion that the major and severe risks are not actionable, and the reviewer urged that DOE does not accept this argument. Difficult breaches happen all the time and the percentage of national state-backed attacks are into the double digits now and increasing. The reviewer suggested that the project team have a follow-on task to focus on the "big ticket items" in the severe category.

Reviewer 3:
The reviewer remarked that the overall objectives are solid and addressing cybersecurity for greater deployment for EVs is critical, particularly given the increased opportunities for attacks and impacts due to involvement of EVSE and the grid. The approach is a bit complex, though the project team is addressing a complex set of issues. However, the approach may be a bit more complex than desirable for a smooth project, and this may have contributed to how much is left to be accomplished at this time with only 3 months left in the project.

Reviewer 4:
The reviewer stated that the work plan addresses the somewhat open-ended task in a comprehensive manner by methodically assessing all possible attack paths and investigating these in detail. The reviewer indicated that mitigation/avoidance plans are desired outcomes for the work.

Reviewer 5:
The reviewer remarked that it appears that the approach is mixing up physical layer, design-performance evaluation with the original objective of cybersecurity evaluation. It is not clear how the physical layer and crosstalk evaluation fits the cybersecurity evaluation. The reviewer also noted that the reference on Slide 6 for the report titled, "Threat consequence report published 9/2020," appears to be missing.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer commented that the project has made excellent progress on the Red Team assessments of EVSE vulnerabilities, the development of attack graphs and demonstration of particular elements of those graphs, and the Best Practices Guide to securing systems and Risk Matrix/remediation.

Reviewer 2:
The reviewer noted that this project has achieved a number of significant technical accomplishments including the following:

- The project has conducted a first of its kind EV charging infrastructure threat analysis. This includes building of attack graphs that illustrate the various ways an adversary can attack a system and identify key components or vulnerabilities that can be exploited by an adversary. The EV charging attack graphs illustrate attacker access points, staging areas, and consequences of concern and illustrate the steps an attacker must take to move from system/network access to consequences of concern. Central nodes have

been identified and prioritized for mitigation efforts. A key finding has been identified—the energy sector cannot mitigate cross-site scripting attacks (XSS) alone and the "ecosystem parties need strong coordinated cyber practices."

- Extensive Red Team assessments have been conducted, which are ideal for complex systems, dynamic adversaries, and security trade-offs. Red Team assessments included, eight DC fast charging (DCFC) and four Level 2 (L2) chargers, two backend networks, and Open Charge Point Protocol (OCPP) 1.6 and International Organization for Standardization (ISO) 15118-2 PKI requirements.
- The project has developed a Best Practices Guide covering all the critical areas of the EVSE ecosystem that provides a high-level view of the entire ecosystem ensuring critical security aspects are not overlooked.
- An updated analysis of power systems consequences has been developed that indicates inter-area oscillations put the grid in an elevated state of risk during system events but does not indicate significant adverse effects caused by the events and scenarios studied.

Reviewer 3:

The reviewer asserted that the project has seemed to accomplish a great deal, including a number of important elements, such as PNNL's grid impacts modeling that showed that major and severe power system impacts are unlikely. The reviewer expressed the concern that there appears to be a lot of work that is still left to be done and the project has only 3 months left. The project team is trying to speed things up, though it may be tough.

Reviewer 4:

The reviewer asked the project team, when considering the smaller sampling rate of evaluated products and assuming that similar identified cybersecurity exist in other non-sampled products, what is the mechanism to enable other manufacturers in the market gain the knowledge and avoid similar pitfalls?

Reviewer 5:

The reviewer commented that, unfortunately, audio was lost on this presentation for quite some time. Some of the reviewer's comments come only from slide review and not from the presentation because of these audio outages.

The reviewer assumed that Slides 6-14 represent the technical accomplishments (though there were not marked as such), again the loss of audio impairs the reviewer's ability to competently comment on the actual remarks. These slides represent an exceptional body of work (with the exception of what the reviewer interpreted is a disavowal of the major and severe consequences on the risk matrix, which the reviewer thought is a position of false hope). The reviewer noted that the attack graphs and the power system consequences update are of particular interest. Additionally, the reviewer thought that the graphic information will go a long way to help educate the general user and power company and aggregator community and help secure the "last leg" better than it has been. This is an important consequence, even if not the most technically sophisticated outcome.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed many key members on the team, including three national laboratories, the Volpe National Transportation Systems Center, four vendors, a utility, EPRI, SAE, and others. These are exactly the organizations that are necessary for addressing this issue. In addition, the project team is coordinating with a number of external agencies, including Department of Homeland Security (DHS), DOT, Army, Navy, and two other DOE programs.

Reviewer 2:
The reviewer noted that the project team included a wide array of relevant organizations. It would be good to have a leading cybersecurity company onboard, and the reviewer did not see one in the list of partnerships and collaborations.

Reviewer 3:
The reviewer stated that the project encompasses a strong group of partners and collaborators across the government, private sector, a utility, and academia. However, the presentation does not indicate the roles or current contributions of many of these partners and collaborators, so it is difficult to assess their true integration and impact on the project.

Reviewer 4:
The reviewer commented that, unfortunately, audio was lost on this presentation for quite some time. Some of the reviewer's comments come only from slide review and not from the presentation because of these audio outages.

While the reviewer was sure this was excellent, the loss of audio hurt the reviewer's ability to comment. Only PNNL was specified as a performer (others were mentioned at the front as teammates, but not given a dedicated slide or bullet comment showcasing their contribution), and there were no graphics or statements showing how coordination and collaboration happened, etc. So, while this is an excellent project and must have had input from the performer community, the loss of audio only allowed the reviewer to see what was on the slides, and the slides did not tell this story.

Reviewer 5:
Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:
According to the reviewer, the breadth of potential future research that was identified is both extremely important and well conceived. The researchers have a clear understanding of how to leverage this initial task under the Identify function and extend it to future R&D programs and their ability to produce informative, industry-facing material (e.g., the Info Graphic) shows that the project team can also bridge concepts into the user community.

Reviewer 2:
The reviewer remarked that the next steps are an appropriate extension of the work done so far.

Reviewer 3:
The reviewer commented that the project team has appeared to identify a number of important future areas for proposed research, indicating that this project has been only a beginning in this critical area. The high level of collaboration has clearly benefited this project in the identification of future needs.

Reviewer 4:
The reviewer stated that the presentation provides merely an adequate discussion of future proposed research by identifying areas requiring additional research, including standardized policies, perimeter defenses, situational awareness and intrusion detection and prevention systems, response mechanisms, and contingency operating modes.

The reviewer expressed concern that the proposed future research appears to be lacking a high-level, overall strategic approach to cybersecurity for the EV ecosystem, which is an ideal role for government. A number of relevant issues and questions to possibly consider include the following:

- What is the process to achieve cross-sector cybersecurity coordination across the EV/EVSE/grid ecosystem? As mentioned earlier, the project has conducted a first of its kind EV charging infrastructure threat analysis with a key finding being that the energy sector cannot mitigate eXtreme Fast Charging (XFC) alone and the "ecosystem parties need strong coordinated cyber practices." As a result, what specific steps need to be taken to address this need for coordination and how do you incentivize and achieve it?

- To date, as it should be, most of the effort has looked at cybersecurity vulnerabilities from the perspective of a specific EVSE and its associated network and subsequent potential grid impacts. In the future, it may be good to examine cybersecurity vulnerabilities from a "system of systems" context. For example, what new and unique cybersecurity vulnerabilities does a full XFC facility or microgrid present where multiple chargers (from different manufacturers) are integrated with battery energy storage and renewable energy generation? How does this scenario present new cybersecurity vulnerabilities and challenges that must be identified and mitigated?

- Overall, what is the "right" high-level cybersecurity strategy? Does a bottoms-up approach, top-down approach, or a combination of the two make the most sense? How does the reality of staggered industry and utility implementation of cybersecurity measures throughout the EV ecosystem affect the effectiveness of the high-level strategy and its implementation?

The reviewer suggested that the project has successfully provided a number of recommendations on how to enhance cybersecurity. The reviewer added some additional suggestions to the project team. A question is how do you further encourage EV ecosystem entities to implement these recommendations? In addition, in the future, it would be good to work with EVSE and grid entities to determine which mitigation strategies and recommendations are truly feasible to implement from a technical and economic standpoint. When not feasible, consideration should be given to going back to drawing board to identify alternate mitigation solutions.

Reviewer 5:
Not applicable was indicated by this reviewer.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:
The reviewer stated that this project shows an outstanding alignment with DOE's emerging mission as the power source for surface transportation over the next decade and securing the common generation and distribution system that will continue to power our homes and businesses.

The "contingency operating modes" sound closely aligned with an automotive industry current imperative for resilience, and there would likely be strong and very relevant future work on that, too.

Reviewer 2:
The reviewer stated that this project is very relevant as cybersecurity threats to critical U.S. infrastructure will become increasingly pronounced as the transition to EVs at scale and integration with the grid accelerates.

Reviewer 3:
The reviewer said that the quantifying cybersecurity risk to EV grid integration supports the overall DOE objectives.

Reviewer 4:

The reviewer remarked that the EVSEs are a key infrastructure element to enable the DOE goal of widespread EV adoption. Protecting that infrastructure from cyberattack is critical, especially if vulnerabilities can expose the electric grid to risk of failure.

Reviewer 5:

The reviewer noted that the project is addressing cybersecurity for EV charging systems, from the vehicle to the EVSE to the grid. Addressing this concern is critical to greater deployment of EVs while maintaining safety, security, and privacy.

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

Reviewer 1:

The reviewer stated that the project is progressing well with the resources provided.

Reviewer 2:

The reviewer remarked that while there were no specific logistical slides, it is clear the project was well managed and produced excellent output. It seems resources were appropriate and well used.

Reviewer 3:

The reviewer stated that the resources provided to date have been sufficient to meet project objectives.

Reviewer 4:

The reviewer indicated that the there was no indication that additional resources are required. The PI did indicate that this is just the beginning of work in this area, so future projects are anticipated.

Reviewer 5:

Not applicable was indicated by this reviewer.

Presentation Number: elt199
Presentation Title: Cybersecurity: Consequence-Driven Cybersecurity for High-Power Charging Infrastructure
Principal Investigator: Richard Carlson (Idaho National Laboratory)

Presenter

Richard Carlson, 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.

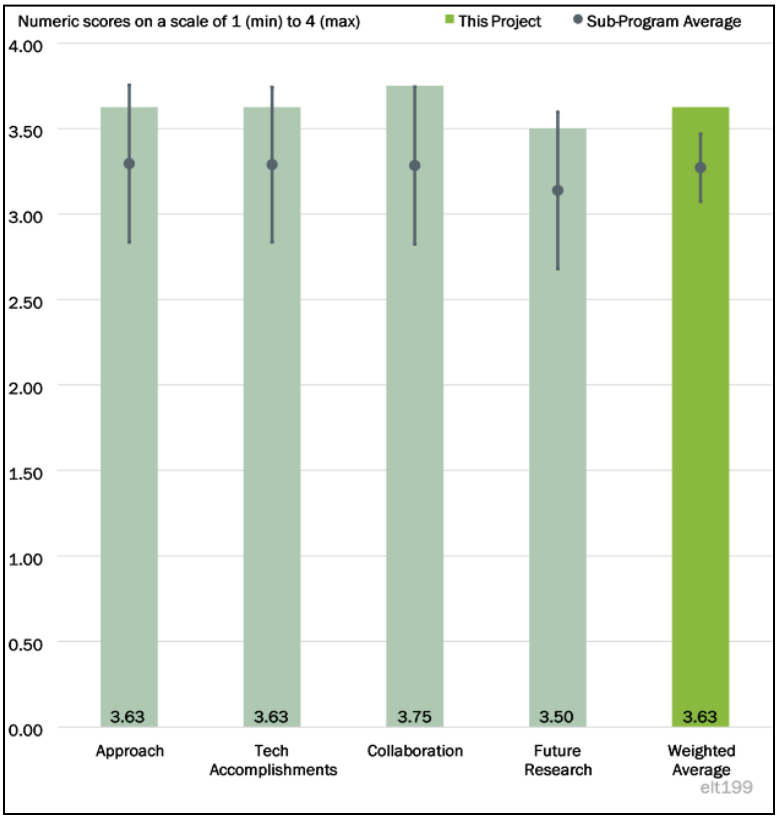

Figure 4-8 - Presentation Number: elt199 Presentation Title: Cybersecurity: Consequence-Driven Cybersecurity for High-Power Charging Infrastructure Principal Investigator: Richard Carlson (Idaho National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer commented that the project team presented an excellent approach on high consequence events (HCEs).

Reviewer 2:

The reviewer said that the project has a reasoned and straightforward approach for addressing cybersecurity issues, focused on identification, scoring, and developing mitigation strategies for high consequence events (HCEs). The approach included not only established scoring but then using laboratory evaluations for verification.

Reviewer 3:

The reviewer stated that the project team presented an excellent overall approach. The threat matrix application appropriate and allowed reducing the field of interest to less than half of potential study targets allowed focus on what was most relevant. The reviewer added that the use of consequential scoring also highlighted broad areas for study.

Spending time here near project completion to recommend set of mitigating strategies is a great way to end the project (and disseminate that knowledge and set of recommendations). To the point about mitigating strategies, the reviewer posed two questions to the project team. Firstly, and with regard to chipset features, has the

project team looked at (or is there a plan to look at this in some future project) the integrity of manufacturer code and reducing risk of foreign sourced components to provide supply-chain assurance and is there a plan in place to sample and validate imported hardware? Secondly, and with respect to micro-patching, has the project team interacted with the Defense Advanced Research Projects Agency's (DARPA) Assured Micropatching Program (AMP) program (this could be additional future work)?

Reviewer 4:
The reviewer stated that the approach identifies an effective means to evaluate the criteria and leads to scoring the impact. This allows utilities, vehicle, EVSE suppliers, and others to focus on their concerns and on actions to reduce security effects.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer remarked that the project team has created an impressive, broad, and actionably body of work. Creating mitigation examples reinforces this.

The project team has also ensured, through broad study and accomplishments, that different aspects of risk are covered such as safety, grid impacts, and even the economic health of corporations. There is clearly "red meat" in the project team's work for many audiences.

While the reviewer is not a strong proponent of intrusion detection system (IDS) type solutions, the reviewer understood why the project team has included these solutions. The project team's work with additional gate driver logic, the safety instrumented system (SIS) concept, and the buffering solution is very interesting, as is (of course) improved communications integrity.

Reviewer 2:
The reviewer noted that the project appears to have identified and scored a number of very specific HCEs, including some that may have not been anticipated initially (like cooling systems). In particular, the project team identified multiple attack pathways, then identified vulnerabilities and attempted system compromise approaches. The project team is now completing development of mitigation approaches. Overall, the project team appears to have accomplished most of what it set out to do in the approach, with the remainder scheduled soon. The reviewer wanted to know if the project team acknowledges that the project may run long by a few weeks or even a month, due to COVID-19-related delays.

Reviewer 3:
The reviewer commented that the project is at the stage to offer several solutions that can be included to reduce security issues.

Reviewer 4:
The reviewer acknowledged that this group understands the high impact HCEs.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer said that the project is primarily collaborating among three national laboratories, two charger equipment manufacturers, and a charge site owner-operator. In addition, the project team is also collaborating externally with Volpe, the National Motor Freight Traffic Association (NMFTA), the 21st Century Truck Partnership, a bus manufacturer, a wireless charger manufacturer, a university, and four other DOE cybersecurity projects. Together, this provides a very strong approach to collaboration.

Reviewer 2:
The reviewer said that the partners and collaborators included have the background and experience to lead to positive results. This project varies from others as it focuses on consequences, impact severity, and safety aspects.

Reviewer 3:
The reviewer noted that there has been good outreach thus far. The project team still needs to go to grid operators as they put in XFCs.

Reviewer 4:
The reviewer commented that while both ORNL and NREL had a special slide dedicated to them, the other performers did not have any special call-outs, so it was difficult to evaluate collaboration for this task. It is obvious that a lot of great work was performed, and the audience can infer coordination, but that content was not built into the slides, so the reviewer cannot really see it.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:
The reviewer stated that, as noted in the slides, the work is nearly complete, and the project is at its scheduled end. With that said, there are clear potentials for work with industry and also excellent potential for future government research programs that may not be limited to DOE. Supply chain matters and micro-patching are examples of work applicable to DOE and other government research programs, and things like buffering and developing new circuit logic could be DOE only.

The reviewer added that mitigating the set of problems described in the objectives is a big issue with big potential impacts, and this research points a clear direction for future work build upon this solid platform.

Reviewer 2:
The reviewer stated that the presentation identified the research remaining under the existing project but did not really identify any future research under potential next projects. Upon questioning, the PI did identify a few ideas for future projects. There is an on-going project for resilient charging (ELT267) that focuses on a near-term need. The PI also indicated that there is related work underway at the site level or multi-site level.

Reviewer 3:
The reviewer said that the future work is expected to include implementing these solutions on future product to validate these claims.

Reviewer 4:
The reviewer noted that there is going to be continued research on this project. The devil, however, is in the details of Mitigation & Improved Planning across the Grid. The reviewer asked where that future research is noted.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:
The reviewer affirmed that this absolutely is relevant to DOE. Larger vehicles (over-the-road trucks) will need to have XFC to be relevant. Automobiles will need to have XFC to be able to mimic the time “for fueling” of internal combustion engine (ICE) vehicles. The reviewer strongly emphasized that this is a very relevant project.

Reviewer 2:

The reviewer remarked that the project is focused on preventing system compromises for higher-power EV charging, a key cybersecurity area necessary for increased penetration of electric vehicles. This protection is necessary to ensure safe, reliable, and private charging of EVs, while also protecting the grid.

Reviewer 3:

The reviewer stated that this project deals with public safety, the economic health of the electrical suppliers and aggregators, etc., by understanding potential economic impacts, the overall health of the grid, personally identifiable information (PII) issues, and operational stability of local and regional electrical systems. The reviewer was not sure how any project could have more areas of interest to DOE, or how any other single project could have such wide applicability to support the nation's steady progress toward electrified transportation infrastructure.

Reviewer 4:

The reviewer commented that the results from this ranking and scoring of high-consequence events will help the industry and focus the effort into proper categories of impact severity and cyber manipulation. Generally, targets are focused on higher impact areas; however, even lower levels still need attention. Lab results will provide continuous improvement in security approaches.

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

Reviewer 1:

The reviewer noted that while there is critical work still required to be completed, there was no indication that funds were not sufficient. At the same time, as with all the cybersecurity projects, this project likely has formed a basis for future work.

Reviewer 2:

The reviewer commented that funding is "sufficient" for how this project is currently scaled and detailed.

Reviewer 3:

The reviewer remarked that the reviewer had no opportunity to observe the milestones, but it was a great project, so the project team clearly used whatever it was given to great effect.

Reviewer 4:

The reviewer said that the collaboration with other labs, equipment manufacturers, and charge point providers provided a good balance of focus on the goals of this project and is expected to lead to positive results.

Presentation Number: elt201
Presentation Title: Charging Infrastructure Technologies: Smart Vehicle-Grid Integration (ANL)
Principal Investigator: Keith Hardy (Argonne National Laboratory)

Presenter

Keith Hardy, 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.

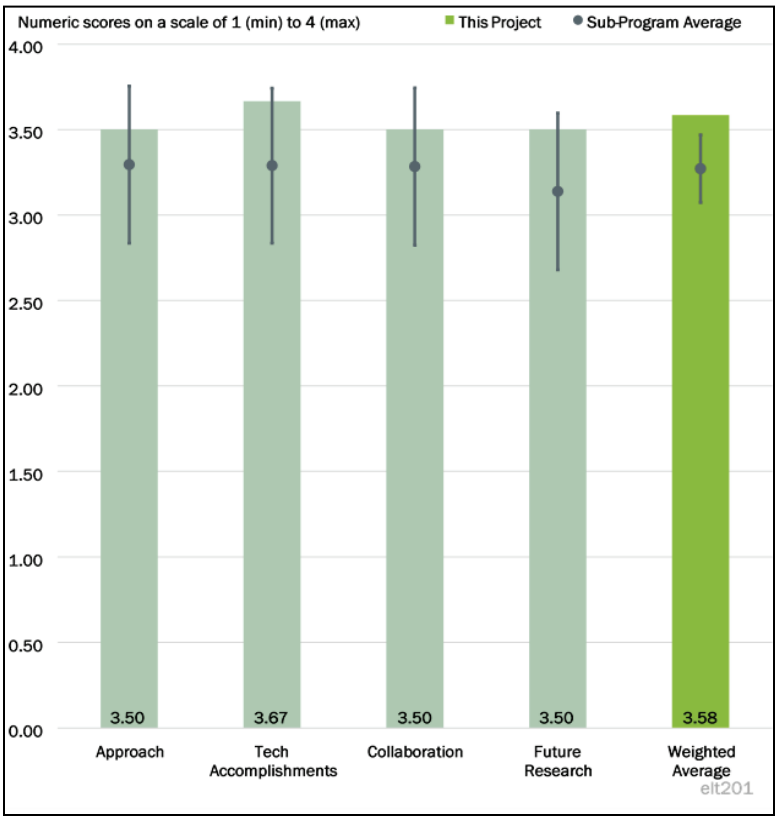

Figure 4-9 - Presentation Number: elt201 Presentation Title: Charging Infrastructure Technologies: Smart Vehicle-Grid Integration (ANL) Principal Investigator: Keith Hardy (Argonne National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer applauded the excellent ground-up approach considering that many of the technologies are not well developed. The creation of "reduction to practice" hardware for the vehicle-grid integration (VGI) vision is a valuable contribution.

Reviewer 2:

The reviewer remarked that the updates to the Smartgrid EV Communication (SpEC) II communication controller with diagnostics and a phone app provide alternative tools to capture information and establish analysis on charging sessions. SpEC is an excellent tool to aid in VGI, diagnostics, and other items for the charging session.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked that the project accomplished great progress considering COVID-19 interruptions. Use of simulated real-time transmission system and distribution grid linked between ANL and INL was a great alternative to actual systems. Development of the ISO 15118 ecosystem was another great accomplishment that can be leveraged by industry.

Reviewer 2:

The reviewer commented that progress was made with the ISO 15118 EVSE and the capability to capture power line communication (PLC) data. The dashboard that includes digital and graphical information is a good tool for the customer and OEMs to use.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that ANL has led the collaboration and coordination and ensured that the teams in other regions are included in this effort. Information exchange of the approach and progress at ANL, INL, and the Joint Research Center (JRC) labs are used to mature and validate the standards for energy management communication and controls.

Reviewer 2:

The reviewer noted that a wide array of collaborations occurred to get the work done, and all relevant parties appear to be participating.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer remarked that ANL has an outstanding future research position because charging systems are still evolving, and energy plaza capabilities will be able to validate updates to the standards and identify issues that need to be resolved for further updates to improve charging system interoperability. The monitoring and diagnostic tools being developed will continue to aid in the development of existing and new features.

Reviewer 2:

The reviewer said that the next steps are appropriate extensions of the work done to date.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that the project supports the DOE vision of making EV technologies more widely available by providing hardware and software implementation examples that industry can leverage in products deployed in the field.

Reviewer 2:

The reviewer stated that this project supports DOE objectives by providing a national laboratory approach for development and validation to improve and expand the communication and equipment standards. The project contributed by developing diagnostics and metering equipment and complements this by providing solutions for the industry.

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

Reviewer 1:

The reviewer stated that ANL has sufficient resources for this project and is able to balance OEM and EVSE supplier needs.

Reviewer 2:

The reviewer emphasized that the team is doing a good job with resources provided.

Presentation Number: elt202
Presentation Title: Charging Infrastructure Technologies: Smart Electric Vehicle Charging for a Reliable and Resilient Grid (RECHARGE)
Principal Investigator: Jesse Bennett (National Renewable Energy Laboratory)

Presenter

Jesse Bennett, 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.

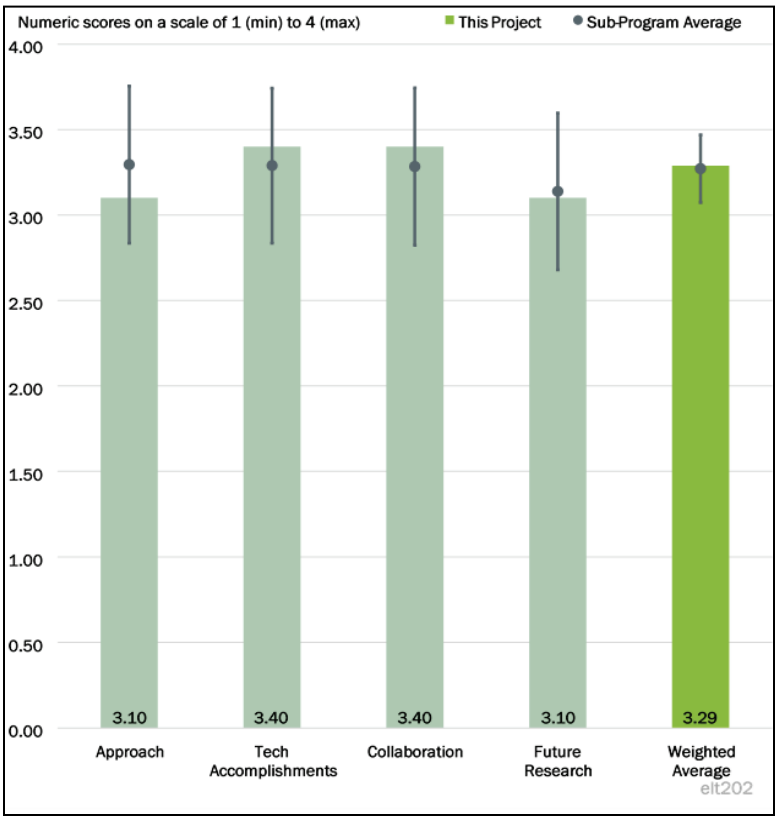

Figure 4-10 - Presentation Number: elt202 Presentation Title: Charging Infrastructure Technologies: Smart Electric Vehicle Charging for a Reliable and Resilient Grid (RECHARGE) Principal Investigator: Jesse Bennett (National Renewable Energy Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that this project has an excellent approach for optimized use of the grid for balancing the grid and meeting vehicle charging requirements. This project provides the background for a variety of loads and management scenarios.

Reviewer 2:

The reviewer observed an impressive project approach because the project seems very comprehensive. Would like the final Annual Merit Review (AMR) to provide more detail on how lessons learned from this work will be transferred to industry. The reviewer asserted that this work is so important, it should be transferred to utilities other than just those involved with the project.

Reviewer 3:

The reviewer observed that the model development appears to be very good, and it is apparent that much effort and thought went into it. The reviewer was less clear about how the various assumptions and strategies relate to real-world behavior. As an example, how would a random time-of-use (TOU) strategy actually be implemented?

The reviewer also mentioned that scenarios also assume everyone behaves exactly the same way and asked what percentage of EV owners today can and do take advantage of time-of-day pricing. Does EDF Renewables or the utility partners not have those data?

Reviewer 4:

The reviewer noted that several changes are needed to the work approach. A straight, across-the-board percentage cut of conventional cars cannot be assumed to adopt EVs. DOT has found that socioeconomic class (i.e., affluence) affects vehicle purchase because EVs are discretionary purchases—not purchases out of necessity. Because socioeconomic class also affects geographic distribution of residences, power distribution for EV recharging will also be affected, which has to be taken into account.

Additionally, this reviewer indicated that commercial vehicles (i.e., trucks and buses) need to be taken into account. Resiliency was only considered for hurricanes in the Atlanta area; no such consideration for resiliency was made for Minneapolis. The reviewer also remarked that changes in home-work travel patterns have occurred, and more work-at-home is expected after the pandemic. This needs to be taken into account.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the project appears to be well managed and is on track to meet the stated schedule.

Reviewer 2:

The reviewer commented that the milestone chart in the AMR presentation slides was very helpful in evaluating this dimension. The reviewer was very interested in seeing the final project review, which will hopefully be able to go into more depth on all phases of the project and not just the final year of work. One concern expressed by the reviewer is that it looks like very many of the difficult tasks need to be completed in the final 6 months of the project.

Reviewer 3:

The reviewer suggested that using charging history as input is needed to predict future needs. This balances the planning for additional and changing needs to include vehicle charging in infrastructure plans. Considerations that have included climate effects to grid loads have demonstrated a full approach for aggregators and planners to establish the optimal control and user benefits for balancing vehicle charging needs.

Reviewer 4:

The reviewer commented that the technical accomplishments for passenger EVs are satisfactory as measured against performance indicators. However, the geographic distribution of EVs as affected by socioeconomic class and thus the recharging and distribution of power for recharging were not taken into account.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer noted that the overall coordination appeared very good except with respect to actual, real-world data that this reviewer believed some of the partners could be providing.

Reviewer 2:

The reviewer said that this project has demonstrated close coordination with other national laboratories and includes assignment of resources to optimize the effort of all participants.

Reviewer 3:

The reviewer was very glad that the project is working with three separate cities and their representative power companies. This collaboration should help make certain that project results are transferable to any utility in the

United States. However, because the project plans to "Develop and evaluate the effectiveness of smart charging control strategies," it would be helpful to increase vehicle OEM participation in this project.

Reviewer 4:

The reviewer stated that no real challenges were faced—the only external stakeholders were the few who supplied data.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer noted that this year will integrate the approaches previously developed and then be able to validate the approaches. More effort can be applied to DER combined with optimized energy usage.

Reviewer 2:

The reviewer commented that the proposed Future Research was not fully explained in the AMR presentation. Time was short for the question and answer (Q&A) period, but this reviewer was interested in more detail on the "publication development" bullet point on the Proposed Future Work slide. Again, this is a very good project, and the team should work to make certain that it and the results are appropriately transferred to industry.

Reviewer 3:

The reviewer remarked that the project team seems to have identified a potential risk in the TOU immediate scenario. It is not likely that every EV owner behaves the same way, but even if 25% or 30% do respond to TOU, there appear to be risks to the infrastructure. The reviewer asked the project team why that is not addressed.

Reviewer 4:

The reviewer referenced prior comments and explained that the only research seen as needed is addressing the four approach shortcomings previously pointed out.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer remarked that this project very directly supports several of the DOE's goals but is primarily aimed at efficient use of the grid to charge EVs.

Reviewer 2:

The reviewer stated that this is relevant as major metropolitan areas are where EV adoption is highest and where the need is greatest.

Reviewer 3:

The reviewer affirmed that this project supports DOE objectives by including planning functions for grid stability. This planning and approach are expandable as the quantity of vehicles increases and the management approach is expanded to other locations.

