Prologue

Dear Colleague:

This document summarizes the comments provided by peer reviewers on hydrogen and fuel cell projects presented at the fiscal year (FY) 2014 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 16–20, 2014, in Washington, DC. In response to direction from various stakeholders, including the National Academies, this review process provides evaluations of the Hydrogen and Fuel Cells Program's projects in applied research, development, demonstration, and analysis of hydrogen and fuel cells. A joint plenary session opened the meeting with a keynote address from Alan Taub, Professor of Material Science and Engineering at the University of Michigan, followed by overview presentations from the Hydrogen and Fuel Cells Program, the Vehicle Technologies Office, and the Basic Energy Sciences Program. A plenary for Hydrogen and Fuel Cells Program participants included overviews on each of the eight sub-program areas: 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 projects from relevant experts. The recommendations of the reviewers are taken into consideration by DOE technology managers in generating future work plans. The table that follows lists the projects presented at the review, evaluation scores, and the major actions to be taken during the upcoming fiscal year (October 1, 2014–September 30, 2015). The projects have been grouped according to sub-program area 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 2015 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 2015 AMR, which is presently scheduled for June 8–12 in Arlington, Virginia. Thank you for participating in the FY 2014 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 *Amgad Elgowainy; Argonne National Laboratory*	3.3	X			Reviewers commended the analytical work and collaboration with industry and suggested extending the collaboration to other federal agencies. Recommendations included improving the analysis to address the cost of the pump at stations and the high-pressure tube trailer valves. Reviewers also suggested including multiple pathway analysis to provide ideas for new/modified pathways to reach U.S. Department of Energy (DOE) cost targets.
PD-022	Fiber-Reinforced Composite Pipelines *George Rawls; Savannah River National Laboratory*	3.6	X			Reviewers were pleased with the performance and progress of the project, noting that fiber-reinforced-polymer pipelines demonstrate great potential for long-term development of hydrogen fuel technology. Reviewers suggested that additional fluid dynamic analyses for each proposed joint concept are needed to study the choked flow through reduced internal diameters, and that testing should include pressurized hydrogen.
PD-025	Hydrogen Embrittlement of Structural Steels *Brian Somerday; Sandia National Laboratories*	3.4	X			Reviewers complimented the project team's ability to address DOE technical barriers and maintain a continued understanding of the problem and scientific challenges. Reviewer suggestions included conducting analyses of installation costs and detailed cost savings. They also recommended conducting more testing on fatigue crack growth measurements in steel pipe exposed to hydrogen from other sources.
PD-028	Solarthermal Redox-Based Water Splitting Cycles *Al Weimer; University of Colorado*	3.0	X			Reviewers applauded the innovative, high-quality efforts and progress made with this project as well as the effective use of collaboration. They expressed concern about the technical challenges of moving solid materials at high temperatures and low pressures and recommended industrial or other expert input for the reactor system design and modeling. Reviewers also recommended a stronger focus on the materials development aspects of the project and continued updating of the Hydrogen Analysis (H2A) model, with particular attention on capital and operations and maintenance (O&M) costs.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
PD-035	Semiconductor Materials for Photoelectrolysis *Todd Deutsch*; *National Renewable Energy Laboratory*	3.5	X			Reviewers commended the project for its depth of understanding of the III/V semiconductor materials class, which offers one of the most promising pathways to achieving DOE goals for cost-effective photoelectrochemical (PEC) solar hydrogen production. The project's extensive collaborations with the broader PEC Working Group were viewed as a particular strength. Some concerns were expressed related to the project team's limited access to dedicated III/V semiconductor fabrication equipment, and related to the limited scope of materials characterizations—particularly related to durability investigations. Reviewers recommended expanding the project scope and bringing in new cross-office and cross-institute research and development (R&D) partnerships to leverage the relevant materials innovations.
PD-037	Biological Systems for Hydrogen Photoproduction *Maria Ghirardi;* *National Renewable Energy Laboratory*	2.9		X		Reviewers noted that the project is focused on addressing DOE barriers related to oxygen accumulation and hydrogen production rates. They stated that the project uses a logical approach. They noted the changes in scope and delays to the project, but they approved of plans to combine multiple mutations into a single strain as a logical completion and laudable goal. This project will be discontinued for programmatic reasons in early fiscal year (FY) 2015.
PD-038	Fermentation and Electrohydrogenic Approaches to Hydrogen Production *Pin-Ching Maness;* *National Renewable Energy Laboratory*	3.3	X			Reviewers recognized the progress the project has made in improving hydrogen production from the fermentation of cellulose and commended the project for its strong collaborations in the areas of feedstock sources, microbial electrolysis cell work, and genetic engineering. They noted the lack of technoeconomic analysis, and would have appreciated more information about Task 4, which involved developing a case study. Reviewers suggested adding analysis of the area of metabolic flux; potential uses for other components such as C5 sugars, lignin, and proteins; and chemical engineering.
PD-048	Electrochemical Hydrogen Compressor *Ludwig Lipp;* *FuelCell Energy, Inc.*	3.4			X	According to reviewers, the project has an excellent approach and has made good, steady progress. Reviewers found the project to be highly relevant to DOE goals because of its potential for achieving better operating cost and reliability than mechanical compressors. Reviewers suggested that the project assess the economics of high-volume manufacturing, and the potential for compressor variability in high-volume production. Additionally, while reviewers commended the partnership between FuelCell Energy and Sustainable Innovations, they recommended that the project add partners to help with research initiatives such as optimizing the compressor membrane. This project will be completed in FY 2014.

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PD-058	Characterization and Optimization of Photoelectrode Surfaces for Solar-to-Chemical Fuel Conversion *Tadashi Ogitsu; Lawrence Livermore National Laboratory/National Renewable Energy Laboratory*	3.5	X			Reviewers commented that the PEC theoretical tools and expertise developed through this project are outstanding and extremely valuable to broader PEC R&D efforts. The coordination of theoretical model development with experimental validation work based on spectroscopic results was highly commended. There was some concern that the project scope covered too many topics, given the project budget. It was recommended that the project team establish broader ties with the semiconductor and catalysts R&D communities to leverage synergistic theoretical and computational resources.
PD-081	Solar Hydrogen Production with a Metal-Oxide-Based Thermochemical Cycle *Tony McDaniel; Sandia National Laboratories*	3.1	X			Reviewers remarked on the outstanding approach to materials discovery and characterization, innovative reactor concept development, and systems analysis, as well as the excellent credentials and facilities of the project team. They expressed concern about the complexity of the reactor design and the high efficiencies and large decrease in capital cost required to meet the cost targets. Reviewers recommended a stronger emphasis on materials R&D, including screening methods prior to synthesis, characterization of materials durability during thermal cycling, and continued technoeconomic analysis.
PD-088	Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage *Zhili Feng; Oak Ridge National Laboratory*	3.0	X			Reviewers complimented this project's technical approach and progress to date in proving technical viability. The concept of vent ports to allow for hydrogen to diffuse out of the steel was particularly well received. The project was criticized for not considering the viability of vessels' installation at forecourt stations with respect to their size, the potential for diffusion paths being plagued by on-site moisture, and installation costs. Reviewers recommended conducting a cost comparison of the vessels with respect to existing fiber-wound storage technologies.
PD-094	Economical Production of Hydrogen through Development of Novel, High-Efficiency Electrocatalysts for Alkaline Membrane Electrolysis *Katherine Ayers; Proton OnSite*	3.1	X			According to reviewers, this project takes a novel approach to reducing the capital costs of electrolysis by developing alkaline membrane technology with the potential to move electrolyzers to a new, lower-cost curve. Despite the reduction in capital costs, reviewers indicated that this is a small percentage of the levelized cost of hydrogen. It was noted that degradation and stability need to be better characterized. Some other reviewer recommendations included focusing on improving cell efficiency, optimizing the catalyst chemistry, and performing an H2A model analysis to evaluate the ability of this work to reduce the cost of hydrogen.

