Prologue

Dear Colleague:

This document summarizes the comments provided by peer reviewers on hydrogen and fuel cell projects presented at the fiscal year (FY) 2011 U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting (AMR), held May 9–13, 2011, in Arlington, Virginia. In response to direction from various stakeholders, including the National Academies, this review process provides evaluations of the Program's projects in applied research, development, demonstration, and analysis of hydrogen, fuel cells, and infrastructure technologies. A joint plenary session opened the meeting with a presentation on "California's Clean Energy Future," followed by overview presentations from the DOE Office of Basic Energy Sciences, Hydrogen and Fuel Cells Program, and Vehicle Technologies Program. A plenary for Hydrogen and Fuel Cells Program reviewers and attendees included overviews on each of the 10 sub-programs: Hydrogen Production and Delivery; Hydrogen Storage; Fuel Cells; Manufacturing Research and Development; Market Transformation; Technology Validation; Safety, Codes and Standards; Education; Systems Analysis; and American Recovery and Reinvestment Act (ARRA).

The recommendations of the reviewers are taken into consideration by DOE technology development 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, 2011–September 30, 2012). The projects have been grouped according to sub-program and reviewed according to appropriate evaluation criteria. For the first time, the AMR included a session on Market Transformation that featured a number of new projects initiated in FY 2011. This year's AMR also featured the second annual review of hydrogen and fuel cell projects funded under ARRA. The weighted scores for all of the projects are based on a four-point scale. 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, as appropriate, in their FY 2012 plans.

In addition to thanking all participants of the AMR, I would like to express my sincere appreciation to the reviewers. 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 2012 AMR, which is presently scheduled for May 14–18, 2012, in Arlington, Virginia. Thank you for participating in the FY 2011 AMR.

Sincerely,

Sunita Satyapal
Program Manager
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 or CDP*	Summary Comments
PD-002	Biomass-Derived Liquids Distributed (Aqueous Phase) Reforming *David King; Pacific Northwest National Laboratory*	2.7	X			According to reviewers, this project was strengthened by experimenting with the 10 individual components of bio-oil. However, they expressed concern over the high cost of production and suggested finding an improved catalyst. Recommendations were made to consider better quality bio-oil and to collaborate with industry on process development and engineering.
PD-004	Distributed Bio-Oil Reforming *Stefan Czernik; National Renewable Energy Laboratory*	2.8	X			Reviewers noted that the project has made progress in achieving high-energy conversion efficiency and improving hydrogen yield and catalyst durability. It was recommended that future work include component/process optimization, catalyst development and lifetime testing, and assessment of the impact of catalyst life on costs.
PD-007	Composite Pd and Alloy Porous Stainless Steel Membranes for Hydrogen Production and Process Intensification (Office of Fossil Energy) *Yi Hua (Ed) Ma; Worcester Polytechnic Institute*	2.8	X			Reviewers stated that the high flux achieved by the project during long-term testing is encouraging. However, they were concerned that the membrane has low selectivity and does not tolerate even low concentrations of sulfur. It was suggested that future work should include membrane testing in simulated feed streams containing sulfur compounds and in a coal gasifier slipstream.
PD-008	Development of Robust Hydrogen Separation Membranes (Office of Fossil Energy) *Bryan Morreale; National Energy Technology Laboratory*	3.0	X			Reviewers found this to be a strong project with good collaborations and a good combination of conceptual and experimental research. However, it was noted that long membrane lifetime and high flux still have not been demonstrated for multilayer membranes. Reviewers recommended selecting the most promising membranes for characterization, assessment of operational lifetime, and testing in the presence of contaminants in addition to sulfur.
PD-009	Scale-Up of Hydrogen Transport Membranes for IGCC and FutureGen Plants (Office of Fossil Energy) *Carl Evenson; Eltron Research and Development Inc.*	2.4		X		Reviewers acknowledged the project's accomplishment of building and operating a scaled-up system, but they noted that U.S. Department of Energy (DOE) targets for membrane flux and stability have not been demonstrated. The reviewers recommended improving flux and stability before further scaling-up of the system takes place.