Reviewer 4:

The reviewer said that this research is premature, that is, ahead of its time. It is not possible to have any idea of what the adoption rates for EVs will be.

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

Reviewer 1:

The reviewer noted that the resources appear to be sufficient to meet the goals by the end of the project.

Reviewer 2:

The reviewer commented that this project sufficiently steps through the actions needed to meet current needs while planning for additional growth of the electrification market. This project demonstrates the ability to dynamically adjust and adapt as conditions change due to climate and vehicle availability and usage varies while matching the grid stability functions. National laboratory resources are imperative to establish the foundation for this analysis, and tools that can be then used by aggregators and planners. No single or combined entities in the private sector can accomplish this task.

Reviewer 3:

The reviewer said that there are no issues noted in this area.

Reviewer 4:

The reviewer stated that the $6 million is excessive for this kind of modeling work.

Presentation Number: elt204
Presentation Title: Charging Infrastructure Technologies: Development of a Multiport, >1 MegaWatt Charging System for Medium- and Heavy-Duty Electric Vehicles
Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

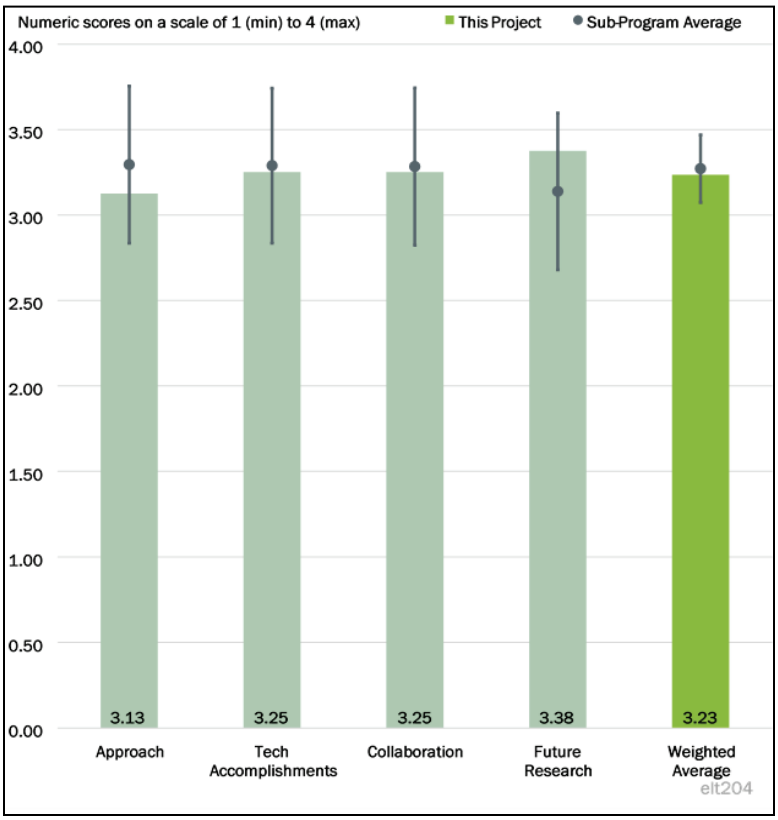

Figure 4-11 - Presentation Number: elt204 Presentation Title: Charging Infrastructure Technologies: Development of a Multiport, >1 MegaWatt Charging System for Medium- and Heavy-Duty Electric Vehicles Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

Presenter

Andrew Meintz, 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: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer noted that the approach to the technical work and engagement with standards bodies looks very good, but there are still three points that could be clarified better:

- A lack of end-user industry project partners. Many industry engagement partners are listed, but it is not clear to what extent any have contributed information or data for this particular project.
- The end product is a journal article and a prototype of one portion rather than a physical demonstration of the entire system. Many technical issues can crop up when taking a design to actual real-world usable hardware.
- The reviewer questioned whether end-users actually want a physically connected 1+ megawatt (MW) charger when there are wireless chargers in development with similar power and 92% target efficiencies (mentioned in Project ELT240), though this is a small portion of the overall objectives.

Reviewer 2:
The reviewer commented that the project is well planned and, given that it is near the end, expected that it will be completed. However, the reviewer stated that there is not a great deal of evidence in the budget details corresponding to deliverables and outcomes.

Reviewer 3:
The reviewer observed good tool use and development and an approach that accounts for all the right key elements.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer remarked that the milestones indicate the team is on track to complete the project. It would be helpful to the evaluators if the project team would make the quarterly reports available because they are referenced in the milestones.

Reviewer 2:
The reviewer stated that the project team has accomplished a lot from site analysis, power engineering (PE) design, battery options, and connector design.

Reviewer 3:
In the past few years, the reviewer has seen a decrease in evidence presented in these AMR reviews to confidently share that technical accomplishments have been made. Specifically, the reviewer expected to see more details in a waterfall chart on the freight efficiency improvements.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer commented that there is a clear connection to industry partners for inputs.

Reviewer 2:
The reviewer noted that the presentation does not specify which partner is responsible for which part of the project. However, since technical progress appears to be proceeding to plan, is the reviewer assumed that collaboration among named partners is good.

Reviewer 3:
The reviewer remarked that there seems to be little evidence to the claims made concerning industry engagement outside of the specific partners that are funded. The reviewer believed there should be more effort on fleet and other engagements in these programs.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:
The reviewer stated that the proposed next steps are in line with the stated objectives.

Reviewer 2:
The reviewer observed a good program and there is a need within industry for help.

Reviewer 3:
It was not completely clear to the reviewer how the remaining challenge of "Definition and refinement of 1+ MW charging site scenario (distribution feeder and charger utilization) that will drive understanding and

R&D" is different from the challenge that was addressed in the project. The reviewer asked for clarification by asking the project team whether this has already been done by this project.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that this project supports DOE objectives to reduce fuel use in commercial vehicles by helping to understand if the charging infrastructure is possible to support electrified commercial vehicles.

Reviewer 2:

The reviewer briefly stated that the project is very relevant to the overall DOE objectives.

Reviewer 3:

The reviewer stated that the project furthers the DOE objective of advancing electrification in transportation, although the reviewer believed it would be much more effective with an industry partner, resulting in demonstration hardware for a whole system.

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

Reviewer 1:

The reviewer stated that the project team did not indicate that they were short of any resources.

Reviewer 2:

The reviewer commented that the funding seems to be sufficient.

Reviewer 3:

The reviewer remarked that a lot was achieved, and it was a lot of money. It appears that the labs brought enough resources to make the work happen as good results were achieved in all areas. Considering the value to the commercial vehicle charging industry, it would seem that some industry cost share could be expected.

Presentation Number: elt205
Presentation Title: Cybersecurity for Grid-Connected Extreme Fast Charging Station (CyberX)
Principal Investigator: David Coats (ABB)

Presenter

David Coats, ABB

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.

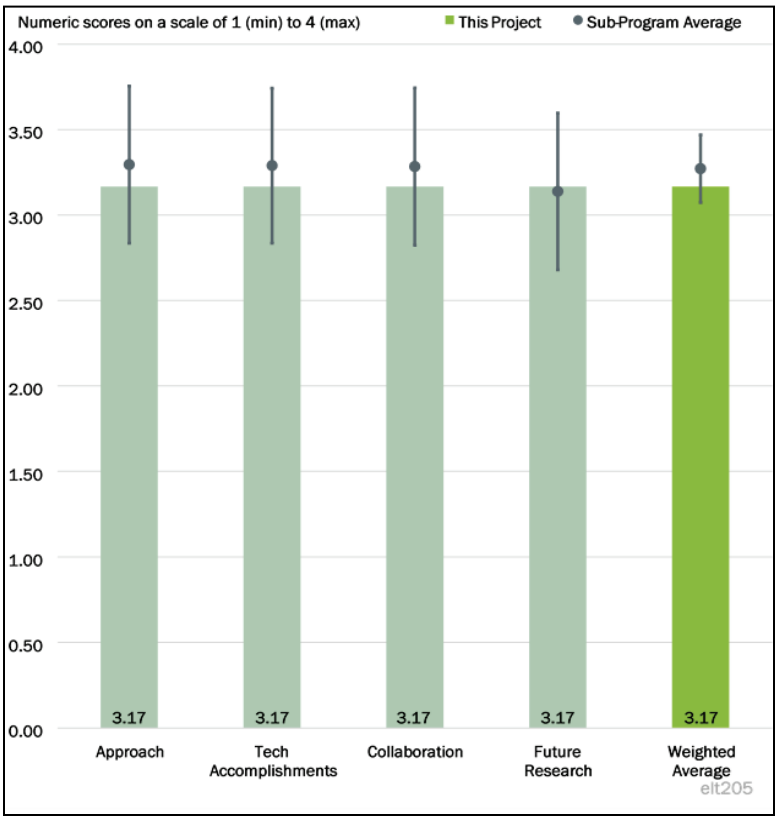

Figure 4-12 - Presentation Number: elt205 Presentation Title: Cybersecurity for Grid-Connected Extreme Fast Charging Station (CyberX) Principal Investigator: David Coats (ABB)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that this is a good approach with modeling, simulation, then HIL testbed.

Reviewer 2:

The reviewer remarked that this approach appears to train the system to address a fairly limited range of operating conditions.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the schedule milestone completion listing indicates that good progress has been made. However, the AMR contains limited technical data evidence to support the summary status listings.

Reviewer 2:

The reviewer commented that the Milestone 5 was marked completed since last year's AMR. It would have been good to see some more details and data regarding the results of this effort.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the progression of the work from the ABB lab to INL indicates strong collaboration and coordination across the project team.

Reviewer 2:

The reviewer commented that it was good to see utilization of both ABB and INL testing capabilities. It looked to the reviewer like all partners are contributing.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the proposed future research indicates that future work would appropriately focus on previous gaps.

Reviewer 2:

The reviewer noted that it looks like the right work to close out the project with high power testing at INL.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

This project supports the overall DOE objectives to advance the state of the art of cybersecurity for high-power EV charging systems.

Reviewer 2:

The reviewer stated that it is not completely clear how high a priority this work is. Certainly, charging is needed to meet DOE goals, and secure charging needs to be part of that. It was just not clear to the reviewer how big a problem secure charging is and whether it is at the level where DOE-funded research is needed to enable it.

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

Reviewer 1:

The reviewer stated that, in light of the COVID-19 induced delays, this project likely needs more resources.

Reviewer 2:

The reviewer commented that the project has sufficient resources. COVID-19 hurt, but that was unavoidable.

Presentation Number: elt206
Presentation Title: Cybersecurity Platform and Certification Framework Development for Extreme Fast Charging, Integrated Charging, Infrastructure Ecosystem
Principal Investigator: Sunil Chhaya (Electric Power Research Institute)

Presenter

Sunil Chhaya, Electric Power Research Institute

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.

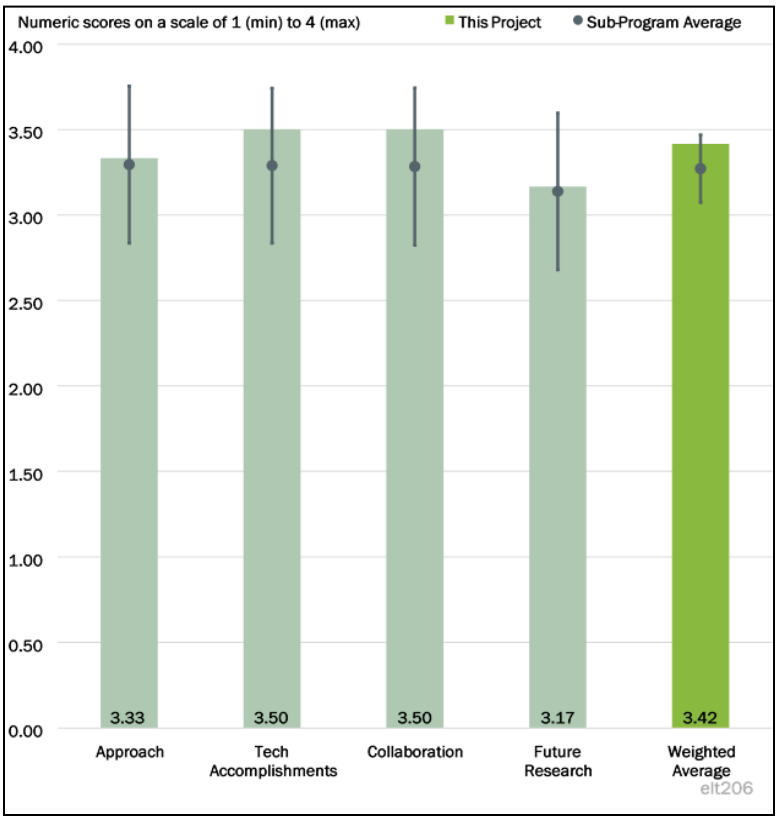

Figure 4-13 - Presentation Number: elt206 Presentation Title: Cybersecurity Platform and Certification Framework Development for Extreme Fast Charging, Integrated Charging, Infrastructure Ecosystem Principal Investigator: Sunil Chhaya (Electric Power Research Institute)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the work has an excellent division of effort at CSRL, ANL, and NREL. Each work group has the ability to work both independently but also toward common approaches and solutions to improving security.

Reviewer 2:

The reviewer stated that the overall approach appears straightforward for addressing cybersecurity concerns, with a focus on a specific solution—the secure network interface card (S-NIC). The approach includes clear elements on assessment, define and design, build, test and validation, and outreach and coordination.

Reviewer 3:

The reviewer remarked that it is good to be looking at the whole ecosystem. Open-source NIC would seem like a good starting point, but the reviewer asked if the industry would use an open-source device.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer noted that the common approaches are tested at multiple sites to validate the approach and results. Each lab also includes specific functions that add to the completion of the project.

Reviewer 2:

The reviewer stated that the project appears to have largely accomplished what it set out to do, with the key accomplishment being the design and development of the S-NIC. During 2020-2021, there were three primary areas of focus—testing to verify results, developing an integrated grid tool, and then working to get the word out on developments including through the Working Group. The project did hit some COVID-19-related delays and will therefore be ending a bit later than originally anticipated, although all project objectives are expected to be met.

Reviewer 3:

The reviewer said that the EV Communications and Cybersecurity Management (EVC2M) tool seems to be a significant accomplishment to help the industry, but it does not seem to have been released yet per the schedule in the presentation.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the project looks like excellent collaboration between labs and industry on defining the reference architecture and understanding the ecosystem.

Reviewer 2:

The reviewer noted that the core team is led by EPRI and includes two national laboratories, a system integrator, a charge system network provider, and an EVSE manufacturer. The project team appears to be clearly taking advantage of the unique capabilities of each research organization. In addition, the project team externally engaged an EV Infrastructure Cybersecurity Working Group, as well as a utility, three EV manufacturers, and a site operator-owner.

Reviewer 3:

The reviewer said that each participant complements the other in working toward the goals of the project. Validating this at the various labs provides the support to ensure improved security approaches.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer said that the project is essentially complete. The stated future goal of incorporating project knowledge into standards seems like a good approach.

Reviewer 2:

The reviewer stated that this effort is applicable to the continued effort required for new security threats. Continued evaluation is needed as threats and solutions continue to evolve.

Reviewer 3:

The reviewer stated that the project team has identified several areas for future research, particularly in the areas of scale-up, field testing and verification, and aligning results and recommendations with national-level

industry approaches. In effect, the PI was recommending a continuation of the path this project has established, although perhaps without providing too many specifics on individual research activities.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the project is focused on approaches to ensure secure high-power charging of EVs, which is critical to the expansion of use of EVs.

Reviewer 2:

The reviewer stated that EV charging is needed and some standards on secure charging are needed to move this forward.

Reviewer 3:

The reviewer commented that this project allows the analysis of existing standards to be evaluated and improved. While each of the team's approaches this from different angles or aspects, more solutions can be realized than from a project with less diverse and smaller teams.

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

Reviewer 1:

The reviewer stated that there was no indication by the PI that the resources were insufficient. As with all cybersecurity projects reviewed, there was an indication that this project formed the basis for future work.

Reviewer 2:

The reviewer commented that the resources seem fine.

Reviewer 3:

The reviewer remarked that these labs have the equipment and resources to accomplish this task. Additional vehicles and chargers are always harder to include, but as production and diversity continues, this will be more sufficient in future projects.

Presentation Number: elt207
Presentation Title: Enabling Secure and Resilient Extreme Fast Charging: A Software/Hardware Security Co-Design Approach
Principal Investigator: Ryan Gerdes (Virginia Tech University)

Presenter

Ryan Gerdes, Virginia Tech 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.

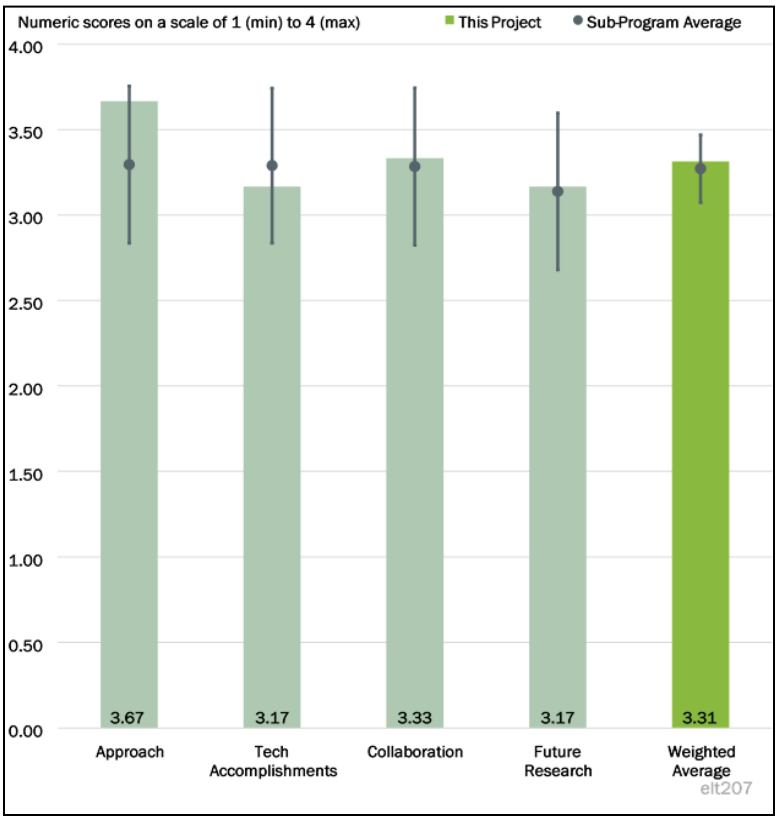

Figure 4-14 - Presentation Number: elt207 Presentation Title: Enabling Secure and Resilient Extreme Fast Charging: A Software/Hardware Security Co-Design Approach Principal Investigator: Ryan Gerdes (Virginia Tech University)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach should be able to identify failures in implementing communication standards and lead to more robust systems.

Reviewer 2:

The reviewer commented that the software-hardware co-design approach is good. The cost optimization thinking is a good approach. The reviewer liked that the moving target defense does not have to have a known model of the system. It makes it more generic and useful, but the reviewer asked if it can be shown to be as effective as having a model of the system.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the task assignments of effort for lead and support is well defined and will help to show positive results in each category.

Reviewer 2:

The reviewer commented that it looks like good progress across a range of milestones in hardware and software. Milestones 10 and 11 list functional testing of the hardening features as outcomes and as complete,

but the material does not clearly show results of those tests. In fact, the details for Milestone 11 say "waiting for printed circuit boards (PCBs)" so it appears that the "complete" status in the initial table is inaccurate.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that each team has a clear focus on each task and what it is expected to contribute to the overall progress.

Reviewer 2:

The reviewer stated that it is good to see the lead on different milestones being spread around to different team members.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that it is good to see a number of areas covered.

Reviewer 2:

The reviewer remarked that the expanding the approach to other communities and products now in the market will validate the approach used in this project.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer commented that secure charging is needed to help EV's meet DOE objectives.

Reviewer 2:

The reviewer stated that more vehicles and EVSEs continue to enter the market and additional updates to standards are also being implemented. These need to be continually analyzed for security aspects. This is an ongoing effort and needs to expand as the market grows.

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

Reviewer 1:

The reviewer commented that the resources seem fine.

Reviewer 2:

The reviewer stated that the resources are sufficient for the start of this approach. Expansion to other suppliers and charge point operators along with additional utilities are key to maximizing input for a robust solution and need to expand to include more of these variations.

Presentation Number: elt208
Presentation Title: Highly Integrated Power Module
Principal Investigator: Emre Gurpinar (Oak Ridge National Laboratory)

Presenter

Emre Gurpinar, Oak Ridge 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.

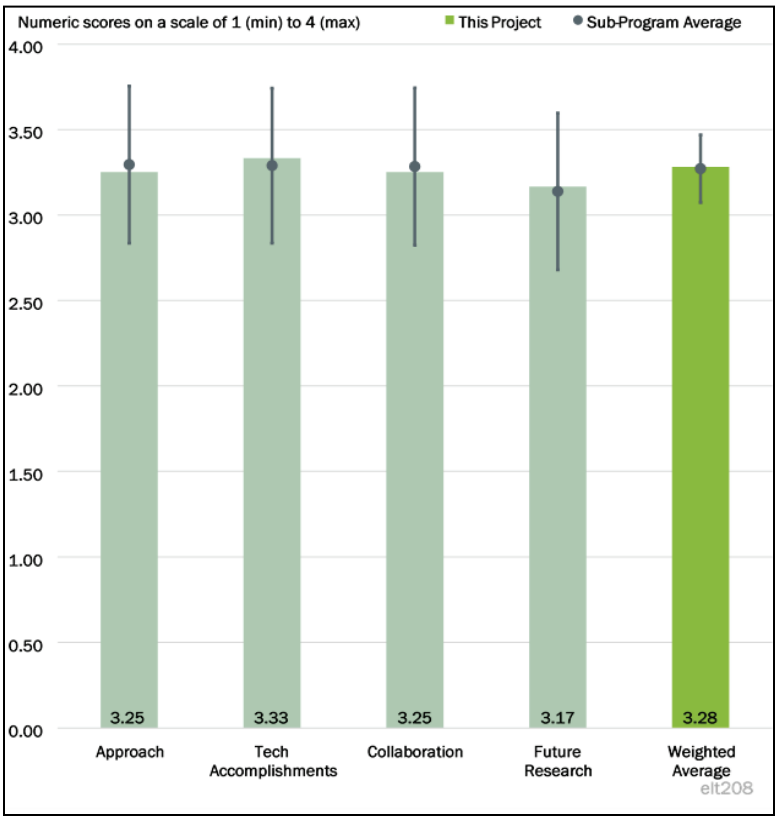

Figure 4-15 - Presentation Number: elt208 Presentation Title: Highly Integrated Power Module Principal Investigator: Emre Gurpinar (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the presentation seems to be logically organized, which may reflect the project status.

Reviewer 2:

The reviewer stated that it looks like accumulated experience and know-how from the past ORNL projects are nicely utilized to move further forward.

Reviewer 3:

The reviewer said that the presentation included many good data slides and information reviewed. It would help to show a summary slide that describes the purpose of each tested component. There is a good comparison to DOE technical goals, but it would also be good to see a comparison to the current state of the art.

Reviewer 4:

The reviewer remarked that the proposed technical approach is sound and addresses many critical issues associated with power module reliability. This area of focus is a key enabler for increasing power density and efficiency to achieve the 2025 DOE ELT technical targets. The team would benefit from expanding the rigorous multi-objective optimization approach to other aspects of the design, including thermals.

Reviewer 5:

The reviewer commented that, overall, the approach is reasonable. Not all technical barriers have been addressed. For example, there is no discussion of activities relating to reliability of the device and system under severe NVH conditions. This is important since this power electronics device is aimed at traction vehicles.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the progress that has been reported thus far is quite good.

Reviewer 2:

The reviewer noted that very nice progress can be observed. In particular, a prototype of the optimized heat-sink is good. Also, good is that switching transient waveforms is much cleaner than those presented last year. The reviewer emphasized that it is very important to fully utilize wide band gap (WBG) power semiconductor capability without electromagnetic interference (EMI) problems.

Reviewer 3:

The reviewer stated that it looks like good progress was made and the project is on track.

Reviewer 4:

The reviewer remarked that the details of the testing and design are shared, but a high-level overview of accomplishments compared to the plan would be beneficial.

Reviewer 5:

The reviewer said that the team has shown significant progress toward technical goals and objectives early in FY 2021. However, the reviewer added that the primary deliverables and milestones for FY 2021 are not hardware oriented. Upcoming milestones of hardware testing will be critical for benchmarking recent team progress.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the national laboratories, universities, and industry coming together demonstrates excellent collaboration.

Reviewer 2:

The reviewer stated that the partnership among different participating entities is excellent, and distribution of work is very good.

Reviewer 3:

The reviewer stated that it looks like the workload is well divided.

Reviewer 4:

The reviewer remarked that the presentation did not note where the project team mentioned how partners were involved with the work.

Reviewer 5:

The reviewer remarked that collaborations are claimed in the slides, but partner organization specific contributions are not highlighted in the detailed technical slides. Also, the deliverables (publications, etc.) appear biased toward ORNL team members. The project looks very ORNL-centric, and the reviewer wondered

to what extent the other team members are being engaged and contributing. Team members should be more clearly highlighted, and their contributions specifically identified.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The project has identified hardware-oriented go/no-go decisions to guide future project outcomes. This is a strength. One opportunity for improvement would be enhanced quantitative metrics surrounding decision points and criteria.

Reviewer 2:

The reviewer said that the future challenges are documented.

Reviewer 3:

The reviewer said that the future research is well documented.

Reviewer 4:

The reviewer stated that the project team presented a very good and reasonable step-by-step plan for the continuing work. It would be even better if a cost reduction requirements estimation could be done for the piezoelectric (PZLT) capacitors and other possibly expensive components in order to meet the United States Driving Research and Innovation for Vehicle efficiency and Energy sustainability (U.S. DRIVE) Electrical and Electronics Technical Team Roadmap (EETT) cost target of $2.70/kW.

Reviewer 5:

The reviewer noted that, in Future Research, there is no discussion of activities relating to how reliable the device and the system will be under severe NVH conditions. This is important since this power electronics device is aimed at traction vehicles.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that for the high-power density power electronics of the DOE objectives, this line of highly integrated power modules is one of the key factors. The relevance of this project to the overall Electric Drive Technology (EDT) Consortium is very high.

Reviewer 2:

The reviewer stated that it is very relevant and expressed interest in seeing some industry engagement.

Reviewer 3:

The reviewer remarked that the power electronics devices are vital to various energy systems and more electrification of various systems, including vehicles. All of these are within the scope of DOE objectives.

Reviewer 4:

The reviewer said that, yes, the project is well aligned.

Reviewer 5:

The reviewer commented that the expected impact on traction power would be good to know. How does the DOE goal influence this?

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

Reviewer 1:

The reviewer said that, for the defined scope of work, the resources should be sufficient.

Reviewer 2:

The reviewer observed sufficient, available resources based on Slide 2 of the AMR presentation.

Reviewer 3:

The reviewer stated that the resources appear sufficient, but it is unclear what the resource breakdown is between partner organizations. So, more optimal distribution may be possible with detailed analysis.

Reviewer 4:

The reviewer remarked that the sufficiency of the resources was the assumption.

Reviewer 5:

The reviewer did not see the overall budget number in the AMR presentation.

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 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.

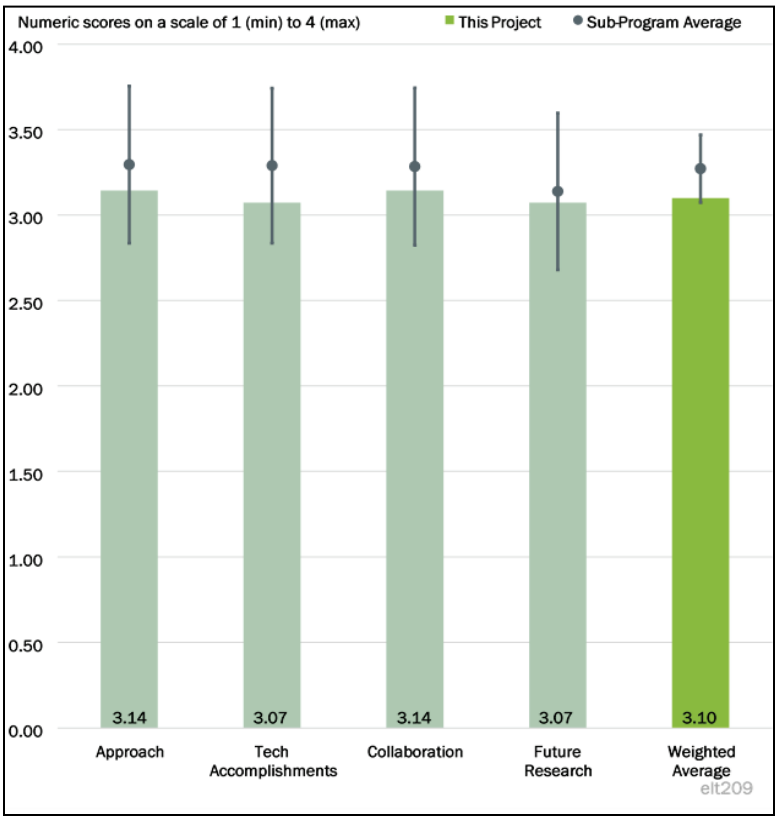

Figure 4-16 - Presentation Number: elt209 Presentation Title: High-Voltage, High-Power Density Traction-Drive Inverter Principal Investigator: Gui-Jia Su (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer asserted that the very thorough design work and step-by-step problem solving to getting a minimum capacitor in an inverter DC bus is an excellent approach.

Reviewer 2:

The reviewer stated that it seems to be one of the "group" projects, which is very good.

Reviewer 3:

The reviewer commented that the project is a nicely thought through approach, including comparative evaluation with the open-end winding three-phase six-leg inverter.

Reviewer 4:

The reviewer remarked that the team seeks to explore various inverter architectures, increase bus voltage, and optimize bus bar designs to maximize power density and reduce the size of passives. This is an important objective, and the team pulls from strategic partners for critical inputs (Virginia Polytechnic Institute and State University [Virginia Tech], power modules, University of Arkansas, sensors, NREL, and thermals).

Reviewer 5:

The reviewer stated that the approach used is in line with the project objectives.