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PD-095	Improving Cyanobacterial O_2-Tolerance Using CBS Hydrogenase for Hydrogen Production *Pin-Ching Maness; National Renewable Energy Laboratory*	3.3	X			According to reviewers, the project is well organized and focused on addressing oxygen inhibition in synechocystis, though it was noted that the work is only part of what would be required to meet the ultimate DOE goals. Reviewers noted the strong collaborations and the progress made, but also the lack of hydrogen production data. They felt that the proposed future work is logical and has the potential to meet the project goals. They recommended better definition of the pathway and the potential for hydrogen production, as well as better understanding of protein function and activity.
PD-096	Electrolyzer Component Development for the Hybrid Sulfur Thermochemical Cycle *William Summers; Savannah River National Laboratory*	2.9	X			Reviewers recognized the electrolyzer performance as the critical barrier to the hybrid sulfur cycle and commended the progress made in electrocatalyst screening, electrolyte membrane development, and the design and fabrication of a pressurized button cell for higher-temperature and pressure testing. They were concerned about the emphasis on polybenzimidazole membranes, noting that they are known to have stability issues. It was recommended that this issue be addressed and that other membrane and catalyst candidates be investigated.
PD-098	Low-Noble-Metal-Content Catalysts/Electrodes for Hydrogen Production by Water Electrolysis *Katherine Ayers; Proton OnSite*	3.1	X			Reviewers were generally satisfied with the progress made in reducing platinum group metal (PGM) loading of electrolyzer electrodes through leveraging core-shell catalyst technology developed at Brookhaven National Laboratory. However, several reviewers noted that PGM loading is only a small percentage of the system cost and is therefore unlikely to have a large impact on the cost of hydrogen. Some reviewers felt that the future work was not well defined and that project tasks were not integrated well. It was recommended that the team consider performing the H2A cost analysis earlier in the project to assess the potential impact of the work, rather than waiting until the end.
PD-100	700 bar Hydrogen Dispenser Hose Reliability Improvement *Kevin Harrison; National Renewable Energy Laboratory*	3.5	X			This project was well received by reviewers because of its relevance to enabling low-cost hydrogen delivery and its technical approach. In particular, reviewers appreciated the use of a robot to simulate fueling. Reviewers recommended that future research include exposure to realistic service conditions such as sunlight, environmental contaminants, and hysteresis. They also recommended that the project collaborate with station owners in California, Yokohoma Rubber in Japan, and/or other domestic hose manufacturers. Reviewers felt that such collaborations would ensure that the project accounts for fueling abnormalities that occur in service, such as breakaway events.

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PD-102	Hydrogen Pathways Analysis for Polymer Electrolyte Membrane Electrolysis *Brian James; Strategic Analysis, Inc.*	3.1	X			Reviewers appreciated the project team's inclusion of two national laboratories and commended the involvement of four electrolyzer companies in developing polymer electrolyte membrane (PEM) case studies. The results of the studies were seen as useful, especially the capital cost breakdown and sensitivity analysis. The reviewers commented that the correlation between the project results and relevant DOE targets should be made clearer. Recommendations included extending the PEM case studies to include alternative electrolyzer operating conditions (e.g., in current density), and establishing quantifiable limits to electrolytic hydrogen production achievable through capital and operating cost improvements.
PD-103	High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis *Hui Xu; Giner, Inc.*	3.3	X			Reviewers were pleased with the progress made toward developing lower-PGM-loading, high-performing electrocatalysts for PEM water electrolysis. They also commented on the strength of the team and the very good collaboration between the team members. Reviewers recommended placing more emphasis on longer-term durability testing. They also suggested considering possible down-selection among the different catalysts being developed.

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 noted that the project is an important tool for the Hydrogen Storage sub-program and provides useful understanding of the impact of new technologies. The project was commended for its good overall accomplishments; in particular, for defining the sorbent storage property requirements. Reviewers commented that the resin additive study results need to be validated because other researchers showed different results. Reviewers also recommended that the project be careful in generalizing suitable high-density polyethylene (HDPE) operating temperatures because different grades of HDPE can operate at lower temperatures.
ST-004	Hydrogen Storage Engineering Center of Excellence *Don Anton; Savannah River National Laboratory*	3.5	X			Reviewers commended SRNL for its overall management of the Hydrogen Storage Engineering Center of Excellence (HSECoE) because of its effectiveness in focusing the coordination and collaboration between Center partners on the objectives. The use of spider charts to show performance against targets, the use of detailed milestone charts to track progress, and carrying out a lessons learned activity were specifically cited as practices future collaborative efforts should adopt. It was recommended that greater emphasis be directed toward the more challenging targets for sorbent systems (e.g., loss of usable hydrogen).
ST-005	Systems Engineering of Chemical Hydrogen, Pressure Vessel, and Balance of Plant for Onboard Hydrogen Storage *Kriston Brooks; Pacific Northwest National Laboratory*	3.2	X			The project, as part of the HSECoE, was commended for its extensive collaboration with other Center partners. Reviewers commented on the high relevance of the project activities. With completion of the work on chemical hydrogen (CH) storage systems within the HSECoE, reviewers recommended completion and dissemination of the system models and other project results. They also emphasized that the cost analyses for the chemical and sorbent systems should be completed.
ST-006	Advancement of Systems Designs and Key Engineering Technologies for Materials-Based Hydrogen Storage *Bart van Hassel; United Technologies Research Center*	3.2	X			This project is part of the HSECoE. The reviewers commended United Technologies Research Center (UTRC) for its weight/volume reduction and integration of the gas liquid separator and ammonia filters into the CH storage system, allowing the CH system to meet the U.S. Department of Energy's (DOE's) 2017 target for volumetric capacity. In addition, reviewers acknowledged the importance of UTRC's role in developing graphical user interfaces for the publicly available Simulink models, which will allow material researchers to understand the effect of material properties on system-level performance. There was some concern related to the potential premature development of auxiliary systems for material that may not be commercialized.

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ST-007	Chemical Hydrogen Rate Modeling, Validation, and System Demonstration *Troy Semelsberger; Los Alamos National Laboratory*	3.2			X	The work by LANL on chemical hydrogen storage systems, as part of the HSECoE, was considered to be highly relevant to the sub-program, even though the system was not selected for continuation as an HSECoE Phase III activity. The determination of chemical hydrogen storage material property requirements for a system to meet the DOE performance targets was noted as being highly valuable. Reviewers recommended publishing the material requirements and system models in peer-reviewed journals. This effort is being wrapped up as a result of chemical hydrogen storage system activities not being continued in Phase III of the HSECoE.
ST-008	System Design, Analysis, and Modeling for Hydrogen Storage Systems *Matthew Thornton; National Renewable Energy Laboratory*	3.2	X			Reviewers commended this NREL project, as part of the HSECoE, on the integrated framework model that couples vehicle, fuel cell, and hydrogen storage system models for system/materials performance evaluation. Reviewers commented that these models should be extremely useful to the research community in the future, and that making them available to the public on the Internet should be a high priority.
ST-010	Ford/BASF-SE/UM Activities in Support of the Hydrogen Storage Engineering Center of Excellence *Mike Veenstra; Ford Motor Company*	3.3	X			This project is part of the HSECoE. Overall, reviewers were impressed with the project's accomplishments, ranging from its role as sorbent system architect to metal-organic-framework-5 (MOF-5) scale-up, failure mode and effects analysis coordination, and performance/cost modeling. Reviewers applauded the principal investigator (PI) and his overall leadership, noting that this project "seems to be a nerve center for the entire HSECoE." Reviewers were encouraged by the identification of several new, promising MOF materials, but there were still concerns regarding the inability of MOF-5 to meet DOE's volumetric capacity targets. As a result, the reviewers said that the project provides a very valuable original equipment manufacturer perspective on the practicality of adsorbents as onboard hydrogen storage materials.
ST-019	Multiply Surface-Functionalized Nanoporous Carbon for Vehicular Hydrogen Storage *Peter Pfeifer; University of Missouri*	2.5			X	The reviewers applauded the efforts the University of Missouri has taken to correct or remove previous results that were deemed unsubstantiated, and they suggested further collaboration with the validation group at NREL to ensure that future results are valid. The reviewers questioned the progress to date, as well as the results related to the reported amount of sp^2 bonded boron in the carbon lattice, which is the inherent key to the proposed approach. When these results are combined with the overall uncertainty in the hydrogen uptake measurements, most reviewers concluded that this project should end as scheduled in November 2014.

