Prologue

Dear Colleague:

This document summarizes the comments provided by peer reviewers on hydrogen and fuel cell projects presented at the fiscal year (FY) 2016 U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program Annual Merit Review and Peer Evaluation Meeting (AMR), held in conjunction with DOE's Vehicle Technologies Office Annual Merit Review on June 6–10, 2016, Washington, D.C. In response to direction from various stakeholders, including the National Academies, this review process provides evaluations of the DOE-funded projects in applied research, development, demonstration, and analysis of hydrogen and fuel cell technologies. Acting Assistant Secretary for the Office of Energy Efficiency and Renewable Energy (EERE) David Friedman opened the joint plenary session with more than 1,000 attendees, followed by a keynote address from Senator Byron L. Dorgan (ret.). The joint plenary also included overview presentations from the Fuel Cell Technologies Office and the Vehicle Technologies Office, as well as both offices' annual awards presentation. A plenary for Hydrogen and Fuel Cells Program participants included overviews on each of the eight programs: Hydrogen Production and Delivery; Hydrogen Storage; Fuel Cells; Manufacturing R&D; Technology Validation; Safety, Codes and Standards; Market Transformation; and Systems Analysis.

DOE values the transparent, public process of soliciting technical input on its projects and overall programs from relevant experts with depth and breadth of knowledge across a number of broad areas. The recommendations of the reviewers are taken into consideration by DOE technology managers in generating future work plans. The table in this report lists the projects presented at the review, evaluation scores, and the major actions to be taken during the upcoming fiscal year (October 1, 2016–September 30, 2017). The projects have been grouped according to program and reviewed according to the appropriate evaluation criteria. The weighted scores for all of the projects are based on a four-point scale, with half-point intervals. To furnish principal investigators (PIs) with direct feedback, all of the evaluations and comments are provided to each presenter; however, the authors of the individual comments remain anonymous. The PIs are instructed by DOE to fully consider these summary evaluation comments, along with any other comments by DOE managers, in their FY 2017 plans. In addition, DOE managers contact each PI individually and discuss the comments and recommendations as future plans are developed.

In addition to thanking all participants of the AMR, I would like to express my sincere appreciation to the reviewers for your strong commitment, expertise, and interest in advancing hydrogen and fuel cell technologies. You make this report possible, and we rely on your comments, along with other management processes, to help make project decisions for the new fiscal year. We look forward to your participation in the FY 2017 AMR, which is presently scheduled for June 5–9 in Washington, DC. Thank you for participating in the FY 2016 AMR.

Sincerely,

Sunita Satyapal
Director
Hydrogen and Fuel Cells Program
U.S. Department of Energy