Reviewer 6:

The reviewer commented that the project is very well addressed to a high degree and is feasible. Overall, the approach is reasonable. Not all technical barriers have been addressed. For example, there is no discussion on activities relating to how reliable the device, and the system will be under severe NVH conditions. This is important since this power electronics device is aimed at traction vehicles. On cost issues, it has not been noted if these are for volume quantities. Another thing is about the 300,000-mile reliability and lifetime definition—it is important to mention for what kind of vehicles and under what kind of terrain and drive cycle are these numbers valid.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the technical accomplishments are promising and demonstrate good achievements.

Reviewer 2:

Great progress has been made since the 2020 AMR according to this reviewer.

Reviewer 3:

The reviewer said that the progress made is compatible with the timeline.

Reviewer 4:

This reviewer noted good technical accomplishments including 100 kW inverter design completion. The motivation for "metal–oxide–semiconductor field-effect transistor (MOSFET) only," "MOSFET with Body-Diode," and "Diode" comparison for the third quadrant operation on Slide 10 was not crystal clear to this reviewer because it is going to be "MOSFET with Body-Diode" anyway in the inverter operation.

Reviewer 5:

The reviewer remarked that the accomplishments should be clearly highlighted and not just work done stated.

Reviewer 6:

The technical accomplishments of the project appear acceptable, but focus primarily on simulations, designs, and down selections. There is a lack of clear metrics identified for performance targets, and so it is difficult to fully assess progress relative to expectations. More clear benchmarking can occur once the hardware prototypes are fabricated and tested in upcoming quarters.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer noted that the collaboration seems to be good, and it is vital for success.

Reviewer 2:

The reviewer said that the group is very capable, and the participating entities got the correct assignments for each.

Reviewer 3:

This reviewer observed good teamwork by the ONRL team led by Gui-Jia Su, which is collaborating with NREL, Virginia Tech, and the University of Arkansas.

Reviewer 4:

The reviewer stated that the national laboratories and university collaboration is good. It would be even better if there were industry collaborators.

Reviewer 5:

The team has demonstrated collaborations with other partners (Virginia Tech, University of Arkansas, and NREL), although partner contributions could be more clearly identified. This is particularly true for NREL in which it is not clear to what extent it has been engaged in the project to date.

Reviewer 6:

The reviewer commented that the collaboration was reviewed fairly quickly and did not provide much detail.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the planning is excellent.

Reviewer 2:

The reviewer indicated that the proposed future work focuses on hardware prototypes, benchmarking, validation, and iteration. This is the appropriate next phase in the work, given the current status of the program. The reviewer looks forward to seeing the full hardware prototype testing results.

Reviewer 3:

It was logical to this reviewer that once the power stage of power-dense inverter is designed, it is time to complete the control board. The team is following logical steps in designing a power-dense SiC inverter.

Reviewer 4:

The reviewer observed a good plan for continuing work. The reviewer is enthusiastically looking forward to hearing about the hardware prototype built and its test results. Also, it would be great if cost reduction requirements estimation would be carried out for some of the possibly expensive components, such as TDK Ceralink capacitors and silicon carbide (silicon carbide [SiC]) MOSFETs, in order to meet the U.S. DRIVE EETT cost target of $2.70/kW.

Reviewer 5:

The reviewer stated that the plan outline for future work is consistent with the scope of the project timing.

Reviewer 6:

The reviewer stated that it is nothing new, just continuing the project. The reviewer would have liked to see some adjustments based on recent findings.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer noted that, yes, high-power density inverters are highly relevant to the EDT Consortium target. This project is tackling the challenging problem of building a very high-power density inverter as one of the keystone items.

Reviewer 2:

The reviewer liked this keystone “bundle” projects and would have liked to see more of them.

Reviewer 3:

The reviewer said that the project supports the DOE objectives and is relevant to transportation and other energy related activities.

Reviewer 4:
The reviewer stated that the inverter architecture trade studies and hardware design and development are critical to meeting technical targets.

Reviewer 5:
The reviewer is looking forward to seeing the final results.

Reviewer 6:
The reviewer remarked that this project fulfills DOE's aspiration to get to a 100-kW inverter. However, the reviewer was not very sure the cost target will get to $2.7/kW. This project is very relevant to industry's need for improved understanding of vehicle power inverters.

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

Reviewer 1:
The reviewer stated that the resources seem well aligned with requirements.

Reviewer 2:
This reviewer indicated that the team has enough resources and great support from universities.

Reviewer 3:
The reviewer commented that the project is on track to complete the work.

Reviewer 4:
The reviewer said that the resources are reasonable for the stated milestones.

Reviewer 5:
The reviewer noted that the resources seem to be sufficient.

Reviewer 6:
Based on Slide 2 of the AMR presentation, the reviewer interpreted the resources for the project as sufficient.

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 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.

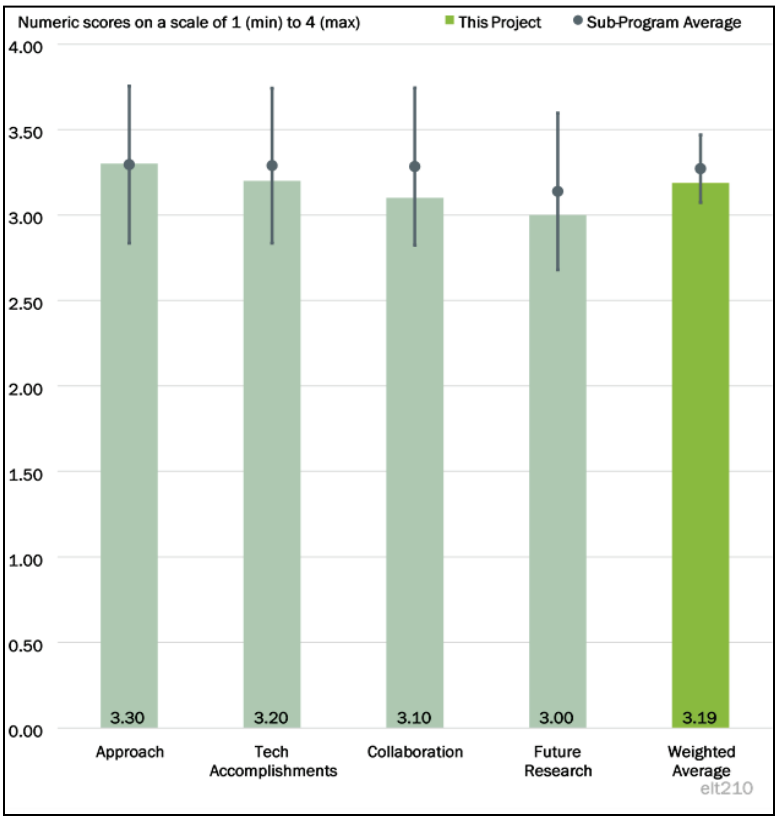

Figure 4-17 - Presentation Number: elt210 Presentation Title: Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain Principal Investigator: Andrew Binder (Sandia National Laboratories)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that the proposed work is well developed and has a strong path forward. Exploring gallium nitride (GaN) devices and optimizing, considering system level issues, is an acceptable technical approach.

Reviewer 2:

This reviewer noted that a logical progression to get to GaN MOSFET with GaN Diode seems like a good approach. The PI is applying knowledge from the SiC MOSFET + SiC Diode to SiC MOSFET+GaN Diode to finally having both as GaN-based devices.

Reviewer 3:

The reviewer commented that multiple paths (both SiC and GaN) are taken into account and challenging goals are set (e.g., vertical GaN) with the convincing approach. The step-by-step approach shown on Slide 6 is also convincing—SiC MOSFET + SiC diode, SiC MOSFET + GaN Diode, and then GaN MOSFET and GaN diode. Because MOSFETs are being used as active devices, the reviewer wondered if the external diodes are going to be eliminated eventually for cost reduction.

Reviewer 4:

The reviewer stated that the barriers are very clearly defined in terms of real facts. The reviewer suggested that it would be better if the cost target of $/kW is also correlated with volume involved. Similarly, operational life should also be related to the drive cycle and types of driving profile involved.

Reviewer 5:

The lack of participation from device manufacturers concerned this reviewer about whether the right, most pressing issues are being addressed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer observed there are good technical accomplishments on the project. In particular, the first vertical GaN MOSFET demonstration is good. The reviewer was looking forward to hearing about the scaled-up demonstration.

Reviewer 2:

The reviewer commented that quite a bit of device testing, including thermal testing, has been carried out.

Reviewer 3:

The reviewer stated that the technical accomplishments are reasonable as of now.

Reviewer 4:

The reviewer stated that the project team demonstrates strong positive results, particularly given COVID-19 constraints occurring during FY 2020 and FY 2021.

Reviewer 5:

The reviewer observed that the work is being done systematically. Appropriate testing and experimentation are being done and results made available.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the touch points with other projects, both at Sandia National Laboratories (SNL) and with other collaborators (ORNL, NREL, State University of New York [SUNY] Polytechnic Institute Albany Campus, Ohio State University, and Lehigh University) are clear and acknowledged. The team is doing a good job of reaching out for capabilities to supplement in-house expertise.

Reviewer 2:

This reviewer observed great teamwork consisting of universities, DOE labs led by SNL, and small industry.

Reviewer 3:

The reviewer stated that the distribution of activities is very well specified.

Reviewer 4:

The reviewer commented that the collaboration of national laboratories and universities is good. It would be even better if there were an industry collaborator.

Reviewer 5:

The reviewer observed that the lack of an industrial partners is a real weakness of the project.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the proposed future work seeks to continue demonstrating and improving upon specifications and technical targets with GaN devices. The proposed future scope is aligned with technical needs and rational.

Reviewer 2:

The reviewer stated that iterative design and testing activities in the project will give good confidence to the project team. Additionally, this reviewer indicated that the device-to-system approach planed for future research seems quite appropriate.

Reviewer 3:

The reviewer remarked that the new device R&D require a lot of time and efforts. The proposed future work looks quite reasonable based from that viewpoint. It might be out of the scope of this particular project and too farfetched, but it would be great if some cost reduction requirements estimation would be carried out for the U.S. DRIVE EETT cost target $2.70/kW.

Reviewer 4:

The reviewer indicated that the future activities are less clear and are noted as dependent on funding level, which will be available in the future on the AMR presentation slides. Also, it seems that the power level and current level of the devices are less than the overall objectives set earlier in the slides. For example, the forward currents noted seem to be less than what will be needed to accomplish the objectives of the overall system power.

Reviewer 5:

The reviewer expressed the concern that the project team needs industry input from manufacturers of devices.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that the DOE objectives and U.S. DRIVE EETT target accomplishments require full utilization of WBG semiconductors. This project is highly relevant from that viewpoint.

Reviewer 2:

The reviewer remarked that the development of GaN devices, if successfully implemented, will support the overall DOE objectives. The technology, although relatively less mature, deserves attention in terms of research efforts.

Reviewer 3:

The reviewer stated that advanced devices will play a critical role as a foundation of next-generation power electronics technologies.

Reviewer 4:

This reviewer remarked that WBG power electronics-related research is quite relevant to industry and DOE labs.

Reviewer 5:

The reviewer answered that, yes, GaN has a value proposition for automotive uses.

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

Reviewer 1:

The reviewer indicated that the SNL-led team is well resourced and has great support from universities.

Reviewer 2:

The reviewer stated that the resources seem appropriate.

Reviewer 3:

Based on Slide 2 of the AMR presentation, this reviewer interpreted project resources as sufficient.

Reviewer 4:

The reviewer remarked that the funding level is sufficient at this time. It is not clear at this time if future activities will need additional funding support or not.

Reviewer 5:

The reviewer expressed the concern that until there is direct input from device manufactures, it is difficult to say if the resources are appropriate.

Presentation Number: elt211
Presentation Title: Power Electronics Thermal Management
Principal Investigator: Gilbert Moreno (National Renewable Energy Laboratory)

Presenter

Gilbert Moreno, 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.

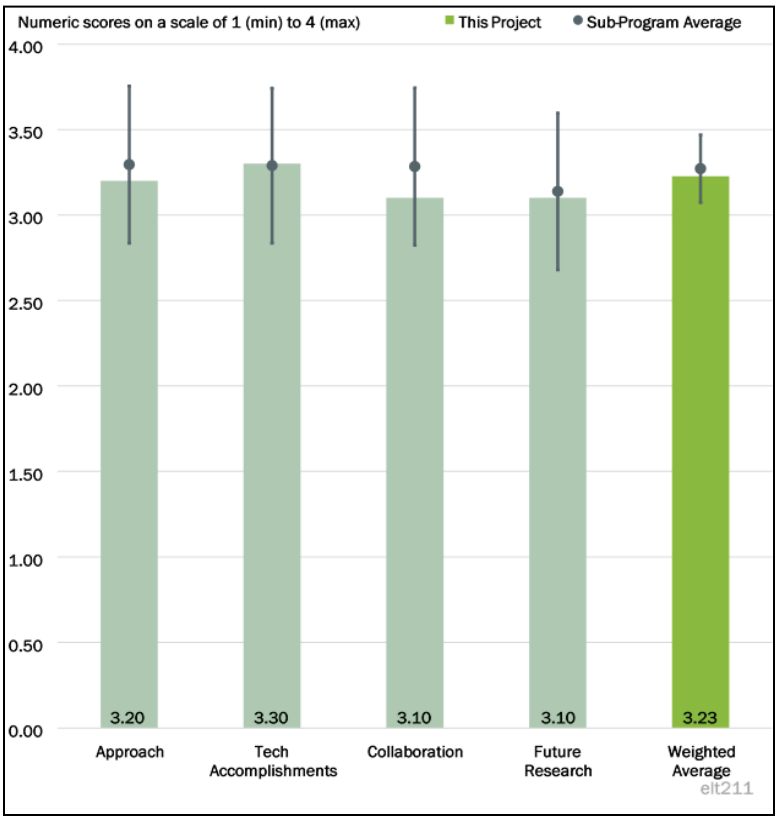

Figure 4-18 - Presentation Number: elt211 Presentation Title: Power Electronics Thermal Management Principal Investigator: Gilbert Moreno (National Renewable Energy Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the proposed approach is very strong and leverages strong capabilities in thermal modeling and measurements to explore various thermal management options. The double-sided cooling strategy seems quite effective, and exploration of advanced cooling fluids further adds to the value of the work.

Reviewer 2:

The reviewer stated that dielectric fluid cooling has a great potential for a better cooling scheme. Identifying the most suitable dielectric fluid is a key factor. The approach taken by this project is reasonable and convincing. Also, the comparison of single-sided versus double-sided cooling schemes is good.

Reviewer 3:

The reviewer said that the approach used is in line with the project objectives.

Reviewer 4:

The reviewer stated that better thermal can lead to better matching of application to typical load instead of overbuilding a component based on rare, high-power events. The reviewer expressed interest in seeing work performed that integrated dielectric fluid cooling with other methods to see if a combination of techniques may yield a better result.

Reviewer 5:
This reviewer commented that a systematic thermal design approach is being followed. Also, the NREL team led by Gilbert is applying knowledge from the previous, successfully completed, project year.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
Excellent design and simulation work has been carried out since last year, which this reviewer emphatically described as a great job.

Reviewer 2:
The reviewer said that the work is moving along and being done very systematically. The project team has used well thought out experiments.

Reviewer 3:
The reviewer remarked that the various interesting and useful outcomes can be observed here as accomplishments. Identifying AC-100 as one of the best candidates for low pumping power requirement is an important outcome. Also, quantitative comparison between the single-sided scheme and the double-sided scheme is a useful information so that the right trade-off estimation can be done.

Reviewer 4:
The reviewer stated that the technical progress has been acceptable, particularly given COVID-19 constraints in FY 2020 and FY 2021. Several dielectric fluids have been investigated as well as a dual-side cooling approach and various flow configurations. Productivity of the team has been strong throughout this period, including a review article and several invention disclosures.

Reviewer 5:
The reviewer indicated that the accomplishment to date is reasonable and well planned.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer observed excellent teamwork consisting of a DOE lab, universities, and industry (ROHM).

Reviewer 2:
The reviewer described national laboratories, universities, and industry coming together and collaborating as very good.

Reviewer 3:
The reviewer remarked that the collaborations are effective and well-documented with Georgia Institute of Technology (Georgia Tech), ROHM Semiconductor, and dielectric coolant manufacturers. There is some question regarding the extent to which the ORNL-NREL teams are coordinating on the thermal management solutions effectively, and this should be made clearer and more explicit moving forward. For example, does NREL access the thermal optimization tools being utilized in the ORNL programs and vice versa?

Reviewer 4:
The reviewer expected more details and specifics on the collaboration by the key partners than was provided by the project team.

Reviewer 5:
The reviewer expected to see more collaboration, especially with some others working on thermal solutions.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer explained that device reliability is one of the industry issues faced. A new package and method for thermal management that are not mainstream is an industry non-starter. Therefore, proposed reliability is an excellent idea from this reviewer's perspective.

Reviewer 2:

As part of the long-term reliability, the reviewer was interested in knowing how that is going to be achieved and under what parameters.

Reviewer 3:

The reviewer stated that this is a good future research proposal. Particularly important is an estimation of the long-term reliability of the dielectric fluid through experiments. The reviewer was looking forward to hearing about the outcomes.

Reviewer 4:

The reviewer said that the proposed future directions are acceptable.

Reviewer 5:

The reviewer suggested that the project team broaden future work to include investigating some alternatives beyond jet impingement.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

Efficient thermal management is one of the key factors to realize high-power density power electronics. From this viewpoint, this project is highly relevant to the overall DOE objectives and EDT Consortium goal to meet U.S. DRIVE EETT targets.

Reviewer 2:

The reviewer described this project as very relevant to industry needs and also highlighted the 100 kW/L power-density target set by the DOE VTO Tech Team.

Reviewer 3:

The reviewer stated that this project will have an impact on how systems are designed and perform.

Reviewer 4:

The reviewer said that the thermal management is a key requirement to achieve DOE Tech Team targets.

Reviewer 5:

The reviewer indicated that this project has the potential of having a big impact on power electronics that support the DOE objectives.

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

Reviewer 1:

The reviewer remarked that the NREL-led team is well resourced and has support from university and industry.

Reviewer 2:
The reviewer said that the resources are on track to support the project objectives.

Reviewer 3:
Based on Slide 2 of the AMR presentation, the reviewer believed that the resources available are sufficient.

Reviewer 4:
The reviewer observed that the resources seem to align with the current work. If the work scope is increased to broadening the investigation, then additional resources should be provided.

Reviewer 5:
The reviewer said that the project funding seems sufficient for the proposed work.

Presentation Number: elt212
Presentation Title: Non-Heavy Rare-Earth High-Speed Motors
Principal Investigator: Tsarafidy Raminosoa (Oak Ridge National Laboratory)

Presenter

Tsarafidy Raminosoa, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% 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.

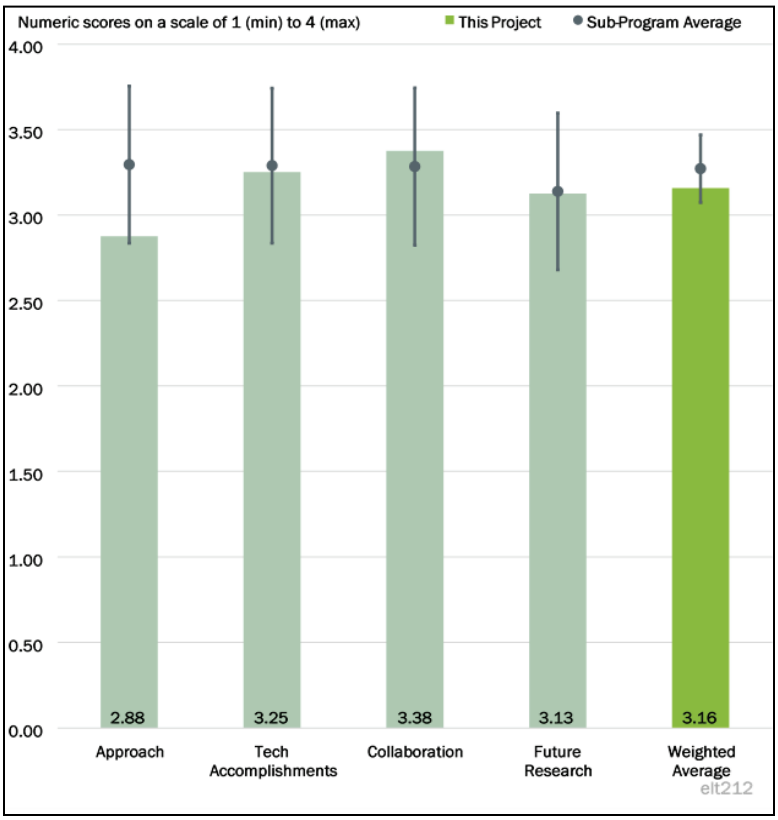

Figure 4-19 - Presentation Number: elt212 Presentation Title: Non-Heavy Rare-Earth High-Speed Motors Principal Investigator: Tsarafidy Raminosoa (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that at a first glance, the approach appears quite exotic. It will however be very interesting to see how this motor will perform with the segmented inverter in ELT209 titled, "High-Voltage, High Power Density Traction Drive Inverter." The reviewer looked forward to hearing about how this approach will come out through the prototype and test results down the road.

Reviewer 2:

The reviewer remarked that the technical barriers are well recognized. Regarding the cost barrier of $3.30/kW, it is better to also include at what volume quantity this is valid. On the 300,000-mile lifetime barrier, it is important to know what the vehicle drive cycle and drive profile are. Also, the issue of NVH is important, i.e., whether there will be any issues with the survivability of the motor, given that it has the magnets in the outer rotor. On the peak power of 100 kW and the peak torque of 143 Newton-meter (Nm), it is beneficial to know the duration allowed for these peak quantities.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the accomplishments, as of present, are impressive.

Reviewer 2:

The reviewer remarked that completing the design is a good accomplishment. Looking forward to hearing about the prototype build in the future.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the work distribution is clearly indicated between various teams and is clearly defined.

Reviewer 2:

Collaboration among national laboratories is good sharing of the tasks for electromagnetic, thermal, and material. It would be even better if university and industry collaborators would be there as well.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

Prototype building and testing are very important, and the reviewer looked forward to hearing about it. It would also be great if cost reduction requirements estimation could be carried out, particularly as associated with using Litz wire, a high-volume permanent magnet (although no dysprosium [Dy] is used), and reducing the manufacturing complexity, to estimate proximity to the U.S. DRIVE EETT cost target of $2.70/kW.

Reviewer 2:

The reviewer stated that the future research indicated is reasonable. Application of three-dimensional (3-D) (or additive manufacturing) has been indicated regarding electrical connections. Given that this is an outer rotor machine, it may be beneficial to look into 3-D technology for other parts of the system as well.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the high-power density non-heavy rare-earth (HRE) electric motor R&D is highly relevant to the overall DOE objectives and EDT Consortium goals.

Reviewer 2:

The reviewer stated that the project takes a different perspective on the technology and using non-HRE metals and is within the overall DOE objectives.

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

Reviewer 1:

Based on Slide 2 of the AMR presentation, the reviewer considered that the financial resources available are sufficient.

Reviewer 2:

The reviewer said that the funding available is sufficient and is compatible with the work done so far.

Presentation Number: elt214
Presentation Title: Electric Motor Thermal Management
Principal Investigator: Kevin Bennion (National Renewable Energy Laboratory)

Presenter

Kevin Bennion, 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.

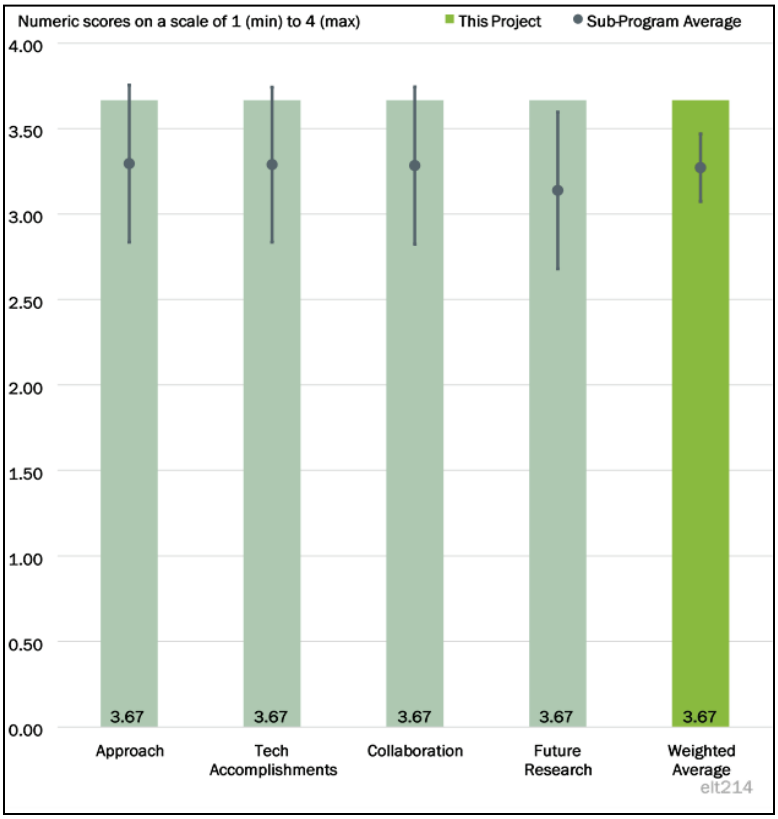

Figure 4-20 - Presentation Number: elt214 Presentation Title: Electric Motor Thermal Management Principal Investigator: Kevin Bennion (National Renewable Energy Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer commented that one of the most critical aspects of the machine design is thermal design. Using innovative materials and techniques plays a crucial role in increasing the power density of the motor. This project is vital for finding better solutions using better materials, methods, and implementation. The project aims to support mechanical and thermal measurements of new motor materials, thermal support analysis of electric machines, and measurement of slot-liner materials. This project has a systematic approach to evaluate new materials and test them. The reviewer found this project to be very important and timely for research on the development of motors that would meet the power density requirements of DOE.

Reviewer 2:

The reviewer indicated that the approach addresses the need for thermal and mechanical properties measurements on engineering materials, as well as the computational analysis of thermal systems. The project was well designed, and the goals were achievable and feasible.

Reviewer 3:

The reviewer stated that the AMR presentation provided a very good explanation and detail of each motor component. It would be good to see an overall estimate of how the combined improvements will, or will not, achieve the overall goal.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the team reported that it completed all of the technical milestones for this period. The final report is currently in preparation.

Reviewer 2:

The reviewer stated that it would be good to see a milestone schedule for the status of work.

Reviewer 3:

The reviewer stated that one of the most critical aspects of the machine design is thermal design. Using innovative materials and techniques plays a crucial role in increasing the power density of the motor. This project is vital for finding better solutions using better materials, methods, and implementations. The project aims to support mechanical and thermal measurements of new motor materials, thermal support analysis of electric machines, and measurement of slot-liner materials. This project has a systematic approach to evaluate new materials and test them. The reviewer found this project to be very important and timely for research on the development of motors that meet DOE power density requirements DOE. The reviewer observed excellent lab and personnel with high qualifications on the project.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the project team displayed excellent communication that described what partners are contributing.

Reviewer 2:

The reviewer stated that the project team has made multiple, effective collaborations with subject matter experts in other national laboratories and in universities. The reviewer suggested that collaboration with industrial partners, both OEM and lower tiers in the supply chain, may be useful.

Reviewer 3:

The reviewer noted that the project collaborates with two universities, ORNL, SNL, and Ames Laboratory. It is evident from the presentation material that the team is successful in providing expertise in mechanical and thermal design to these entities.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer remarked that the project has robust plans to continue the research. Future research includes improving the certainty in the field-epoxy samples' thermal conductivity measurement and preparing for the mechanical property tests with SNL material samples. In addition, the study will continue to support material characterization efforts, support universities for thermal analysis, modeling, and material selection. Challenges and barriers are well identified, and plans are made to carry out the next step in research.

Reviewer 2:

The reviewer said that the AMR presentation provided an excellent summary of upcoming needed work.

Reviewer 3:

The reviewer stated that, yes, the proposed future research adequately addresses the goals and needs of the EDT Consortium.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said, yes, the project supports the overall DOE objectives by providing needed thermal and mechanical properties data on engineering materials as well as computational analysis of thermal management systems.

Reviewer 2:

The reviewer stated that the project is very relevant because thermal design is extremely critical to increase the power density of the motor and reduce the cost.

Reviewer 3:

The reviewer said that, yes, electric motor efficiency is absolutely required to assist EVs.

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

Reviewer 1:

The reviewer indicated that the resources are sufficient and observed excellent lab and personnel with high qualifications on the project.

Reviewer 2:

The reviewer stated that the resources are sufficient to achieve the stated milestones.

Reviewer 3:

The reviewer assumed that the resources are sufficient.

Presentation Number: elt215
Presentation Title: Permanent Magnets Without Critical Rare Earths to Enable Electric Drive Motors with Exceptional Power Density
Principal Investigator: Iver Anderson (Ames Laboratory)

Presenter

Iver Anderson, Ames 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.

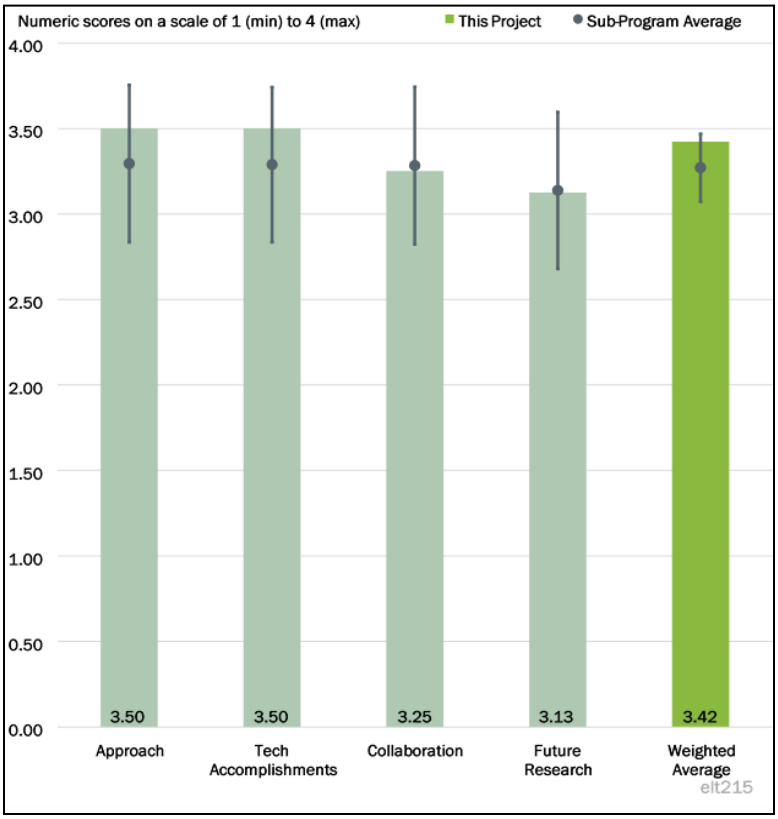

Figure 4-21 - Presentation Number: elt215 Presentation Title: Permanent Magnets Without Critical Rare Earths to Enable Electric Drive Motors with Exceptional Power Density Principal Investigator: Iver Anderson (Ames Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer remarked that the material selection is critical to reduce cost and increase the performance of motors. Better materials allow increased flux density, stronger magnets, avoiding HRE metals, and better thermal cooling. Using innovative materials is extremely important in increasing the power density of the motor. This project aims to develop HRE-free rare-earth permanent magnets (RE-PM) by processing ultra-fine grain size. This project has a systematic approach to develop and evaluate ultra-fine powder using various techniques, including powder passivation technology. The reviewer found this project to be very important and timely for the research for the development of motors that would meet the power density requirements of DOE and reduce the cost and dependency on other countries.