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ST-044	Savannah River National Laboratory Technical Work Scope for the Hydrogen Storage Engineering Center of Excellence: Design and Testing of Adsorbent Storage *Bruce Hardy;* *Savannah River National Laboratory*	3.3	X			The technical efforts on modeling and evaluating hydrogen sorbent systems by SRNL, as a partner in the HSECoE, were considered critical for the overall success of the HSECoE. Reviewers commented that the approach and activities were well planned and highly relevant to the sub-program. Reviewers suggested that the project team should produce recommendations on the materials' requirements needed to meet DOE system targets, as well as look at system balance-of-plant (BOP) components. It was also recommended that the project team put more emphasis on improving performance against the remaining challenging targets, such as loss of usable hydrogen.
ST-046	Microscale Enhancement of Heat and Mass Transfer for Hydrogen Energy Storage *Kevin Drost;* *Oregon State University*	3.0	X			This project is part of the HSECoE. Reviewers were generally pleased with the progress of the project and acknowledged the promise of the novel modular adsorbent tank insert (MATI) design to meet the unique challenge of optimizing the amount of hydrogen stored in a given volume while also accounting for challenging heat transfer requirements compounded by adsorbent media densification. There were concerns noted regarding whether the MATI was sufficiently robust to operate reliably for the necessary lifetime under the variable pressure and temperature conditions present in an adsorbent system.
ST-047	Development of Improved Composite Pressure Vessels for Hydrogen Storage *Norman Newhouse;* *Hexagon Lincoln*	3.3	X			This project is part of the HSECoE. In addition to the importance of having a tank manufacturer on the HSECoE team, the reviewers acknowledged several positive contributions from Hexagon Lincoln (HL), including the development of flexible tanks for system testing, the development of lower-cost/lighter-weight tanks, and the demonstration of improved vessel subsystem capabilities (i.e., operation at cryogenic temperatures and isolation bottle approach). The main weaknesses identified relate to the lack of correlation between HL's results and the DOE targets, and the perception that HL's proposed Phase III work will not benefit the ultimate outcome of the HSECoE Phase III effort.
ST-063	Reversible Formation of Alane *Ragaiy Zidan;* *Savannah River National Laboratory*	3.1	X			Overall, the reviewers commented favorably on the progress this SRNL project has made in the past year. They especially commended the project on focusing on process cost reduction and addressing key technical barriers that have been identified. It was recommended that the team remain focused on addressing reaction kinetics and understanding the cause of the required overpotential. The addition of Ardica as a potential commercialization partner was considered positive.

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ST-093	Melt-Processable PAN Precursor for High-Strength, Low-Cost Carbon Fibers *Felix Paulauskas; Oak Ridge National Laboratory*	3.1	X			Reviewers commended the project's move toward using polyacrylonitrile with methyl acrylate as the precursor formulation material because it allows the possibility of meeting the required carbon fiber (CF) mechanical properties. Reviewers suggested that the project obtain industrial confirmation of manufacturing and feasibility assumptions as it develops a cost model for the project. Reviewers also suggested that in future presentations, the PI include as much information as possible to allow a better understanding of how technical issues were addressed without invoking intellectual property issues.
ST-099	Development of Low-Cost, High-Strength Commercial Textile Precursor (PAN-MA) *Dave Warren; Oak Ridge National Laboratory*	3.2			X	Reviewers commented that the project has a good overall approach to decrease CF cost, and that there is good cooperation between FISIPE, the precursor manufacturer, and ORNL. Reviewers noted that there is a need to clarify the types of final CF testing to be conducted by a tank manufacturer. Reviewers also stressed the importance of completing a cost analysis that accounts for yield loss and product quality. This project has been completed.
ST-100	Ongoing Analysis of Hydrogen Storage System Costs *Brian James; Strategic Analysis, Inc.*	3.1	X			The project was praised for focusing on analyzing the cost of BOP—the highest cost component of the compressed storage system at low manufacturing volumes. Reviewers also commended the approach of using compressed natural gas BOP cost analysis to validate the cost model for compressed hydrogen storage at low production volumes, as well as the good efforts in gaining data from and vetting results with BOP component manufacturers. Reviewers recommended that the project investigate the cost impacts of higher inspection demands and safety verification.
ST-101	Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks *Kevin Simmons; Pacific Northwest National Laboratory*	3.1	X			Reviewers commented that the project has done a great job of validating models with empirical studies in composite properties, as well as demonstrating properties of matrix modifications, nanofillers, and catalysts for curing. Reviewers also commended the project's advances in addressing gas dormancy of cold gas versus other cryogenic storage approaches. However, reviewers commented that the robustness of the resin, liner, and fibers being considered is either unknown, or highly uncertain, at cold temperatures and should be sufficiently evaluated.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
ST-103	Hydrogen Storage in Metal-Organic Frameworks *Jeffrey Long; Lawrence Berkeley National Laboratory*	3.2	X			The reviewers acknowledged the methodical approach of the highly qualified team that appears to be well aligned with the DOE targets. They reported that the project appears to be correctly focused on developing framework materials with increased binding energies at ambient temperatures and conclusively showing multiple hydrogens bonded per open metal site, noting that this is a lofty goal. However, the reviewers also noted several project weaknesses, including a general lack of progress in synthesizing new materials and concern that the modeling, neutron, and high-pressure work carried out by project subcontractors is not properly guiding or benefiting the core material development task of the project.
ST-104	Novel C-B-N-Containing Hydrogen Storage Materials *Shih-Yuan Liu; Boston College*	3.4	X			Reviewers commended the comprehensive approach and active down-selection to systematically investigate novel compounds, as well as the accumulation of a rather large library of CBN compound data as hydrogen storage materials. Reviewers also praised the synthesis of difficult-to-make CBN heterocycle compounds and the characterization of dehydrogenation reaction products. Reviewers recommended that the project team place more focus on exploring new compounds with higher capacities and that can be recharged with hydrogen onboard the vehicle.