Hydrogen Production and Delivery

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-014	Hydrogen Delivery Infrastructure Analysis *Krishna Reddi; Argonne National Laboratory*	3.0	X			Reviewers appreciated the project for maintaining a solid approach and addressing fundamental and key issues through its scenario modeling efforts. They recognized that the analytical examination of key cost factors and commercial feasibility of different pathways under different conditions is helpful in setting research priorities. Reviewers recommended that the approach should evolve to accommodate limits in data availability and that the project should work to involve more industry partners to improve the quality of the data. They expressed concern about the use of a single value as a cost data point for infrastructure and hydrogen, and they suggested that a range of values be used to feed the model to capture uncertainty.
PD-025	Fatigue Performance of High-Strength Pipeline Steels and Their Welds in Hydrogen Gas Service *Joe Ronevich; Sandia National Laboratories*	3.1	X			Reviewers praised the overall approach of this project, specifically the focus on low- and high-strength welds. They also noted that the project is well thought out and relevant to the development of long-term delivery pathways with strong potential impact on pipeline cost reductions. They noted that the project team has made good progress to date but recommended a stronger focus on the role of microstructure in accelerating crack growth and on demonstrating the relevance of the project results to U.S. Department of Energy (DOE) targets and industry. Reviewers also noted that they would like to see more information on the project collaborations, such as with ORNL, NIST, and the Colorado School of Mines.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-031	Renewable Electrolysis Integrated System Development and Testing *Michael Peters; National Renewable Energy Laboratory*	3.1	X			According to reviewers, the project shows considerable progress in developing concepts for electrolyzer integration with intermittent renewable energy sources. Reviewers noted that all milestones in fiscal year (FY) 2015 and FY 2016 were complete and future milestones were on track. They commended the project team for drawing relevant and insightful conclusions from the data, as opposed to just reporting numerical results, and on productive cooperation between NREL and industry participants. Reviewers recommended that the results obtained in the project should be made publicly available so that other research groups can further analyze the data to fine tune their energy storage concepts and designs.
PD-038	Biomass to Hydrogen (B2H2) *Pin-Ching Maness; National Renewable Energy Laboratory*	3.3		X		Reviewers found the project approach to be sound and reasonable, and they commended the project team for its effective partnerships and notable accomplishments toward meeting project milestones and DOE goals. Reviewers questioned the value of the ionic liquid treatment task, stating that the reasoning for focusing on a new feedstock was not clear; instead, they recommended focusing on a single feedstock. They also expressed interest in seeing additional details on methods and quantitative results for some of the project tasks.
PD-088	Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage *Zhili Feng; Oak Ridge National Laboratory*	2.7		X		Reviewers appreciated the project's vessel demonstration results and analysis showing a pathway for meeting DOE's cost reductions targets. They questioned, however, the use of steel/concrete composite as the most appropriate approach and specifically wanted to see validation of the fatigue life of the vessel in hydrogen. They stressed the importance of including the cost of transport, handling, and site preparation in the cost analysis, as these costs could negate the savings of this new vessel technology when compared to today's incumbent technologies.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-096	Electrolyzer Component Development for the Hybrid Sulfur Thermochemical Cycle *William Summers; Savannah River National Laboratory*	3.1	X			Reviewers commended the project's progress in solar-thermochemical plant design, process design, and cost analyses using process flowsheet models and the Hydrogen Analysis (H2A) model analysis. They also commented on the productive collaborations with highly qualified research groups and industry partners. Reviewers said that they would like to have seen more detailed technical and economic inputs and assumptions used for the techno-economic analysis. They also highlighted membrane performance and durability in the hybrid sulfur cycle's electrolysis step as a key technical challenge.
PD-100	700 bar Hydrogen Dispenser Hose Reliability Improvement *Kevin Harrison; National Renewable Energy Laboratory*	3.4	X			Reviewers praised this project, noting its excellent approach and highlighting its relevance to the reliability of the hydrogen dispenser hose, which is a key station component that currently has few vendors and exhibits high failure rates. They were impressed by the project's identification of leaks from nozzle fittings and were interested in learning more about the magnitude and behavior of these leaks. Reviewers suggested improved project collaboration with industry, for example through inclusion of fitting manufacturers, and also recommended publishing technical reports and/or journal articles that share project results.
PD-101	Cryogenically Flexible, Low-Permeability Hydrogen Delivery Hose *Jennifer Lalli; NanoSonic, Inc.*	3.4	X			Reviewers praised this project's approach and accomplishments to date and highlighted project relevance, particularly in light of the current lack of hydrogen dispensing hose suppliers on the market and the limited durability of the available hoses. They expressed specific appreciation for the project's inclusion of hose fittings. Reviewers also commended the project team's collaboration with NREL, though they noted challenges in collaborating with industry. They recommended that future focus include the hose's impact on fuel quality.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-102	Analysis of Advanced Hydrogen Production Pathways *Brian James; Strategic Analysis, Inc.*	3.1	X			Reviewers recognized the high-impact and usefulness of the techno-economic analyses performed by the project team as well as the team's expertise and experience in this area. They would have liked to have seen more information from relevant industry partners in the development of the case studies, though they acknowledged the challenges presented by the low Technology Readiness Level (TRL) of the dark fermentation and solid-oxide electrolysis cell (SOEC) cases presented. Reviewers would also like to have seen further details on the technical and economic assumptions of the analysis. They specifically expressed concerns about the aggressiveness of some of the assumptions presented for the future cases studies.
PD-103	High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis *Hui Xu; Giner, Inc.*	3.3	X			Reviewers gave high scores to the project for its progress in developing new, reduced-platinum group metal (PGM) electrocatalysts for polymer electrolyte membrane (PEM) electrolysis, which offer the potential to lower the costs and promote wider acceptance of the PEM technology. Reviewers noted the well-defined roles, productive collaboration, and "healthy competition" among the project participants. A specific project strength cited was the development of standard testing protocols, though the challenge of getting broad acceptance of these protocols was also noted. Reviewers said that in spite of good initial performance of the new catalysts, the long-term durability is still lacking. They recommended concentrating on durability improvements in future work.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-107	Hydrogen Fueling Station Pre-Cooling Analysis *Amgad Elgowainy; Argonne National Laboratory*	3.2	X			Reviewers commended the project for its technically-sound and comprehensive approach to pre-cooling analysis. Reviewers praised the technical analysis for its contribution to overcoming fundamental challenges in pre-cooling and were impressed by project timeliness. Reviewers commented that the potential impact of pre-cooling on the price of the station could be minimal since the refrigeration loop is a small part of the total cost; they recommended an increase in the scope of the fueling station analysis. They also noted that the refrigeration cycle analyzed might not be representative of the industry and recommended inclusion of additional industry partners to address this.
PD-108	Hydrogen Compression Application of the Linear Motor Reciprocating Compressor *Eugene Broerman; Southwest Research Institute*	2.6		X		Reviewers noted that the project has the potential to improve compressor reliability if successful and highlighted the project team's success in developing detailed designs to meet project milestones to date. Reviewers expressed concerns, however, that the project approach is too focused on theoretical assumptions and that it lacks sufficient go/no-go decision points. They commented that stronger collaborations with industry early on may have flagged key design issues, including limited efficiency and the costs and durability of the materials selected. Reviewers expressed particular concern with the technical feasibility of achieving DOE's efficiency target of 1.3 kWh/kg.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-109	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage *Zhili Feng; Oak Ridge National Laboratory*	2.3		X		Reviewers noted the value of the project's initial approach to stationary storage vessels using concrete reinforcement but emphasized that, based on project results, the current, updated vessel designs do not offer a viable pathway to hydrogen delivery and storage. Reviewers generally agreed that this technology would not be competitive when benchmarked against other available technologies for stationary storage. They commented that the project approach has focused on cost optimization but has not addressed technical feasibility and compatibility with existing stations. For example, the cycle life and demand for vessels of this size have not been addressed.
PD-110	Low-Cost Hydrogen Storage at 875 bar Using Steel Liner and Steel Wire Wrap *Amit Prakash; Wiretough Cylinders*	3.3	X			Reviewers praised the project's approach and progress made to date in developing the wire-wrapped technology for stationary hydrogen storage. They highlighted the successful ASME certification of this technology as a particular accomplishment. Reviewers expressed interest in seeing additional information specifically related to the vessel's resilience to fatigue in hydrogen. In particular reviewers would like to know how autofrettage affects fatigue crack growth in hydrogen under various pressures and temperatures.