Reviewer 2:

The reviewer said that AMR presentation did well explaining the current work and process involved.

Reviewer 3:

The reviewer stated that the project is pursuing grain size control as a method to increase coercivity in RE magnets instead of using expensive HRE elements, such as Dy. The approach leverages powder processing methods used in other industries and is adapting them for use with reactive RE powders. Where appropriate, surrogate materials, such as Bakelite powder, are used during process development.

Reviewer 4:

The reviewer remarked that the proposed approach seems good but noted that it is important to provide a clear comparison of the expected properties and the properties of commercially available Dy-free neodymium-iron-boron (NeFeB) permanent magnets.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project is making acceptable progress despite finding limitations in certain powder processing methods like ball milling. The project is working to address those challenges by using jet milling combined with passivation methods and sintering aids to inhibit grain growth. These approaches are yielding progress toward achieving a magnet microstructure with superfine (1-3 micron) grain sizes.

Reviewer 2:

The reviewer rated the project team on the progress it had made when compared to performance indicators as well done.

Reviewer 3:

The reviewer remarked that the good progress had been made. According to the reviewer, it is important to quantify the expected benefits in terms of motor performance, assuming the magnet development is successful and the predicted material properties are achieved.

Reviewer 4:

The reviewer indicated that the technical accomplishments and progress of the project included collaboration with ORNL, NREL, and SNL for the newly developed magnetic materials' thermal and mechanical properties and evaluation. In addition, the project provides support and expertise on material selection for other universities, including permanent magnet selection.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer said that the project is successfully collaborating with other national laboratories engaged in advanced electric motor design and systems developments.

Reviewer 2:

The reviewer stated that the project team collaborates with ORNL, SNL, and Ames Laboratory. It is evident from the presentation material that the project team is successful in providing expertise in material knowledge to these entities.

Reviewer 3:

The reviewer indicated that the project showed reasonable collaboration between Ames Laboratory, NREL, and, to some extent, SNL.

Reviewer 4:

The reviewer indicated that the project team showed reasonable collaboration on the AMR slide provided.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer said that the project has robust plans to continue the research. Future research includes finding access to a multi-milling jet system to achieve ultra-fine powder for the HRE-free RE-PM, allowing the development of mechanical properties and sintering additive composition and developing RE-PM magnets for testing final shaping. In addition, the project plans to continue to support material characterization efforts, support universities for material selection, including permanent magnets. Challenges and barriers are well identified, and plans are made to carry out the next step in research.

Reviewer 2:

The reviewer said that the plan to use a Netszsch Jet mill to produce the ultra-fine grain size powder is appropriate and feasible. However, there seem to be few options beyond the jet mill to enable reaching the targeted superfine grain size.

Reviewer 3:

The reviewer noted that the proposed future research is good, but the future research needs to include a clear comparison of the expected properties and the properties of commercially available Dy-free NdFeB permanent magnets and quantification of the potential project performance in terms of the motor performance.

Reviewer 4:

The reviewer remarked that the AMR presentation provided a very good list of future research that may be needed. However, the plans need to have relevance attached to them. How do the specific future work ideas impact the ability to achieve overall goal?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said eliminating heavy rare-earth material is very relevant to meeting cost targets and developing sustainable electric drivetrains.

Reviewer 2:

The reviewer said that, yes, the project supports the overall DOE objectives of enabling higher performing motors with reduced dependence on critical materials, such as Dy.

Reviewer 3:

The reviewer said that, yes, the project is necessary for future, cost-effective EVs.

Reviewer 4:

The reviewer stated that the project is very relevant because HRE-free RE-PMs have strategic importance because they eliminate HRE metals and reduce the dependency on other countries. They also reduce costs.

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

Reviewer 1:

The reviewer said that the personnel with high qualifications are working on the project. It appears that the project has sufficient resources. It is noted that the jet-milling challenge was addressed last year, and the team has plans for scaling up the capability.

Reviewer 2:

This reviewer noted sufficient resources based on the proposed scope.

Reviewer 3:

The reviewer stated that the resources available to the project are sufficient to achieve the stated milestones. However, the use of a jet mill at a vendor facility may pose a schedule risk if that equipment becomes unavailable.

Reviewer 4:

The reviewer rated the resources as insufficient since it appears that the project is 30% complete and is behind schedule.

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.

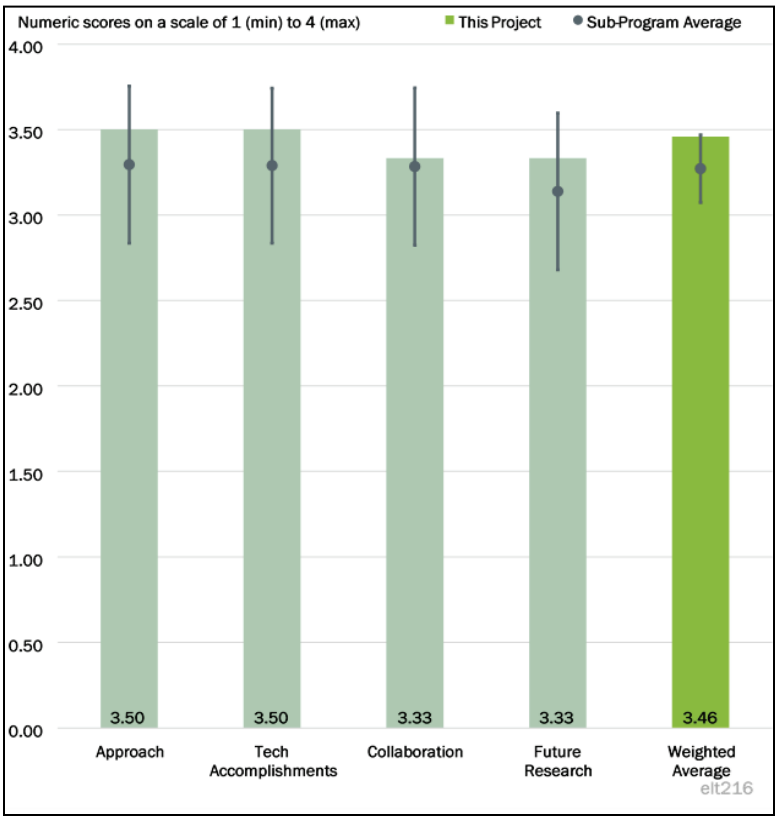

Figure 4-22 - Presentation Number: elt216 Presentation Title: Isotropic, Bottom-Up Soft Magnetic Composites for Rotating Machines Principal Investigator: Todd Monson (Sandia National Laboratories)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach is good, but it is not clear what the expected material properties are and, if successful, how they compare to other commercially available soft magnetic composites.

Reviewer 2:

The reviewer stated that the project is well-designed and has taken a systematic toward the engineering of iron-nitride (Fe_4N)-filled epoxy matrix composites for use as soft magnetic motor components. The major requirements of temperature dependent properties, mechanical strength, and thermal conductivity have been thought through and are being thoroughly tested.

Reviewer 3:

The reviewer remarked that the project is about developing new soft magnetic composites for electrical machines. Better, soft magnetic materials are needed for motor designs to reduce the losses and improve the power density. It is possible to use soft magnetic materials on motor topologies to avoid RE magnets. Using innovative materials for soft magnetic materials is extremely important in increasing the power density of the motor. This project aims to demonstrate a net-shaped, Fe_4N soft magnetic motor component with a vol. % loading of Fe_4N greater than 70% and evaluate its saturation magnetic polarization and eddy-current losses. This project has a systematic approach to develop high magnetization, low-loss Fe_4N-based soft magnetic composites for electrical machines that will lower losses even further and enable efficient operation at

rotational speeds up to 20,000 revolutions per minute (rpm). The reviewer found this project interesting for the research to develop motors that would use better soft magnetic materials and avoid RE magnets.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project has made good progress in developing a process to form highly loaded Fe_4N epoxy composites. This includes the development of the starting powder, epoxy formulation, and diamine catalyst selection. This also includes a hot-pressing method to form coupons with high volume fraction of Fe_4N. The project has met the milestone of making and characterizing a composite with a volume fraction greater than 70%.

Reviewer 2:

The reviewer said that reasonable progress has occurred, but it remains to be seen what material properties can be achieved. In addition, some quantification of potential benefits in terms of motor performance is needed from the project team.

Reviewer 3:

The reviewer remarked that the project collaborates with ORNL, Purdue University, and the Illinois Institute of Technology (IIT) for the newly developed soft magnetic materials' part shapes. It also collaborates with Ames Laboratory and NREL for magnetic material manufacturing, advanced packaging, reliability, prognostics, thermal management, and thermal and mechanical testing.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer found a reasonable level collaboration but suggested that more collaboration is needed to quantify the benefits of the developed material in terms of the material's effect on motor performance.

Reviewer 2:

The reviewer stated that the project is effectively working with collaborators in other national laboratories and universities engaged in advanced motor R&D.

Reviewer 3:

The reviewer noted that the project collaborates with Purdue University, IIT, ORNL, SNL, and Ames Laboratory. It is evident from the presentation material that the team is successful in coordinating the efforts to use the new soft magnetic material on a motor design.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer indicated that the project has excellent plans to continue the research. Future research includes evaluating the eddy current losses that will require hot pressed toroids of greater than 70 vol.% Fe_4N/epoxy composites to make additional comparisons to the state-of-the-art materials (e.g., Si electrical steel and soft-magnetic composite [SMC]). Challenges and barriers are well identified, and plans are made to carry out the next step in research, including, in collaboration with NREL, evaluating the mechanical properties of Fe_4N composites.

Reviewer 2:

The reviewer stated that the proposed research plans to measure magnetic properties and eddy currents in toroidal shaped samples. This is critical for understanding the advantage of this material compared to conventional soft magnetic materials, such as SMC and Si electrical steel. If the Fe_4N composites are intended to be used in rotating components, then the mechanical properties of the Fe_4N composites should also be measured.

Reviewer 3:

The reviewer indicated that proposed research is good and will identify what level of material properties can be reached and how motor performance is affected.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer remarked that the proposed material is relevant in terms of potentially meeting the power density, efficiency, and cost targets, and more specifics about its use and impact on performance of specific motor topologies are needed to support the overall DOE objectives.

Reviewer 2:

The reviewer stated that, yes, this project supports the overall DOE objectives of enabling higher efficiency, high-power density electric machines.

Reviewer 3:

The reviewer remarked that the project is very relevant because using soft magnetic materials without RE permanent magnets has strategic importance because they eliminate HRE metals and RE materials for motor design and reduce dependency on other countries. They also reduce costs of materials for motors.

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

Reviewer 1:

The reviewer indicated that the personnel with high qualifications are supporting the project. It appears that the project has sufficient resources and partnerships with universities and other national laboratories.

Reviewer 2:

The reviewer said that the resources seem adequate for meeting the milestones on the proposed schedule.

Reviewer 3:

The reviewer stated that the resources are sufficient.

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 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.

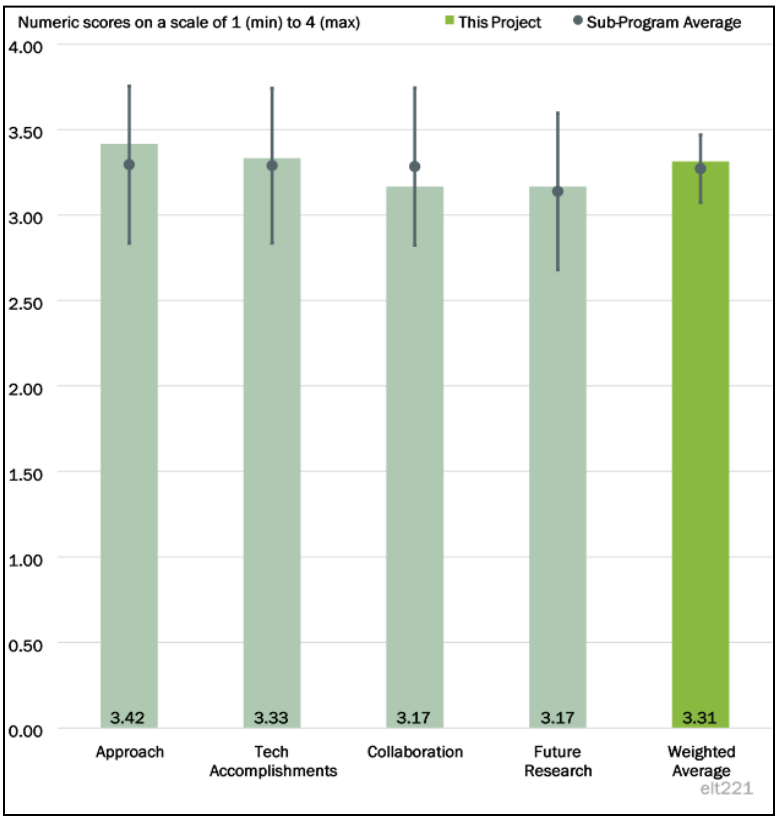

Figure 4-23 - Presentation Number: elt221 Presentation Title: Integrated Electric Drive System Principal Investigator: Shajjad Chowdhury (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer indicated that the approach and outline of the parameters are well understood.

Reviewer 2:

The reviewer stated that this is an important piece of the Keystone project.

Reviewer 3:

The reviewer noted a very interesting approach with putting together each of the unique approaches from ELT209 and ELT212 as one integration project, ELT221.

Reviewer 4:

The reviewer indicated that the approach to performing the work was well done.

Reviewer 5:

The reviewer stated that the proposed technical approach is sound and includes thermal analysis, electrical analysis, reliability, and performance benchmarking of capacitors and includes new packaging approaches.

Reviewer 6:

The reviewer said that the approach is addressing the component variations of this combined system to ensure compliance. The critical attributes are being evaluated and properly addressed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the capacitor study is very important. The comparative evaluation, characterization, packaging design, and layout design are all very informative. It would be great if capacitor piece-to-piece variation sensitivity estimation would also be carried out, because so many capacitors being put together. A slight characteristics variation could end up with unexpected hot-spot and/or current sharing imbalance.

Reviewer 2:

The reviewer stated that the design and data that were provided were presented clearly in outline format in the AMR presentation. The reviewer is interested in how the final design will perform.

Reviewer 3:

The reviewer said that the team has showed significant progress toward the overall objectives. The number of publications and patents is evidence of progress toward objectives.

Reviewer 4:

The reviewer observed that the packaging and characterization is progressing on schedule with positive results.

Reviewer 5:

The reviewer commented that the project seems to be making good progress and appears to be on track.

Reviewer 6:

The reviewer called the project well done on technical accomplishments and progress but suggested that it would be good to see a summary of the progress versus the plan.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer really liked this Keystone project where collaboration is essential.

Reviewer 2:

The reviewer stated that the national laboratories collaboration is good. It would be even better if university and industry collaborators would be there.

Reviewer 3:

The reviewer remarked that the information provided demonstrated the collaboration and coordination across project team.

Reviewer 4:

The reviewer stated that the collaboration is clearer in this project than in others presented. The reviewer recommended engaging the Ames Laboratory team more strongly in these efforts moving forward.

Reviewer 5:

The reviewer indicated that the ORNL and NREL have close coordination. There was no detail regarding the effort of SNL and Ames Laboratory for their contributions or status.

Reviewer 6:

The reviewer stated that a high-level overview of the type of collaborations was provided. The reviewer emphatically stated that there is a need to show more specific and details and how they measure against the project objectives.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer remarked that the continuing component level (substrate, capacitor boards, and current sensors) study is certainly important for the integration coming afterward. The reviewer was looking forward to hearing about the three-phase inverter built and integrated into the motor of ELT212 beyond 2022.

Reviewer 2:

The reviewer stated that the project team seems to be managing their focus well.

Reviewer 3:

The reviewer remarked that this is a good list and indicated that it would also be good to see some detail of how the future plans will be accomplished outside of normal plan.

Reviewer 4:

The reviewer stated that the future plans are acceptable as proposed. Thermal management must be a key element of the solution.

Reviewer 5:

The reviewer remarked that the future plan is fine. There is a need to assure that the design is well tested under extreme operating conditions.

Reviewer 6:

The reviewer indicated that there was no information on how to move this project to production products. There is no participation or material from the vehicle OEM or a Tier 1 supplier to the OEM.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The project has promising applications and is consistent with the future outlook for electrification applications to optimize the systems performance.

Reviewer 2:

This is a very important Keystone project, and the reviewer expressed interest in seeing it work.

Reviewer 3:

This project is highly relevant for the challenging high-power density electric drive target of the EDT Consortium and U.S. DRIVE EETT. Hence, this project supports the overall DOE objectives accordingly.

Reviewer 4:

According to the reviewer, this project is required for future EV efficiency.

Reviewer 5:

The integrated drive concept offers substantial potential benefits for overall size, weight, and efficiency. The reviewer noted that this is an attractive project to be pursued for DOE VTO impacts.

Reviewer 6:

The reviewer commented that vehicle modules need to be more integrated and offer more options. This reduces vehicle complexity, weight, and cost of the system.

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

Reviewer 1:

The reviewer stated that the project seems to be sufficiently funded.

Reviewer 2:

According to the reviewer, the distribution of effort properly matches the capabilities from each lab.

Reviewer 3:

Based on Slide 2 of the AMR presentation, the reviewer understood that the available resources are sufficient.

Reviewer 4:

The reviewer asserted that the project appears to be following the plan.

Reviewer 5:

The reviewer said that the resources appear sufficient.

Reviewer 6:

The reviewer indicated that the project is consistent with the expected objective.

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 (Electric Power Research Institute)

Presenter

Watson Collins, Electric Power Research Institute

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.

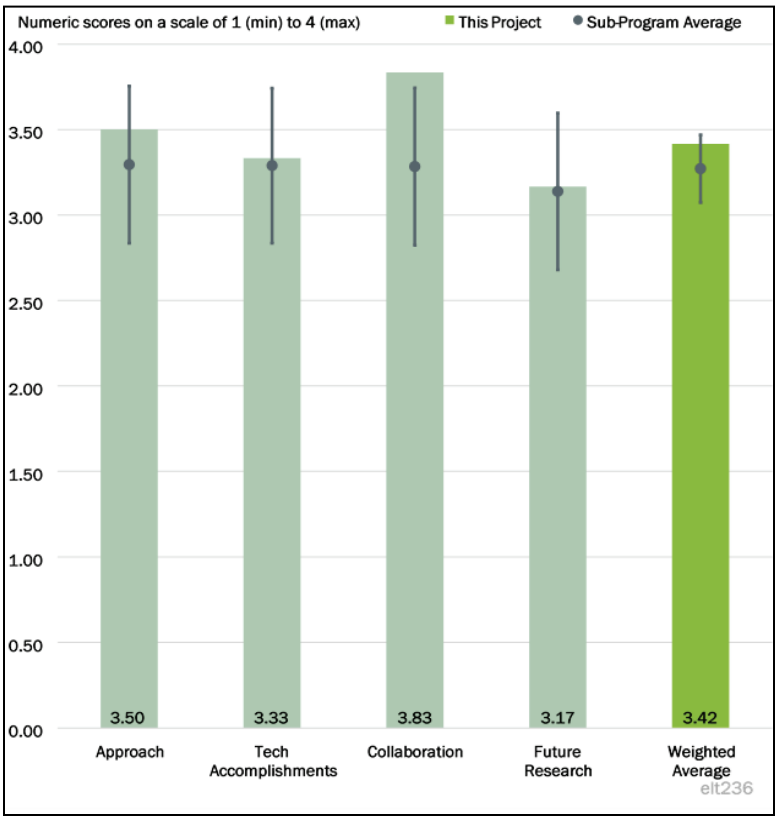

Figure 4-24 - Presentation Number: elt236 Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture Principal Investigator: Watson Collins (Electric Power Research Institute)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the approach is outstanding. The reviewer thought that the highlight of this project is really looking into and optimizing the utility interface and DC load center design. These items are not typically being focused on by other research projects.

Reviewer 2:

The reviewer stated that this seems to be a very logical process to develop the conversion hardware described. A higher rating on Approach could have been earned if there had been more information on the design decisions that were made and why they were made. This knowledge could be more easily transferred to industry after the project concludes.

Reviewer 3:

The reviewer observed an appropriate approach—develop the technology, verify operation, and demonstrate systems at utility partner sites. The approach does not appear to include efforts to estimate the potential cost benefits or increase for the technology nor which entity and/or stakeholder is affected (utility, service provider, equipment manufacturer, etc.).

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the technical accomplishments and progress are excellent. Good progress has been made on the utility interface and the DC load center design. The 40-kW cell and the DC-DC head-end unit seem to be ready last year. The reviewer is looking forward to seeing the medium voltage converter rack, with all the 11 cells, installed and tested and the same for the DC-DC head-end unit, with all the 14 units, installed and tested.

Reviewer 2:

The reviewer remarked that the progress has shown completion and operational verification of the prototype power cells and DC-DC modules, but performance metrics are not shown. Did the components and sub-systems meet the anticipated performance and efficiency requirements? The progress of the DC metering, controls of the multiple DC stages, and the integration (control communications) with various DC loads or DER sources is unclear.

Reviewer 3:

The reviewer stated that it is hard to judge this dimension because the project is not complete. The project will have a better evaluation once there are data showing performance of the planned system versus the actual hardware.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the collaborations among EPRI, Eaton, Tritium, NREL, and ANL are great. Each team member has a very clear deliverable and unique contribution to the final objective.

Reviewer 2:

The reviewer said that the project team brings together the appropriate partners to successfully develop, deploy, and demonstrate this technology.

Reviewer 3:

The reviewer remarked that the team looks very solid and had no issues. Again, it was hard to judge because the reviewer only heard from one of the team members.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer did not know if the project team thinks the "comprehensive system testing at NREL" is part of the proposed future research, but the reviewer gave "outstanding" basically for this proposed testing plan. It looks like the team has a thorough plan and will test and verify Institute of Electrical and Electronics Engineers (IEEE) 1547, IEEE 519, SAE J2894, and IEEE 1668-2017. These are very useful and informative investigations, which are very industrial oriented, and was highly appreciated by this reviewer. Additionally, the reviewer really looked forward to the testing results/waveforms that demonstrate the charger's performance and prove that it satisfies all standard requirements.

Reviewer 2:

The future research is appropriate for the completion of the development and demonstration of the technology. The reviewer was confused because the "Future Work" slide is labeled as FY 2021, which is 65% completed at the time of presentation; perhaps, the slide is mislabeled and should say FY 2022?

Reviewer 3:

The work that was planned out seems satisfactory. What would be helpful is to plan the future—estimate how industry will use the output of this project when it is completed. The reviewer asked what is the technology transfer plan to get this integrated into industry?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

Improving the efficiency, robustness, and cost of high-power EV charging infrastructure is directly aligned with DOE objectives.

Reviewer 2:

This project supports the overall DOE objectives.

Reviewer 3:

The reviewer stated that one goal of DOE is to make that certain battery electric vehicles (BEVs) can be integrated with the electrical grid efficiently. This project will create hardware to support that goal. The only issue that is not clear is what is the main problem being solved? It was unclear to this reviewer whether the project will "just" create hardware, or whether it evaluates the different designs possible to determine the "best" one.

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

Reviewer 1:

The resources are appropriate for completion of the development and demonstration of this technology.

Reviewer 2:

The resources are sufficient.

Reviewer 3:

The reviewer heard no issues with the resources.

Presentation Number: elt237
Presentation Title: Enabling Extreme Fast Charging with Energy Storage
Principal Investigator: Jonathan Kimball (Missouri S&T)

Presenter

Jonathan Kimball, Missouri S&T

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.

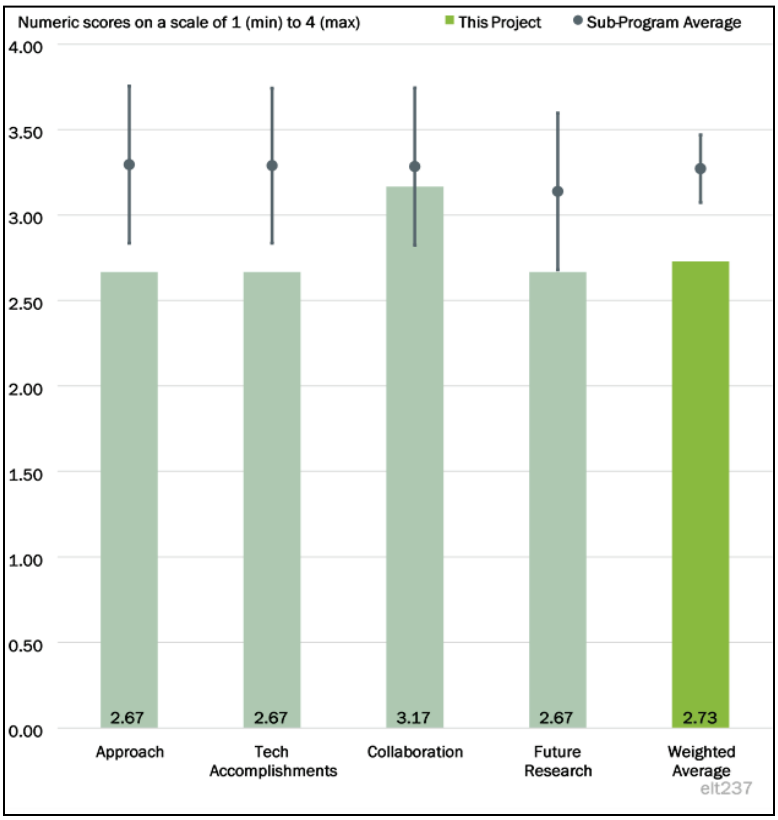

Figure 4-25 - Presentation Number: elt237 Presentation Title: Enabling Extreme Fast Charging with Energy Storage Principal Investigator: Jonathan Kimball (Missouri S&T)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that the project seems to be on track but would like to see the contributions highlighted.

Reviewer 2:

The reviewer stated that the development work for algorithms based on simulations looks well thought out. A key concern that lowered the reviewer rating for "Approach" is the development plan for the stacked inverter structure. Referencing previous work, the practical "stacking" of inverter modules that alone cannot standoff the voltage applied across the stack is very challenging. The work presented did not seem to address packaging and design issues that will arise with the overall inverter structure. The reviewer was very pleased to see that the project team has a vendor partner, Bitrode, with packaging experience. It was not clear if Bitrode has medium-voltage (15 kilovolt [kV] class) experience. The project appears to have a large volume of work to complete over the next year to meet all milestones—battery design, electrical hardware assembly, and lab validation of the hardware.

Reviewer 3:

The reviewer remarked that it is unclear why the project is developing its own vehicle battery packs. This is the exclusive domain of vehicle OEMs. The fast charger, regardless of whether it has its own energy storage or not, will take commands from the vehicle to control charge. Many other projects are looking specifically at battery operation in XFC duty. The reviewer encouraged the project to focus on the power electronics and do more of the good work performed on uncertainty modeling.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

It was noted that COVID-19 had impacted component availability to the project—this may have delayed inverter design and construction testing. As noted previously, the reviewer did not see much supporting work for the inverter construction and module integration. There did appear to be clear packaging plans based on the Bitrode cabinet. It looked like the control algorithm supporting work was well thought out and supported with simulations. A key concern is, again, the MV front-end design and construction.

Reviewer 2:

The reviewer said that it seems that some data on battery aging were collected, though this may be already well researched phenomena.

Reviewer 3:

The reviewer remarked that the project is nearing 60% of the proposed schedule consumed, but is showing only 35% complete (apparently based on expenditures to date). The reviewer would agree with the 35% complete, as the full-scale implementation will be time and resource consuming. The concern is whether there will there be sufficient schedule to complete the project. The footnote on Slide 5, "Any proposed future work is subject to change based on funding levels," adds additional concern.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that it appears that Missouri University of Science and Technology (Missouri S&T) has done an excellent job of working with project partners based on the material presented. The LG Chem battery design looked to be progressing well and is the packaging layout and design with Bitrode for the inverter assemblies.

Reviewer 2:

The reviewer indicated that the greatest collaboration requirements will be with Bitrode and Ameren as a full-scale system is implemented in BP 3. Collaboration with LG Chem seems to be good, with batteries obtained and testing underway.

Reviewer 3:

The reviewer indicated that a high-level workflow breakdown was never presented by the project team.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the project plan looks reasonable. The key concern is that the topic area is broad with many elements for the project still in their early design phases. There remain a large number of elements that must be completed for a full-up system test with the full front-end operating from MV with a live battery system.

Reviewer 2:

The reviewer stated that the contribution is somehow questionable.

Reviewer 3:

The reviewer said that the project barriers listed are more the inverse of the project objectives than specific barriers that must be addressed to complete BP 2 and BP 3 scope. The full-scale implementation in BP 3 will be a significant challenge. However, no plans were presented for the scale-up or for the conduct of testing.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the development of lower cost and more reliable approaches to provide for high power charging will be critical to widespread deployment of EVs, especially in applications like fleets of MD and HD vehicles. These are likely to require high power charging where tight integration with the distribution grid will be critical to control cost and make systems reliable. Forward-looking work like that being funded in this project is likely to be very valuable to future EV charging applications.

Reviewer 2:

The reviewer said that the Is not an interesting and very important topic, however given that the project has been running two years already, the reviewer expected some more progress.

Reviewer 3:

The work on uncertainty modeling and power conversion is very supportive of DOE objectives. As the reviewer previously stated, work on vehicle battery charging and pack design is not relevant to DOE objectives outside a vehicle OEM environment (e.g., United States Council for Automotive Research [USCAR]).