Fuel Cells

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-007	Extended, Continuous Pt Nanostructures in Thick, Dispersed Electrodes *Bryan Pivovar; National Renewable Energy Laboratory*	3.0	X			Reviewers thought the approach of developing extended thin-film cathode catalysts has merit for improving catalyst activity and durability. They commended the project for its significant progress over the last year in developing highly active catalysts based on rotating disk electrode (RDE) measurements, and for translating some of them into membrane electrode assemblies (MEAs), albeit with lower fuel cell performance. Reviewers commented on the high quality of the team and its collaborative efforts. Recommendations included increasing efforts in electrode development to translate the high-activity RDE results into MEA performance. Also, reviewers saw transition metal leaching as an issue impacting durability that needs to be further addressed.
FC-008	Nanosegregated Cathode Catalysts with Ultra-Low Pt Loading *Vojislav Stamenkovic; Argonne National Laboratory*	3.6	X			According to reviewers, the synthetic results, characterization effort, and achievements in specific activity and mass activity are excellent. The reviewers noted that ANL's contribution to the structure-performance of catalyst structures is of great importance to the whole fuel cell community. They also noted that the project team is suitable, with industry, universities, and national laboratories represented. Reviewers suggested that greater emphasis be placed on integrating the catalysts into an MEA, followed by fuel cell testing, versus RDE testing.
FC-009	Contiguous Pt Monolayer O_2 Reduction Electrocatalysts on High-Stability, Low-Cost Supports *Radoslav Adzic; Brookhaven National Laboratory*	3.4	X			According to reviewers, the project is very well managed and continues to produce excellent results. Reviewers felt that the development of core-shell catalysts constitutes one of the most promising pathways to the reduction of Pt usage in polymer electrolyte membrane fuel cells (PEMFCs). They applauded the project's record on practical invention and efforts toward commercialization. They did request, if possible, for an update on development progress at the licensees (e.g., N.E. ChemCat Corporation) of the patents from this project to be given at DOE reviews. Some reviewers questioned the use of platinum group metals (PGMs) for a sufficiently stable core.

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FC-013	Durability Improvements through Degradation Mechanism Studies *Rod Borup;* *Los Alamos National Laboratory*	2.9	X			Reviewers stated that LANL has made great progress in defining MEA degradation mechanisms and, to some extent, providing mitigation conditions. They felt that the approach is generally good and addresses the known issues of durability in PEMFCs. However, they noted that the project overlaps with activities (e.g., cathode carbon degradation) being pursued by automotive and fuel cell stack original equipment manufacturers (OEMs). They also noted a lack of automotive OEM collaboration. They suggested that LANL minimize efforts to explore the impact of catalyst layer cracks on membrane durability, because of technical advances that have eliminated the membrane cracks.
FC-016	Accelerated Testing Validation *Rangachary Mukundan;* *Los Alamos National Laboratory*	3.4	X			Reviewers lauded the project's excellent detail and accomplishments over the last year. Reviewers stated that the team is varied and experienced, with good characterization capabilities. They noted that analyzing accelerated stress tests (ASTs) to determine which conditions and tests are too aggressive and which are too passive, based on real data, is an important step. They felt that defining gaps in ASTs and working to develop ASTs to fill those gaps was also a great accomplishment. Reviewers suggested that more work should be done to determine how the gas diffusion layer aging affects performance. Reviewers also encouraged ANL to offer solutions to enhance the durability and performance of the materials.
FC-017	Fuel Cells Systems Analysis *Rajesh Ahluwalia;* *Argonne National Laboratory*	3.3	X			Reviewers noted that ANL has looked at a number of material configurations that are relevant to next-generation catalysts, heat rejection constraints, and optimization studies related to the system cost/catalyst metal loadings. They stated that these are all high-impact areas for fuel cell manufacturers, and that a validated system model that provides guidance for optimization in these areas is highly valuable. Reviewers applauded the inclusion of the fuel cell heat rejection requirement ($Q/\Delta T$), and they found the new results intriguing and challenging because the fuel cell will have to operate at higher temperatures. Reviewers suggested including a turbo compressor in the model and completing a cost study that also considers end-of-life performances.

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FC-018	Fuel Cell Transportation Cost Analysis *Brian James; Strategic Analysis, Inc.*	3.5	X			Reviewers viewed the analyses performed by this project as well designed, comprehensive, consistent, rigorous, sharply focused, and providing value to DOE decision makers. Reviewers suggested that more emphasis be placed on alternative systems and technologies, such as low-pressure PEMFC systems and transportation systems with different degrees of hybridization and fuel cell sizes. Reviewers also suggested the following: an increased focus on BOP, consideration of lower manufacturing volumes, comparisons of projected cost estimates with real-world fuel cell prices, evaluation of the use of dispersed Pt/C catalyst layers (instead of nanostructured thin film), and examination of portable power and low-temperature stationary fuel cell applications. Reviewers also questioned the potential of analyzing the limit of cost reduction.
FC-020	Characterization of Fuel Cell Materials *Karren More; Oak Ridge National Laboratory*	3.6	X			Reviewers remarked that this project contributes significantly to the fundamental understanding of degradation mechanisms, and that the team is developing characterization methods that help address critical needs of the fuel cell research community. Collaborations were found to be numerous and of high quality, and reviewers noted that they included international collaborations that provided access to unique imaging/analysis (microscopy) capabilities. Reviewers considered the recent work in adapting conditions to allow characterization of the ionomer dispersion in the catalyst layer a major accomplishment. However, they believed more work needs to be done for this methodology to be used as a quantitative measure for ionomer degradation.
FC-021	Neutron Imaging Study of the Water Transport in Operating Fuel Cells *David Jacobson; National Institute of Standards and Technology*	3.5	X			Reviewers noted that the team has developed a very effective approach to achieving continual improvement of the characterization techniques and testing infrastructure, while also allowing a substantial amount of time for user access to benefit the community at large. They stated that NIST has achieved impressive spatial resolution in water imaging and sped up the time frame over which measurements can be made. Reviewers lauded the project's progress to increase resolution to <10 microns, but they noted that the signal-to-noise ratio and the time resolution must be improved.