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PD-011	Advanced Palladium Membrane Scale-Up for Hydrogen Separation (Office of Fossil Energy) *Sean Emerson; United Technologies Research Center*	3.0	X			This project was recognized by the reviewers for its ability to be scaled up. They expressed concern, however, over the choice of a palladium-copper alloy, as it is known to have low flux in the presence of sulfur. Reviewers suggested that the project focus on improving the flux and manufacturability of the membranes to meet DOE goals. They also suggested addressing other syngas contaminants in addition to sulfur.
PD-013	Membrane/Electrolyzer Development in the Cu-Cl Thermochemical Cycle *Michelle Lewis; Argonne National Laboratory*	2.8	X			Reviewers indicated that the project has made good progress in membrane development and is appropriately focused on critical barriers. However, it was recommended that the team run longer membrane tests and continue to optimize and improve the system to show both technical and economic feasibility.
PD-014	Hydrogen Delivery Infrastructure Analysis *Marianne Mintz; Argonne National Laboratory*	3.4	X			Reviewers found this project to be critical to the production and delivery sub-program's portfolio. They felt that the analysis provided relevant guidelines for direction of scarce funding towards the highest pay-off technology pathways. While reviewers thought that the work excelled in its consideration of different factors, they recommended that an uncertainty analysis be conducted to account for cost variability.
PD-015	Hydrogen Delivery Analysis *Olga Sozinova; National Renewable Energy Laboratory*	2.8	X			Reviewers observed that this project has conducted the first thorough analysis and modeling of hydrogen transport by rail. However, reviewers were unsure of the impact that rail delivery will really have, outside of niche applications. They were also concerned that the 2007 rail report used is out of date given the recent challenges the ethanol industry has faced in shipping fuel-grade denatured ethanol from the Midwest to the coasts.
PD-016	Oil-Free Centrifugal Hydrogen Compression Technology Demonstration *Hooshang Heshmat; Mohawk Innovative Technology, Inc.*	3.4	X			Reviewers commented that the partnership between Mohawk and Mitsubishi appeared to be quite good and valuable for the project. They observed that the project has demonstrated feasibility (through analysis) and is making progress toward designing a lower-cost delivery system. A stronger effort on testing and verification of materials compatibility was recommended.

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PD-017	Development of a Centrifugal Hydrogen Pipeline Gas Compressor *Frank Di Bella; Concepts NREC*	3.2	X			Reviewers observed that good progress has been made in completing a detailed design and in testing materials. They noted that the next step to build and test a full-scale module is essential, but they felt that capital costs needed further reduction. Reviewers observed that the projected capitol expense for this design is $4.8 million for 240,000 kilograms/day throughput, which is twice that of current reciprocating pipeline compressors on an equivalent throughput basis. Researchers recommended subsystem testing of the components prior to construction of a full-scale system.
PD-018	Advanced Hydrogen Liquefaction Process *Joe Schwartz; Praxair*	2.5		X		Reviewers noted that the company is experienced in the field of liquefaction, but they found that only small improvements were achieved by this project. The project showed that catalytically enhanced ortho-para conversion has the potential to reduce total power requirements for liquefaction by 2.4%. This project is being discontinued.
PD-020	Inexpensive Delivery of Cold Hydrogen in Glass Fiber Composite Pressure Vessels *Andrew Weisberg; Lawrence Livermore National Laboratory*	2.8	X			Reviewers recognized the recent efforts this project has made in burst testing a full-scale glass-fiber pressure vessel. However, they were concerned about the project stating that the burst test had been passed when the failure mode is unknown. Reviewers recommended researchers collaborate with industry experts on new polymer matrix material needs.
PD-021	Development of High Pressure Hydrogen Storage Tank for Storage and Gaseous Truck Delivery *Don Baldwin; Lincoln Composites*	3.3	X			Reviewers observed that this project has demonstrated promising results for a 3,600-pounds per square inch (psi), 8,500-liter delivery vessel, which could play a critical role in reducing the cost of transporting hydrogen. They felt that the approach taken in analyzing the future feasibility of a higher-pressure, higher-capacity vessel design was good. Reviewers commended future plans to design a tank capable of achieving higher capacity at 5,000 psi.
PD-022	Fiber Reinforced Composite Pipelines *Thad Adams; Savannah River National Laboratory*	3.4	X			Reviewers noted that this project has made good progress in addressing the production and delivery sub-program's pipeline cost and durability goals. They felt that developing data for code certification (including, but not limited to, ASME) is the appropriate next step. However, the reviewers stated that the investigators need to make sure that Oak Ridge National Laboratory's researchers working on fiber-reinforced polymer are included in this effort if DOE continues to support both projects.