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

Reviewer 1:

The reviewer stated that the project team has shown reasonable progress over the first portion of the project, indicating that resources have been sufficient to complete the work.

Reviewer 2:

The reviewer said that the project seems to be well funded.

Reviewer 3:

The reviewer noted that Missouri S&T resources have been sufficient to this point in the project. The Bitrode and Ameren resources will be tested in BP 3.

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 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.

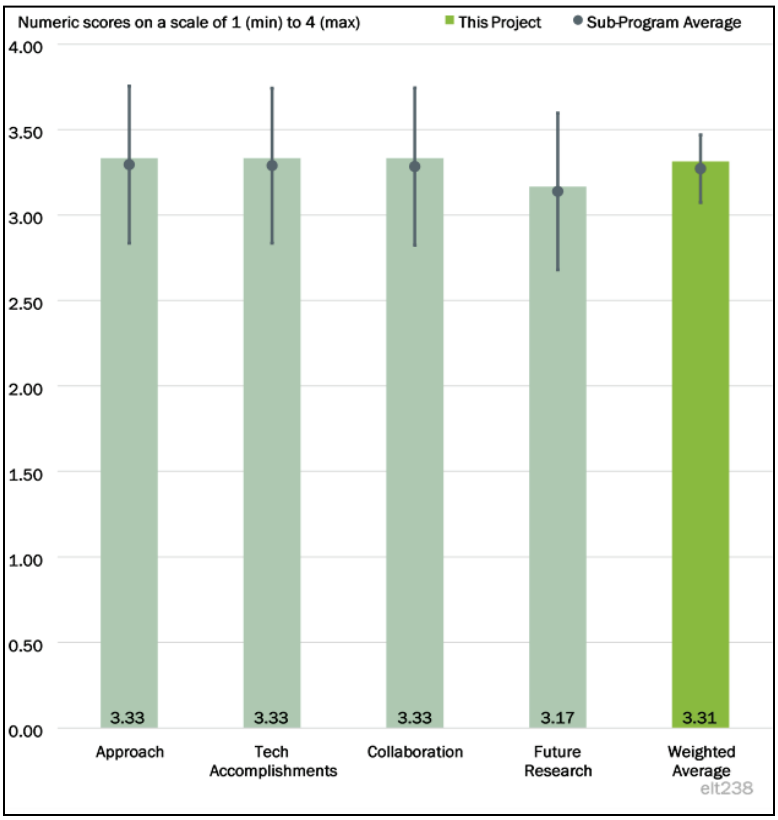

Figure 4-26 - Presentation Number: elt238 Presentation Title: Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State Direct-Current Protection Principal Investigator: Srdjan Lukic (North Carolina State University)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that this project approach is outstanding.

Reviewer 2:

The reviewer stated that the approach seems reasonable. It was not perfectly clear in the presentation (but the Q&A did help a bit) about the use of solid-state relays and their origin. The basic approach seems to be to design into this project's EVSE solid-state relays that were already developed by industry.

Reviewer 3:

The reviewer stated that the barriers are directly addressed through the development, evaluation, and demonstration of MV to DC charging and DC protection. It is unclear if the XFC nodes are being developed in this project or are being sourced, which may be problematic due to availability of XFC designed for the DC source. The potential cost increase or decrease is very important yet does not appear to be within the scope of the project.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer remarked that the technical accomplishment and progress are outstanding. The solid-state transformer (SST) with a scaled-down version has been designed and built to provide insight for the final full power design. The startup and load change testing done on this scaled-down version also shows that the team is carefully thinking through the possible scenarios that could happen in the field and is timing each individual step effectively, verifying its functionality, and applying protections. The final 1 megavolt-ampere (MVA) SST has been further optimized and is under single module construction and testing. To achieve the final goal within the planned time is very promising.

Additionally, the DC solid-state circuit breaker has been demonstrated with very thorough and detailed testing results. It is a very promising technology that will be commercially available in the near future by ABB.

A site location has been chosen and is under preparation. The reviewer was really looking forward to the final field demonstration and data collection.

Reviewer 2:

The reviewer stated that good technical accomplishments are presented showing the evaluation of prototype MV SST to DC bus. The transient startup operation is detailed. However, it is unclear if the prototype hardware meets the expected efficiency and performance goals.

Reviewer 3:

The reviewer said that the PowerPoint charts on the Representative Tests Passed and System Test Passed were very helpful in evaluating this project in this dimension. What is missing, however, is the linkage back to existing technology—how does the new design compare with non-solid-state devices? What is the interruption speed of the new technology in the tests versus the "benchmark" for mechanical relays? The score provided might improve with a comparison chart for technical performance.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the collaboration is outstanding. North Carolina State University (NCSU)utilizes their expertise to push the SST to another level by deploying it to New York Port Authority (NYPA) site. ABB has pushed the DC solid-state circuit breaker to commercialization.

Reviewer 2:

The reviewer said that the team brings together the necessary organizations to design, develop, evaluate, and demonstrate the technology at an approximate 1-MW scale.

Reviewer 3:

Certainly, there is a strong existing team working on this project. Since the goal is to improve EVSE technology, the reviewer suggested that it would be good if there were additional participants in the area of EVSE design and manufacturing. It might also be helpful to include charge point operators on the team to get requirements from that segment of the industry.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

What is left in this project is system integration, deployment, and data collection, and the reviewer agreed with the team's excellent plan.

Reviewer 2:

The reviewer said that the proposed future research of system integration and deployment and demonstration will be very important and beneficial to validate the benefits of this technology and potentially identify any areas of additional refinement and/or improvement.

Reviewer 3:

The reviewer stated that the site preparatory work seems well planned and executed, with the goal of making hardware installation proceed very efficiently. The reviewer would have liked to see what went into the selection criteria because the photo on the slide shows the site to be fairly remote. The Milestones slide only gave limited insight into planned BP 3 work.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that reducing the number of conversion stages from the utility distribution feeder to the EV charging infrastructure directly supports DOE objectives.

Reviewer 2:

The reviewer said that this project is relevant to the overall DOE objectives.

Reviewer 3:

The reviewer stated that this project is borderline on relevance, likely because little data were shared on why the planned design is an improvement over existing technology. Perhaps this was discussed in last year's review. It certainly needs to be addressed as part of the final project review. How does this project reduce costs for the final EV driver or improve electrical efficiency? If additional data were provided, this project could definitively be classified as supporting DOE objectives.

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

Reviewer 1:

The reviewer said that the resources are sufficient given the size, capacity, and power level of the technology being developed and demonstrated at full power (approximately 1 MW).

Reviewer 2:

The reviewer said that the project results show that the team has sufficient resources.

Reviewer 3:

The reviewer stated that this project seems to be one of many that have been, and/or continue to be, impacted by COVID-19. Other than by this cause, no resource issues were identified.

Presentation Number: elt239
Presentation Title: High-Power Inductive Charging System Development and Integration for Mobility
Principal Investigator: Omer Onar (Oak Ridge National Laboratory)

Presenter

Omer Onar, 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.

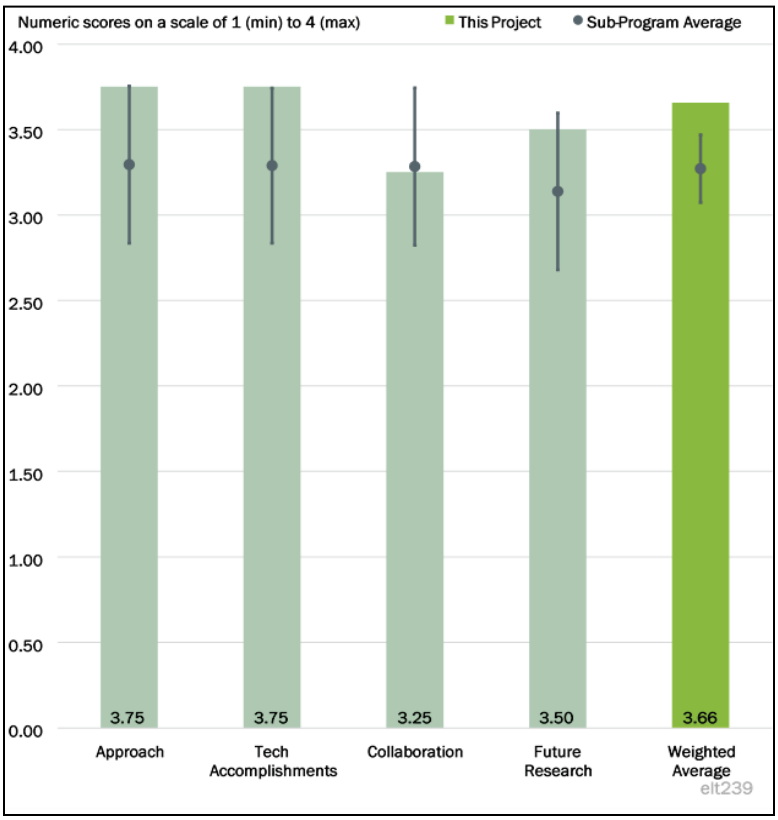

Figure 4-27 - Presentation Number: elt239 Presentation Title: High-Power Inductive Charging System Development and Integration for Mobility Principal Investigator: Omer Onar (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer loved it and emphatically stated that this is an excellent project.

Reviewer 2:

The reviewer stated that the approach is outstanding. The system is scalable. The proposed topology and polyphase coupler both are contributing to the optimized design, with minimum DC link capacitance, lower current ripples, and higher power density. The reviewer was curious about whether the project team should use liquid cooled capacitors for the resonant capacitor in all the wireless power transfer applications. Will that be the trend?

Reviewer 3:

The reviewer observed that the project's approach appears very solid, with an appropriately methodical path laid out to accomplish the project's objectives, particularly as related to testing needs. The project focused first on design, modeling, simulation, and analysis, then building the systems, followed by integrating the systems and conducting testing and data collection. This clear approach was then specifically followed to accomplish planned activities, despite the EVSE manufacturer pulling out of the project.

Reviewer 4:

The reviewer stated that this project sought to address the following barriers—operating efficiencies over 90% and charge rates of 100 kW and 270 kW. The project approach was an iterative process of design, analysis, modeling, simulation, testing, validation, and integration. The approach seems to be working as the project is achieving overall efficiencies greater than 90%.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer noted a tremendous amount of accomplishment and would love to see the results of the testing. The reviewer asked the project team to please include cybersecurity as the project team design this, including the micro components.

Reviewer 2:

The reviewer stated that the project has accomplished a great deal, basically exactly what it said it would at the beginning and then some. Efficiencies so far appear to be over 95% (compared to original objective of over 90%). It will be interesting to see if the efficiency holds once the systems are integrated into vehicles and tested. The project, if fully successful when completed, will demonstrate a significant increase in surface power density. It has also developed key knowledge in a number of inductive charging areas that will be of significant use to other projects. The accomplishments of the project are even more impressive given that the original EVSE manufacturer pulled out of the project. Due to COVID-19-related delays, it appears the project will require about a 6-month extension from the original schedule.

Reviewer 3:

The reviewer stated that the progress and accomplishments of this project are tremendous. A great amount of work has been carried out, and the proposed topology and winding structure seem very attractive.

Reviewer 4:

The reviewer said that the PI presented several accomplishments and provided the case for how those accomplishments were moving the project closer to the end goal. At the time of the presentation, the project was in the process of completing bench top tests and appears to be on track for performing vehicle integrations and preparing demonstrations at the two power levels.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the collaboration among the partners seems to be less than in the other projects, but that is understandable, so the reviewer rated collaboration as excellent. Different projects will have different weights on each collaborator. This project is mainly relying on ORNL to develop and demonstrate this high-power wireless charging system technology to the OEMs.

Reviewer 2:

The reviewer remarked that the project is led by ORNL and includes two vehicle manufacturers. The vehicle OEMs appear to be fully on board with the project. It was a bit surprising that there is not an EV charger company on-board, but the PI indicated the original EVSE partner pulled out of the project after it started. It would be good for further projects to include charger manufacturing input. The PI indicated the team is looking for a manufacturer partner for future efforts.

Reviewer 3:

The reviewer remarked that the laboratory included on its team two OEMs to ensure that the system was interoperable. The team however seemed to be lacking an industrial partner that would be able to scale the

solution. The PI candidly explained that while ChargePoint was originally a partner, the company has not been able to participate due to COVID-19-related financial reasons. This type of challenge could not have been foreseen, but it would have been good to hear more about how the team was mitigating the risk associated with the missing partner's participation.

Reviewer 4:

The reviewer said that the once the project team gets into test mode with the OEMs, it will see how the collaboration actually worked. The reviewer expressed concern about EMC shielding on the vehicle, on the charger, and on the user.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the PI indicated the project team is looking to next move toward 600-kW and 1-MW systems, which would match with the needs of MD and HD EVs. This is highly appropriate as there is currently more interest in inductive charging for HD vehicles, particularly transit buses.

Reviewer 2:

The reviewer stated that the future research proposed by the team is to integrate the design in the two vehicles provided by the two OEMs. That is definitely an important step toward demonstrating the effectiveness of the design.

Reviewer 3:

The reviewer stated that the proposed future work is the vehicle validation at the two power levels. That is the logical step needed to confirm that the design is capable of operating on a road vehicle and outside a laboratory environment.

Reviewer 4:

The reviewer emphatically stated a desire to see the outcome and testing of this, as noted previously. The reviewer expressed concern about "cybersecurity" being designed in, as well as EMC concerns all around. The reviewer thought that more future needs will be seen once the project team tests, and encouraged the team to have a Red Team hack.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer enthusiastically said, yes, and was excited about XFC from an EV charging standpoint. However, the reviewer cautioned that many concerns need to be addressed to "hit production."

Reviewer 2:

The reviewer said that the project is focused on high-power inductive charging for EVs, an area that may be critical for certain EV applications as market penetrations increase.

Reviewer 3:

According to the reviewer, the project is definitely relevant to the DOE objectives.

Reviewer 4:

Wireless charging technology provides more options for EVs by making them accessible to other categories of consumers. The reviewer indicated that this project improves EV accessibility by enabling XFC.

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

Reviewer 1:

The reviewer stated that the project resources were adequate for the development of a wireless charging system.

Reviewer 2:

The reviewer indicated that the resources appear sufficient to complete the originally planned activities, though it appears there will be a 6-month, no-cost time extension required.

Reviewer 3:

It seems like the project team is making good progress. Again, the reviewer expressed concern as the project team goes to "test."

Reviewer 4:

The reviewer remarked that the resources are sufficient, but the team could include a charging operator or a charging equipment manufacturer in this project.

Presentation Number: elt240
Presentation Title: Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks)
Principal Investigator: Mike Masquelier (WAVE)

Presenter

Mike Masquelier, WAVE

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.

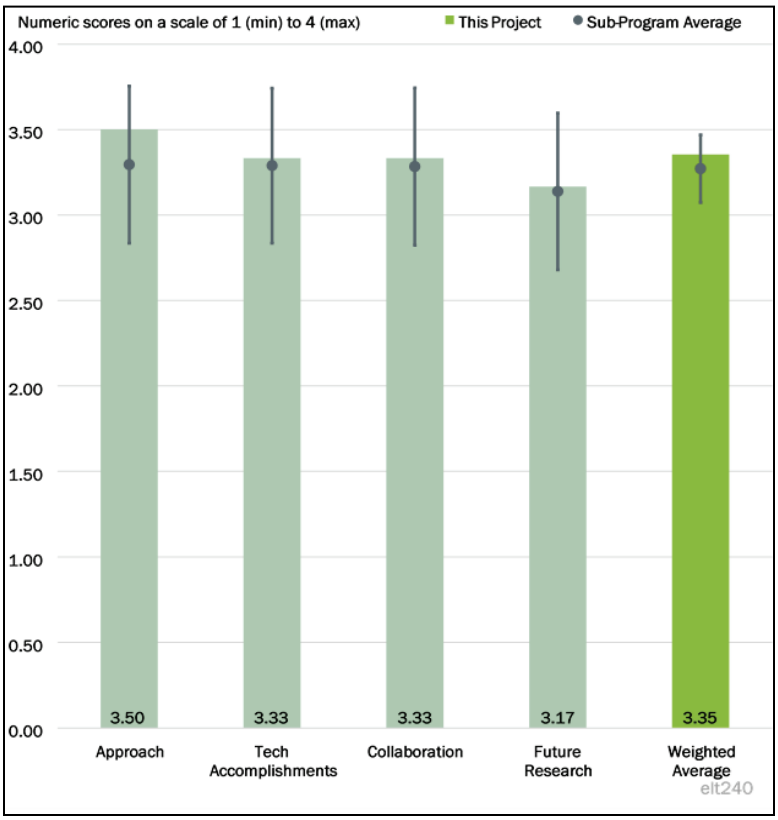

Figure 4-28 - Presentation Number: elt240 Presentation Title: Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks) Principal Investigator: Mike Masquelier (WAVE)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the project is very well designed and integrates multiple advances into the project systems. It increases the performance envelope of wireless charging systems, applies an advanced HD truck powertrain, and MV grid power supply technology to enable HD vehicle electrification.

Reviewer 2:

The reviewer observed that the approach to the work is well underway, and the right players are involved to make the project a success. Good progress is being made relative to objectives. The reviewer would have liked to see some more details on the feasibility versus the project goals, specifically on a breakdown of anticipated hardware costs versus targets for both charging pad and the vehicle-based hardware. Perhaps these could be presented in way that would not reveal proprietary information.

Reviewer 3:

The reviewer stated that the team seems to have had several technical challenges but has managed to find solutions that should meet the TTSI targets for the truck. The reviewer questioned the project team with respect to the design approach, particularly the use of passive battery cooling. This team has the luxury of knowing the exact duty cycle in which the truck will operate and was able to make the decision to use passive cooling because their analysis shows it is sufficient for this duty cycle. Given time and budget constraints and the project goal, this is a logical decision, but it may not be the same one the project team would reach if the

project team had to design a more general drayage truck. This may be a trivial point because it is possible that adding active cooling is not a large step, but it left the reviewer wondering what other similar decisions were made elsewhere in the system design.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the design surpasses the target performance objectives in terms of vehicle range and duty cycle.

Reviewer 2:

The reviewer said that the rework of the power supply to compensate for not having MV input available obviously was a setback and the project team has a good workaround. It seems the feasibility of getting MV input to many trucking facilities could be a very big challenge to implementing this technology. Also, the reviewer was unclear about where the project team stands relative to the 92% efficiency goal from MV supply to vehicle battery pack—this seems like an admirable but very aggressive goal.

Reviewer 3:

The reviewer remarked that the team appears to have made good progress in the past year and has truck validation underway. However, it does appear the team is behind, and it is unclear how much system validation can be accomplished relative to what may have been planned at the beginning of the project.

The reviewer expressed a concern with respect to grid-to-battery efficiency. A 92% target feels ambitious—some DC-to-DC efficiency data were presented, but not much else. Modeling results and data from the 250-kW system would have been helpful.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer remarked that, from the presentation and discussion, it seems there is a good project team, and the collaboration and coordination are working well.

Reviewer 2:

The reviewer stated that the integration of the design progress reflects significant collaboration and coordination by the various partners.

Reviewer 3:

The reviewer stated that the presentation showed that the team is making good progress on many fronts, indicating that partners are now actively engaged though the site relocation indicates that this may not have been the case for the entire project.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The proposed future work makes sense for addressing the remaining barriers, according to the reviewer.

Reviewer 2:

The reviewer stated that it is not clear whether the proposed future research is intended to address remaining goals of this project or for other potential projects. The evaluation criteria are how the proposed work achieves the remaining objectives of this project.

Reviewer 3:

The reviewer remarked that the plan for future work looks good, although the discussion was not clear on overcoming some of the known barriers. As mentioned above, it is not clear where the project team is relative to the 92% efficiency goal. In addition, no plans to measure and address EMI concerns while charging and what that will take to address those concerns were provided by the project team. Another barrier mentioned was the land-based equipment footprint compared to the real estate necessary for the actual charging pads and parking area for the vehicle.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that this project paves the way for wireless MW charging in many other heavy-truck applications and is therefore very relevant.

Reviewer 2:

The reviewer stated that this project directly addresses DOE's objective to advance transportation electrification of HD vehicles.

Reviewer 3:

The reviewer observed that this project is totally in line with DOE objectives and is a critical part of implementing electrified vehicles in the larger commercial vehicle industry. The ability to minimize "fueling times" is critical to making BEVs of this size feasible to that particular population of vehicles.

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

Reviewer 1:

The reviewer stated that the resources appear to be sufficient at this time to meet the schedule milestones.

Reviewer 2:

The reviewer stated that the main resource that appears to be strained is the schedule timeline due to unanticipated delays in establishing the MV grid power supply.

Reviewer 3:

The reviewer stated that the team is making good progress on hardware design and the prototype builds. There is no detail with respect to actual spending versus planned spending at this point in the project, which is usually a good indicator of progress as well as whether sufficient resources remain. More details in this area would have been appreciated.

Presentation Number: elt241
Presentation Title: High-Efficiency, Medium-Voltage Input, Solid-State, Transformer-Based 400-kW/1000-V/400-A Extreme Fast Charger for Electric Vehicles
Principal Investigator: Charles Zhu (Delta Electronics)

Presenter

Charles Zhu, Delta Electronics

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.

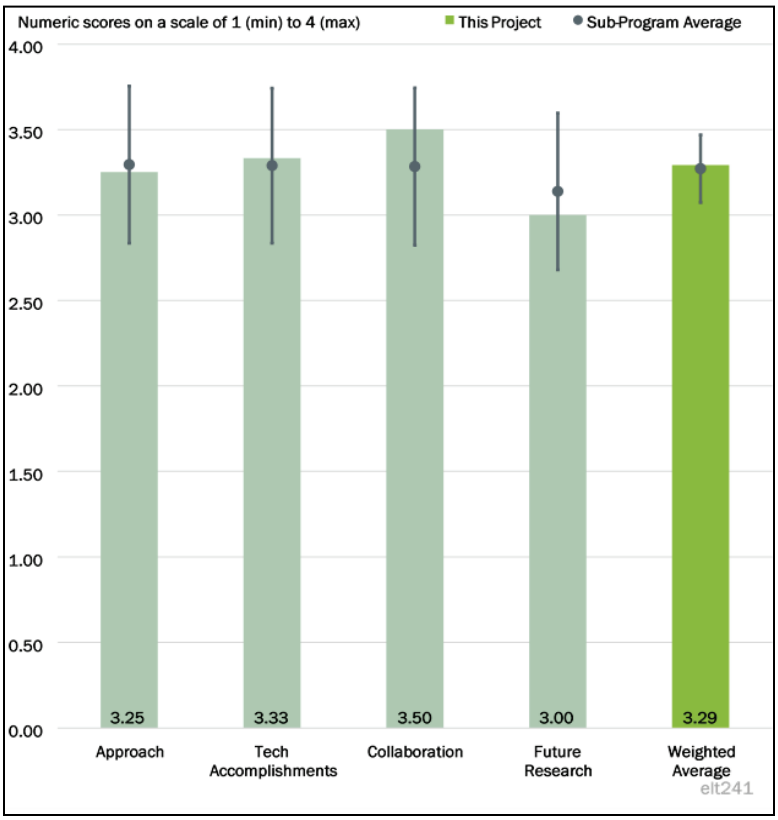

Figure 4-29 - Presentation Number: elt241 Presentation Title: High-Efficiency, Medium-Voltage Input, Solid-State, Transformer-Based 400-kW/1000-V/400-A Extreme Fast Charger for Electric Vehicles Principal Investigator: Charles Zhu (Delta Electronics)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer said that this is a fascinating project that is explained well.

Reviewer 2:

The reviewer stated that the project's approach has sequentially validated major elements at lower power levels while developing the higher power level system. The project team has successfully demonstrated at the 13.2-kV/400-kW level at end of 2020, beyond the original goal of 4.8 kV at that time. The project is on target to meet or exceed performance goals of 96% energy conversion efficiency. The project could be improved by also evaluating the efficiency of total energy use, including cooling systems and other loads.

Reviewer 3:

The reviewer commented that work on developing the SST has been well planned and executed. The SST barriers are well defined and being addressed, and Delta's experience is clearly coming into play here. No barriers were presented for the rechargeable energy storage system (RESS). It appeared to this reviewer that some very high temperatures are being experienced—positive contactor at 96.4˚ Celsius (C), MSD (1,2)/MSD Fuse (3,4) at 81.15˚C. These temperatures should be addressed if it intended that the pack configuration has some future value to partner General Motors (GM).

Reviewer 4:

The approach was clearly focused on accomplishing the objectives of the project—developing an efficient, smaller footprint and a lower cost, high-power EV charger system—although the PI admitted that the cost element will be left to future research. In order to prove successful operation, the project focused not only on the charger itself but also on ensuring that the test vehicle was adequately improved to handle the higher power.

Reviewer 5:

The reviewer suggested that the early charge rate (C) work selected (3C) (but no capability of the vehicle to charge at that rate) seems like more than a little oversight. Some additional partnership development would have gone a long way in the preparation for this work.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

Based on what was explained, the reviewer asserted that this is an excellent technical accomplishment. Of course, the devil is in the details and how well it works.

Reviewer 2:

The reviewer stated that the hardware, analysis, and testing have been on or ahead of schedule with respect to the stated plan. The project team has successfully demonstrated at 13.13.2-kV/400-kW level at the end of 2020, beyond the original goal of 4.8 kV at that time. The project is on target to meet or exceed performance goals of 96% energy conversion efficiency. The project could be improved by also evaluating the efficiency of total energy use, including cooling systems and other loads. Progress toward technical targets has not been impacted significantly by COVID-19 supply chain or work issues. A gap analysis of existing standards would benefit this project to clarify where current standards are insufficient for supporting this technology.

Reviewer 3:

The reviewer stated that the project team has appeared to accomplish a great deal, having demonstrated extremely high efficiency (greater than 95%) in the lab at very high power. A key element of this testing was the thermal testing, which was extremely detailed and thorough. The project team still has the final test and demonstration site work to complete and thus expects to complete the project perhaps a bit later than originally anticipated.

Reviewer 4:

Although sure that there were delays due to the pandemic, this reviewer indicated that the American Center for Mobility (ACM) development seemed to be a little behind schedule. This will impact and significantly reduce the amount of testing on the correct vehicle, which will be capable of accepting the higher charge rate. Are there plans for a no-cost time extension? There are good results provided on the power systems control and RESS build.

Reviewer 5:

The reviewer stated that the design and testing work on the 13.2-kV/ 400-kW solid-state system is excellent. RESS thermal has been completed in parallel with transformer testing. Planning for the final test is in place. However, the original project schedule end date is in jeopardy.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer emphatically stated that the project showed good collaboration to get this up and running thus far and to get to a test facility. The project team made it look easy.

Reviewer 2:
The reviewer said that all partners appear to be engaged, allowing transformer and vehicle work to proceed in parallel and planning for the demonstration site to proceed.

Reviewer 3:
The reviewer said that the project has demonstrated effective team participation, tapping a wide base of expertise that includes academia, test facilities, regional groups, suppliers, and a major OEM.

Reviewer 4:
The reviewer stated that the project team, led by Delta Electronics, includes a vehicle manufacturer, utility, university, energy office, and a city, and is providing an interesting breadth for the team. This does seem to include most of the necessary parties, though it would be good to have an organization on the team dedicated to technology transfer. The project team appears to have made very good use of its team members—GM to modify a vehicle and battery pack combination, a utility to conduct the testing, etc.

Reviewer 5:
The reviewer stated that again, with the exception of the early vehicle selection, there is a good group of partners capable of completing the research, though the timing will be difficult with the schedule of the test site.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:
The reviewer stated that the project is well positioned to conduct its demonstration test.

Reviewer 2:
The reviewer stated that the path to target for future work is appropriate. The project stated in the Q&A session that certification requirements would be a focus of the "next project. This project has had to work with existing standards framework. So, a gap analysis of existing standards would benefit this project to clarify where current standards are insufficient for supporting this technology and to help to scope the need for future projects. An example is the use of Combined Charging System (CCS1) connectors, which are not necessarily rated for higher power levels above 350 kW.

Reviewer 3:
The reviewer stated that this work could be relevant to standards creation, and this aspect should be explored.

Reviewer 4:
The reviewer stated that with COVID-19, there have been some delays, which mean there are several important activities still to complete. As for a next project, the PI indicated that the critical element is to drive down cost—the current unit is expensive. Not much future research was indicated beyond that, other than perhaps additional testing.

Reviewer 5:
The reviewer remarked that the project team just sort of stopped here in terms of getting a facility up and going and suggested there needs to be more thought here. What is the goal for testing? What are the concerns? At what point does the project team consider the project a "success"? Does a Red Team hack the project team from a cyber standpoint, all the way down to the board level?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer emphatically stated, absolutely, XFC needs to happen to make that EV recharge "fast." The project is very relevant to the overall DOE objectives.

Reviewer 2:

The reviewer said that this project directly supports DOE and the administrations goals of accelerating zero-emission vehicle adoption by demonstrating high energy conversion efficiencies with solid-state XFC equipment. Commercially viable technology must also be cost effective, but requires a proof of viability, which this project is accomplishing. This technology is applicable to light duty, MD, and HD commercial implementation of BEV charging infrastructure.

Reviewer 3:

The reviewer stated that this project is focused on high-power charging units, which are necessary to speed charging times. This will be important for greater deployment of EVs as drivers begin to expect charging times closer to refueling times for conventional vehicles.

Reviewer 4:

The reviewer stated that reducing losses in charging infrastructure and reducing the packaging footprint, eventual cost, and system complexity are all in alignment with VTO goals.

Reviewer 5:

The reviewer stated that the work on the SST is excellent and has clear future value for XFC. Little was said about the value of expending resources to modify a Bolt to accept XFC. The reviewer suggested that there be more discussion on the strategy of configuring Volt cells for XFC in a Bolt. It is not clear whether this has future value to partner GM.

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

Reviewer 1:

The reviewer emphatically stated good resources. The project team has made a lot of progress and explained this difficult technology quite well.

Reviewer 2:

The reviewer said that the project has effectively tapped the 50-50 cost-share with participants. The project is on track for completion in November 2021 within the original budget.

Reviewer 3:

The reviewer said that the project appears to be moving smoothly with the resources assigned. Additional (and different) resources will be required to construct the demonstration site. It appears these resources are available from partners DTE and NextEnergy.

Reviewer 4:

The reviewer said that the resources were sufficient as demonstrated by the eventual completion of the test site and vehicle modifications. Lack of testing results is a more time-based delay than a funding issue.

Reviewer 5:

The reviewer said that the resources appear sufficient to complete the originally planned work, although the PI did identify future work to build off of this project (including work on reducing system cost).