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FC-026	Fuel Cell Fundamentals at Low and Subzero Temperatures *Adam Weber; Lawrence Berkeley National Laboratory*	3.3	X			Most reviewers felt that connecting diagnostic data and materials characterization to the cell model was a solid approach. Further, reviewers stated that the focus on nanostructured thin film (NSTF) performance at low temperatures would have broad value to the community, yet some reviewers noted that the project would benefit from a more even split between NSTF and conventional dispersed catalyst electrodes. Reviewers also felt that the project team would benefit from closer collaboration with system integrators or an OEM to provide insight into issues with applying the model to stacks.
FC-065	The Effect of Airborne Contaminants on Fuel Cell Performance and Durability *Jean St-Pierre; Hawaii Natural Energy Institute*	3.2	X			Reviewers reported that this project featured a thorough approach to testing fuel cell performance with selected contaminants. They stated that the principal investigator (PI) has developed an extensive database of contaminants and identified electrochemical and chemical reaction pathways. They felt that the PI's description of the mechanism of the increase in peroxide yield as a function of catalyst contamination was convincing. The reviewers suggested that an overview slide be provided that identifies where the selected contaminants are likely to be encountered.
FC-083	Enlarging Potential National Penetration for Stationary Fuel Cells through System Design Optimization *Genevieve Saur; National Renewable Energy Laboratory*	3.3	X			Reviewers praised the model developed by this project as a flexible and valuable tool with the potential to have broad applicability. The addition of emissions control benefits to the model structure was regarded as useful and important. Reviewers cited as a key strength the fact that the tool is developed in open-source software, and they recommended further efforts to make the model more readily available. Reviewers encouraged validation through existing installed fuel cell systems. They also identified additional collaboration with industry—especially the involvement of fuel cell producers and end users—as a key need to help validate the model. They suggested that the researchers consider model performance assessments (particularly a sensitivity analysis) around the different system elements and input parameters as a part of, or in place of, the model validation effort.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-085	Synthesis and Characterization of Mixed-Conducting Corrosion-Resistant Oxide Supports *Vijay Ramani; Illinois Institute of Technology*	2.6		X		According to reviewers, the approach of using metal oxides as a replacement for conventional carbon supports is worthwhile, but the results with the selected metal oxide systems do not yet meet performance requirements for use in fuel cells. Reviewers noted good progress in preparing indium-tin-oxide (ITO) supports as a lower-cost alternative to the ruthenium-titanium-oxide supports investigated earlier in the project. However, they identified serious issues with the Pt/ITO catalyst, including low platinum surface area and poor MEA performance. Reviewers agreed that scale up of ITO-based MEAs is not worthwhile, because of the low performance thus far. Some reviewers indicated that further R&D on Pt/ITO would be worthwhile, while others indicated that the system is unlikely to have sufficient performance and stability in MEAs to justify further investment.
FC-086	Development of Novel Non-Platinum-Group-Metal Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications *Sanjeev Mukerjee; Northeastern University*	3.0	X			The reviewers remarked that significant progress, especially with respect to catalyst activity and scale up, has been made in the development of non-PGM catalysts for PEMFC cathodes. However, they also expressed that there is still a long way to go before non-PGM catalysts become a practical replacement for Pt-based cathodes, especially for automotive fuel cell applications. Reviewers commended the very good collaboration between the strong team, which, they noted, consists of a good mix of academic, industry, and national laboratory partners. Also, they noted that there was a lack of clarity on future work. Recommendations included further characterization of the catalyst active site and site density.
FC-087	High-Activity Dealloyed Catalysts *Anusorn Kongkanand; General Motors*	3.2			X	For this project, reviewers commended the technical progress achieved and the level of collaboration. They noted the advances in meeting catalyst mass activity and durability milestones, as well as in transitioning the advanced catalyst to MEAs. Some reviewers commented on the lack of control of materials homogeneity limiting the ability to interpret results. Reviewers also suggested that MEA developmental work with the advanced catalyst needs to be continued, and that long-term stability needs to be assessed.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-088	Development of Ultra-Low Doped-Pt Cathode Catalysts for Polymer Electrolyte Membrane Fuel Cells *Branko Popov; University of South Carolina*	2.7		X		The reviewers saw value in the hybrid catalyst concept, where some catalytic activity is derived from the support material, but they stated that characterization and understanding of the synergies need improvement. Questions were also raised about cost and durability. Some reviewers noted an apparent lack of progress from last year. They also noted that while many of the DOE catalyst targets have been met by one or more University of South Carolina formulations, no one formulation meets all the targets. They suggested broadening and strengthening the collaborations to include more direct participation of a catalyst manufacturer. Reviewers recommended providing a better comparison with state-of-the-art catalysts and presenting as-measured data in addition to iR-free data.
FC-091	Advanced Materials and Concepts for Portable Power Fuel Cells *Piotr Zelenay; Los Alamos National Laboratory*	3.1			X	According to reviewers, incremental but significant progress has been made on many fronts relating to the use of liquid alcohol and ether fuels in portable fuel cells. Reviewers felt that the team is strong, well organized, highly capable, and very good at generating new materials. Some reviewers thought that there was limited cooperation between partners and that the interaction between the research groups needs to be improved. Reviewers also suggested that LANL address the scalability of production of the new catalysts and membranes.
FC-096	Power Generation from an Integrated Biomass Reformer and Solid Oxide Fuel Cell (SBIR Phase III Xlerator Program) *Patricia Irving; InnovaTek, Inc.*	3.3			X	According to reviewers, good technical progress has been made, especially in terms of simplifying the system design and reducing part count and cost. They were impressed by the estimated cost of $1,722/kW at 50,000 units per year, and they thought this cost would allow for good market penetration. Reviewers found the use of additive manufacturing to be beneficial, and some thought this accelerated the rate of progress. Some reviewers applauded the use of renewable biofuel for hydrogen production, but others cautioned that hydrogen from biofuel may not be cost competitive. Reviewers noted that progress toward the 2015 goals for hydrogen production and combined heat and power (CHP) systems has been impressive; however, they also reported that durability still needs to be demonstrated.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-097	Stationary and Emerging Market Fuel Cell System Cost Analysis—Auxiliary Power Units *Vincent Contini; Battelle*	3.2	X			The reviewers generally endorsed system cost analysis as a tool for assessing potential market size and identifying high-cost components where R&D funding should be applied. They reported that analysis clearly identifies BOP as the major cost driver. Reviewers stated that collaboration is broad but seems to lack input from fuel cell system integrators such as material handling equipment or truck OEMs and/or users. The reviewers recommended more sensitivity analysis; frequent updating of relevant systems, fuel cell types, and manufacturing approaches; and comparison with other cost analysis efforts.
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*	3.1	X			Reviewers noted that the project considered a broad spectrum of fuel cell types and applications. They felt that cost breakdowns provide valuable insight into R&D needs and that health and environmental costs provide additional support for fuel cell use. The reviewers also noted that the team included a good cross section of national laboratories and private industry, but they expressed concern that the one OEM consulted has limited experience with systems integration of CHP systems. Reviewers recommended adding more industry partners to provide needed expertise in CHP systems.
FC-103	Roots Air Management System with Integrated Expander *Dale Stretch; Eaton Corporation*	3.1	X			Reviewers regarded the focus of this project—component development—as very important. Strong product knowledge and collaboration with significant fuel cell partners were viewed as strengths. While reviewers characterized the upstream (i.e., sub-system and system-level) partnerships as strong, they suggested that the project could benefit from a motor/controller partner, noting that these components seem to be the primary barriers to meeting the cost target. Reviewers lauded the progress on modeling and improving designs, as well as the hardware testing, but they saw overall progress as relatively slow. Reviewers noted that it is not clear how the proposed technology plans to achieve the DOE targets, and they indicated that it would be useful to see trade-off analysis on critical parameters. Reviewers also suggested using accelerated testing so that potential failure modes could be determined more quickly and possibly mitigated. They also recommended scaling back the plastic rotor development work because it did not seem to significantly benefit either cost or efficiency gaps.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
FC-104	High-Performance, Durable, Low-Cost Membrane Electrode Assemblies for Transportation Applications *Andrew Steinbach; 3M*	3.0	X			Reviewers commented that the project achieved significant technical progress during the past year, and that it has good collaboration with well-coordinated partners. Some reviewers noted that the current approach may not be sufficient to further improve the developed MEA's operational robustness to allow for practical application. Some reviewers also stated that catalyst-layer architecture modification and catalyst development beyond Pt-Ni are required to improve durability and performance.
FC-106	Rationally Designed Catalyst Layers for Polymer Electrolyte Membrane Fuel Cell Performance Optimization *Deborah Myers; Argonne National Laboratory*	3.2	X			Reviewers stated that the project has a good team that includes expertise in advanced catalyst materials and fabrication, catalyst layer characterization, and modeling and diagnostics. They felt that this project addresses an essential topic for successful fuel cell commercialization. They were impressed that the project has already successfully accomplished the modification of catalyst powder with proton conducting groups. Reviewers suggested that ANL carry out durability studies and increase activities to address mass transport losses.
FC-107	Non-Precious-Metal Fuel Cell Cathodes: Catalyst Development and Electrode Structure Design *Piotr Zelenay; Los Alamos National Laboratory*	3.2	X			Reviewers stated that the project team is excellent and features a great breadth of collaborators as well as a highly experienced PI and supporting institution. They noted that this project has the potential to provide many answers about the complex electrochemistry of non-PGM catalysts. They applauded LANL's strong technical improvements over the current state of the art. Reviewers suggested that LANL address durability and increase mechanistic studies.
FC-108	Advanced Ionomers and Membrane Electrode Assemblies for Alkaline Membrane Fuel Cells *Bryan Pivovar; National Renewable Energy Laboratory*	2.9	X			Most reviewers noted that the approach to developing novel AEMs was reasonable, albeit with a relatively high degree of risk. They commented that the assembled team was excellent and a very good mix of national laboratories, academia, and industry. The reviewers viewed the project as being in an early stage of development, with progress, perhaps, being a bit slow. There was concern that the hydroxide form of the membrane had not yet been characterized sufficiently (especially for OH^- conductivity), and reviewers recommended that more focus be placed in this area.