PD-111	Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions *Wei Liu; Pacific Northwest National Laboratory*	3.0	X			Reviewers commended the project team for its progress in developing and testing innovative catalysts and carbon sorbent materials, and they recognized the strong collaborations between industry, national laboratory, and academia partners. They noted, however, significant operational challenges facing the swing reactor system integration and control. Reviewers felt that H2A and greenhouse gas emissions analysis employed an oversimplified set of assumptions, and they recommended devoting more effort to the operational aspects of system integration and mass and heat balance in the reforming/regeneration cycles. They also expressed concern that the effect of bio-oil feed variability was not properly analyzed.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-113	High-Efficiency Solar Thermochemical Reactor for Hydrogen Production *Tony McDaniel; Sandia National Laboratories*	3.2	X			Reviewers scored the project well for its relevance to long-term, large-scale renewable hydrogen production, as well as its effective project planning and execution with well-defined roles and capable partners. They specifically highlighted the project team's progress in the design and validation of the cascading pressure receiver reactor for solar-thermochemical redox cycles. Reviewers recommended that technical and economic inputs and assumptions used for the techno-economic analysis be updated and improved. They expressed specific concern that significant heliostat cost reductions appear to be necessary to meet DOE's hydrogen production cost targets according to the current techno-economic projections.
PD-114	Flowing Particle Bed Solarthermal Reduction–Oxidation Process to Split Water *Al Weimer; University of Colorado*	3.0	X			Reviewers commended the project's comprehensive approach and noted the significant progress made with a highly qualified group of collaborators. They specifically highlighted the effectiveness of the multi-phase reactor modeling, performance prediction, and materials discovery. Reviewers recommended that project priorities be shifted toward efforts that increase the TRL, since the techo-economic analysis has identified a pathway for meeting DOE hydrogen production cost targets. Reviewers generally noted that the range of project objectives were too broad and recommended further refinement of activities.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-115	High-Efficiency Tandem Absorbers for Economical Solar Hydrogen Production *Todd Deutsch; National Renewable Energy Laboratory*	3.5	X			Reviewers highly scored the project and were impressed by the project team's ability to enhance the efficiency of III-V semiconductor photoelectrochemical (PEC) devices to a new world record of 16.3%. They specifically highlighted the project team's expertise and innovation in employing the inverted metamorphic multijunction approach to accelerate PEC device development. Reviewers, however, expressed concern over the limited stability and high cost of the III-V materials under development. They generally agreed that increasing the durability of the materials will be necessary in order to meet the upcoming targeted demonstration of 875 hours stability at high efficiencies.
PD-116	Wide-Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting *Nicolas Gaillard; University of Hawaii*	3.5	X			Reviewers praised the project for its focus on an important class of chalcopyrite materials that has the potential to meet long-term DOE goals for PEC hydrogen production. They specifically commended the well-designed project for its demonstrated ability to precisely tune the bandgap of these materials to produce high-efficiency tandem devices. Reviewers expressed concern over the project's ability to achieve long-term durability targets, especially since the project team has focused primarily on the absorbers and less on the surface chemistry and catalysis. They recommended that the researchers focus on increasing durability.
PD-123	High-Performance Platinum-Group-Metal-Free Membrane Electrode Assemblies through Control of Interfacial Processes *Katherine Ayers; Proton OnSite*	3.5	X			Reviewers gave high scores to the project for its logically-structured work plan and excellent progress in developing non-PGM catalysts and enhancing alkaline membrane stability. They commented that the project's success offers the potential to achieve significant reduction in the capital cost of electrolyzers, which is critical for technology introduction on a larger scale. Reviewers recommended performing additional H2A analysis of the impact of the non-PGM catalysts on hydrogen production cost. They also would like to have seen a more detailed investigation of the significant and unexplained effect of adding potassium carbonate to the system.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-124	Solid-Oxide-Based Electrolysis and Stack Technology with Ultra-High Electrolysis Current Density (>3A/cm^2) and Efficiency *Randy Petri; Versa Power Systems*	3.3	X			Reviewers commended the project, specifically highlighting the demonstration of impressive cell performance at extremely high current densities (>3A/cm^2). They also noted, however, the lower efficiencies and higher degradation rates observed under these high-current operating conditions. They highly recommended the project team's thorough techno-economic analysis to assist in the determination of the optimum current density for the solid-oxide electrolysis cell (SOEC) stack, which balances performance with capital cost.
PD-125	Tandem Particle Slurry Batch Reactors for Solar Water Splitting *Shane Ardo; University of California, Irvine*	3.0	X			Reviewers appreciated the project team's approach to analyzing the feasibility of a particle-based PEC reactor through comprehensive physical modeling. They specifically highlighted the significant progress made in modeling electrolyte effects and in synthesizing/analyzing candidate absorber materials. Reviewers expressed concern over the project's ability to meet some upcoming milestones, including the reduction of piping and pumping energy demand by 80%. They also recommended better leveraging of proposed project collaborations.
PD-126	Compressorless Hydrogen Refueling Station Using Thermal Compression *Kenneth Kriha; Gas Technology Institute*	2.9	X			Reviewers expressed satisfaction with the project's initial progress in modeling and data collection, and they noted that the technical approach was comprehensive. They also recognized that the project offers significant potential to lower station costs if successful. Reviewers expressed concern over the cost of increasing a station's footprint to accommodate the numerous small vessels in this approach and over the potential of heat leaks in this system. They additionally commented that storage vessels assumed in the project are not yet commercial. Reviewers urged that data from project demonstrations be used to assess the concept's technical and economic feasibility.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-127	Sweet Hydrogen: High-Yield Production of Hydrogen from Biomass Sugars Catalyzed by In Vitro Synthetic Biosystems *Y-H Percival Zhang; Virginia Tech*	3.2	X			Reviewers noted that the proposed hydrogen production pathway is innovative and that the project is making progress toward its goals, particularly in protein expression and peak production rates. They expressed concern, however, over the practicality of the approach, and noted that the techno-economic analysis presented was mostly qualitative and not thorough enough. Reviewers also raised questions about whether the hydrogen production rates in this approach could be sufficiently prolonged. They recommended enhanced collaborative leveraging of other research.
PD-130	Improved Hydrogen Liquefaction through Heisenberg Vortex Separation of Para- and Orthohydrogen *Christopher Ainscough; National Renewable Energy Laboratory*	3.5	X			Reviewers praised the project for its innovative and promising approach to small-scale hydrogen liquefaction and specifically highlighted the project's significant potential to reduce the cost of hydrogen production and delivery, if successful. They commended the project team for first modeling, then validating the model with testing, and they encouraged the team to move forward on actual vortex tube experimentation and validation. Reviewers recommended the development of enhanced techno-economic models for better assessing the potential for future cost savings.
PD-131	Magnetocaloric Hydrogen Liquefaction *Jamie Holladay; Pacific Northwest National Laboratory*	3.3	X			Reviewers gave high scores to the project for making substantial progress over a short period of time, highlighting its effective leveraging of strong expertise and knowledge bases in the development of novel magnetocaloric materials for hydrogen liquefaction. They recommended, however, that the project team clearly identify the key novel technical features that distinguish the current project from past work and that they increase industry collaboration, particularly to better characterize scale-up potential. Reviewers expressed slight concern that the scope of the project was overly broad.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-132	Advanced Barrier Coatings for Harsh Environments *Shannan O'Shaughnessy; GVD Corporation*	3.5	X			Reviewers praised the project for its progress and approach, specifically highlighting the vacuum tumbler approach to manufacturing. They also commented on the strong collaboration across industry, applauding the inclusion of a seal manufacturer, a manufacturer of compressor equipment, an industrial user, a hydrogen fuel system designer, and a national laboratory in the development to ensure the coatings are being designed for the application and use environment. Reviewers recommended investigating the possible contamination that may outgas from the coating.
PD-133	Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) – Consolidation *Christopher Ainscough; National Renewable Energy Laboratory*	3.2	X			Reviewers commended the project approach for its significant potential impact on hydrogen fueling infrastructure cost reduction and highlighted the impressive project progress that has been made to date. They felt, though, that more detailed information on the project schedule and more clarity on the project results compared to a benchmark station would be beneficial. They appreciated the current laboratory and industry collaborations; they recommended the inclusion of additional industry partners.
PD-134	Cryo-Compressed Pathway Analysis *A.J. Simon; Lawrence Livermore National Laboratory*	3.2	X			Reviewers appreciated the project for its innovation and for the cutting-edge nature of the cryo-compressed options. However, they expressed skepticism about the likelihood of cryo-compressed dispensing being adopted by hydrogen refueling stations as a competitor to other incumbent technologies for dispensing 700 bar compressed gas. Reviewers recommended that future work in this project should consider the full well-to-wheels analysis of cryo-compressed dispensing at scales consistent with capacities of current and future stations.