Presentation Number: elt257
Presentation Title: Directed Electric Charging of Transportation Using eXtreme Fast Charging (XFC) (DIRECT XFC)
Principal Investigator: Tim Pennington (Idaho National Laboratory)

Presenter

Tim Pennington, Idaho National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% 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.

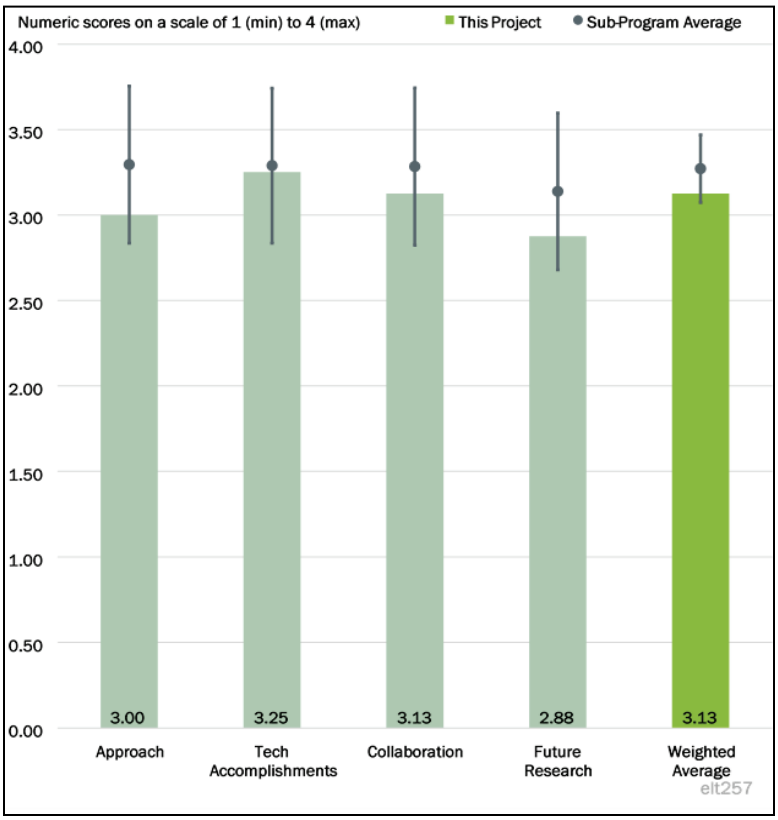

Figure 4-30 - Presentation Number: elt257 Presentation Title: Directed Electric Charging of Transportation Using eXtreme Fast Charging (XFC) (DIRECT XFC) Principal Investigator: Tim Pennington (Idaho National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the general approach is useful for simulation. There are no vehicle OEM, XFC charger companies, or city planners involved in this phase of the work. Validation of this methodology could be improved by incorporating some of their business processes and policy planning assumptions.

Reviewer 2:

The reviewer stated that this approach is good since it considers the baseline with no controls in the system and sequentially adds stationary storage, communication, and reservations for evaluation of result combinations. This also includes both AC and DC charging and fleet and private EVs. It however needs to identify how reservation may be used to reroute customers to less utilized locations as options to balance the energy supply and demand.

Reviewer 3:

The reviewer stated that it was not clear how the extra cost for XFC (over and above that for regular or overnight home recharging) was estimated. Even the need or want for XFC was unclear, and whether this is for a certain percentage of EVs. The assumptions should have been elucidated on a separate slide for everyone to see.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the PI met the technical accomplishments and satisfactorily progressed as measured by the performance indicators.

Reviewer 2:

The reviewer stated that the team has made substantial progress to objectives, given the challenges of 2020.

Reviewer 3:

The reviewer stated that the initial operation and approach are clear and seem to be on target. Expanding the reservation function and being able to broadcast that to customers seem to be the next steps.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the labs have variations to their expertise and their contribution is a good match to success of this project.

Reviewer 2:

The reviewer said that there were no real challenges in team partner coordination and collaboration, and further commented that all partners were DOE national laboratories.

Reviewer 3:

The reviewer said that the DOE partners seem to be very well coordinated on the technical aspects of this project. It is less clear how the coordination with non-DOE partners is functioning. More regular interaction could provide significant benefit to validation of the methodology. In addition, adding collaboration with vehicle OEMs and city planners in later phases could enhance the project outcome.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer said that no future research is needed on this topic.

Reviewer 2:

The reviewer stated that the data are expected to provide results to guide planning of grid usage and benefits of balancing stationary storage needs with communication and reservation requirements to meet EV charging needs. This needs to be balanced to either expand capacity at various sites or reroute customers to less used locations that still meet their travel needs.

Reviewer 3:
The reviewer said that the one key aspect that is not being addressed is in determining how this tool could be adopted into the marketplace, should it prove to address the major XFC adoption barriers.

Reviewer 4:
Not applicable was indicated by this reviewer.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:
The reviewer stated that the project supports DOE objectives for adoption of low carbon transportation.

Reviewer 2:
The reviewer stated that the project is very relevant since it provides information on how and where to add resources and communication at charging locations to meet customer travel needs.

Reviewer 3:
The reviewer stated that the need for XFC has not clearly been established. Even if it were, the cost justification was not presented.

Reviewer 4:
Not applicable was indicated by this reviewer.

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

Reviewer 1:
Resources to execute this project seem to be appropriate to deliver the objectives.

Reviewer 2:
These labs have the resources to accomplish this project goals and provide guidance on how to balance the grid and vehicle charging needs.

Reviewer 3:
The reviewer remarked that the expenditure of $3 million on a modeling project that benefits those who can afford the luxury of XFC is excessive and akin to building “Lexus Lanes” for those drivers who can afford to pay extravagant $40-50 tolls. The reviewer explained that this is the expression that state highway administrations are accused of.

Reviewer 4:
Not applicable was indicated by this reviewer.

Presentation Number: elt258
Presentation Title: Grid-Enhanced, Mobility-Integrated Network Infrastructures for Extreme Fast Charging (GEMINI-XFC)
Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

Presenter

Andrew Meintz, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% 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.

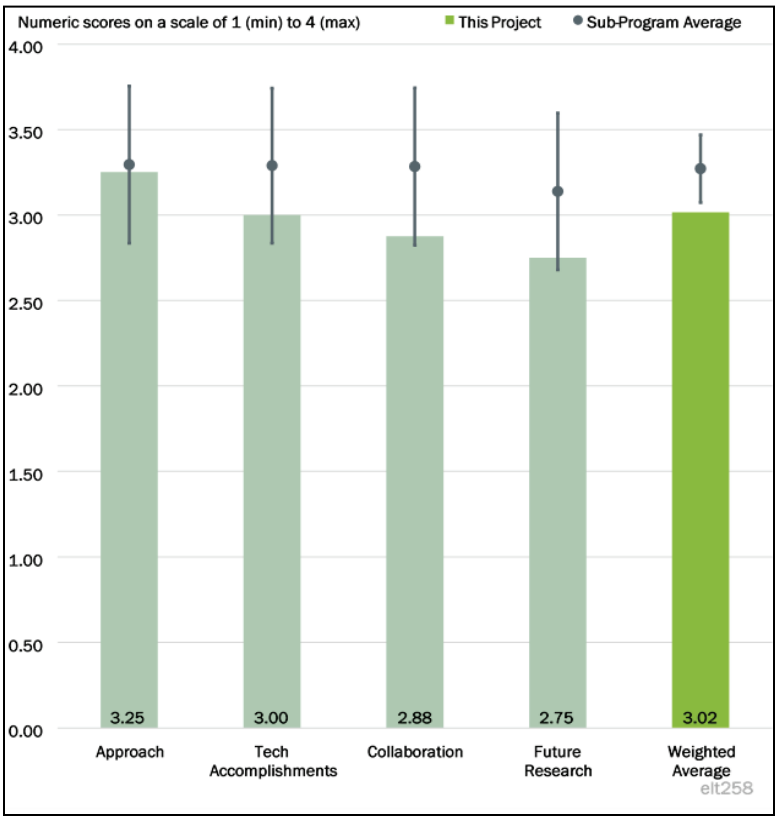

Figure 4-31 - Presentation Number: elt258 Presentation Title: Grid-Enhanced, Mobility-Integrated Network Infrastructures for Extreme Fast Charging (GEMINI-XFC) Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the project focus is on densely populated areas. This project also needs data from cities that have more space and options for other slower charge systems.

Reviewer 2:

This is a very wide-scale project with a very complex approach, making it difficult to explain in a short AMR presentation. The reviewer was glad the project will "leverage existing capabilities," but the slides did not give a clear picture of where existing resources end and where new capability will be developed. Time permitting, it would have been helpful if the investigators could have elaborated on a couple key points, like "EV route scheduling" or "Minutes for driving dynamics.

Reviewer 3:

The reviewer suggested that the approach could be improved as follows:

- Show that the TEMPO, BEAM, HELICS, and PyDSS models have been validated and/or verified. The reviewer had no assurance or confidence that these are valid models. If the project team has, please include that information in backup slides.
- Include commercial vehicles (trucks and buses) in the overall travel pattern.

- Establish the need/want for XFC and the cost justification for XFC. Certainly, there are, or will be, some that will need it. But what percentage of all the EVs, and what percentage of the time?
- Locating XFC stations will be affected by socioeconomic status (affluence). Thus, certain neighborhoods will be much more affected than others and, subsequently, power distribution will be much more affected in certain neighborhoods than others. Just owning an EV is discretionary—not a necessity. Even more so, both owning an EV and affording to pay a premium for XFC is definitely a luxury.
- Note that the pandemic has changed work-home travel patterns, such that there will be less travel and more work at home. This should be taken into account.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer said that the technical accomplishments and progress are satisfactory as measured against performance indicators.

Reviewer 2:

The reviewer stated that it was not always clear in the review what the inputs were to the simulation versus the outputs from the simulations. For example, it is assumed input to the simulation was that "charging for electrification of 1million vehicles (16% of the fleet)" while the output plots of power draw were shown on the right of the chart. Then, to complete the flow of logic, it would be good to explain or estimate how this information could be used by grid planners to improve utilization.

Reviewer 3:

The reviewer stated that this is still early in the project and more time and data are needed to validate the analysis.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that there were no real challenges. All the collaboration and coordination were among DOE national laboratories.

Reviewer 2:

The reviewer stated that the milestones need to show what lab is performing that function and, if both, then a percentage of effort needs to be included.

Reviewer 3:

The reviewer stated that this large of a project does require coordination across a large time. Based on the scope and the detail in the presentation, there seem to be no coordination issues. It is a bit surprising that there are not electric utilities on the team since the output from the project seems most applicable to this industry.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the investigators did include information on the AMR slides about future research within this project.

Reviewer 2:

The reviewer stated that as more extended range vehicles approach this market, their effect needs to be included. More time in this project will lead to a better conclusion on future research potentials.

Reviewer 3:

The reviewer stated that future research is needed to address the points made in response to "the technical accomplishments and progress are satisfactory as measured against performance indicators."

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that this project very directly supports several of the DOE's goals but is primarily aimed at efficient use of the grid to charge EVs.

Reviewer 2:

The reviewer stated that passenger cars may use more f XFC in highly populated areas, but their effect needs to be included in other, less densely populated cities.

Reviewer 3:

The reviewer expressed that this research is premature and far ahead of its time because neither the adoption rate of EVs nor the need or want for XFC are known. As mentioned previously, the costs of XFC have not been justified. The reviewer is of the humble opinion that XFC will benefit the affluent.

Reviewer 4:

Not applicable was indicated by this reviewer.

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

Reviewer 1:

The reviewer stated that the modeling tools are well defined, more results are needed to validate the predictions.

Reviewer 2:

The reviewer observed no issues or apparent negative impact of the COVID-19 pandemic.

Reviewer 3:

The reviewer considered that a budget of $3 million is excessive for a modeling project that looks at a speculative technology impact that is not needed until the future and will be used by a small percentage of primarily EV owners, benefiting the affluent.

Reviewer 4:

Not applicable was indicated by this reviewer.

Presentation Number: elt259
Presentation Title: Development and Commercialization of Heavy-Duty Battery Electric Trucks Under Diverse Climate Conditions
Principal Investigator: Marcus Malinosky (Daimler Trucks North America)

Presenter

Marcus Malinosky, Daimler Trucks North America

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.

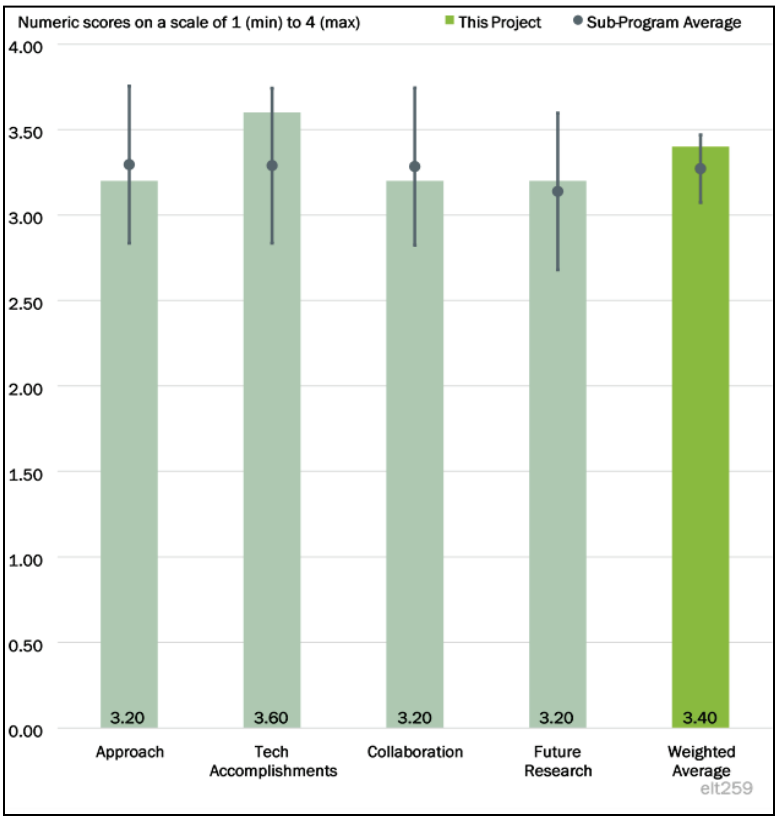

Figure 4-32 - Presentation Number: elt259 Presentation Title: Development and Commercialization of Heavy-Duty Battery Electric Trucks Under Diverse Climate Conditions Principal Investigator: Marcus Malinosky (Daimler Trucks North America)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the main objective seems to have been to demonstrate that an electric Class 7/8 truck could travel 250 miles in a day, and that was successfully achieved, so the project team was clearly doing the right things to get there. Actual road tests were crucial for identifying issues to be addressed in later models.

Reviewer 2:

The reviewer stated that the aspect of diverse climate conditions was not described extensively. The weatherization aspect of the research should be better represented. Additionally, is the 50 miles per hour (mph) speed assumed in the range analysis sufficiently high? It seems that the average speed may be higher based on the content of freeway driving in the various drive-cycle scenarios. It would be nice to see the actual speed-level content for the assumed drive cycles in this analysis.

Reviewer 3:

The approach to deliver a demonstration vehicle is reasonable. However, it appeared to the reviewer that the process taken may limit the ability to transfer to a high-volume design-for-manufacturability, design-for-service. Aspects' business approach was neglected in order to focus on the technical challenges.

Reviewer 4:

The reviewer remarked that the project is tied to commercial development efforts for HD EVs. As such, there are parallel activities going on that are contributing to progress but are outside the scope, funding, and control of this project. That said, this project is well on track in developing, validating, and entering commercial production of a Class 7/8 EV tractor capable of stated goals and timeline. The barriers and contingency work have been identified and proactive steps taken to mitigate issues and maintain schedule. Seasonal environmental and operational aspects of risk were not discussed in the review; however, the parallel commercial activities appear to be addressing validation through vehicles to be deployed in early fleets and a substantial number of early prototypes already fielded with fleets.

Reviewer 5:

The reviewer remarked that the stated barrier to adoption of Class 7/8 trucks is limited range and lack of full-line manufacturers. The primary barrier to range is battery technology. As described, this project does not place adequate emphasis or resources on understanding, designing, verifying, and improving battery technology. Very little information was given about battery pack and cell design, development, and testing. A secondary barrier is efficiency of the electric powertrain. Again, very little information was shared about what Daimler Trucks North America (DTNA) is doing to understand design factors that affect efficiency and exploit these to maximize efficiency. Finally, despite the project's title, very little information was provided on how the truck is being designed to ensure range, battery life, and system efficiency in diverse climates and at temperature extremes.

Good work has been done to understand customer use cases and set targets that meet customer needs in those cases. The philosophy of minimizing complexity of the electric powertrain and avoiding deviation from conventional truck design to the extent possible is a good one. This is a powerful means to avoiding reliability and durability problems.

The incorporation of accelerated component and system testing based on real-world data to replace on-road testing that was not possible due to COVID-19 is good, although the reviewer was surprised that this kind of accelerated component and system testing was not already part of DTNA's product development process and planned in this project. Based on the presenter's response to a reviewer question, it sounds like DTNA has much more design verification testing planned than was described (e.g., dynamometer testing by a subcontractor and by Daimler in Germany). More information should be shared next year about the comprehensive design verification plan.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that this project is ambitious and the progress, considering COVID-19-related delays, seems on track and notable.

Reviewer 2:

The reviewer stated that the team made substantial progress and was very creative in overcoming barriers of the 2020 pandemic.

Reviewer 3:

The reviewer stated that the team has stayed on schedule, despite challenges due to COVID-19, by carefully managing its supply chain, working hard to complete prototype builds with limited staff, and by applying sound, accelerated testing techniques.

Reviewer 4:

The reviewer remarked that the main performance indicators for this project were range, which has been achieved, and the corresponding fuel efficiency. Unfortunately, no estimates of the TCO were provided.

Reviewer 5:

Phase 1a and 1b progress was on track, including B sample build and testing, and C sample specification. Track and road testing has been conducted sufficient to have confidence in the next iteration of the vehicle to meet program performance targets. The reviewer would have liked to see more explanation of where duty-cycle profiles of actual real-world routes with EV trucks were obtained, to ensure that proving ground track and shaker table modeling were truly representative of these cycles. The parallel activities of launching and certifying a production, new model truck at an OEM are far beyond the budget and capability of this project, so it is challenging to determine what is specifically and actually part of this DOE project versus what is being done in parallel by the OEM and supply base. However, the milestone of commercializing a truck within the time frame of this project appears to be on track.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the DTNA team is leveraging significant internal resources well and has partnered with two relevant fleet partners.

Reviewer 2:

The reviewer said that the role of the project partners (besides shipping customers) was not particularly clear, but it looks like the majority of the work is being performed by the PI.

Reviewer 3:

The reviewer indicated that it is assumed that test runs with the trucks will be carried out by the partners; the presentation does not clarify which actions were carried out by which partners, but the reviewer assumed that on-road tests in actual operation on routes will be performed.

Reviewer 4:

The reviewer stated that the great collaboration and partnerships. Adding a partner to the team who could help to further expand the possible freight use cases via a generalized modeling approach (INL, ANL, and NREL for example) based on field data from the current partners could lend even further credence to the ability of a BEV to meet customer needs and expectations and potentially help speed the technology to market.

Reviewer 5:

The reviewer remarked that the project team has managed to stay on schedule, coordinating activities, and adapting to challenges presented by COVID-19-related supply chain shortages of equipment, materials, and labor. The team discussed is largely Daimler personnel and supply base. Industry group participation is inferred through Daimler, but was not specifically mentioned, so things like standards were not discussed as part of commercialization or market adoption. Also, no mention of DOE participation as either consultants or participants from DOE laboratories, where clearly there is expertise and potential assets and resources. Where this project is being assisted by or benefitting industry groups such as CharIN, SAE, IEEE, ISO, etc., should be detailed as part of the standards part of “commercialization.”

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the scope of the future work is good. It is expected that the diverse climate condition testing will be better addressed in future presentations to understand the performance of the system in real-world driving use cases.

Reviewer 2:

The trucks will be tested on actual routes. Presumably, range and fuel efficiency will be verified. The reviewer would have liked to see volume cost estimates and also more about the batteries. Will the batteries last?

Reviewer 3:

As stated above, adding another partner who could model even more use cases and validate field testing from the demonstration trucks could help to address adoption barriers. In addition, the reviewer suggested that addressing some challenges around depot charging scenarios may be valuable.

Reviewer 4:

The reviewer remarked that the project has been planned out and is in the process of procurement for C-sample vehicle and testing and the further refinement of the D-sample vehicle in BP 2. The project reports it is 70% complete as of AMR 2021. The remaining 30%, however, is tied to production start of a commercial product line at the OEM and testing for certification of the product; these activities are largely outside the direct control of this project. Additionally, the project specifically states that it will include diverse climate conditions, so winter and summer testing may need to be simulated in environmental test facilities and may not be validated in real-world fleet use in the timeframe of the project.

Reviewer 5:

The reviewer stated that the future plans include continuation of component procurement, design, prototype builds and integration, testing, fleet demonstration, and data collection—the standard (and appropriate) steps for a vehicle development project of this kind. However, details on future work are sparse. A design verification plan and plan for demonstration data collection and analysis, with emphasis on critical questions that need to be answered, should be developed.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the electrification of trucks will provide a major impact on the DOE mission of sustainable transportation and energy independence.

Reviewer 2:

The reviewer stated that in order to maximize U.S. displacement of diesel fuel by electricity, trucks must be electrified. That is non-trivial for local delivery fleets, but medium-range and long-haul trucking have issues with battery range, mass, and time to charge. This project demonstrates that medium-range trucks can practically be electrified.

Reviewer 3:

The reviewer stated that the project is highly relevant to the DOE objective for increasing adoption of low carbon transportation tools.

Reviewer 4:

The reviewer remarked that the project directly supports DOE and the administrations goals of accelerating zero- emission vehicle adoption for hauling freight by HD EV tractors by assisting in commercialization of a viable 250-mile range EV tractor below 20,000-pound tare weight. Many of the challenges to EVs by detractors can be quantifiably addressed with success of this project. Combined with other DOE projects in XFC, this project builds confidence that HD EV tractors can accomplish significant portions of freight hauling's duty cycle.

Reviewer 5:

The reviewer stated that developing the capability to produce long-range battery-electric class 7/8 trucks is core to DOE objectives for reducing the cost, energy consumption, and emissions of goods transport.

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

Reviewer 1:

The reviewer stated that the resources seem sufficient for the proposed future scope.

Reviewer 2:

The reviewer stated that it is hard to answer this, since there was no information about how many trucks were being built all together.

Reviewer 3:

The reviewer stated that the project is sufficiently budgeted to achieve the stated objectives.

Reviewer 4:

The reviewer remarked that the project did not report that budget was a limiting factor. Combined with the progress to date and the parallel activities of the OEM in ramping up a production line for EV tractors that are benefitting this project, the project appears to have sufficient resources to meet its technical objectives of commercializing an EV tractor. Whether the market will invest in the product is an unknown, but marketing is not part of the project, only bringing a capable performing product to market. A viable, competitive manufacturing cost for the truck does not appear to be a factor directly tied to this project, although relevant to commercial success.

Reviewer 5:

The reviewer remarked that the in light of the significant delays and hardships incurred by the COVID-19 pandemic, the project team may need more time to complete the project. The reviewer commended the team for their hard work and ingenuity to stay on schedule; the project team will undoubtedly continue to do all it can to remain on schedule, but it already has compressed schedules. Any additional delays may push completion later. Uncertainty due to supply chain shortages is a significant risk that may be beyond the team's control.

Presentation Number: elt260
Presentation Title: Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management
Principal Investigator: Teresa Taylor (Volvo)

Presenter

Teresa Taylor, 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.

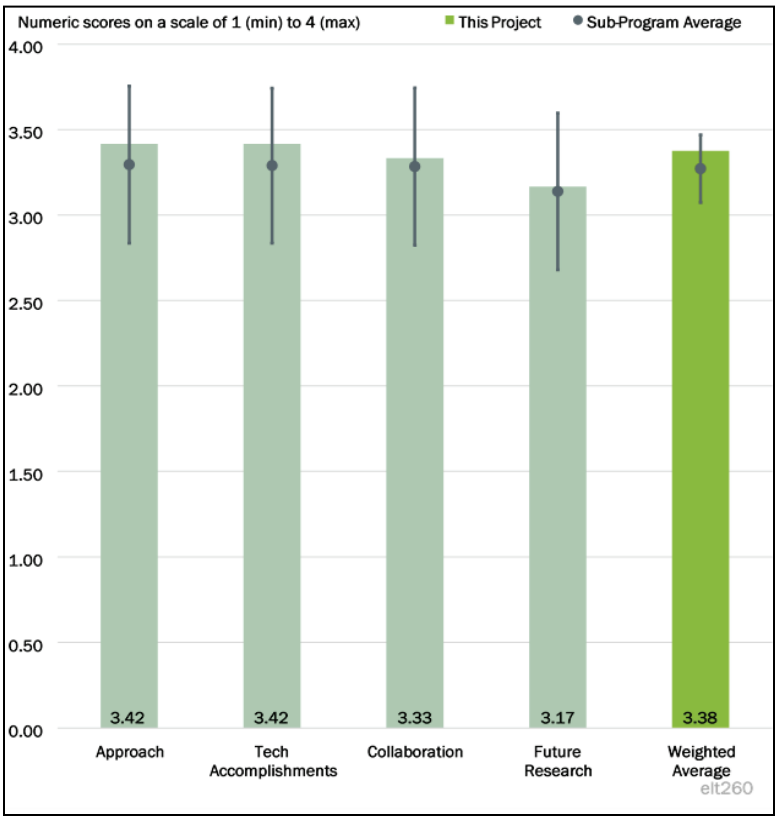

Figure 4-33 - Presentation Number: elt260 Presentation Title: Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management Principal Investigator: Teresa Taylor (Volvo)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer noted that the use of machine learning will enable this team to obtain the maximum performance from the two trucks the project team is acquiring. Not only will the trucks be able to maximize miles per charge, but the intelligent management system under development will enable optimal placement of the charging infrastructure to minimize charging time and number of stops, while not installing more stations than are required.

Reviewer 2:

The reviewer remarked that the project addresses EV adoption in MD and HD markets by studying current utilization and developing demonstration vehicle property and software to show feasibility. These steps are all needed to provide a convincing demonstration.

Reviewer 3:

The reviewer stated that, overall, the project and approach are relevant and interesting.

Reviewer 4:

The reviewer commented that the project is well planned and, given that it is near the end, expected that it will be completed. There is not a great deal of evidence in the budget details corresponding to deliverables and outcomes.

Reviewer 5:

The reviewer noted that the project will develop and demonstrate a driver-decision support tool for a HD battery-electric truck that recommends an energy-efficient route and recommends the minimum charging energy needed on-route to arrive at the truck's destination. Results will be compared to conventional diesel trucks and BEV trucks without decision support. The project will also develop a method for choosing optimal location for charging stations.

The project is using a machine learning algorithm recurrent neural network (RNN) to predict energy needed to complete the designated route and to recommend minimum charging energy required on-route to arrive at the destination; this is a novel and worthwhile approach. Likewise, the approach for energy-efficient routing (based on past data using a look-up table or based on model for trip links that have not been driven before using deep neural network (DNN) is good. Including a constrained budget in the charger placement optimization is important and often not included in academic research. Finally, the practice of validating the system in real-world demonstration using prototype human-machine interface and display in hot and cold climates using two trucks with different specifications (265 kWh and 565 kWh batteries) is excellent.

The reviewer suggested the following items for the project team to consider:

- The project will validate the developed energy consumption model against OEM model, which is good, but it should also validate the model against actual truck performance and energy consumption during the demonstration.
- The project's outcome will be limited if it cannot apply the routing algorithm to include re-routing for charging.
- Clarification of what demand data will be used for charger placement optimization is necessary. To be effective, a large set of trips will be needed.
- Comparing demonstration results to past BEV truck performance without decision support and to a conventional diesel truck will be difficult to accomplish in a meaningful way. More emphasis should be placed on the approach for this comparison and ultimate metrics by which success will be judged.

Reviewer 6:

The reviewer noted that the approach to this project focuses heavily on overcoming technical barriers. However, many barriers for adoption are related to behavior and economic factors. These have not been addressed in the model. Also, justification for the value of using trained neural net models instead of a heuristic modeling approach was not sufficiently described. Access to training and validation data and the expansion of this approach could be difficult for a more generalized solution.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the team has made good progress on the truck build and excellent progress on vehicle modeling and the energy management software aspects of eco-routing for delivery fleet EVs.

Reviewer 2:

The reviewer stated that the team made good progress toward achieving the planned activities of their project.

Reviewer 3:

The reviewer said that the project has accomplished its major analytical tasks on time, with successful outcomes demonstrated. Delays in hardware procurement are to be expected due to the COVID-19 pandemic.

Reviewer 4:
The reviewer stated that, luckily, the development of machine learning hardware and software and data acquisition were not impacted by the COVID-19 pandemic.

Reviewer 5:
The reviewer commented that there are good accomplishments to date on the project. It would be useful to put dates on the milestones. Some of the plots in the Accomplishments slides are difficult to read. On Slide 8, it is not clear if the SOC chart labels are flipped. On the same slide, the title for a couple of figures indicate that velocity is being plotted, but the units are labeled as "m."

Reviewer 6:
The reviewer said that, in the past few years, the reviewer has been seeing a decrease in evidence presented in these AMR reviews to confidently share that technical accomplishments have been made. Specifically, the reviewer expected to see more details in a waterfall chart on the improvements in freight efficiency.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer asserted that there is excellent collaboration between industry partners (fleet business and technology suppliers) and the academic team.

Reviewer 2:
The reviewer stated that good collaborations seem to be happening with the team members.

Reviewer 3:
The reviewer noted that both Volvo and the University of Minnesota have moved on to complete their tasks; the company partners are waiting in the wings to perform their parts as soon as the trucks are ready.

Reviewer 4:
The reviewer commented that the partnerships between academia and industry were good. However, there seemed to be limited interaction between the University of Minnesota and Volvo trucks. More regular interaction could contribute to improved understanding of real-world needs of industry partners by the university researchers, and the industry could gain better insights into the type of data needed by the models to reduce the need for training sets and increase prediction robustness for additional use cases.

Reviewer 5:
The reviewer stated that there seems little evidence to the claims made concerning industry engagement outside of the specific partners that are funded. The reviewer believed there should be more effort on fleet and other engagements in these programs.