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*	3.2	X			Reviewers indicated that the first-year project has made good progress. They reported that the approach of using multiple acid sites per side chain, including sulfonate and sulfonimide sites, was a viable pathway toward preparing ionomers that combine high conductivity with low swelling. Reviewers felt that the use of inert electrospun nanofibers to provide mechanical stability was a promising route to achieving a high degree of stabilization with a minimal increase in resistance. However, they highlighted the lack of information about the scalability and expected manufacturing cost as a concern. Reviewers suggested cost analysis of the ionomer and electrospinning process as a future task. Increased reliance on larger-scale testing was also suggested as a way to identify possible problems and down-select materials earlier in the process.
FC-110	Advanced Hybrid Membranes for Next-Generation Polymer Electrolyte Membrane Fuel Cell Automotive Applications *Andrew Herring; Colorado School of Mines*	2.9	X			Reviewers noted that the project does address the critical barriers and builds on the PI's previous projects developing HPA-containing polymers. It is mentioned, however, that much of the work so far has been reviewing work previously completed. Reviewers noted that the approach is fundamentally sound and may lead to a large improvement in performance, as opposed to smaller incremental gains. However, reviewers felt that progress so far has been limited, while noting that the project is in its early stages. Reviewers felt that appropriate partners are identified; however, there does not appear to be much collaboration to date.

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*	3.4	X			The reviewers noted that the relevance of the approach to actual manufacturing practices and to industry is implicit in the collaborations with membrane electrode assembly and membrane suppliers. They commended the implementation of the quality control (QC) techniques in industry and recommended bringing the QC techniques to additional original equipment manufacturers. Reviewers applauded the decision to stop work on an ionomer/carbon ratio diagnostic, because it showed that the team is grounded in the practical development of techniques and not wasting time on tasks that are not feasible. The reviewers would like to see a correlation established between defect or defect size and fuel cell performance. This issue should be addressed in fiscal year 2015.

Technology Validation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-008	Fuel Cell Bus Evaluations *Leslie Eudy; National Renewable Energy Laboratory*	3.7	X			Tangible results from this project were found to provide a consistent history of technology performance and cost improvements over time while also delivering value to decision makers. Reviewers noted that thorough evaluations, quality information, and active collaboration with stakeholders have led to a better understanding of the status of technology development relative to DOE's goals. Reviewers reported that changes in fleet management and some buses going out of service have posed challenges and questions related to the potential impact. Reviewers suggested evaluating more transit agencies while also comparing findings with similar data from other countries.
TV-016	Stationary Fuel Cell Evaluation *Genevieve Saur; National Renewable Energy Laboratory*	3.4	X			While the project was noted to have useful market data and analyses, some data-related concerns were raised. The collection of data on a voluntary basis led to reviewers questioning whether there could potentially be bias (poor performers may be less willing to share data compared to better performers). It was noted that there is a lack of disaggregation of data according to technology categorizations and applications. The reviewers recommended that the data evaluation process be more clearly linked to key research or technology deployment questions, and that feedback should be given to DOE about the gaps in technology performance and market status. Reviewers also suggested expanding collaborations and obtaining more state partners in order to provide geographic variability.
TV-019	Hydrogen Component Validation *Kevin Harrison; National Renewable Energy Laboratory*	3.2	X			Because compressors are a key reliability issue in hydrogen stations, this project's evaluation of compressor failure mechanisms was seen to have the potential for a large impact. Reviewers indicated that the project has a well-structured approach and addresses a key area that has not had much transparency in the past. They expressed concern that the "accelerated" test program does not follow the right approach. Reviewers suggested that, initially, specific failure modes of the compressor should be explored, followed by a repetition of those factors. Reviewers also highly recommended obtaining input from other compressor suppliers. Other recommendations included the development of a "generic" tool to also be used by other compressor technologies, and conducting technoeconomic analysis of the impact of the project.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-020	Validation of an Advanced High-Pressure Polymer Electrolyte Membrane Electrolyzer and Composite Hydrogen Storage, with Data Reporting, for SunHydro Stations *Larry Moulthrop; Proton OnSite*	3.4	X			The project was perceived as well designed, with a real-world strategy and the potential to lower costs. The coordination between the four project partners was noted to be a true partnership, with each bringing its strength to the team. Reviewers praised the attention given to safety, codes, and standards. An area identified as needing more attention was cost targets and estimation, along with the evaluation of the economic impact of installing high-pressure electrolysis. Reviewers recommended considering scale-up of the station; integrating the containers/components into one pallet (to enable ease of shipping); and comparing power consumption values from this project to those of the California State University, Los Angeles, hydrogen station project (TV-024). Reviewers also noted that they would like to see more detailed data on total electrolyzer energy consumption.
TV-021	Forklift and Backup Power Data Collection and Analysis *Jennifer Kurtz; National Renewable Energy Laboratory*	3.8	X			The project was observed as adding value to the commercialization of niche market hydrogen and fuel cell technologies while also addressing barriers and giving appropriate attention to the types of metrics required to confront these barriers. Reviewers viewed outstanding sensitivity analysis and active interaction with manufacturers and users as key strengths of the project. While reviewers did not identify any major weaknesses, they did make several recommendations for enhancement; for example, they suggested that the project team should further gauge whether industry would be willing to continue to provide data, and that encouragement to do so would be beneficial. Reviewers also noted that obtaining qualitative verbal feedback from operators of these systems could provide better insight.
TV-024	California State University, Los Angeles, Hydrogen Refueling Facility Performance Evaluation and Optimization *David Blekham; California State University, Los Angeles*	3.0	X			The project was seen as having the potential to identify optimization potentials for components of electrolysis-based hydrogen fueling stations while having the added benefit of an educational aspect. However, reviewers noted a lack of clarity in plans regarding how the station will be optimized, as well as a lack of a technoeconomic plan to evaluate the economic advantages of the proposed solutions. While collaboration with California Weights and Measures was seen as valuable, increased collaboration with other entities that have developed hydrogen stations was highly recommended. Further reviewer suggestions included developing measurable goals for addressing barriers and meeting targets, and providing feedback on how to reduce capital and operating costs. Reviewers also suggested comparing the electrolyzer power consumption with that of the electrolyzer used in project TV-020.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
TV-025	Performance Evaluation of Delivered Hydrogen Fueling Stations *Michael Tieu;* *Gas Technology Institute*	3.1	X			The project was viewed by reviewers as having the potential to provide valuable data on hydrogen stations while also enabling comparisons across stations and helping to expand the network of stations. Reviewers noted that they expected to see more details on the performance parameters that are being validated and a clearer expression of how barriers are being addressed. The partnership with Linde was perceived as a key strength of the project because these partners have a good working relationship and bring vast experience to the table. Because the project timeline is dependent on factors outside the control of the project investigators (e.g., permitting and construction delays), reviewers suggested that the project team reevaluate the feasibility of implementing all five stations as well as perform risk analysis and planning. Reviewers also noted that addressing costs targets should be a part of project goals.
TV-026	Hydrogen Fueling Infrastructure Research and Station Technology *Brian Somerday;* *Sandia National Laboratories*	2.5	X			Reviewers viewed the project as having the potential to contribute to the deployment of hydrogen stations and to address real-time technology performance and operation issues. However, the project was perceived as too new to be comprehensively evaluated, and some reviewers were uncertain about the value proposition of such an effort. Reviewers suggested that further attention be devoted to characterizing H2FIRST, and that indicators of project success be measurable. Reviewers also cautioned that care should be given to effectively manage the entities involved while specifying objectives within each project team.