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PD-024	Composite Technology for Hydrogen Pipelines *Barton Smith; Oak Ridge National Laboratory*	2.9	X			Reviewers commented that progress has been made on understanding the compatibility of materials and that the improved test methods for measuring hydrogen diffusivity and permeation are based on sound science. They felt that planned cyclic testing will be important for qualifying fiber-reinforced polymer (FRP) pipe for hydrogen service. While the reviewers disagreed on whether a demonstration pipeline is an appropriate next step, they believed that the investigators need to include the Savannah River National Laboratory's FRP researchers in their efforts if DOE continues to support both projects.
PD-025	Hydrogen Embrittlement of Structural Steels *Brian Somerday; Sandia National Laboratories*	3.4	X			Reviewers remarked that this project appears to be making good progress, despite problems with inconsistent funding. They observed that fundamental properties of fracture threshold and fatigue crack growth were being measured in relevant hydrogen conditions. There were concerns, however, about whether steel pipeline transport will meet the Program's long-term cost targets given that it is unlikely that hydrogen will be distributed in urban areas by pipeline because of the high installation and right of way costs.
PD-027	Solar High-Temperature Water Splitting Cycle with Quantum Boost *Robin Taylor; Science Applications International Corporation*	2.8	X			Reviewers observed that progress has been made in improving the efficiency of the system, although efficiency still remains low compared with other solar thermochemical reaction cycle technologies being investigated. While reviewers commented positively on the concepts of molten salt thermal energy storage and continuous operation, they expressed concern that the complexity of the project will make it difficult to overcome cost and efficiency barriers. Reviewers recommended that cost components be clearly defined in order to better understand cost reductions resulting from process improvements rather than from reductions in heliostat costs.
PD-028	Solar-Thermal Atomic Layer Deposition Ferrite-Based Water Splitting Cycles *Al Weimer; University of Colorado*	3.0	X			Reviewers acknowledged the project team's increased understanding of the formation and stability of hercynite at the temperatures of interest. Reviewers recommended continued economic assessment of the hercynite cycle relative to the hydrogen threshold cost, with clear definition of cost components in order to better understand cost reductions resulting from process improvements rather than from reductions in heliostat costs. Bench-scale demonstration of materials durability during fast-cycling at cycle temperatures over thousands of cycles was also recommended.

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PD-029	High-Capacity, High-Pressure Electrolysis System with Renewable Power Sources *Paul Dunn; Avalence LLC*	3.0	X			Reviewers observed that the project appears to be well focused on critical barriers and issues, especially safety. They commented that the advantage of this system's design lies in its production of a dry gas and its lack of need for a compressor. They noted, however, that the project has moved at a slow pace, and they recommended more specific data be provided regarding efficiency.
PD-030	PEM Electrolyzer Incorporating an Advanced Low Cost Membrane *Monjid Hamdan; Giner Electrochemical Systems, LLC*	3.7	X			Reviewers commented that this project has made significant progress and noted that it has exceeded DOE's efficiency and capital cost targets. They observed that the project was sharply focused on reducing cost through improved design and manufacturing processes.
PD-031	Renewable Electrolysis Integrated System Development and Testing *Kevin Harrison; National Renewable Energy Laboratory*	3.4	X			Reviewers commented that this project has provided valuable data for guiding future technological advancements, stating that long-term stack testing and data provided by the different coupling systems will provide valuable insight for future system designs. Reviewers recommended that future work should move away from hydrogen fueling and focus primarily on the integration of electrolyzers with renewable energy sources.
PD-033	Nano-Architectures for 3rd Generation PEC Devices: A Study of MoS_2, Fundamental Investigations, and Applied Research *Thomas Jaramillo; Stanford University/National Renewable Energy Laboratory*	3.6	X			Reviewers observed that this project has demonstrated the impressive catalytic activity of nano-MoS_2, which has been shown to be a viable catalyst for the reaction. They also commented that the project shows strong synthesis and characterization capabilities, and has achieved improvements in component materials. However, reviewers questioned the feasibility of implementing the technology on a commercial scale and recommended that researchers consult an industrial partner for advice.
PD-035	Semiconductor Materials for Photoelectrolysis *John Turner; National Renewable Energy Laboratory*	3.5	X			Reviewers commended the laboratory for its leadership and lauded the technical skills of those within the Photoelectrochemical Working Group. They found that small amounts of progress have been made in the many facets of this project, including an effort to eliminate corrosion on a more promising material, the GaInP2/GaAs tandem. However, they noted that proposed future work focuses on incremental advancements, which would not be sufficient to achieve DOE targets. Some reviewers suggested narrowing the focus of the project.