Hydrogen Storage

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-001	System-Level Analysis of Hydrogen Storage Options *Rajesh Ahluwalia; Argonne National Laboratory*	3.4	X			Reviewers commended the project for providing unbiased analyses of hydrogen storage options and showing depth in technical evaluation across multiple storage approaches. Reviewers also commended the project's work on system/material trade-offs, assessing design variations and engineering features for diverse hydrogen storage systems and materials, and highlighting areas that either have potential for improvement or are already constrained to current values. However, reviewers cautioned that the assessment of a high-pressure metal hydride storage option needs to be completed with greater emphasis on overall thermal management issues of the charging performance. Reviewers also recommended that the project actively seek out experimental data from experienced researchers when the source of data for analysis is unavailable or unreliable.
ST-004	Hydrogen Storage Engineering Center of Excellence *Don Anton; Savannah River National Laboratory*	3.3			X	The reviewers were very satisfied with the approach and accomplishments of the Hydrogen Storage Engineering Center of Excellence (HSECoE) and stated that its findings were of utmost relevance to the overall Hydrogen Storage program. They felt that the large group of partners was sufficiently diverse and collaborations were well-organized and beneficial for the project. The reviewers also specified that making the modeling package available to the community was very significant and that the data obtained on the storage systems will provide a solid foundation for development when a suitable material emerges.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-008	Hydrogen Storage System Modeling: Public Access, Maintenance, and Enhancements *David Tamburello; Savannah River National Laboratory*	3.3	X			This is a follow-on project to the HSECoE. The reviewers commended the project for its efforts to enhance the performance and user-interface of the models and to ensure that the hydrogen storage research community is able to access and use these models in the most practical and user-friendly manner. The reviewers agreed that it is important to preserve the wealth of information and understanding of engineering concepts and required hydrogen storage material properties developed during the HSECoE. While reviewers also applauded the project's emphasis on the end user and strong collaboration with HSECoE stakeholders, they stated that including input/feedback from users who are not former HSECoE members could be beneficial to the overall success of the effort.
ST-063	Reversible Formation of Alane *Ragaiy Zidan; Savannah River National Laboratory*	3.1	X			The reviewers agreed that some progress had been made in alane synthesis and crystallization, specifically noting the development of the MgNi-based cathode to reduce dendrite formation during the electrochemical process. They added that the project has the potential to meet U.S. Department of Energy (DOE) goals for portable power applications, and therefore, they applauded its relevance. The reviewers questioned the collaboration between the project and their partners and specifically worried that the division of labor and communication lines between the two seem unclear.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-100	Hydrogen Storage Cost Analysis *Brian James; Strategic Analysis, Inc.*	3.2	X			Reviewers commended the project's approach and in depth analysis, including an uncertainty analysis that vets and captures potential cost reduction concepts. Reviewers commended project interactions and collaborations, including data exchange with other institutes and industrial partners. Reviewers suggested collecting more data on low-cost carbon fibers and towpreg to refine assumptions where excessive fuzz causes tow breakage and results in increased winding time. Reviewers also recommended considering economic drivers such as cost versus performance metrics, to ascertain what drives the "buy" decision. Reviewers commented that the model has a strong foundation but that the project can add other features such as certification costs, tank finishing/rework, and scrap costs.
ST-111	Thermomechanical Cycling of Thin-Liner, High-Fiber-Fraction Cryogenic Pressure Vessels Rapidly Refueled by Liquid Hydrogen Pump to 700 bar *Salvador Aceves; Lawrence Livermore National Laboratory*	2.9		X		Reviewers noted that the project is relevant because it advances the understanding of the impact cryo-compressed vessels can have on hydrogen storage capacity. However, reviewers stressed how important it is for the project to address key technical issues, as it is not clear whether the project has a grasp on aspects related to thermal insulation, dormancy, or tank liner failures. The reviewers complimented the team for completing the commissioning and certification of the cryo-pump testing facility but stated they would like to see non-invasive methods and instrumentation for evaluating and monitoring tank robustness and quality used before conducting further tank testing. Reviewers also noted that collaboration between project partners seems adequate but suggested obtaining additional input from stakeholders with extensive expertise in high-pressure tank design. This is a joint project funded by the Hydrogen Storage, Technology Validation, and Hydrogen Delivery programs.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-113	Innovative Development, Selection, and Testing to Reduce Cost and Weight of Materials for Balance-of-Plant Components *Jon Zimmerman; Sandia National Laboratories*	3.1	X			Reviewers commented that the project is well designed and strong in the fundamental understanding of hydrogen embrittlement. They noted there should not be overreliance on stacking fault energy. Reviewers also commented that it is unclear how the experiments are used to validate the theory and whether configurational degrees of freedom have been considered. Reviewers recommended that the project include Cr, which is another important composition variable, and should not limit the main composition variable to predominantly Ni. Reviewers commended the project for strong collaboration with materials companies and component suppliers, specifically for engaging balance-of-plant and stainless steel manufacturers. Recommendations include acquiring further input from manufacturers regarding the cost and machining of these materials.
ST-114	Next-Generation Hydrogen Storage Vessels Enabled by Carbon Fiber Infusion with a Low-Viscosity, High-Toughness Resin System *Brian Edgecombe; Materia*	3.4	X			Reviewers commended the project's significant accomplishments, including employing a good mix of modeling and experiments to infuse and test panels and small-scale tanks to demonstrate feasibility of use, as well as preparing and bursting small Type 3 composite overwrapped pressure vessel (COPV) tanks. Reviewers recommended that the project team work on confirming relationships between voids, composite performance, and carbon fiber reduction opportunities. Reviewers also recommended leveraging the vast experience of the composites community in vacuum assisted resin transfer molding processing to fully accomplish the objective of vacuum infusing a full-scale prototype tank. Reviewers commended the project's strong technical team and good collaboration among partners. However, reviewers noted that the project would benefit from a series-production tank manufacturer either as a partner or in a consulting role to better guide development toward commercialization.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-115	Achieving Hydrogen Storage Goals through High-Strength Fiberglass *Hong Li; PPG Industries, Inc.*	2.5		X		Reviewers commented that the loss of fiber strength, as compared to the loss of strength in pristine glass fiber, is a major setback. Without improved stress rupture performance, it will be hard to reduce the tank design safety factor as proposed to offset the additional weight, volume, and manufacturing cost required for the added fiber. Reviewers recommended that the project address the fiber manufacturing issues to produce glass fiber with low translation loss.
ST-116	Low-Cost a-Alane for Hydrogen Storage *Richard Martin; Ardica*	2.9	X			The reviewers commented that significant progress has been made on the cost models and that the methodology has been clearly explained and focused. They confirmed the project's relevance for small portable power applications. The reviewers stated that while the teams were good, the level of collaboration with national laboratories could be improved. They also suggested that future efforts be focused on progress with the reactor.
ST-118	Improving the Kinetics and Thermodynamics of Mg(BH4)2 for Hydrogen Storage *Brandon Wood; Lawrence Livermore National Laboratory*	3.0	X			The reviewers complimented the project's highly integrated theoretical, characterization, and experimental approaches. They noted that this project fits nicely into the overall Hydrogen Storage program and should be able to interface with the Hydrogen Materials—Advanced Research Consortium (HyMARC) extremely well, as many of HyMARC's capabilities will suit the project's needs. The reviewers commented that work on this specific system is highly relevant, as the material is one of the few that has the potential to meet the storage targets. They also felt that reversibility and cycling studies should be included in future work.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-119	High-Capacity Hydrogen Storage Systems via Mechanochemistry *Vitalij Pecharsky; Ames Laboratory*	2.5		X		The reviewers commended the project's high-risk, high-reward approach to target a new class of high-capacity materials. They also commended the initial theoretical work to screen potential target compounds. However, the reviewers expressed concern that the targeted compounds can be synthesized. The reviewers believe that the project would benefit from possible future interactions with the HyMARC. They suggested that the planned borohydride-graphene composite work be dropped to allow more effort on the mechanochemical synthetic tasks.
ST-120	Design and Synthesis of Materials with High Capacities for Hydrogen Physisorption *Brent Fultz; California Institute of Technology*	2.6		X		The reviewers felt that the project had made progress toward its milestones at these early stages. However, they stated that the presentation lacked a sufficient description of why the project's targeted materials and strategies were selected. They also expressed concern regarding the microscopy results, claiming that gold atoms dispersed on the surfaces do not show significant agglomeration. The reviewers also questioned the extent of the stated collaborations with national laboratories.
ST-121	High-Capacity and Low-Cost Hydrogen-Storage Sorbents for Automotive Applications *Hong-Cai (Joe) Zhou; Texas A&M University*	2.0		X		While the reviewers stated that the project's goal of developing materials with hydrogen storage greater than the typical 1 wt.% per 500m^2/g is valid and well-defined, they had significant issues with several aspects of the project. They understood that the main target material displayed higher uptake than expected based on surface area but were disappointed that the project did not focus on the scientific reasons why this occurred. The reviewers were also unhappy that this target material did not meet the go/no-go metrics, and the presentation did not attempt to provide an explanation for why.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-122	Hydrogen Adsorbents with High Volumetric Density: New Materials and System Projections *Don Siegel; University of Michigan*	3.3	X			The reviewers applauded the manner in which the project used computational screening to direct synthesis and characterization of materials. They complimented of the team and its progress in the first year of the project. The reviewers also felt that the project would benefit from improved access to other existing materials databases and suggested that the project attempt to investigate high hydrogen capacities closer to room temperature.
ST-126	Conformable Hydrogen Storage Coil Reservoir *Erik Bigelow; Center for Transportation and the Environment*	2.8	X			Reviewers noted the storage geometry approach is novel with potential for improved volumetric density and installation flexibility. Reviewers commented that the hydrogen permeation target needs to be based on industry permeation standards, which has a lower value than the current standard based on loss of useable hydrogen. Reviewers also commented that the project should ensure permeability is managed safely. Reviewers recommended that the project evaluate Kevlar® strength reduction resulting from the known abrasion induced from vibration, as well as analyze failure modes to evaluate burst pressure in the conformable configuration. Reviewers also suggested that the project include an original equipment manufacturer as a partner to identify showstoppers and drive the design and requirements.
ST-127	Hydrogen Materials–Advanced Research Consortium (HyMARC): A Consortium for Advancing Solid-State Hydrogen Storage Materials *Mark Allendorf; Sandia National Laboratories*	3.2	X			Overall, the reviewers were satisfied with the structure and organization of the consortium and believe that HyMARC has the potential to make significant progress in the development of hydrogen storage materials. Specifically, the reviewers regarded the parallel development of foundational computational and experimental methods to be a positive and logical strategy and noted that progress and collaboration among the team members has been sufficient for its first year. Reviewers did point out that work at national laboratories investigating graphene nanobelts could be better integrated into the overall consortium compared to the other tasks.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-128	HyMARC: Sandia National Laboratories Effort *Mark Allendorf; Sandia National Laboratories*	3.1	X			The reviewers complimented the strong team that has been put together as part of the national laboratory efforts within HyMARC, as well as its extensive network of collaborators. Several of the capabilities were identified as being impactful and important to the field of hydrogen storage, including the upgraded high-pressure reactor, the new clean sample transfer systems, and the low-energy ion scattering (LEIS) instrument. The reviewers expressed slight concerns over the ongoing work on older materials, specifically the Li_3N and $NaAlH_4$ systems and suggested a careful prioritization of future efforts to ensure that information gained from the model systems will be carried forward to newer materials.
ST-129	HyMARC: Lawrence Livermore National Laboratory Effort *Brandon Wood; Lawrence Livermore National Laboratory*	3.2	X			The reviewers had positive comments about the national laboratory component of the HyMARC, specifically the group's extensive computational capabilities. They were satisfied with the progress made in the first year of the project and believed that the work being carried out has the potential to be of value in the development of hydrogen storage materials. They also pointed out that the foundational knowledge that the modeling efforts can provide are of need in the area. The reviewers expressed a desire to have seen more details on why specific materials were chosen for investigation.
ST-130	HyMARC): Lawrence Berkeley National Laboratory Effort *Jeffrey Urban; Lawrence Berkeley National Laboratory*	3.0	X			The reviewers viewed the national laboratory component of HyMARC to have made sufficient progress at this early stage. They regarded the efforts as being well-coordinated within HyMARC and having significant external collaborations as well. Spectroscopic work was identified as being important for the field. The reviewers did raise some minor concerns that these efforts are more of a materials development approach than the overall HyMARC goal of developing foundational knowledge about storage mechanisms. They also stated that the work on Mg encapsulation may need to be re-evaluated for its relevance to the overall project.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-131	Hydrogen Storage Characterization and Optimization Research Efforts *Thomas Gennett; National Renewable Energy Laboratory*	3.2	X			The reviewers commended several aspects of this effort, including the hydrogen capacity validation services, development of the thermal conductivity apparatus for external use, and organization of the round robin volumetric capacity testing. They agreed that these services are highly relevant to the DOE Hydrogen Storage program and important for the community as a whole. They felt that the team and its level of collaboration are well-managed and that they have made significant progress in their first year. The reviewers also commented that certain aspects of the national laboratory materials development work may need to be re-evaluated for its potential to yield useful storage materials.
ST-132	Hydrogen Storage Characterization Research Efforts *Tom Autrey; Pacific Northwest National Laboratory*	3.3	X			The reviewers were happy with the developments in the first year of the efforts to enhance the strong nuclear magnetic resonance spectroscopy capabilities and to tie them into the consortium and the storage portfolio as a whole. They indicated that the team involved is strong and that the level of collaboration with the many partners is good. They agreed that the effort should provide significant scientific details about storage behavior and that the goals of the project clearly support the DOE's hydrogen storage objectives.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-133	Hydrogen Storage Characterization and Optimization Research Effort *Jeffrey Long; Lawrence Berkeley National Laboratory*	3.2	X			The reviewers complimented the group as being at the forefront of metal-organic framework research and stated that the collaborations they have formed for this project are well-established and productive. They specifically commended the demonstration of two hydrogen molecules at one open metal site and viewed this as an important result in the area of sorbent materials. The reviewers believe that the materials targeted by the project have the potential to be viable onboard storage materials and that the group's focus on high volumetric capacities at ambient temperatures is valid. While the reviewers commended the project's materials development efforts, they also stated that its scope should be more tailored to reflect the overall goals of the project team.