Reviewer 6:
The reviewer observed that the organizations making up the team seem to be working mostly independently at this point in the project, with Volvo providing University of Minnesota data and guidance. Closer collaboration will be needed to succeed in the second half of the project to successfully plan and complete the demonstration, algorithm validations and improvements, and performance assessment.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the next steps are absolutely needed to demonstrate the project successfully and are well developed.

Reviewer 2:

The reviewer said that, overall, the proposed future research is good.

Reviewer 3:

The reviewer commented that the plans are good.

Reviewer 4:

The reviewer stated that all the calculations that have been done will form the basis for guiding the actual road tests. The theoretical work is interesting but does not mean a thing until vehicles are actually out on the road delivering freight under real-world conditions. So, the future work is key to proving the utility of the intelligent management.

Reviewer 5:

The reviewer said that most of the future work proposed is focused on model and algorithm improvement. The testing and demonstration phase needs to be much better defined to be successful.

Reviewer 6:

The reviewer remarked that overcoming barriers related to having sparse datasets will be a substantial challenge. It may benefit the project team to reach out to other organizations to help overcome this limitation, for example, local grid operators, charger operators, DOE labs (like ANL or NREL) who may have access to more travel data, and city planners who can help to understand policy and planning barriers to adoption of charging infrastructure, etc.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that the project is directly aligned with VTO goals and objectives. It is highly relevant and important work.

Reviewer 2:

The reviewer stated that the project contributes to the DOE goal of wider EV adoption to reduce GHG emissions. MD and HD trucks are challenging transport segments that produce significant carbon dioxide (CO_2).

Reviewer 3:

The reviewer said that the demonstration of electric trucks at medium range is a key step in electrification of transportation.

Reviewer 4:

The reviewer asserted that this project helps to support DOE objective for adoption of low carbon transportation solutions.

Reviewer 5:

The reviewer remarked that the improving productivity of HD EVs through intelligent energy management contributes to the overall DOE objectives of minimizing energy consumption.

Reviewer 6:

This reviewer indicated that this project very much supports the overall DOE objectives.

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

Reviewer 1:

The reviewer stated that the resources appear to be sufficient to complete the project based on current reporting from the project team.

Reviewer 2:

According to the reviewer, the budget seems appropriate.

Reviewer 3:

The reviewer said that the resources appear to be sufficient.

Reviewer 4:

Resources appeared to be sufficient to the reviewer.

Reviewer 5:

The reviewer said that, yes, resources are sufficient.

Reviewer 6:

The reviewer remarked that the resources seem sufficient to achieve the remaining milestones.

Presentation Number: elt261
Presentation Title: High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter
Principal Investigator: Ben Marquart (Ricardo)

Presenter

Ben Marquart, Ricardo

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.

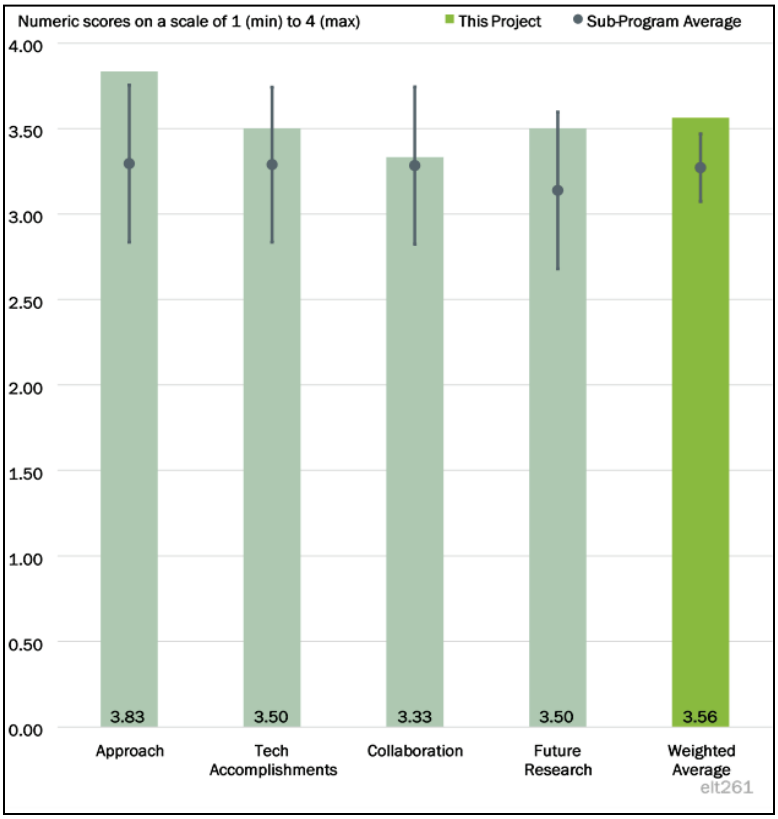

Figure 4-34 - Presentation Number: elt261 Presentation Title: High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter Principal Investigator: Ben Marquart (Ricardo)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the project is largely on track to successfully demonstrate a life cycle, cost-effective Class 8 BEV using a 250 kW SiC high-voltage inverter for a vehicle capable of greater than 250 miles/day operation with increased efficiency versus a baseline diesel unit. The interim development testing and analysis has provided confidence that the final designs can exceed project performance targets.

Reviewer 2:

The reviewer commented that the project is following contemporary system engineering practices and a define, design, and verify product development approach.

Reviewer 3:

The reviewer said that, overall, the approach is exciting. There does seem to be a lot left to do; it would be useful to provide specific timelines for the milestones.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project has achieved outstanding results and exceeded goals for A-sample inverter efficiency.

Reviewer 2:

According to the reviewer, the project has dealt with parallel component development of the powertrain, including moving targets on major specification such as voltage level and motor and other system placement. Thermal testing and system-level analysis at lower power have substantiated trends that higher power can achieve or exceed performance targets. Bench-model inverter units have been successfully built and tested.

Reviewer 3:

Overall, the technical accomplishments are good, though there seems to be a lot that still needs to be done. Some more details of the motor being utilized will be helpful. The module maximum temperature could be driven to much higher than 125°C at this point. Some additional information about the coolant flow configuration would also be useful to the reviewer to understand the technologies being utilized.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the collaboration team is lean but with qualified resources and assets at Ricardo Inc., NCSU, and Meritor Inc. The project leadership has effectively tapped these resources to develop, model, build, and validate designs using both emulation and hardware. Engagement with DOE laboratory resources was not mentioned and may represent opportunities for both the labs and the project.

Reviewer 2:

The reviewer remarked that the project has good collaborations with NCSU and Meritor Inc.

Reviewer 3:

The reviewer stated that the collaboration seems to be excellent, although the presentation lacks detail on how the organizations are working together.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the proposed future research is excellent. It will be good to also quantify the fuel savings.

Reviewer 2:

The project effectively described future research plans culminating in a 10-month demonstration in fleet operations. Challenges from COVID-19- related supply chain shortages may impact the ultimate schedule, but the reviewer commented that the project is taking proactive steps to order long lead items.

Reviewer 3:

The project has defined data to be collected during the system-level demonstration, but the reviewer suggested that more attention should be given to the vehicle test plan. How will the vehicle duty cycle be determined, and how will that cascade to the component level to ensure that the inverter duty-cycle during testing is sufficiently rigorous?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that this project is needed for DOE to meet its objectives of developing the technology for widespread electrification of HD vehicles.

Reviewer 2:

The reviewer indicated that this project directly supports DOE and the administrations goals of accelerating zero- emission vehicle adoption for hauling freight by HD EV tractors. The project does this by demonstrating inverter efficiencies greater than 98.5% at charging levels of 250 kW, a key factor in maximizing the net efficiency of HD BEV tractors versus alternatives and baseline diesel units. Commercially viable technology must also be cost effective, and the project is on track toward showing this feasibility.

Reviewer 3:

According to the reviewer, the project supports the overall DOE objectives of design, development, evaluation, and demonstration of electric-drive HD vehicles, which can help with reduction of fuel consumption and GHG reductions.

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

Reviewer 1:

The reviewer found the resources to be adequate.

Reviewer 2:

The reviewer indicated that the project appears to have sufficient resources.

Reviewer 3:

This reviewer stated that the project did not identify resources as a limiting factor. The state of the project appears to be on track, barring significant unknown schedule impacts from potential part availability challenges in the supply chain. The reviewer suggested that contingencies for added costs for expedited work, shipping, and arranging testing windows should be considered by the project team.

Presentation Number: elt262
Presentation Title: Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging
Principal Investigator: Brian Lindgren (Kenworth)

Presenter

Brian Lindgren, Kenworth

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.

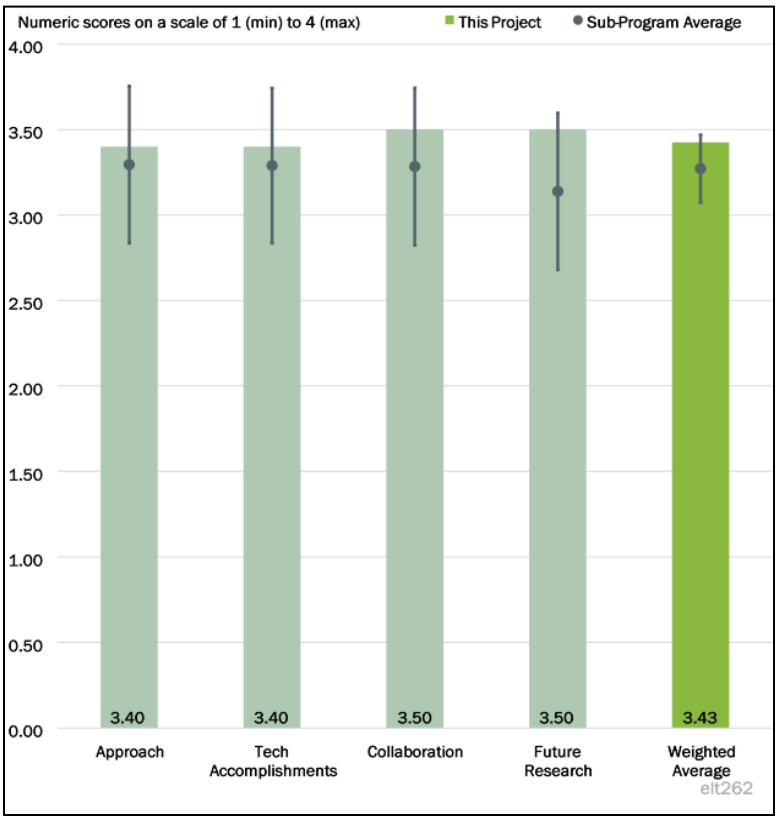

Figure 4-35 - Presentation Number: elt262 Presentation Title: Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging Principal Investigator: Brian Lindgren (Kenworth)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the project has identified barriers and proactively taken steps to address them through research, testing, and advance work with affected agencies, such as permitting groups, utilities, and fleets, while effectively dealing with complications from COVID-19 travel and supply chain issues. Smart choices were made to adapt available systems where feasible while maintaining a focus on developing the key new technologies. Using extended-range EVs early to obtain actual vehicle performance profiles on the actual routes was an excellent step.

Reviewer 2:

The reviewer commented that the approach to this ambitious project goals is appropriate due to the development, deployment, and demonstration of the technology. The demonstration and operation across several months or a year are valuable to capture the operational variations due to ambient temperature impacts.

Reviewer 3:

The technical barriers that this team set for themselves are daunting, but when achieved will represent a major step toward practical application of battery trucks beyond local haul. The reviewer found the wireless fast charging to be particularly impressive.

Reviewer 4:

The reviewer stated that the approach to HD electrification is good. Since vehicle efficiency is a high priority in EVs, the reviewer asked if the team had looked into maximizing vehicle efficiency, particularly aerodynamics measures for highway trucks.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer indicated very good progress on the wireless charging components, vehicle electrification, and the battery system.

Reviewer 2:

The reviewer remarked that the progress has been on schedule in spite of setbacks caused by the pandemic. Test runs to understand test route characteristics were very useful. The wireless charger design is particularly impressive, as is the truck modification to go with it.

Reviewer 3:

The project is on schedule overall, with some level of risk from industry-wide supply chain challenges. Proof of concept validation of coil design at Utah State University (USU) and chassis layout at Kenworth were completed. The project team has had appropriate concern and has paid attention to static vehicle charging, thermodynamics of cooling systems, and the potential for recirculation of hot air at charging sites that impact performance. Using extended range EVs early to obtain actual vehicle performance profiles on the actual routes was an excellent step. The reviewer indicated a concern about whether the project is attaining adequate seasonal effect evaluation prior to project completion—including severe winter and summer conditions between Seattle and Portland environments.

Reviewer 4:

The accomplishments indicate the developed wireless charging system and vehicle systems will fulfill the requirements of the designed route. Despite COVID-19 logistics issues, the project has fulfilled technical accomplishments. The battery aging/thermal limitations are presented indicating the potential charging limitation resulting in longer charging time. The table of battery charge profile results on Slide 9 is unclear, indicating longer charge time when starting at higher initial SOC (47 min. charging from 20% to full compared to 29 min. charging from 10% to full), which this reviewer questioned.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the project requires a number of contributors from different organizations. The collaboration appears to be excellent.

Reviewer 2:

The reviewer said that the project team consists of all the necessary collaborators to successfully complete this ambitious project.

Reviewer 3:

The reviewer stated that the several partners are needed to work in concert to design and build the wireless charging system; likewise, to get the on-truck components designed and built to be compatible with the charger is a major accomplishment requiring significant cooperation.

Reviewer 4:

The project team is composed of the appropriate technical expertise with representation from utilities, fleet, academia, and industry. The project, however, did not mention any DOE national laboratory engagement from high power charging subject matter experts. According to the reviewer, engagement of DOE assets might benefit both the project and parallel work by those DOE assets.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the project has actively managed the project plan, addressing schedule challenges, identifying risk areas and scheduling go/no-go decision points. Several influencing factors are somewhat beyond control of the project team such as industry-wide supply chain issues, permitting processes, and unknowns regarding site work for installation of the charging systems. The team is proactively communicating with parties to streamline the process. But these three items this year have led to automotive industry production stoppages from lack of computer parts, permitting always seems to take longer than expected, and site work always seems to discover unknown issues causing some delay and added expense. The project appears to be actively keeping all participants engaged and communicating and attempting to spot issues in time to take corrective steps to prevent delays.

Reviewer 2:

The reviewer said that the team plan looks at the main challenges ahead and is appropriate.

Reviewer 3:

The reviewer indicated that integration, full system (wireless charger and vehicle systems) operation, and evaluation are critical to the success of this project. The proposed plan shows a clear path for completion of these project tasks. Operation of the vehicle and wireless charging system for many months to a year is important to understand and quantify the operational performance variation due to ambient temperature impacts as well as resilience and durability.

Reviewer 4:

The reviewer said now that everything is designed, it will be necessary to complete the building and make it work. This could involve some challenges.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that this project directly supports DOE and the Administrations goals of accelerating zero emission vehicle adoption for hauling freight by HD EV tractors. Rapid recharging will be critical for regional haul operations with longer ranges and multi-shift use of truck assets by companies. Eliminating driver interaction with plug-in connections also is an industry need to simplify adoption of EVs Minimizing transmission losses and establishing that adequate energy transmission efficiencies can be achieved is important to the credibility of accurate total cost of ownership modeling in comparison to alternatives.

Reviewer 2:

The reviewer said that the project objectives and accomplishments directly support the DOE objective for advanced electrified transportation and enabling potential autonomous charging solutions required for fully autonomous transportation.

Reviewer 3:

The reviewer affirmed that the project addresses HD electrification, which is a significant hurdle for the DOE goal of more widespread EV adoption.

Reviewer 4:

The reviewer indicated that the electrification of trucking is key to reducing petroleum use.

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

Reviewer 1:

The reviewer stated that the work is progressing well with the available resources.

Reviewer 2:

The reviewer said that the resources are sufficient given the high power and capacity levels required to meet the objectives.

Reviewer 3:

The project did not present spend-to-date information, only the overall budget and 50% completion as of the 2021 AMR. The project did not identify budget as a risk area. This, combined with the confidence in the progress shown in the milestone schedule as expressed by the project, led the reviewer to conclude that sufficient budget exists to complete the schedule and deal with any contingencies.

Reviewer 4:

The reviewer said that this project involved a significant amount of hardware design and testing, which could get costly.

Presentation Number: elt264
Presentation Title: Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams
Principal Investigator: Joe Picarelli (Exelon/Pepco Holdings Inc.)

Presenter

Joe Picarelli, Exelon/Pepco Holdings 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.

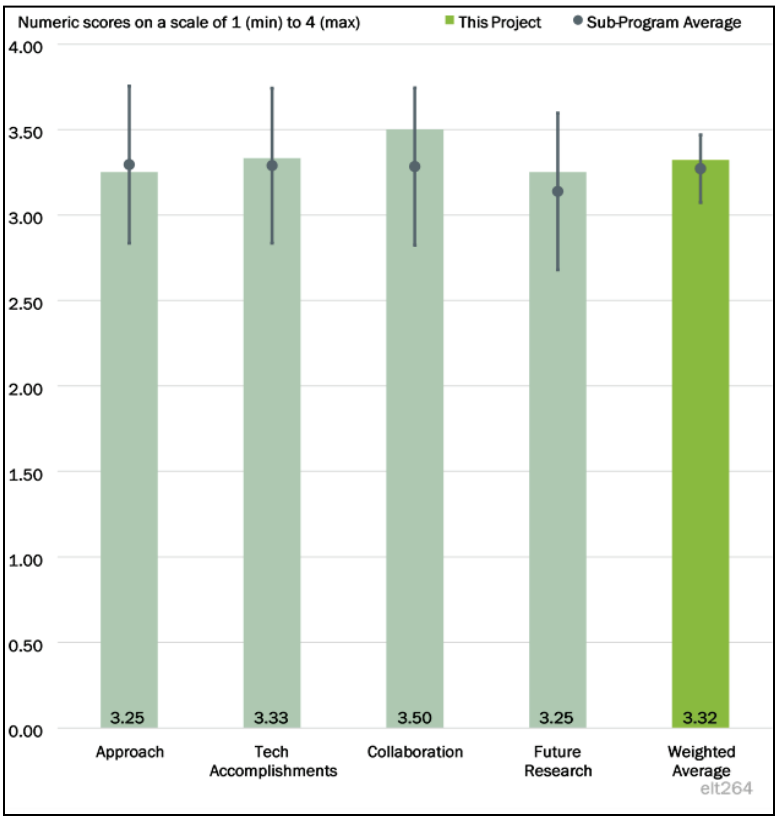

Figure 4-36 - Presentation Number: elt264 Presentation Title: Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams Principal Investigator: Joe Picarelli (Exelon/Pepco Holdings Inc.)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the project is well planned and well thought out. Significant barriers have been identified and addressed; however, identified risk of regulatory approval could be significant. To overcome regulatory approval risk, the project might need to include a demonstrated financial commitment from Baltimore Gas & Electric (BG&E) rather than only relying on the offset from DOE funding. Some commissions will evaluate a company's commitment based on the company's financial contribution rather than relying on federal or rate payer funding. The project could also benefit from additional focus on customer engagement. It might be beneficial to utilize research from organizations like the Smart Energy Consumer Collaborative, which talks directly with consumers and potentially incorporates focus groups to glean additional insights and feedback on program design. The project will provide important research on the impacts to both transmission and distribution circuits. The different project targets—residential (passive and active), fleets, and public charging—will provide insights across different segments, which will be important.

Reviewer 2:

The approach appears to be very broadly based, including considerations ranging from cybersecurity to signing up customers to completing a final assessment. However, the reviewer pointed out that it is very difficult to get a good picture of such a large project from a 20-minute presentation.

Reviewer 3:

The reviewer liked the overall approach and raised some questions regarding the threat modeling portion of the "perform cybersecurity testing" objective. How is the project team looking at nation-state sponsored cyberattacks? By 2019, roughly 25% of attacks were state sponsored, and that number has increased in the past 2 years. How is the project team developing the threat matrix and is the project team artificially downplaying an enemy state? Also, why is cybersecurity and telematics placed in different silos? It seems these two are very much related.

The reviewer looked forward to next year's briefing to see what the BP 2 cybersecurity impact analysis has to say. How is the project team developing the assessment plan?

Reviewer 4:

The reviewer stated that this is an exciting and ambitious project that wisely addresses both EVSE-based and vehicle-based communication to manage charging. The project is actively learning from other utilities who have already conducted smart charge management pilots, which is important to build on the findings of the others. However, much of the planned cybersecurity work is duplicative with other VTO-funded research. The project should draw on existing threat models and past EV and EVSE vulnerability assessments conducted by others.

Reviewer 5:

The overall objective of the project seemed clear to the reviewer. Specifically, to conduct R&D and a wide-scale demonstration of a Smart Charge Management (SCM) system to develop optimal managed charging structures for grid value, to evaluate the impact of EV charging on local distribution utility operations, and to evaluate the utilities' ability to control EV charging load based on grid conditions.

The reviewer reported that proposed impacts include the following: identifying managed charging techniques that can be shared industry wide; reducing the impact EV charging has on the utility's distribution and transmission systems; lessening the ratepayer capital investment required to manage EV charging demand; identifying cybersecurity risks and vulnerabilities of EVSEs and vehicle telematics software; and understanding the grid impact of EV charging. Overall, the project is proposing to cover an awful lot of ground—maybe too much. It does give pause to the reviewer as to whether the project is being too aggressive and should maybe consider narrowing the scope down somewhat. For example, is it fully appropriate to be exploring the cybersecurity risks and vulnerabilities of telematics software as part of this project?

An extensive list of milestones has been provided, which seemed logical and relatively comprehensive to the reviewer. Some milestones though do invite inquiry. For example, the cybersecurity milestone for November 2021 regarding attack graphs and a threat model—how does this effort potentially dovetail with and augment the threat modeling previously conducted by SNL and PNNL? For the December 2022 milestone to install L2 chargers and DCFC at utility-owned public stations, it may be good to consider XFC up to 350 kW as part of these demonstrations.

It seemed odd to the reviewer that the approach does not appear to include demonstration of SCM for workplace charging. Workplaces may be the most suitable applications for SCM due to consistent, long, and flexible dwell times, which facilitate implementing and maximizing the benefits of SCM. Furthermore, since the preponderance of charging will take place at home and the workplace, opportunities for greater benefits exist there.

The approach would have benefitted from a clearer explanation of why certain elements are being included. For example, it was not entirely clear to the reviewer why the project would incorporate cybersecurity testing and validation of specific EVSE equipment within the context of this effort.

The reviewer noted that it appears, ostensibly, that the project will also focus on distribution and transmission grid impacts. This is good as distribution impacts in particular are likely to pose the biggest challenges and have not been extensively studied.

The reviewer commented that a satisfactory list of barriers has been provided, including those involving regulatory issues, the value proposition, and the establishment of a user base.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project team has only just begun; so, just laying out the broad scope and plan of such a large project at this early stage represents significant progress.

Reviewer 2:

The reviewer asserted that the project is making good progress moving forward. The aggressive schedule and some tasks have been delayed, but do not appear to affect overall program implementation. However, attention is needed in order to avoid further delays.

Reviewer 3:

Market research and the SCM design accomplishments seem particularly strong and certainly show this as a fine project. The reviewer did not see any industry partners for the telematics component of the project threat model and asked if the project team is contemplating adding such an entity. If not, there is an open-source "reference" produced by NMFTA, which may yield utility.

Reviewer 4:

The market research and program design accomplishments are strong. It was unclear to the reviewer why the cybersecurity milestone was not met.

Reviewer 5:

The reviewer indicated that a satisfactory listing of technical accomplishments has been provided, especially given the relatively recent initiation of the project in October 2020. These accomplishments include market research for rate design, best practices for marketing, and best practices for customer classes. The design of SCM programs includes collection of charging data and unique incentives, as well as smart charge actions for each customer segment. The initiation of the acquisition of EVSE is through the request for proposal (RFP) process. The reviewer also stated that the project does appear to be falling a little behind the schedule out of the gate, though.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer stated that the collaboration appears to be excellent at this early stage of the project.

Reviewer 2:

The reviewer remarked that the project team appears strong and appropriate encompassing a utility, national laboratory, an association, an EVSE and charge network operator, telematics software solutions provider, and smart charge adapter company. The role of each of the project partners has been identified and seems to cover all necessary program elements.

Reviewer 3:

The reviewer asserted that there are good project collaborators representing breadth of stakeholders. Outreach to other utilities with similar projects is worthwhile and helpful for designing programs.

Reviewer 4:

The reviewer commented that it appears that all members of the team have been involved in the initial planning, which bodes well for both future cooperation and also assuring buy-in for actions at later stages.

Reviewer 5:

Collaboration is excellent, but there was not a clear breakdown of activities performed and how different performers were coordinating and integrating their efforts. It would be useful in future presentations to show some participant responsibilities on sub-tasks and perhaps describe how collaboration was happening. The reviewer acknowledged that this is a new project so some of that material may not yet exist; it is clearly a well-thought-out program, but the reviewer asked the project team to present more evidence of collaboration in future briefings.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the proposed future research for BP 3 and 4 seems reasonable and does lay out a high-level pathway of what will be done, tools that will be used, and what the expected outcomes are.

Reviewer 2:

The reviewer acknowledged good project planning. The project team has allowed for recruitment of participants in two budget years that would allow for modifications and adjustments. Key decision points have been incorporated into the plan. More information about overcoming potential participation barriers and challenges would be good.

Reviewer 3:

The reviewer stated that the project team appear to have all the bases covered, but again stressed the dearth of information these presentations provide.

Reviewer 4:

The reviewer asked how adding 1,000 customers in this pilot project meaningfully provides intelligence to achieve and/or supports the goal of understanding the impact of high EV adoption. This seems like an insignificant number for the market area the project is serving and conducting research in. How does the project team draw enough information to model a truly widespread adoption?

The project team asserted that the cybersecurity assessment, etc., is complete in BP 3, but the reviewer wanted to know why the project team does not revisit it or verify it during the demonstration phase of BP 4 That seems like a perfectly reasonable opportunity. The project team also emphasizes the cyber-physical aspect and call out networks. The reviewer would be very interested in how that modeling is performed and the state of assumptions.

Reviewer 5:

The reviewer stated that the future work plan is strong at a high level. Some details are lacking. The presenter stated that the project will use OpenADR “and any other communication protocol we might use.” The presenter also stated that one of the project’s biggest challenges is determining which communication protocol to use. What criteria will be used to select the protocols? How will success be determined? Also, ATEAM simulation will be conducted to model the grid impact of charging. How will the data be collected and used to accurately model customer charging behavior? Finally, how will the value of smart charge management be assessed and weighed against the cost?

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer indicated that this project looks like exactly what DOE is prioritizing and is central to it mission.

Reviewer 2:

The reviewer stated that this project is highly relevant and addresses top DOE priorities for enabling widespread EV adoption without negatively impacting the grid.

Reviewer 3:

The reviewer commented that this research is very relevant to DOE objectives and will provide important findings for other utilities implementing smart charge management. Understanding impacts to distribution and transmission circuits will be critical for widespread adoptions.

Reviewer 4:

The reviewer said that aggressive implementation of smart charge management is essential to integrate large numbers of EVs within the electric grid without massive and costly scale-up of infrastructure. The wide-scale demonstration of SCM is necessary to determine the feasibility of SCM, identify and resolve critical barriers, determine optimum implementation strategies, and build confidence.

Reviewer 5:

The reviewer indicated that this project seeks to make EV charging more efficient and economical, furthering DOE's goal of electrifying U.S. transportation.

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

Reviewer 1:

The reviewer said that the budget and other resources seem appropriate given the level of research and work.

Reviewer 2:

The reviewer remarked that the project has an excellent team and significant funding that should be sufficient to successfully complete this important and ambitious project.

Reviewer 3:

According to the reviewer, the project appears sufficiently funded at this time and pointed out that the project has a 58% utility cost share.

Reviewer 4:

The reviewer found that the resources seem fine.

Reviewer 5:

The reviewer asserted that there is lots of work that will be required; it is difficult to judge costs with so few details provided.

Presentation Number: elt265
Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale
Principal Investigator: Duncan Woodbury (Dream Team LLC)

Presenter

Duncan Woodbury, Dream Team 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.

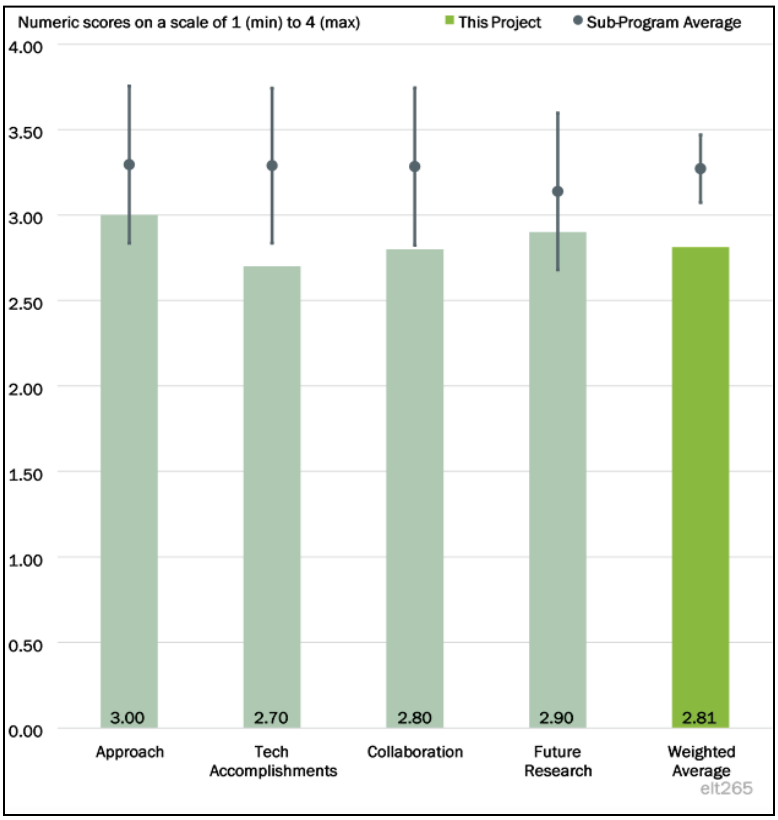

Figure 4-37 - Presentation Number: elt265 Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale Principal Investigator: Duncan Woodbury (Dream Team LLC)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer described the approach as excellent thus far, but the project team is just getting started. The PI has put together a strong technical team.

Reviewer 2:

The reviewer said that the approach is appropriate and well defined with the challenges identified. More detailed information on potential risks would be beneficial. Open source will be valuable for integrating additional devices and overcoming proprietary solutions that can increase costs.