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PD-036	Maximizing Light Utilization Efficiency and Hydrogen Production in Microalgal Cultures *Tasios Melis; University of California, Berkeley*	3.6	X			Reviewers commented that outstanding progress has been made as a result of the efficient approach of this project. They observed that the project has met and exceeded DOE milestones ahead of schedule and is approaching the theoretical limit of chlorophyll antenna size. Reviewers noted that there was significant interest from industry in the outcome of this project, and that a patent and licenses have already been issued. Reviewers recommended that the investigator consider translating research to other commercial algal strains.
PD-037	Biological Systems for Hydrogen Photoproduction *Maria Ghirardi; National Renewable Energy Laboratory*	3.1	X			Reviewers observed that significant progress has been made toward overall goals, although hydrogenase modifications were not as effective as hoped. Some reviewers commented that they would have liked to see an energy balance analysis to confirm that the amount of energy produced by the algae exceeds the amount used to produce acetate. Others expressed concern that the project suffered from having too many secondary tasks due to the complexity of the primary task. They noted, however, that most milestones have been met on time with encouraging results.
PD-038	Fermentation and Electrohydrogenic Approaches to Hydrogen Production *Pin-Ching Maness; National Renewable Energy Laboratory*	3.3	X			Reviewers noted that this project has demonstrated incremental progress toward most objectives and that hydrogen production has been improved due to various factors. Reviewers were concerned, however, with data that indicated the fed-batch reactor system doesn't scale well. They suggested that the team investigate the cause of poor performance rather than continue to scale up the system and also conduct a full system energy and material balance for their process to help guide future improvements.
PD-039	Hydrogen from Water in a Novel Recombinant Oxygen-Tolerant Cyanobacterial System *Phil Weyman; J Craig Venter Institute*	3.1	X			Reviewers acknowledged that this project is making steady progress considering that it involves a longer-term technology. They noted that although the gains in oxygen tolerance have been moderate, the approach to modify the redox potential of the ferredoxin has yielded significant results. Some reviewers questioned why cyanobacterium was chosen as opposed to other organisms and suggested providing greater specification, beyond relative terms such as "oxygen tolerant."

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PD-048	Electrochemical Hydrogen Compressor *Ludwig Lipp; FuelCell Energy, Inc.*	2.8	X			Reviewers observed that the electrochemical hydrogen compressor (EHC) appears to be a viable approach for increasing compression efficiency and reducing operating expenses. They noted that progress made thus far appears to be good and that the demonstration of a two-stage approach would be a valuable step toward meeting the pressurization objectives. However, they expressed concern regarding the lack of detail provided about the project, noting that not enough information was provided on EHC development and testing efforts. Additionally, reviewers would like to understand the projected capital expenditures for the technology when sized to forecourt throughput needs.
PD-049	Integrity of Steel Welds in High-Pressure Hydrogen Environment *Wei Zhang; Oak Ridge National Laboratory*	3.1			X	Reviewers noted that the project is on track and is about 90% complete. They commented that the team has developed a thorough capability for testing materials in a hydrogen environment. However, they expressed concerns about the value of testing 4340 steel and not X-series pipeline steels. They also had concerns about using finite element modeling to validate the spiral notch tension test (SNTT), because they felt that the primary value of the SNTT is to identify the most susceptible microstructure in the weld zone.
PD-051	Characterization of Materials for Photoelectrochemical Hydrogen Production *Clemens Heske; University of Nevada, Las Vegas*	3.7	X			Reviewers observed that this project, which uses high-precision materials characterization, has identified differences among samples that were thought to be identical and provided insight into the surface of semiconductors. They commented that it has provided great potential for the future and could aid in the creation of new viable materials for photoelectrochemical hydrogen production. The only concern expressed by reviewers was the dependence of the project on other groups to supply materials.
PD-053	Photoelectrochemical Hydrogen Production *Arun Madan; MVSystems/Hawaii Natural Energy Institute*	3.3	X			Reviewers felt that the team's focus on developing a viable prototype was encouraging. They noted that accomplishments have been made for each of the three primary materials, although some are very moderate, and they recognized the project's achievement of 4.3% efficiency. Some reviewers expressed concern that the complexities of integrating this technology into a system would make it difficult to achieve the target cost of hydrogen.