Fuel Cells

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-017	Fuel Cells Systems Analysis *Rajesh Ahluwalia; Argonne National Laboratory*	2.7		X		Reviewers commented that the approach was satisfactory overall and that the project maintained a strong collaboration effort. However, some reviewers noted that it was difficult to fully understand what has been accomplished and how all the data results will really impact fuel cell systems. Reviewers stated that the project would benefit if it focused less on the nanostructured thin film (NSTF) approach for future work.
FC-018	Fuel Cell Vehicle and Bus Cost Analysis *Brian James; Strategic Analysis, Inc.*	3.4	X			Reviewers were in consensus that the approach is solid. They commented that the team has done well in documenting all results and estimates while providing quality analysis. They also noted that the team has reduced the range between gas diffusion layer and bipolar plate costs and the team made recommendations for further cost savings. The reviewers recommended that future cost evaluations show where processes were volume-optimized.
FC-020	New Fuel Cell Materials: Characterization and Method Development *Karren More; Oak Ridge National Laboratory*	3.2	X			Reviewers commended the approach and highlighted the progress made in three-dimensional (3-D) imaging of catalyst layers. They also commended the project for its collaborations. They noted that since the automotive and commercial membrane electrode assembly (MEA) companies may be hesitant to share their state-of-the-art MEAs for outside evaluation and publication, the team may need to find a more realistic way to obtain MEA samples for comparison. The reviewers recommended an increased emphasis on new and improved microscopy techniques, and not just application. Also, they noted that the scope should be directed toward imaging catalyst layers under wet or in situ conditions.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-021	Neutron Imaging Study of the Water Transport in Operating Fuel Cells *David Jacobson; National Institute of Standards and Technology*	3.2	X			Reviewers were impressed with the project's approach to improve fuel cell water imaging needs. They stated that the neutron imaging capabilities are impressive and contributing to the advancement of more tools for water management. Reviewers commented that the current capabilities of the facility seemed to be underutilized. Reviewers recommended that x-ray/neutron combined experiments be predicated on interest.
FC-052	Technical Assistance to Developers *Tommy Rockward; Los Alamos National Laboratory*	3.4	X			Reviewers stated the project's approach is generally good, using accepted industry practices and procedures. They commended the project team's broad knowledge of polymer electrolyte membrane (PEM) technology and its positive impact on the collaborative work. Reviewers stated that the narrow focus on PEM technology was a weakness and recommended that the project be expanded to include the application of knowledge gained.
FC-081	Fuel Cell Technology Status: Degradation *Jennifer Kurtz; National Renewable Energy Laboratory*	3.0	X			The reviewers commended the project's interaction with industry to collect data. However, they stated that the uniform analysis (no matter what the technology is) and the scattered data make interpretation and comparisons difficult. One reviewer recommended a comparison between different international regions.
FC-097	Stationary and Emerging Market Fuel Cell System Cost Analysis – Primary Power and Combined Heat and Power Applications *Vincent Contini; Battelle*	3.3	X			Reviewers commented that the approach does an adequate job of identifying the main contributions to the cost of fuel cell systems. They noted that the project provides a lot of valuable data and analysis; however, results would benefit from information from additional commercial suppliers, including international ones, selling combined heat and power (CHP) systems.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-098	A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications *Max Wei; Lawrence Berkeley National Laboratory*	3.3	X			Overall, reviewers were in agreement that the approach is generally good. Reviewers stated that the project produced excellent results. However, the project would have benefited from the inclusion of additional technologies, such as high temperature PEM. Reviewers recommended an attempt to calculate the health/environmental externality financial cost confidence interval to highlight fuel cell societal benefits.
FC-104	High-Performance, Durable, Low-Cost Membrane Electrode Assemblies for Transportation Applications *Andrew Steinbach; 3M*	2.7		X		Reviewers noted that the approach and progress achieved were good and that collaborations with other institutions were strong. However, it seems like progress is not sufficient to meet the robust goal of allowing NSTF technology to be the design of choice for future automotive stacks. Reviewers recommended that the project focus on changes to the basic support structure of NSTF or to non-NSTF MEAs in order to address NSTF technology limitations.
FC-106	Rationally Designed Catalyst Layers for Polymer Electrolyte Membrane Fuel Cell Performance Optimization *Deborah Myers; Argonne National Laboratory*	3.1			X	Reviewers stated that the approach is reasonable and can be used to perform careful analysis of relevant materials. They noted that the project made good progress and included a strong team. However, some reviewers highlighted the limitations of the insight gained from this project. They noted that the project did not seem to provide information about mechanisms or alternative approaches that could lead to improved MEA performance.
FC-107	Non-Precious Metal Fuel Cell Cathodes: Catalyst Development and Electrode Structure Design *Piotr Zelenay; Los Alamos National Laboratory*	3.2			X	The reviewers commended the project for its significant progress over its lifetime and its relevance and potential to reduce PEM fuel cell cost. They noted that the team demonstrated non-platinum group metal (non-PGM) catalysts with increased activity making good progress toward meeting the U.S. Department of Energy (DOE) targets. Reviewers stated that the project needs additional focus on catalyst layer engineering and high current density operation, which should be the focus of future efforts.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-109	New Fuel Cell Membranes with Improved Durability and Performance *Michael Yandrasits; 3M*	3.5	X			Reviewers were all in agreement that the approach was excellent and the project was well executed. They stated that, with an amazing team and strong polymer background, the project was able to provide results with proper control and targets. Reviewers recommended more work on elucidating membrane degradation issues.
FC-110	Advanced Hybrid Membranes for Next-Generation Polymer Electrolyte Membrane Fuel Cell Automotive Applications *Andrew Herring; Colorado School of Mines*	2.7		X		Reviewers commented that the approach pursued is promising but that the project achieved limited progress. They noted that there needs to be more focus on the membrane mechanical properties and its potential durability. Reviewers recommended that the project further explore the viability of the heteropoly acid approach and demonstrate it in MEAs.
FC-116	Smart Matrix Development for Direct Carbonate Fuel Cell *Chao-yi Yuh; FuelCell Energy, Inc.*	3.4	X			Reviewers noted that the approach is very clear and promises to improve the durability of molten carbonate fuel cells. They stated that the team was able to accomplish many milestones and produced excellent results by demonstrating a new matrix that will improve performance and durability relative to the baseline. However, reviewers stated that the project should provide more detail about the materials and processes used during the analysis.
FC-128	Facilitated Direct Liquid Fuel Cells with High-Temperature Membrane Electrode Assemblies *Emory DeCastro; Advent Technologies, Inc.*	2.9	X			Reviewers stated that the approach is novel and builds on previous work. However, it is unclear whether this approach will be able to achieve relevant targets. They noted that the performance does not seem like it will really crossover to or impact the PEM fuel cells for transportation. Reviewers recommended more technical detail be presented and techno-economic analysis to demonstrate technology competitiveness in specific markets.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-129	Advanced Catalysts and Membrane Electrode Assemblies for Reversible Alkaline Membrane Fuel Cells *Hui Xu; Giner, Inc.*	2.7		X		Reviewers stated that progress was achieved; however, they did not all agree that the selection of catalyst materials was sensible. They expressed disappointment that the catalysts were not tested in an MEA. They noted that the team did not examine an innovative class of materials for ORR/OER and made little attempt to perform a detailed structure property relationship study with catalyst activity. The reviewers recommended further catalyst testing and materials down-selection.
FC-130	Development of Platinum-Group-Metal-Free Catalysts for Hydrogen Oxidation Reaction in Alkaline Media *Alexey Serov; University of New Mexico*	3.1	X			Reviewers stated that the approach was generally good with reasonable accomplishments. However, reviewers noted lack of sufficient information for proper accomplishment evaluation. They noted that the team made promising initial results, but it is not clear whether the kinetic data can be translated to MEA data. The reviewers recommended doing more testing, while also providing more catalyst benchmark data for the relevant systems.
FC-131	Highly Stable Anion-Exchange Membranes for High-Voltage Redox-Flow Batteries *Yushan Yan; University of Delaware*	2.6		X		Reviewers found the synthetic approach of combining a stable cation with a stable backbone to be solid and reasonable, but were concerned that the degradation tests are not the most accurate. In addition, reviewers expressed concern about the results achieved, particularly with respect to conductivity and stability. They recommended adding conductivity and stability targets or milestones and establishing a go/no-go decision point.
FC-132	Innovative Non-Platinum-Group-Metal Catalysts for High-Temperature Polymer Electrolyte Membrane Fuel Cells *Sanjeev Mukerjee; Northeastern University*	3.0	X			Reviewers were impressed by the strong collaborative team and the project's innovative and promising approach to eliminating PGM from fuel cells. However, reviewers noted that the project had already missed two milestones and that fuel cell performance was not satisfactory. They recommended that the project focus on addressing catalyst performance improvement, perhaps by identifying the most promising formulation and focusing on it.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-135	Fuel Cell Consortium for Performance and Durability – Consortium Overview *Rod Borup; Los Alamos National Laboratory*	3.1	X			Reviewers universally lauded the strength of the project team and the proposed approach to collaboration with each team member focusing on its core competency. However, they warned that integration of new partners and coordination of the whole consortium could be a weakness if a strong and clear communication plan is not in place. Reviewers recommended that the consortium should focus more on novel fuel cell testing techniques.
FC-136	Fuel Cell Consortium for Performance and Durability – Electrocatalysts and Supports *Debbie Meyers; Argonne National Laboratory*	3.3	X			Reviewers praised the relevance of the project's focus on durability of catalysts and supports, as well as the collaboration among team members. They noted, though, that collaboration with other DOE-funded projects and with suppliers may be a challenge. Reviewers recommended stronger collaboration with other members of the Fuel Cell Performance and Durability consortium.
FC-137	Fuel Cell Consortium for Performance and Durability – Electrode Layer Integration *Shyam Kocha; National Renewable Energy Laboratory*	3.1	X			Reviewers stated that the overall approach of applying learnings from rotating disk electrode (RDE) studies to the optimization of MEA-catalyst layers for state-of-the-art catalysts with the help of modeling is good. They noted, however, that the team may be focusing too much on mitigation strategies and recommended that the project focus more on a foundational understanding of the root causes of degradation.
FC-138	Fuel Cell Consortium for Performance and Durability – Ionomers, Gas Diffusion Layers, Interfaces *Adam Weber; Lawrence Berkeley National Laboratory*	3.3	X			Reviewers were impressed by the strength of the team, its access to an extraordinary amount of characterization equipment and techniques and the project's relevance to DOE goals. They identified few weaknesses but noted that the project would benefit from increased interaction with industrial partners and original equipment manufacturers (OEMs). Reviewers recommended that the project team maintain an emphasis on membrane interfacial resistance.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-139	Fuel Cell Consortium for Performance and Durability – Modeling, Evaluation, Characterization *Rangachary Mukundan; Los Alamos National Laboratory*	3.3	X			Reviewers identified the team members and their well-balanced approach with specific goals and targets as a project strength. They noted, though, that the project team could improve the quality of its collaborations with commercial suppliers and with stack developers. Reviewers recommended that the project better define the modeling work.
FC-140	Tailored High-Performance Low-Platinum-Group-Metal Alloy Cathode Catalysts *Vojislav Stamenkovic; Argonne National Laboratory*	3.1	X			Reviewers praised the project for developing novel in situ characterization techniques that enable real-time measurements of Pt dissolution and for the high activity of its catalysts. However, they expressed concern that the project was focused too heavily on RDE testing and ORR activity without a commensurate focus on MEA testing. Reviewers noted that the project would benefit from moving more quickly to MEA testing activities.
FC-141	Platinum Monolayer Electrocatalysts *Radoslav Adzic; Brookhaven National Laboratory*	2.7		X		Reviewers stated that the project has strong team members demonstrating novel electrocatalysts. However, they also stated that these novel electrocatalysts rely too heavily on replacing Pt with other PGM catalysts. Also, reviewers commented that the project remains overly dependent upon RDE testing. Reviewers recommended a shift to focus on the non-PGM core materials, such as niobium and niobium nitride.
FC-142	Extended Surface Electrocatalyst Development *Bryan Pivovar; National Renewable Energy Laboratory*	3.0	X			Reviewers praised the strength of the project team and the rational approach to using catalyst powders, which lends itself to high specific activity and a higher “ceiling” for activity. The reviewers stated, however, that the project was not placing enough emphasis on mitigating Ni leaching or Pt dissolution. Recommendations were mixed, ranging from identifying a method to evaluate the stability of the nickel substrates to increasing the project’s emphasis on integrating the powders into catalyst layers.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-143	Highly Active, Durable, and Ultra-Low-Platinum-Group-Metal Nanostructured Thin Film Oxygen Reduction Reaction Catalysts and Supports *Andrew Steinbach; 3M*	3.1	X			Reviewers noted that the project team has a good track record of working with NSTF and that NSTF is a good platform for high throughput with the potential to achieve high activity and durability. They stated, however, that the project has not prioritized operational robustness, a key technical barrier to the technology. Therefore, they recommended increasing the project's focus on improved operational robustness and, in particular, including automotive OEMs in order to specifically probe relevant operating conditions.
FC-144	Highly Accessible Catalysts for Durable High-Power Performance *Anu Kongkanand; General Motors (GM)*	3.1	X			Reviewers stated that the project is relevant to achieving DOE targets and uses a systematic approach with clearly defined goals. One weakness noted was the lack of a clear path toward understanding and minimizing Pt and Co dissolution during fuel cell operation. Reviewers universally recommended that the project focus more on catalyst development.
FC-145	Corrosion-Resistant Non-Carbon Electrocatalyst Supports for Proton Exchange Fuel Cells *Vijay Ramani; Illinois Institute of Technology*	2.7		X		The reviewers noted that the project team has a good grasp on the challenges associated with the project, has a proven track record in developing and executing similar projects, and has a systematic approach. However, the project does not address technical problems with metal supports, does not have an alternative approach if the proposed systems do not work, and the approach is not innovative. Recommendations varied widely from clarifying the material criteria to paying more attention to hydrophilicity in oxide supports.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-146	Advanced Materials for Fully Integrated Membrane Electrode Assemblies in Anion Exchange Membrane Fuel Cells *Yu Seung Kim; Los Alamos National Laboratory*	3.3	X			Reviewers noted the multi-faceted approach including a wide range of ionomers with good alkaline stability and the excellent synthetic chemistry expertise. They also noted, however, that it is not yet clear how anion exchange membrane fuel cell (AEMFC) approaches will compete with PEM fuel cells for accomplishing hydrogen-based energy conversion. In addition, they expressed concern that low-PGM loading or non-PGM catalysts were not addressed and recommended that a non-PGM catalyst be considered in the binder selection process.
FC-147	Advanced Ionomers and Membrane Electrode Assemblies for Alkaline Membrane Fuel Cells *Bryan Pivovar; National Renewable Energy Laboratory*	3.4	X			Reviewers noted that the team has excellent participants with experience working together and that the team has a tightly focused approach to a novel system for AEMFCs. Despite the novel approach, they noted that it is unclear whether AEMFCs will ultimately achieve commercial relevancy. The only recommendation was to expand work on MEA performance.
FC-149	Multiscale Modeling of Fuel Cell Membranes *Adam Weber; Lawrence Berkeley National Laboratory*	3.2			X	Reviewers noted that the project has a novel approach. They stated, however, that the project would benefit from experimental interactions with collaborators and that it was unclear whether the work would be relevant to other ionomers. They recommended that the work be expanded to include the investigation of perfluorosulfonic acid membranes with other side chains as well as hydrocarbon ionomers.