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*	3.1	X			Reviewers recognized the importance and potential impact of this project and the extensive list of collaborators involved, noting the scope and breadth of the work as a clear strength. However, they also noted that stronger engagement with and more substantive feedback from industry stakeholders, national laboratories, and trade associations is needed. Reviewers commented on the lack of a cohesive approach or strategy to codes and standards deployment and outreach. They suggested that the work would benefit from increased coordination with related projects active at other laboratories or programs. Reviewers stated that deployment efforts should include the international community and that project activities should focus on more substantive outputs and accomplishments.
SCS-002	Component Standard Research and Development *Robert Burgess; National Renewable Energy Laboratory*	2.5	X			Reviewers recognized that this work is critical to the advancement of regulations, codes, and standards for hydrogen and fuel cell technologies. The project was commended for its collaboration with manufacturers and system installers to ensure that certified products are commercially available. Project collaborations with codes development organizations (CDOs), standards development organizations (SDOs), and industry were cited as a strength, as was the project's work to focus standards development efforts at the component level. However, reviewers noted that collaboration and/or teaming with SNL could avoid duplication of effort. Reviewers recommended that the project team craft a more strategic approach and scope for the project. They also suggested that the project team better leverage the expertise of other national laboratories (e.g., SNL). In addition, reviewers noted that rather than focusing on a single component, the project team should focus on assessing multiple components for a given set of infrastructure hardware.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-004	Hydrogen Safety, Codes, and Standards: Sensors *Eric Brosha;* *Los Alamos National Laboratory*	2.9	X			Reviewers acknowledged the significant progress made in developing a hydrogen-specific sensor; however, they also noted the lack of a commercial manufacturing partner to demonstrate the feasibility and questioned if commercially available, economically viable sensors would result. Reviewers praised the project's potential for deploying improved sensors that include wireless communications and backward compatibility with relatively low operating costs. In addition to the lack of a mainline sensor manufacturer partner, reviewers noted the lack of analysis of sensor performance versus International Organization for Standardization 26142: Hydrogen Detection Apparatus as a weakness. It was recommended that the project team expand the field tests to better replicate real-world conditions. The researchers also noted that the project team should better define the life cycle cost and market price of a deployment-ready sensor, as well as how the market price compares to commercially available products.
SCS-005	Research and Development for Safety, Codes and Standards: Materials and Components Compatibility *Chris San Marchi;* *Sandia National Laboratories*	3.5	X			Reviewers noted that the project team demonstrated a sound and valuable approach to addressing key technical gaps. Reviewers also commended the project team for its engagement with CDOs and SDOs and its progress, noting that it is relevant and aligned with that of industry. Cited project strengths included the direct impact on current and near-term standards development activities and the valuable input to industry regarding lower-cost steels and the benefits of automated welding over manual welding. Reviewers recommended an increased focus on communicating results and lessons learned to station builders and design engineers as well as improving efforts to address actual service conditions. Reviewers noted that while future work advances logically from the achievements to date, it is important to ensure that the end goal supports the development of American National Standards Institute standards.

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*	3.6	X			Reviewers recognized the progress made in developing an in-line fuel quality analyzer to enable the commercialization of fuel cell electric vehicles. The participation of international and domestic CDOs and SDOs, and the project's strong technical data development, were seen as strengths that are positively contributing to the international harmonization of fuel quality standards and addressing barriers to the deployment of hydrogen infrastructure. However, reviewers noted a lack of reference to and support of SAE J2719, as well as the project's limited national outreach and feedback activities. Reviewers recommended that future work extend testing from the membrane electrode assembly to the stack level. J2719 compliance testing was also recommended for future work.
SCS-011	Hydrogen Behavior and Quantitative Risk Assessment *Katrina Groth; Sandia National Laboratories*	3.4	X			Reviewers commended the progress made in developing the Hydrogen Risk Assessment Models tool and how the project team addressed the previous years' feedback. The development of a performance-based approach to risk assessment and the establishment of a benchmark metric for station readiness were noted as major accomplishments. However, reviewers commented on the lack of engagement with code officials—the ultimate end users of the quantitative risk assessment toolkit. Recommendations included developing an approach to educate code officials and expanding collaborations with international entities, hydrogen suppliers, and car manufacturers.
SCS-015	Hydrogen Emergency Response Training for First Responders *Monte Elmore; Pacific Northwest National Laboratory*	3.1	X			According to reviewers, this project has demonstrated continued progress through the provision of online and in-person training and education. However, reviewers identified a lack of urgency in conducting training events and a need for a more creative means of educating first responders. They recommended that the project team develop an improved strategy to engage targeted stakeholders such as local fire and police departments. Reviewers also suggested seeking increased feedback from key stakeholders and participants in training activities.
SCS-017	Hands-On Hydrogen Safety Training *Salvador Aceves; Lawrence Livermore National Laboratory*	3.1	X			According to reviewers, this project fills an important knowledge gap but could have a greater impact if larger audiences were targeted. Cited project strengths included LLNL's ability to leverage its expertise to provide practical training courses—particularly, the provision of both Internet-based and hands-on safety classes. Reviewers noted the lack of significant progress and the heavy focus on high-pressure systems, rather than on hydrogen gas and hydrogen-specific applications, as weaknesses. It was recommended that the project team identify a long-term plan to engage broader audiences or hand off the training course for industry to continue.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-019	Hydrogen Safety Panel and Hydrogen Safety Knowledge Tools *Nick Barilo;* *Pacific Northwest National Laboratory*	3.8	X			Reviewers commended the project's flexibility in developing tools and resources that keep pace with the changing stages of technology commercialization. They also recognized the Hydrogen Safety Panel for doing outreach to project developers and for being involved in the early design stages. Cited strengths included the outreach to insurance groups and authorities having jurisdiction to better understand user needs and the innovative approaches for providing informational tools and resources. Reviewers recommended collaborating with the Fuel Cell & Hydrogen Energy Association (FCHEA) and NREL to avoid duplication of effort and to provide more robust products.
SCS-021	National Renewable Energy Laboratory Hydrogen Sensor Testing Laboratory *William Buttner;* *National Renewable Energy Laboratory*	3.2	X			This project was recognized for its focus on addressing technical barriers in terms of reliability, durability, and the cost of deploying hydrogen sensors. Reviewers acknowledged the project's potential impact in terms of supporting stationary applications and vehicle repair facilities, its strong international collaborations on basic research, and its efficient use of resources. Reviewers questioned the lack of collaboration with automotive original equipment manufacturers (OEMs) and the Asian hydrogen communities, given their resources and expertise. Reviewers recommended an increased focus on stationary applications rather than vehicles; an industry workshop to identify the needs of OEMs, code requirements, and a path to listing hydrogen-specific sensors in UL 2075; and increased alignment of hydrogen fuel quality detection activities with related work in other Safety, Codes and Standards and Hydrogen Delivery sub-program projects.
SCS-022	Fuel Cell & Hydrogen Energy Association Codes and Standards Support *Karen Hall;* *Fuel Cell & Hydrogen Energy Association*	3.1	X			Reviewers acknowledged FCHEA's collaboration with international and domestic organizations and SDOs and its focus on multiple technology applications (e.g., transportation, stationary power, and portable power). Reviewers praised the depth of expertise and experience that FCHEA demonstrated in its role in coordinating efforts with industry to support DOE activities. Reviewers also noted weaknesses in the project, such as the lack of a cohesive strategy and the lack of identification of specific contributions to optimize the project's relevance and potential impact on industry. It was recommended that the project pursue a more proactive approach to engaging SDOs to help accelerate the standards development process and improve the quality of promulgated standards. Reviewers also suggested collecting more feedback from key stakeholders regarding barriers to commercialization to better leverage the associations' member bases.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
SCS-023	Hydrogen Leak Detector for Hydrogen Dispenser *Igor Pavlovsky; Applied Nanotech*	3.0			X	Reviewers praised this project for its progress, demonstrated repeatability, and high accuracy (at up to 2%) over a wide temperature range. It was also recognized for its collaboration with NREL. Reviewers noted that project strengths such as the simple sensor design and low cost could benefit station developers and automotive OEMs. The project's identified weaknesses included the lack of data on interference, sensor drift, and long-term durability. Reviewers recommended that the project continue to Phase II only if the NREL testing shows promise for the technology. They stated that if the project advances to Phase II, at least one partner (e.g., a fueling station or an OEM) should be added.