Reviewer 3:

The reviewer remarked that there are a lot of general statements, but no specifics. More details on the scale of the EV and EVSEs used on this project and input and output expectations are needed.

Reviewer 4:

The reviewer noted that there are a number of existing standards being worked on to develop communications protocols to enable interoperable charging systems. Instead of working within those existing activities, the approach used in this project seems to be to "develop an open-source, open standards-based utility Smart Charge Management system." No alternative approaches seem to have been considered (unless the approaches were reviewed at an earlier AMR).

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the project is on track and system requirements have been identified. The progress is appropriate given the timeframe for the award.

Reviewer 2:

The reviewer said that this project is in the preliminary stages so further reviews may provide more information on the accomplishments and progress.

Reviewer 3:

The reviewer indicated that the project is "good" here. The reviewer thought that the project itself may be "understated" as to how large of a project this is, and the details as outlined here are just "very broad." The reviewer emphatically noted the concern that there are issues now that need to be fixed with current EV charging and the grid, and there are issues in the future that need to be carefully planned and thought through, such as XFC.

Reviewer 4:

The reviewer observed very little progress to date and reported that the project start was October 2020 and planned completion is December 2024. The project is currently 17% over based on the calendar and 15% complete based on the AMR slides; so, this is close. However, the milestone chart shows only 1 task (row) complete, 4 in progress, and 14 planned. Based on the milestone chart, the project is only 6% complete, which is far short of 15%.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer observed that the project has good partnerships.

Reviewer 2:

The reviewer remarked that the project has a great technical team thus far, but now the project team has to explain it to more people.

Reviewer 3:

The reviewer commented that the partners are diverse and more needs to be identified regarding the roles and assignments of each and how they fit into the overall plan.

Reviewer 4:

The reviewer indicated that there are a number of existing standards being worked on to develop communications protocols to enable interoperable charging systems. The reviewer suggested that the existing standard organizations should have been brought into the discussion along with members of the industries that support EV charging.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The project is well planned with appropriate go/no-go decision points. The project could benefit from identifying risk mitigation strategies and more detailed milestones. The "demonstrate grid services capability" seemed somewhat vague to the reviewer.

Reviewer 2:
The reviewer remarked that the project team is just getting started, so most of the project is still in the future. Is the project team going to be able to fix the current EV charging and infrastructure? Is the project team going to be able to plan (well planned) so that future EV charging and infrastructure has "cyber" built in?

Reviewer 3:
The reviewer stated that clarity needs to be included as to the maturity selected for various protocols. For example, the protocol OCPP has several versions (1.6, 2.0, etc.), and the version selected has significant effects on how it is used in this project. The other protocols also have the same approach to updates. Interoperability will depend on matching specific functional capabilities when used in this project.

Reviewer 4:
The reviewer said that the project team seems to have a plan for additional work. One concern here is that one task is labeled "demonstrate cybersecurity use case"; cybersecurity should be considered for every aspect of the project and not confined to a single use case.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:
The reviewer emphasized that the project is super relevant. The reviewer asked if this team could get more money and technical resources to put this project on steroids.

Reviewer 2:
This is an important project as electrification increases and the grid also changes to include more clean energy options. According to the reviewer, matching these needs will continue to be a challenge as these changes are evaluated.

Reviewer 3:
The reviewer said that interfaces and integration with legacy utility equipment will be important for broader deployment and cost-effective approaches for SCM.

Reviewer 4:
This project does support DOE goals, but as the reviewer previously stated, it may not be the best approach.

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

Reviewer 1:
Resources are sufficient to start, but the reviewer emphatically stated that they are miniscule for getting at this large problem that is now and needed.

Reviewer 2:
The budget seemed appropriate for the project scope.

Reviewer 3:
The reviewer commented that the assignments need to be identified to point out their strengths and how they will best fit in obtaining expected results.

Reviewer 4:
Again, to succeed long term, this activity needs to connect with appropriate industry partners. Without these resources, it was very unclear to the reviewer how the output from this project will make the leap to successful deployment.

Presentation Number: elt266
Presentation Title: ANL High Power Charging Charge Profiles
Principal Investigator: Dan Dobrzynski (Argonne National Laboratory)

Presenter

Dan Dobrzynski, 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.

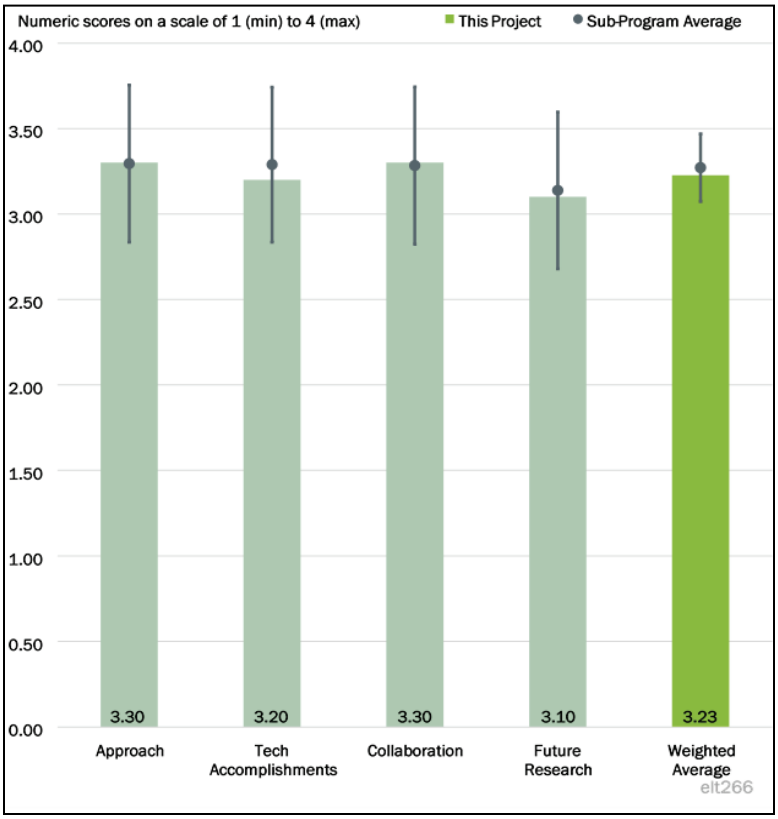

Figure 4-38 - Presentation Number: elt266 Presentation Title: ANL High Power Charging Charge Profiles Principal Investigator: Dan Dobrzynski (Argonne National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The research team has engaged a wide range of stakeholders and is leveraging established testbeds to obtain a range of profiles. The reviewer recommended that the team seek more engagement of standards-making bodies in the later stages of the project.

Reviewer 2:

Although it is a little early in the project to comment about this, the reviewer indicated that the approach appears to be sound.

Reviewer 3:

The overall approach to the project is adequately outlined; however, the mission statement needs focus. The reviewer indicated that "high" power should be accurately defined as above 350 kW, since SAE J1772 and CCS connectors are rated up to 350 kW for DC L 2 charging, whereas the Ll 3, or extreme fast charging, and others are above 350 kW. Inadequately defining "high" in quantifiable terms perpetuates marketing nomenclature that is confusing the industry, where it is common to find a range of interpretations of "high." This project could feed value-added information into SAE and International Electrotechnical Commission (IEC) standards development and help clarify definitions, but at a minimum, terminology should not be in conflict with those standards.

Reviewer 4:
Not applicable was indicated by this reviewer.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer stated that, in this first year, the team has been successful in establishing sound test plans and forging partnerships that will be essential over the course of the project.

Reviewer 2:
The reviewer remarked that the project had not been reviewed previously and started in FY 2021. Progress mid-first year is difficult to assess as the project presented few measurable, auditable deliverables, only discussion of draft work, and initial contractual or legal arrangements in process with unnamed OEM collaborators, named fleet operators, named EVSE manufacturers, named utilities, and DOE lab participants. The project spend-to-date was not included in the presentation, only the annual allocation levels.

Reviewer 3:
This reviewer stated that there are not many light-duty (LD) vehicles that have 200 kW+ charging capability. Even the ones that claim to have that capability perhaps do not charge at that rate for too long, because the currently available production batteries may not handle high rates of charging very well. Given that, the reviewer found it likely that the charging profiles obtained in the current crop of LD vehicles are not necessarily going to remain the same in the future. It may be necessary to rely more on MD/HD vehicles obtain representative charging profiles.

Another consideration suggested by this reviewer is that as the grid gets upgrades to handle the EV charging load, it is likely that the charging profiles may also change as the grid capability goes up. However, including EVSE OEMs and utility companies among the collaborators will account for some of the above-mentioned variables.

Reviewer 4:
Not applicable was indicated by this reviewer.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
As the PI indicates, some of the collaboration agreements are still in process. According to the reviewer, it is essential to finalize these as soon as possible. If one or more partners cannot agree to terms, the team will need to redesign their test plan accordingly.

Reviewer 2:
This reviewer referenced prior comments and stated that including EVSE OEMs and utility companies brings in a expertise that is essential for this project. It could also benefit from the involvement of battery OEMs at the same time.

Reviewer 3:
The reviewer stated that the planned project DOE lab participants are inclusive of the correct centers of expertise. The goal for industry participation is good; however, no detail was presented on who the EV OEMs were, what their product vehicle types were, and when or if they would have production products in place in a time frame and at specification levels consistent with the project. There was no mention of participation of industry groups, such as SAE or CharIN. This is troubling since the intent is to emulate production installations and operations. A gap analysis of project needs versus industry availability was not presented with

respect to vehicles, chargers, or standards. If individual lab engagements with industry groups are being relied on, then that should be stated, and the specific industry groups clarified.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer said that the research team has a sound plan for rolling out its testing. The project team has identified some of the challenges and has plans in place to mitigate any issues.

Reviewer 2:

The project has just started and the while the choices made so far appear reasonable, the reviewer noted that course corrections may be needed depending on how many and which partners come on board.

Reviewer 3:

The reviewer stated that the majority of this project is future work as of mid-first year of project. The technical approach appears appropriate in light of the fact that industry has not yet put much of this into production yet, so both the technology and standards are in a state of development with limited field history. Rapid changes may be required to the project once real-world systems are in use in the field for charging above 350 kW levels. The emulation of OEM donor vehicles was stated as being needed because the vehicles may not be designed to handle the higher-level charging conditions required for the project. This highlights where the modeling may differ from the real world and may devalue the project effort. Similarly, considering only single vehicle charging may not accurately model real-world installations where multiple vehicles may be on the same circuit.

Reviewer 4:

Not applicable was indicated by this reviewer.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer said that, yes, the project supports the overall DOE objectives.

Reviewer 2:

The reviewer stated that to facilitate high-power charging projects, DOE needs to have good data on actual high-power charging equipment. This project will provide essential data for a wide range of researchers.

Reviewer 3:

The reviewer commented that the project supports DOE and administration objectives to help quantify operational details and requirements for faster charging at higher power levels to facilitate adoption of zero-emission vehicles. The details of operations are currently in industry development with few if any production trucks or cars or installed chargers above 350 kW in use, so to some extent, the project is tied to a moving target. Decisions on relevance may change if the market shifts directions on technologies or power levels. The research can be value added for industry groups developing standards, such as SAE, IEEE, and others like CharIN.

Reviewer 4:

This reviewer explained that understanding charging profiles helps understand grid impact, impact on battery life, charging efficiency, etc., all of which influence the overall energy consumption and adoption of EVs.

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

Reviewer 1:

At this point, the resources appeared sufficient to this reviewer.

Reviewer 2:

This reviewer saw no issues with the resource allocation. Obtaining field data is always expensive; the research team has adequately balanced time and efforts with partner commitments.

Reviewer 3:

The reviewer stated that the project did not present spend-to-date information. That is critical to determine if first-year efforts have been adequate. Any delays in inking non-disclosure agreements or contractual arrangements with participants might have highlighted inadequate resources applied to those efforts. The overall planned program spend for 3 years appears adequate, but the spending profile being flat over the 3 years may show that the project has not been adequately planned around costing, since procurement of materials, facilities, and personnel typically vary over the course of this type of project as it moves from planning to execution. The lack of firm commitments on test articles and the reliance on emulated vehicles and potentially donated or borrowed real vehicles and other equipment have some risk with respect to budgeting.

Reviewer 4:

Not applicable was indicated by this reviewer.

Presentation Number: elt267
Presentation Title: ORNL Resilient High Power Charging Facility
Principal Investigator: Madhu Chinthavali (Oak Ridge National Laboratory)

Presenter

Madhu Chinthavali, 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.

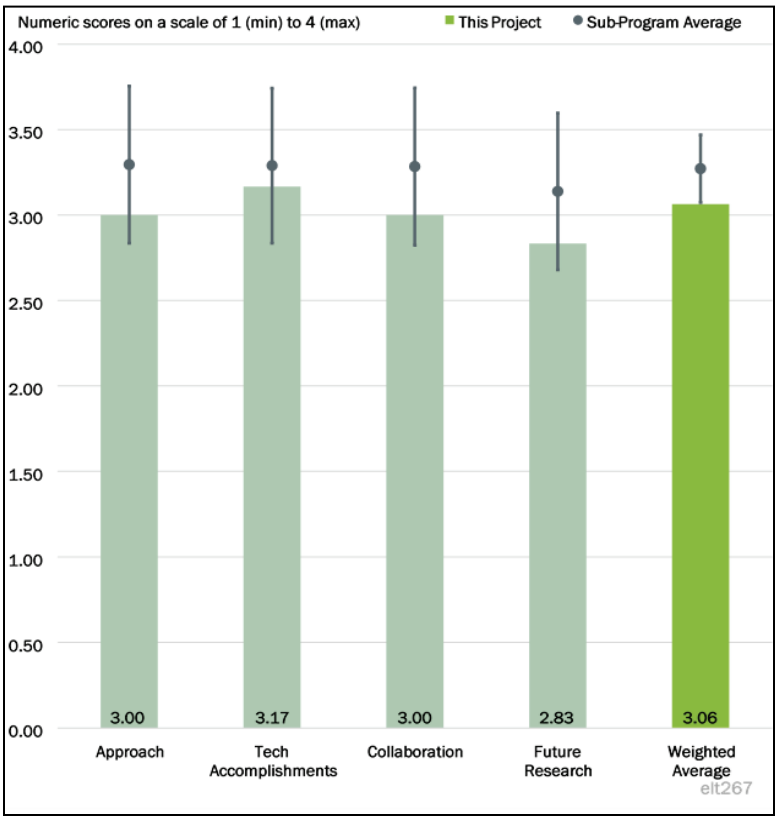

Figure 4-39 - Presentation Number: elt267 Presentation Title: ORNL Resilient High Power Charging Facility Principal Investigator: Madhu Chinthavali (Oak Ridge National Laboratory)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

The reviewer stated that the division of effort is clear, and the roles expected to contribute to a successful project are included. The timeline shows a natural progression of steps required to meet the goals of the project.

Reviewer 2:

The reviewer observed that this project is intending to model real-world production systems that are not yet in production and not yet governed by published standards. Trying to model systems that are themselves still in flux puts the benefit of the project somewhat at risk since decisions made may not reflect real-world systems once they enter production. There is value in attempting to independently model these evolving systems and developing a framework for common discussion that may help influence those developing systems. This begs the question if this open-source deliverable is what industry would use. Some level of gap analysis is needed.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer stated that the organization and assignment of tasks are representative of accurate site conditions and should lead to positive results. Resiliency for charging stations is a critical factor to promote electrification, and planning for issues using multiple sources is a reasonable means to insure this.

Reviewer 2:

The reviewer noted that the project had not been reviewed previously and started in FY 2021. Progress mid-first year is difficult to assess as the project presented few measurable, auditable deliverables. Development of nine use cases was presented, and the overall program has been planned. The project reported that a goal is to deliver an open-source software architecture for managing XFC, but there was not an indication that industry is in need of this or will accept an open-source solution in place of proprietary systems.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer found that the mix of labs, a university, and an EVSE manufacturer matches the capabilities of the project. The tasks also match the capabilities to meet the expectations of the project.

Reviewer 2:

The reviewer stated that the planned project DOE lab participants include the appropriate centers of expertise. The industry involvement includes a major systems company in ABB, but it would help if industry groups were engaged because the project is attempting to model systems that are still evolving, have not yet been put into production, and have limited field experience. If individual lab engagements with industry groups is being relied on, then that should be stated, and the specific industry groups clarified.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer commented that the majority of this project is future work as of mid-first year of project. The technical approach appears appropriate in light of the fact that industry has not yet put much of this into production yet, so both the technology and standards are in a state of development with limited field history. Rapid changes may be required to the project once real-world systems are in use. Interim go/no-go decision gates should include a review of the project with respect to the state of the industry at those times to validate that the project is still representing production intent.

Reviewer 2:

The reviewer remarked that the distance of the photovoltaics (PV) and energy storage (ES) to the dispensers may be appropriate for some installations and using AC energy between these is a good start. If these could be closer, an alternate approach of DC/DC inverters (PV or ES) to the dispensers] could be used in future projects so the conversion efficiency losses could be reduced. Converting from DC to AC at the PV and ES sources, then AC to DC at the dispensers is less efficient and should not be the only approach.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer stated that the goal this project is to establish controls and support to vehicle charging during grid interruptions. These interruptions occur due to climate conditions or planned outages, and vehicle charging needs to be maintained. EVs may need to charge to power homes and other needs, other than for transportation, and this available source needs to be available at sites during these events.

Reviewer 2:

The reviewer said that the project supports DOE and administration objectives to help quantify operational details and requirements for faster charging at higher power levels to facilitate adoption of zero-emission vehicles. The details of operations are currently in industry development with few if any production trucks or

cars, or installed chargers, so to some extent, the project is tied to a moving target. Decisions on relevance may change if the market shifts directions on technologies or power levels. The research can be value added for industry groups developing standards, such as SAE, IEEE, and others like CharIN.

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

Reviewer 1:

The reviewer reported that the project lead and partners are well versed in the requirements and have the capabilities to led to successful results.

Reviewer 2:

The reviewer indicated that the project did not present a spending profile by year but did present a BP 1 estimate of $650,000. A spending profile plan for the course of the project is needed to assess adequacy of resources. Funding was not identified as a challenge by the project presenter, and the bulk of spending will be in BP 2 and 3. Some contingency should be evaluated for keeping the systems up to date with industry changes over this period, as changes may occur from field feedback on introduced systems, and development of new standards.

Presentation Number: elt274
Presentation Title: eMosaic: Electrification Mosaic Platform for Grid-Informed Smart Charging Management
Principal Investigator: David Coats (ABB)

Presenter

David Coats, ABB

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.

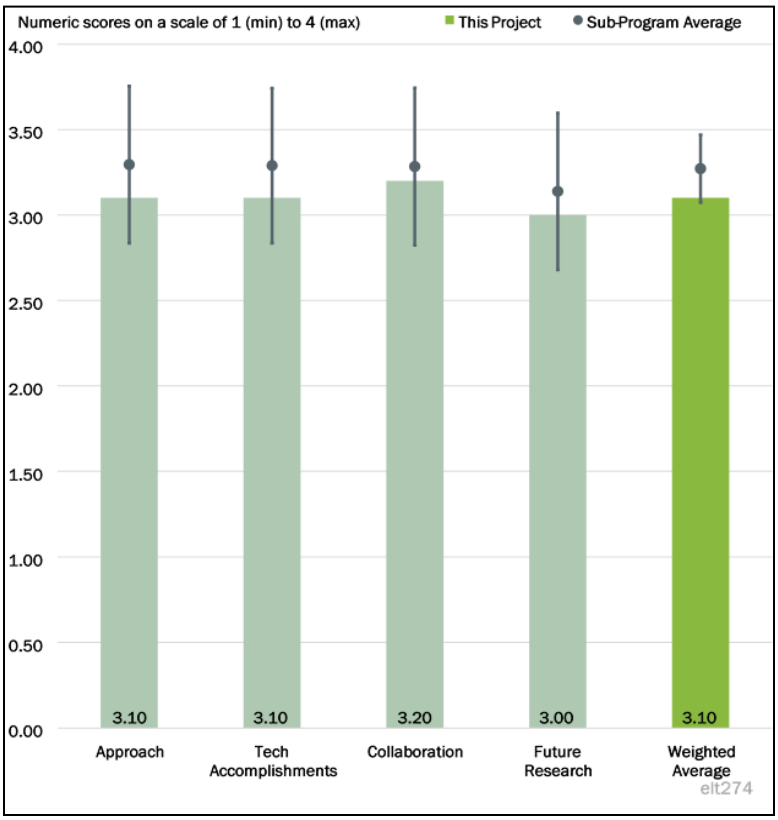

Figure 4-40 - Presentation Number: elt274 Presentation Title: eMosaic: Electrification Mosaic Platform for Grid-Informed Smart Charging Management Principal Investigator: David Coats (ABB)

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:

According to the reviewer, the approach to this project is very good and should address the technical barriers for the project.

Reviewer 2:

The reviewer found that the project plan is detailed and well planned to include important tasks and milestones for each partner.

Reviewer 3:

The reviewer believed that the approach is clear and reasonable. The reviewer strongly urged moving the cybersecurity design review from BP 3–4 to BP 1–2 since it is only a design review. The cybersecurity design review should be accomplished earlier in the program because if there is a poor cyber design, then that will either take much more time and/or resources to fix later in the project or will be ignored. There are many examples of the results of systems for which the cyber design or implementation was poor—and that is not the direction nor result the reviewer suspected is the goal here. This change should not significantly impact approach or schedule.

The next question is not something the reviewer would have expected to see in the slides (too detailed)—how does the project team account for modeling of energy gathering needs and charging assets needs? Specifically,

what kinds of communications (and the security thereof) would be planned for a dynamic system, and how would the project team account for weather affects, if any?

The system functionality test task is clearly important (and it is too early for the project team to give much detail), but the reviewer was looking forward to hearing a lot more about this and about the local versus cloud components of that task next year.

Reviewer 4:

The reviewer stated that the slides presented at the AMR give very little insight into the goals or approach for the project, simply giving three, very high-level but nebulous objectives (develop eMosaic platform, field test, and then demonstrate "a reference EV charging aggregation and control" [system?]). The reviewer asked if eMosaic is a reference to this company's software.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

The reviewer commented that the project has accomplished important tasks that will move the project forward and keep the effort on schedule. The project has begun working with a utility to identify sites this helps for mitigating and avoiding delays—and the project has also identified data for use in models.

Reviewer 2:

The reviewer indicated that the project team has made good progress toward meeting its milestone objectives.

Reviewer 3:

The reviewer stated that this is the first year of the program, so many of the accomplishments will happen in the future—and the reviewer does like the plan of action as described.

Forecasting and grid service algorithm development are essential to success. The reviewer was looking forward to details on these subjects next year as there were not enough details on them in this first presentation to ascertain progress on them though.

The reviewer remarked that the Caldera milestone is due in September but did not see mention of progress on that (much may have been accomplished, but there would be benefit in capturing that—even if just as a percentage-complete graphic—to show progress against in-year milestone goals).

Are load predictions exclusively historically based, or are there dynamic needs-driven data being considered in projections? If the latter, then the reviewer did not see that represented on Slide 10. It seems a dynamic, needs-driven component would be valuable.

Reviewer 4:

The reviewer reported that the project start was October 2020 and planned completion is December 2024. The project is currently 17% over based on the calendar but only 10% complete based on the AMR slides. The Milestone chart shows the Milestone 1 planned completion as June 30, 2021 (9 months in and no major accomplishments), but the Technical Accomplishments slides provide a more complete picture of the work thus far. The reviewer based the rating on the Accomplishments slides.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:

The reviewer asserted that the project has a fantastic project team with all important stakeholders identified and involved.

Reviewer 2:

This is early in the project and, from the schedule in the slides, it is clear that ABB is performing most of the BP 1 work. There is an indication of using each teammate at least a little bit, and there is clear evidence that INL and USU (and therefore Rocky Mountain Power [RMP]) are engaged in the design and initial research and modeling input phases., The reviewer indicated that this is a strong team approach, which seems better than most in being highly inclusive in the project's first year.

Reviewer 3:

The reviewer stated that the project shows good collaboration between existing partners.

Reviewer 4:

The reviewer suggested that the project would benefit from additional companies being involved, such as more EVSE manufactures, a charge point operatory, and more electric utility input. They will help with the goal of obtaining industry-wide acceptance of the project results. It would also help with several of the bullet points listed on the "Remaining Challenges and Barriers" slide.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. Note: if the project has ended, please state project ended.

Reviewer 1:

The reviewer stated that the project tasks and milestones for future work are identified. Challenges and barriers are identified and being addressed.

Reviewer 2:

Although proposed future work is reasonable, the reviewer observed that cybersecurity and model validation/verification are not present in the proposed future work. The reviewer referenced prior comments about where to consider placing this as a priority and schedule item. The reviewer was also concerned that cybersecurity and model validation/verification are not identified for future work either. Insecure systems will increasingly be disadvantaged and have lower likelihood of long service lifespans as there is movement into the soft-war cyber age. The reviewer urged moving this forward and enshrining it in the project team's future work plans.

Reviewer 3:

It seemed to the reviewer that there is some lack of process details for doing real-world validation studies. These will be critical to ensure the tools are sufficiently robust to be commercialized.

Reviewer 4:

The reviewer stated that the AMR slides list the major tasks for the next year-and-a-half of the project. The AMR slides do not show plans that run to December 2024, which is listed as the project end date.

Question 5: Relevance—Does this project support the overall DOE objectives? Why or why not?

Reviewer 1:

The reviewer asserted that this kind of activity clearly supports the direction that DOE is demonstrably intent upon, and which also clearly supports societal and industry intent and prioritization of moving from fossil fuels to electrification across the energy consumption sectors. This project does exactly that and seeks to improve availability of energy product at point of demand and helps forecast needs.

Reviewer 2:

The reviewer noted that the project will be instrumental in advancing grid services for transit and buses. These vehicles have the most potential for offering benefits and to help offset peak load. The project is looking at aggregation and what can be better handled locally versus what is more beneficial or can be handled through aggregation. This is important information and research to further potential for grid services.

Reviewer 3:

The reviewer stated that the project helps to address DOE objectives around adoption of low carbon transportation technologies.

Reviewer 4:

The reviewer found it very hard to evaluate this question since the goals and approach of the project are not clear from the presentation or the AMR slides.

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

Reviewer 1:

The reviewer said that the resources seem to be in line with the work and effort being performed.

Reviewer 2:

Resources looked fine to the reviewer.

Reviewer 3:

The reviewer stated that the resources are sufficient to meet objectives of this project.

Reviewer 4:

The reviewer noted no resource issues.

Acronyms and Abbreviations

°C	Degrees Celsius
3-D	Three-dimensional
AC	Alternating current
ACM	American Center for Mobility
AMP	Assured Micropatching Program
AMR	Annual Merit Review
B	Boron
BEV	Battery electric vehicle
BG&E	Baltimore Gas & Electric
BP	Budget Period
C	Charge rate
CCS1	Combined Charging System
CEC	California Energy Commission
CNG	Compressed natural gas
CO_2	Carbon dioxide
COVID-19	Coronavirus disease 2019
CPUC	California Public Utilities Commission
CSRL	Cybersecurity Research Laboratory
DARPA	Defense Advanced Projects Research Agency
DC	Direct current
DER	Distributed energy resources
DHS	U.S. Department of Homeland Security
DNN	Deep neural network
DOE	US. Department of Energy
DOT	U.S. Department of Transportation
DTNA	Daimler Trucks North America
Dy	Dysprosium
EDT	Electric Drive Technology(ies)
EERE	Office of Energy Efficiency and Renewable Energy
EETT	Electrical and Electronics Technical Team
EMI	Electromagnetic interference

EPRI	Electric Power Research Institute
ES	Energy storage
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCA	Fiat Chrysler Automobiles
Fe	Iron
Fe_4N	Iron nitride
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GaN	Gallium nitride
Georgia Tech	Georgia Institute of Technology
GHG	Greenhouse gas
GM	General Motors
HCE	High-consequence events
HD	Heavy-duty
HIL	Hardware-in-the-loop
HRE	Heavy rare earth
ICE	Internal combustion engine
IDS	Intrusion detection system
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IIT	Illinois Institute of Technology
INL	Idaho National Laboratory
ISO	International Organization for Standardization
JRC	Joint Research Center
kV	Kilovolt
kW	Kilowatt
L	Level
LCC	Inductor-capacitor-capacitor
MD	Medium-duty
Missouri S&T	Missouri University of Science and Technology
MOSFET	Metal-oxide semiconductor field-effect transistor

mph	Miles per hour
MV	Medium-voltage
MVA	Megavolt-ampere
MW	Megawatt
NCSU	North Carolina State University
Nd	Neodymium
NIST	National Institute of Standards and Technology
Nm	Newton-meter
NMFTA	National Motor Freight Traffic Association
NREL	National Renewable Energy Laboratory
NVH	Noise, vibration, and harshness
NYPA	New York Port Authority
OCPP	Open charge point protocol
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PCB	Printed circuit board
PE	Power engineering
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid vehicle
PI	Principal Investigator
PII	Personally identifiable information
PKI	Public key infrastructure
PNNL	Pacific Northwest National Laboratory
PTO	Power take-off
PV	Photovoltaic
PZLT	Piezoelectric
Q&A	Question and answer
R&D	Research and development
RDD&D	Research, development, demonstration, and deployment
RE	Rare earth
ReFUEL	Renewable Fuels and Lubricants Laboratory
RE-PM	Rare-earth permanent magnet

RESS	Rechargeable energy storage system
RFP	Request for proposal
RMP	Rocky Mountain Power
RNN	Recurrent neural networks
ROI	Return on investment
rpm	Revolutions per minute
RTO	Recovery time objective
SAE	Society of Automotive Engineers
SCE	Southern California Edison
SCM	Smart charge management
SiC	Silicon carbide
SIS	Safety instrumented system
SMC	Soft-magnet composite
S-NIC	Secure network interface card
SNL	Sandia National Laboratories
SOC	State of charge
SpEC	Smartgrid EV Communication
SPIN	Smart Power Integrated Node
SST	Solid-state transformer
SUNY	State University of New York
TCO	Total cost of ownership
TOU	Time of use
TTSI	Total Transportation Services Inc.
U.S. DRIVE	United States Driving Research and Innovation for Vehicle efficiency and Energy sustainability
UPS	United Parcel Service
USCAR	United States Council for Automotive Research
USD	Unified School District
USU	Utah State University
V2G	Vehicle-to-grid
VGI	Vehicle-grid integration
Virginia Tech	Virginia Polytechnic Institute and State University

VTO	Vehicle Technologies Office
WBG	Wide bandgap
XFC	eXtreme fast charging
XSS	Cross-site scripting