Manufacturing R&D

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
MN-001	Fuel Cell Membrane Electrode Assembly Manufacturing Research and Development *Michael Ulsh; National Renewable Energy Laboratory*	3.5	X			Reviewers stated that the approach is very good and that there is little that can be improved upon. They also noted that the project was well designed to provide quality information on various control technologies. Reviewers stated that the project team has a formidable collection of facilities and people with the highly specific skills required by the task; they see little room to improve the team's collaboration. The reviewers suggested that providing a summary chart of inspection techniques, including information such as the target defect or variable, required detection limits, required scanning or detection rate, state of development, and state of adoption, would be useful for the end user.
MN-012	Clean Energy Supply Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cell Technologies *Pat Valente; Ohio Fuel Cell Coalition*	2.8	X			Reviewers thought the project's approach to creating and supporting supply chains was generally good. They expressed mixed sentiment regarding the regional technical exchange centers, with some reviewers stating that the team had done an excellent job in establishing the centers and other reviewers questioning the importance of regional exchange centers. In addition, reviewers stated that the project team needs to improve the project's focus and to do a better job of tracking the project's impact with clear metrics. The reviewers recommended that the data collected from the technical exchanges be carefully analyzed to help DOE better achieve its goals.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
MN-013	Fuel Cell and Hydrogen Opportunity Center *Alleyn Harned; Virginia Clean Cities at James Madison University*	3.5	X			The reviewers were impressed with the team's approach and noted that significant progress has been made, particularly in collecting information and combining it into a single website to be used by the fuel cell community. However, they expressed concern that the project team does not have a clear measure for success and thought that the team should identify specific products that might be early commercial markets. The reviewers suggested that the project team clarify some details, such as the metrics used to determine project success and the manner in which the website is going to be maintained after federal funding has ended.
MN-014	U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competiveness Analysis *Patrick Fullenkamp; GLWN – Westside Industrial Retention & Expansion Network*	3.1	X			Reviewers noted that the approach is well structured and effective in generating a competitiveness analysis that is consistent in methodology with previous competitiveness analyses, and they were impressed with the progress made with original equipment manufacturer (OEM) and Tier 1 supplier surveys. The reviewers stated that the project team could have explored the results more thoroughly, including investigating discrepancies between OEM and Tier 1 survey responses. Reviewers noted that it is unclear whether the project will benefit the DOE beyond the current cost analysis and market reports. Reviewers recommended that the team further explore the assessments of manufacturing readiness by OEMs and Tier 1 suppliers.
MN-017	Manufacturing Competitiveness Analysis for Hydrogen Refueling Stations *Margaret Mann; National Renewable Energy Laboratory*	3.2	X			Reviewers stated that the project team's approach is effective, and they noted that the team is successful in making the cost analysis thorough for each component. They thought, however, that the team is trying to study too many subjects in such detail that assumptions are being made without sufficient information. Further, the reviewers noted that the analysis may be too dependent upon the assumptions made for each sub-system. They recommended the project team reach out to existing manufacturers and developers to verify the team's assumptions and review the results.