Market Transformation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
MT-006	Fuel Cell Combined Heat and Power Commercial Demonstration *Kriston Brooks; Pacific Northwest National Laboratory*	3.3	X			Reviewers commented that this project will help introduce combined heat and power systems at consumer locations. Also, reviewers stated that the data collected from these applications has provided valuable insight into the system's effectiveness and reliability. It was suggested that feedback is needed from host organizations about their experiences with the system, the system's costs/benefits, the worthiness of using the system without U.S. Department of Energy support, and any system changes needed.
MT-007	Landfill Gas to Hydrogen *Shannon Baxter-Clemmons; South Carolina Hydrogen and Fuel Cell Alliance*	3.2			X	Several reviewers commented that this project showcases an opportunity to produce hydrogen that is viable for use in fuel cells from landfill gas, which is often an unrealized asset. Reviewers noted that the project lacks cost information on the impact of the revised gas cleanup standards. This project will be completed in FY 2015.
MT-008	Hydrogen Energy Systems as a Grid Management Tool *Mitch Ewan; Hawaii Natural Energy Institute*	3.6	X			Reviewers stated that this project will enhance the ability to use renewables by mitigating the grid instability caused by those renewables. Reviewers suggested that it would be beneficial for the project team to work with utility companies to monetize grid benefits from electrolysis and to install electrolyzers in distributed locations.
MT-011	Ground Support Equipment Demonstration *Jim Petrecky; Plug Power*	3.1	X			Reviewers reported that the plan to complete this project is reasonable, with a number of go/no-go decisions that will help mediate the risk of this project. However, they also stated that the summer 2014 schedule seems very aggressive and will need to be monitored.
MT-013	Maritime Fuel Cell Generator Project *Joe Pratt; Sandia National Laboratories*	3.6	X			Reviewers stated that the project has done an outstanding job of coordinating between the fuel cell supplier, the fuel cell customer, the infrastructure support, and the relevant regulatory agencies. However, reviewers also stated that perhaps Ballard should be added to the project team so that the project team includes fuel cell expertise and not just electrolysis.
MT-014	Fuel-Cell-Based Auxiliary Power Unit for Refrigerated Trucks *Kriston Brooks; Pacific Northwest National Laboratory*	3.0	X			Reviewers stated that this project could meet a need of the trucking industry, save fuel, reduce greenhouse gases, and create a market for fuel cell technology. However, they stated that the funding/time does not seem sufficient for full integration (e.g., electrical integration with the truck refrigeration unit), and that the reason for 400-hour demonstrations was not defined.

Systems Analysis

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
AN-033	Analysis of Optimal Onboard Storage Pressure for Hydrogen Fuel Cell Vehicles *Zhenhong Lin; Oak Ridge National Laboratory*	3.2	X			Reviewers observed that the project approach was sound but needs to include multi-objective optimization because of the importance of different vehicle parameters. They recommended that the project expand the collaboration to automobile manufacturers. Reviewers noted that the project provides a useful analysis of clustered deployment strategies compared to a region-wide infrastructure deployment. They also stated that the project could be strengthened by improving the validation of the underlying assumptions, including the consumer's value of time.
AN-035	Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies *Marianne Mintz; Argonne National Laboratory*	3.4	X			Reviewers agreed that the project is useful, and that the identification of the economic benefits and job creation impacts of hydrogen fuel cell electric vehicles and the associated infrastructure will be valuable for policy considerations and decisions. They stated that the project team should consider including a comparative analysis with other conventional and alternative fuels and refueling infrastructure. They recommended that additional station developers should peer review the technical and economic sections of the model, and that the project scope should be expanded to include displaced jobs.
AN-036	Pathway Analysis: Projected Cost, Life Cycle Energy Use, and Emissions of Future Hydrogen Technologies *Todd Ramsden; National Renewable Energy Laboratory*	3.1	X			Reviewers observed that this project was well developed and utilized a highly structured approach. They commended the project for making excellent progress and noted that the analysis is instrumental for the DOE, industry, and other stakeholders in defending the merits of hydrogen fuel. Reviewers stated that the project could be strengthened by updating key assumptions. In addition, they suggested performing sensitivity cases relative to a decarbonized U.S. economy.
AN-039	Life Cycle Analysis of Water Consumption for Hydrogen Production Pathways *Amgad Elgowainy; Argonne National Laboratory*	3.4	X			Reviewers acknowledged that the project addresses a critical need by adding water consumption to the life cycle analysis of the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model. They commended the project on its excellent progress made to date and its excellent approach for the comparative analysis. They recommended that the project team consider regional analysis of water issues in the future.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed	Summary Comments
AN-044	Impact of Fuel Cell System Peak Efficiency on Fuel Consumption and Cost *Aymeric Rousseau; Argonne National Laboratory*	3.4	X			Reviewers observed that the project is well designed and that the assumptions are realistic. They acknowledged that the use of probability of targets was a good approach and provided a good understanding of the interaction of fuel stack efficiency, cost, and hydrogen storage cost. They encouraged the project team to increase its collaboration with the automobile manufacturers.
AN-045	Analysis of Incremental Fueling Pressure Cost *Amgad Elgowainy; Argonne National Laboratory*	3.6	X			Reviewers commented that the project took an excellent approach to understanding the hydrogen storage and dispensing configurations and the costs for stations. They mentioned that the project provided a thorough understanding of the cost of the station components and the resulting cost for hydrogen dispensed at various pressures. The reviewers encouraged the project team to pursue more in-depth collaboration and consultation with hydrogen component suppliers.
AN-046	Hydrogen Station Economics and Business (HySEB)—Preliminary Results *Zhenhong Lin; Oak Ridge National Laboratory*	3.0		X		It was acknowledged that the analysis provided information and findings on how the station size and deployments can affect the net present value of the station. Reviewers stated that the project goals were too broad, and that the results were difficult to interpret. They noted that a simple definition is needed of the objective function that the consumer/investor seeks to optimize. The reviewers remarked that the project should define the assumptions embedded in the model, and that the analysis could be strengthened by comparing the parameters and assumptions to existing modeling of hydrogen cost, station cost, and infrastructure locations.
AN-047	Tri-Generation Fuel Cell Technologies for Location-Specific Applications *Brendan Shaffer; University of California, Irvine*	3.0	X			According to reviewers, the project's approach was reasonable but limited. They stated that the scope should be expanded to consider other sources of fuel, such as natural gas from pipelines, and economic analysis of the tri-generation system. They also felt that project collaborations should include fuel cell companies with expertise in tri-generation and stakeholders in the Northeast.
AN-049	Electricity Market Valuation for Hydrogen Technologies *Joshua Eichman; National Renewable Energy Laboratory*	3.4			X	Reviewers commented that this analysis project was very relevant to the Fuel Cell Technologies Office goals and objectives and made significant progress. They stated that the project's findings will contribute to understanding of the application of hydrogen for energy storage and the associated costs and financial benefits. They noted that project collaboration should be expanded to include other industry stakeholders and countries that are installing energy storage projects.