Technology Validation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-001	Fuel Cell Electric Vehicle Evaluation *Jennifer Kurtz; National Renewable Energy Laboratory*	3.5	X			Reviewers remarked that the project uses an objective approach in providing valuable real-world insight into fuel cell electric vehicle (FCEV) performance. It was noted that significant understandings have been gained over the past several years of data collection and evaluation. However, reviewers stressed that it is essential to acquire data from the newer generation of commercial vehicles recently introduced in the market. Reviewers also suggested that the driver and refueling interface be evaluated.
TV-008	Fuel Cell Bus Evaluations *Leslie Eudy; National Renewable Energy Laboratory*	3.7	X			Reviewers appreciated that the data are from buses that are in daily revenue service and that there is close collaboration with transit agencies. Increased collaboration with the DOE Vehicle Technologies Office and international partners was advised. It was noted that the value of data was being challenged because of the small number of buses, which are aging, and it was suggested that data be normalized to account for these factors. Reviewers also suggested further investigation into the infrastructure specific to fuel cell electric buses.
TV-017	Hydrogen Station Data Collection and Analysis *Sam Sprik; National Renewable Energy Laboratory*	3.3	X			Reviewers noted that the value of this project will grow as more stations come online and praised the involvement of California stakeholders. They also cautioned that the varying levels of detail collected from partners and discord related to data presented undermines the project's value. Reviewers strongly suggested that all retail hydrogen fueling stations report operational and cost data. Suggestions for future evaluation involved examining same vs. different design stations and small- vs. large-capacity compressor stations, while also strengthening international collaboration and data benchmarking.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-019	Hydrogen Component Validation *Daniel Terlip; National Renewable Energy Laboratory*	3.1	X			This project was viewed as consistent with H2USA priorities and as providing crucial information for increasing hydrogen station reliability. Reviewers cautioned that corrections for altitude should be included in the analyses, as testing is conducted at elevation, but most station deployments are at sea level. While commenting that the project involves robust participation from industry, increased collaboration with various stakeholders through the H2Tools platform was recommended. Reviewers further commented that more emphasis should be placed on discovering the root cause of component failures and providing high-level design suggestions.
TV-025	Performance Evaluation of Delivered Hydrogen Fueling Stations *Ted Barnes; Gas Technology Institute*	3.0	X			The reviewers noted the importance of obtaining real-world performance data on delivered hydrogen fueling stations and commended the collaboration between partners and the progress with the initial stations. However, permitting issues delaying data collection on the remaining three stations were a point of concern. It was suggested that data beyond number of fills—such as fill variations and boil-off rates—also be collected and evaluated.
TV-026	Development of the Hydrogen Station Equipment Performance (HyStEP) Device *Terry Johnson; Sandia National Laboratories*	3.8			X	Reviewers were impressed with the swift deployment of the device—which was seen as vital to accelerating station commissioning—and commended the management of the project. It was suggested that feedback from potential future users be obtained and that the device could potentially also be used for hydrogen quality testing and periodic gauging of station performance.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-027	Station Operational Status System (SOSS) 3.0 Implementation, SOSS 3.1 Upgrade, and Station Map Upgrade Project *Ben Xiong; California Fuel Cell Partnership*	3.7	X			Reviewers praised the project on multiple fronts—its success in implementing the Station Operational Status System on all California stations, enhancing data collection, providing information that is vital to gaining customer acceptance, and developing a disaster recovery plan. However, they stressed that all hardware and software requirements should be fully vetted by experts and that sensitivities around privacy of customer data be considered. Reviewers also suggested considering the addition of several tank categories in order to accommodate vehicles with larger tanks (e.g., buses) and relevant state-of-charge calculations.
TV-028	Advanced Hydrogen Fueling Station Supply: Tube Trailers *John Aliquo; Air Products and Chemicals, Inc.*	3.3	X			This project was viewed by reviewers as being very beneficial to the development of hydrogen infrastructure, with the potential to reduce the need for compressors, which are significant contributors to station issues. Reviewers stressed that obtaining approval from the U.S. Department of Transportation for moving the high-pressure tube trailers on roads should be a priority and that specific system cost goals should be added.
TV-029	Performance and Durability Testing of Volumetrically Efficient Cryogenic Vessels and High-Pressure Liquid Hydrogen Pump *Salvador Aceves; Lawrence Livermore National Laboratory*	3.3	X			Reviewers believed that the project has a strong team and commended the use of team capabilities in safety testing. Reviewers commented that this project may be occupying a limited niche, but they still found it of value for FCEV commercialization. They strongly recommended collaboration with and input from more than one automaker. It was also mentioned that cost analysis and comparative analysis with gaseous storage would add value.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-031	Dynamic Modeling and Validation of Electrolyzers in Real-Time Grid Simulation *Robert Hovsapian; Idaho National Laboratory*	3.3	X			This project was regarded by reviewers as promising and important to understanding how electrolyzers provide benefits to the grid and how penetration of renewables may be increased. Collaboration with key partners, including utilities, was praised. Reviewers suggested including an electrolyzer company partner and investigating revenue streams of future projects with a higher penetration of renewables; evaluating the impact sub-systems supporting the electrolyzer will have on response times; and considering a 4,000 to 8,000 hour demonstration.
TV-032	Fuel Cell Electric Truck Component Sizing *Ram Vijayagopal; Argonne National Laboratory*	3.2			X	Reviewers regarded trucks as a valid market for fuel cells and remarked that the modeling performed provided a good foundation for designing fuel cell trucks. However, they expressed that the modeling would need to be validated with real-world performance using prototype vehicles. Examining life cycle cost and greenhouse gas analyses was suggested as a next step.
TV-033	Brentwood Case Study *Carl Rivkin; National Renewable Energy Laboratory*	3.1	X			Reviewers thought that there would be some useful learnings from the Brentwood case study. However, they stressed that the applicability of learnings would be limited and that investigating the implementation of hydrogen stations at retail sites would have been of more value. It was suggested that messaging on the learnings be coordinated with relevant industry groups and stakeholders; lessons learned from operations be added; and that the findings be revisited and updated as further experience is gained.
TV-034	Fuel Cell Hybrid Electric Delivery Van Project *Jason Hanlin; Center for Transportation and the Environment*	2.8	X			Reviewers noted that the potential impact of this project was promising and that the project team is demonstrating progress. Collaboration with partners was praised and seen as highly valuable. Teaming with a hydrogen tank manufacturer was suggested. It was also suggested that providing fueling for the vans be a focal point earlier in the project.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-037	Hydrogen Meter Benchmark Testing *Michael Peters; National Renewable Energy Laboratory*	3.3	X			Reviewers believed that this effort is important to understand flowmeter performance and meet SAE J2601 standards for refueling and that the project made use of good collaborations. They felt that greater value could be achieved by developing standards and methodologies that can be used across flowmeter manufacturers. It was highlighted that effects of operating conditions—such as cumulative errors during tank fill, ambient weather extremes, and varying vibration conditions—will likely be of more interest to station designers. Reviewers strongly suggested including station owners and operators in the effort.

Safety, Codes and Standards

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-001	National Codes and Standards Deployment and Outreach *Carl Rivkin; National Renewable Energy Laboratory*	3.4	X			Reviewers praised this project's improvement in the areas of collaboration and outreach, particularly for involving a variety of stakeholders. They commended the Continuous Codes and Standards Improvement approach as serving a critical area of need. Reviewers encouraged even further development in the area of outreach on a regional basis and also recommended clarification in areas where there is perceived overlap with other projects.
SCS-002	Hydrogen Component Research and Development *Robert Burgess; National Renewable Energy Laboratory*	3.2		X		Reviewers noted the project's good root cause analysis and forensic review of the problem with temperature and pressure relief device failures and felt that the results would inform industry practices. Other reviewers felt that the effort was limited in its impact, having a small sample size. They also applauded the collaboration with the stakeholders and the effort to incorporate feedback into the work plan. Reviewers found the proposed future work to be too broad and recommended clarification of direction.
SCS-005	Research and Development for Safety, Codes and Standards: Material and Component Compatibility *Chris San Marchi; Sandia National Laboratories*	3.4	X			Reviewers praised this project for its strategy, relevance, and international and domestic coordination, not only with other research institutions and industry but with code development organizations (CDOs) and standards development organizations (SDOs) as well. They noted the efforts to make the project data available broadly through an online database and encouraged further work toward this end. The reviewers recommended that the future work plan be more detailed for clarity.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-007	Hydrogen Fuel Quality *Tommy Rockward; Los Alamos National Laboratory*	3.3	X			Reviewers commended the project's expansion of scope to include recirculation effects and the evaluation of fuel quality under realistic conditions. They noted the progress of the team in developing a prototype detector and expressed a desire to see results from the validation testing. Reviewers felt that the progress of the American Society for Testing and Materials (ASTM) portion of this work needs to move forward more aggressively but also acknowledged that the ASTM portion may be beyond the control of the project team.
SCS-011	Hydrogen Quantitative Risk Assessment *Katrina Groth; Sandia National Laboratories*	3.6	X			Reviewers praised this project for developing a valuable software tool, which can overcome many codes and standards (C&S) barriers. They praised the reports and user guide outputs as well as the coordination and inputs to several CDOs and SDOs. Reviewers encouraged the consideration and implementation of user feedback and recommended that the project continue to add additional models.
SCS-019	Hydrogen Safety Panel, Safety Knowledge Tools, and First Responder Training Resources *Nick Barilo; Pacific Northwest National Laboratory*	3.5	X			Reviewers applauded the expanded impact of the Hydrogen Safety Panel to include non-DOE work. They also noted the international collaboration for first responder training. Reviewers recommended that care be given to avoid scope creep, given the broad nature of the project tasks. Reviewers also raised concerns about having sufficient resources to update items developed elsewhere and hosted on H2Tools.org and whether the efforts to transfer external resources to the site might be duplicative.
SCS-021	National Renewable Energy Laboratory Hydrogen Sensor Testing Laboratory *Bill Buttner; National Renewable Energy Laboratory*	3.4	X			Reviewers commended the blind study approach to sensor validation and felt that the sensor testing portion of the project was very comprehensive. They also stated that the collaborations with industry were excellent. They recommended that clear documentation of sensor application guidance continue to be pursued. Reviewers raised some concerns about the test procedure for the planned vent profile measurement task and made several recommendations, which are contained in the full report.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-022	Fuel Cell & Hydrogen Energy Association Codes and Standards Support *Karen Quackenbush; Fuel Cell & Hydrogen Energy Association*	3.2	X			Reviewers praised the efforts to coordinate and track a variety of C&S activities, and reviewers found the scope of the coordination work to be impressive. The reviewers felt that the direct accomplishments of the project were overshadowed by the number of activities being presented. Reviewers recommended that the purpose of the matrix be made clear so that the benefits to the DOE are easily understood.
SCS-025	Enabling Hydrogen Infrastructure through Science-Based Codes and Standards *Chris LaFleur; Sandia National Laboratories*	3.7	X			Reviewers commended the value and progress of this work and the direct impact it can have on many critical barriers. They particularly praised the real-world alternate means application efforts and the related collaboration. Reviewers recommended that the project work directly with authorities having jurisdiction in states beyond California.
SCS-026	Compatibility of Polymeric Materials Used in the Hydrogen Infrastructure *Kriston Brooks; Pacific Northwest National Laboratory*	3.6	X			Reviewers praised the results already achieved by such a new project, the focus on regular collaboration, and broad stakeholder input, and reviewers stated that the work is highly valuable. They made several recommendations regarding specific tests to be performed and noted that the broad number of materials being studied may be limiting. Reviewers recommended that the project ensure that previous results are taken into account.

Market Transformation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
MT-008	Hydrogen Energy Systems as a Grid Management Tool *Richard Rocheleau; Hawaii Natural Energy Institute*	3.1	X			Reviewers stated that this project ties together multiple benefits (e.g., electrolyzer demonstration, renewable hydrogen for fuel cell deployments, enabling intermittent renewables) into a single package and helps increase awareness and clarity of the permitting process for deployments. Reviewers stated that the proposed future work is similar to the future work proposed for 2015. The reviewers were not clear on the reason for all the delays, such as the MTA shuttle bus conversion that was previously scheduled for September 2015 and is now listed as future work for 2016, and indicated that more attention to project execution barriers is needed.
MT-011	Ground Support Equipment Demonstration *Jim Petrecky; Plug Power*	3.4	X			Reviewers stated that this project has a high potential to meet Hydrogen and Fuel Cells Program goals and enable demonstration for a wide breadth of additional applications. Although reviewers were satisfied in general with progress made in terms of evaluation, design, and development of learnings, concerns about fuel cell stack performance and the timeline for completing the project were expressed. Reviewers also stated that the specific stack problems should also have been explained.
MT-013	Maritime Fuel Cell Generator Project *Joe Pratt; Sandia National Laboratories*	3.3			X	Reviewers noted that this project's objectives were relevant, specifically the focus on lowering emissions and technology/finance risk in a market that needs more efficient power technology is relevant. Reviewers commented that the project addresses the DOE's goal to enable and accelerate expansion of hydrogen and fuel cell system use and that lessons learned from this deployment can be used for similar technologies and other ports. They felt that development of a business case and identification of follow-on opportunities are imperative. Additional deployments with this system and concrete plans on how to expand the number of deployments are needed according to reviewers.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
MT-014	Demonstration of Fuel Cell Auxiliary Power Unit to Power Truck Refrigeration Units in Refrigerated Trucks *Kriston Brooks; Pacific Northwest National Laboratory*	2.7	X			Reviewers agreed that the project is relevant and is a logical extension of other fuel cell applications, such as forklifts. Reviewers mentioned that very low operational time is hampering progress and specific go/no-go decision points were not expressed clearly. Also, reviewers stated that the timeline for the demonstration with the recently added partners is not yet clearly developed. Reviewers noted that progress has been slow and the degree of commitment on the part of the industrial partners is questionable.
MT-017	Medium-Duty Parcel Delivery Truck *Thomas Griffin; FedEx Corporation*	3.4	X			Reviewers stated that this application has great potential and that the project fits well within the DOE's goals and objectives. Bringing one system online, evaluating its performance, and then deploying 19 systems at various sites seems like a reasonable approach, according to reviewers. Some noted that, although there has been a setback with collaborators, evaluating duty cycles and designing appropriate system specifications was time well spent. One reviewer noted that more explanation on refueling is needed.
MT-020	Fuel Cell–Battery Electric Hybrid for Utility or Municipal Medium- or Heavy-Duty Bucket Trucks – Fuel Cell-Powered Auxiliary Power Module *Abas Goodarzi; US Hybrid Corporation*	3.1		X		Reviewers noted that this application is an opportunity for near-term deployment of fuel cell technology, and this project is making progress toward evaluating the market. Reviewers commented that the potential impact of this project will be very limited without a better financial analysis. Insufficient information was provided to definitively understand the energy efficiency and air pollution reductions achieved. Reviewers said that there is an absence of go/no-go decisions and there is not enough detail on the battery storage system.

Systems Analysis

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SA-035	Employment Impacts of Hydrogen and Fuel Cell Technologies *Marianne Mintz; Argonne National Laboratory*	3.1	X			Reviewers acknowledged that the project was well developed and that applying "input/output" modeling was a good approach. The project benefited from strong collaboration with industry and academia but should clearly identify involvement of original equipment manufacturers (OEMs) and the energy companies. Future work should consider expanding the model to include geographical and market impacts, and the resulting job retraction of displaced industries.
SA-039	Life-Cycle Analysis of Water Consumption for Hydrogen Production *Amgad Elgowainy; Argonne National Laboratory*	3.4	X			Reviewers agreed that the project established a good fundamental understanding of water consumption associated with hydrogen pathways, which is essential for comparing multiple fuel pathways and resource analysis. Reviewers further stated that the project provides a good refinement and greater resolution of previous analysis and is critical to hydrogen production pathways. Suggestions included expanding collaboration to multiple stakeholders, including the international community, and more extensive peer review of data and assumptions. Reviewers agreed that the model should be expanded to include regional water assessment.
SA-044	Impact of Fuel Cell and Hydrogen Storage Improvements on Fuel Cell Electric Vehicles *Aymeric Rousseau; Argonne National Laboratory*	3.1	X			Reviewers observed that the project strategy was sound and uses well-respected models to assess the impact of future fuel cell improvements on fuel cell electric vehicle (FCEV) cost and performance. Reviewers thought that project results were extremely useful and relevant in developing future R&D strategies. Suggestions included an assessment of costs at low-volume production levels and more transparency of assumptions and data. Reviewers also suggested that future work consider the marginal costs vs. the marginal benefits of achieving key program targets.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SA-052	The Business Case for Hydrogen-Powered Passenger Cars: Competition and Solving the Infrastructure Puzzle *Robert Rosner; University of Chicago*	2.9		X		Reviewers noted that the project is beneficial in examining the profitability of hydrogen infrastructure beyond government incentives. Reviewers said that the project's collaboration activities should include input from the venture capital and financial community, hydrogen suppliers, and OEMs. They suggested that future work include vetting the input cost data and market analysis of the rollout of the first-generation hydrogen generation stations.
SA-055	Hydrogen Analysis with the Sandia ParaChoice Model *Rebecca Levinson; Sandia National Laboratories*	3.2	X			Reviewers commented that using previously developed models as input and exploring uncertainties and tipping points is a good approach. Reviewers said that the project enables the analysis of market segmentation and market assumption inputs to further explore fuel cell vehicle market penetration. Reviewers commented that the project would benefit from additional collaboration with industry stakeholders and coordination with other models to minimize redundancy. Also, the transparency of the range of values assigned to key variables should be articulated, according to reviewers.
SA-057	Life-Cycle Analysis of Emerging Hydrogen Production Technologies *Amgad Elgowainy; Argonne National Laboratory*	3.6	X			Reviewers noted that the project has made good progress in developing life-cycle analyses for emerging hydrogen production pathways. This information will be valuable in assessing future R&D. Reviewers stated that the efforts should continue to add other emerging hydrogen production technologies, such as photobiological, photochemical, and solar thermochemical systems. Reviewers said that it is critical to engage and collaborate with stakeholders and other entities. They suggested that future work include adding probability distributions for key inputs and parameters and engaging the international community for model input.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SA-058	Analysis of Incentives and Policy Impacts on the Market for Alternative Fuels and Vehicles *David Greene; University of Tennessee*	3.1			X	Reviewers determined that the data and findings from the project are valuable and relevant to understanding cost drivers and policy impacts of transitioning to alternative fuel vehicles and hydrogen FCEVs in particular. They said that the lessons learned provide good information for deployment of FCEVs and will help federal and state governments to better understand implications of policies and incentives. Reviewers suggested that future work include a review of E85 and natural gas infrastructure incentives.
SA-059	Sustainability Analysis *Marc Melaina; National Renewable Energy Laboratory*	3.2	X			Reviewers noted that the addition of the sustainability project will enhance the analysis portfolio and that the project is relevant to hydrogen supply, but that analysis should include the economic and social aspects as well. Reviewers noted that this analysis should encompass more than an "index." They said that the inclusion of stakeholders in the steering team is an excellent way to encourage and extend collaboration activities. Reviewers recommended that future work include a broader mix of hydrogen supply channels, such as liquid hydrogen, distributed natural gas reforming, and central electrolysis.
SA-060	Evaluation of Technology Status Compared to Program Targets *Marc Melaina; National Renewable Energy Laboratory*	3.0			X	The reviewers recognized that the project approach uses vehicle simulation based on program targets with the market adoption potential to create long-term scenarios. They further stated that the project outcome identifies FCEV penetration based on achieving targets. Reviewers stated that the study would benefit from evaluating the scenario based on technology development's falling short of the technical targets. Suggestions included more involvement from OEMs and hydrogen stakeholders. Reviewers recommended that future work consider consumer adoption with incentives, convenience of refueling, and comparison of sales scenarios with planned station deployment.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SA-061	National Fuel Cell Electric Vehicle and Hydrogen Fueling Station Scenarios *Marc Melaina; National Renewable Energy Laboratory*	3.1			X	Reviewers commented that the approach and strategy of using scenario analysis was very effective in assessing the impacts of targets. However, reviewers stated that the analysis should include the impacts of not meeting Hydrogen and Fuel Cells Program targets as well. They recommended that the cost assumptions be improved to include more realistic figures for items such as land rent and electrical power supply. They also recommended that future work include regional considerations and incentives beyond zero-emissions vehicle credits and that the analysis results be reviewed by financial stakeholders.
SA-062	Expanded Capabilities for the Hydrogen Financial Analysis Scenario Tool *Marc Melaina; National Renewable Energy Laboratory*	3.4			X	Reviewers acknowledged that the project aligns well with the Hydrogen and Fuel Cell Program objective of supporting hydrogen infrastructure development, specifically with the addition of a comprehensive financial model to account for multiple cost variables. Reviewers noted that the additions made to the tool are extensive and useful in estimating the economies of refueling stations. Reviewers commended the project on the strong level of collaboration and recommended that future work consider the addition of maintenance of fueling station equipment.