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PD-056	Critical Research for Cost-Effective Photoelectrochemical Production of Hydrogen *Liwei Xu; Midwest Optoelectronics, LLC*	3.2	X			Reviewers noted that the project is progressing according to schedule, with more focus on a single pathway—the immersion-type photoelectrochemical cell. However, reviewers questioned whether the cell is ready to be scaled up, and they suggested more hours of small-cell testing. They also recommended completing a more thorough cost analysis and determining the cost and efficiency of the project.
PD-058	Characterization and Optimization of Photoelectrode Surfaces for Solar-to-Chemical Fuel Conversion *Tadashi Ogitsu; Lawrence Livermore National Laboratory and the National Renewable Energy Laboratory*	3.2	X			Reviewers observed that the project team has successfully created models for the III-V semiconductor system, which will provide significant predictive capability. They noted that the team has identified three corrosion scenarios and that future work appears to be focused on solutions for these scenarios. Reviewers felt that the turnaround time for the models must be shortened in order to remain useful.
PD-070	One Step Biomass Gas Reforming-Shift Separation Membrane Reactor *Michael Roberts; Gas Technology Institute*	2.6		X		Reviewers observed that progress has been made in membrane screening, but some reviewers questioned the fundamental choice of using a membrane separator. It was also noted that the flux goal for hydrogen purification has not been met. It was recommended that the cost analysis be strengthened to establish the basis for the membrane work.
PD-071	High Performance, Low Cost Hydrogen Generation from Renewable Energy *Katherine Ayers; Proton Energy Systems*	3.6	X			Reviewers observed that significant progress has been made in reducing catalyst loading. However, some reviewers felt that the project has focused too much on cost-reduction, at the expense of efficiency. However, it was noticed that the cell potential was slightly higher than that required by Giner, indicating further room for improvement. Reviewers suggested demonstrating stability under corrosive conditions.
PD-073	Zeolite Membrane Reactor for Water-Gas-Shift Reaction for Hydrogen Production *Jerry Y.S. Lin; Arizona State University*	2.4			X	Reviewers noted this project's good fundamental work on membrane development, selectivity improvements, and chemical stability in the presence of hydrogen sulfide, but they also noted that long term durability, cost, and manufacturability were not addressed. They also questioned whether other technologies offer the same or better benefits. They suggested that the project could benefit from a relationship with an industrial hydrogen producer and/or a water-gas-shift (WGS) catalyst company. Recommendations for the project wrap-up focused on optimizing the WGS system and associated scale-up issues, and providing a preliminary cost analysis, rather than exploring new materials or the synthesis of new tubular membranes.

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PD-081	Solar to Hydrogen Production with a Metal Oxide Based Thermochemical Cycle *Nathan Siegel; Sandia National Laboratories*	2.8	X			Reviewers acknowledged the project's development of a novel reactor design with the potential for >20% solar-to-hydrogen conversion efficiency. They were encouraged by the two-step cyclic system, which is the simplest process possible for chemical water splitting. However, they pointed out that extremely high temperatures and a complex design will make completing the reactor very difficult and constant operation impossible. They noted that materials compatibility and durability will be an issue in the future.
PD-084	Advanced Hydrogen Transport Membranes for Coal Gasification *Joseph Schwartz; Praxair*	3.1	X			Reviewers found that significant progress has been made in improving sulfur resistance and hydrogen transport in the MembraGuard membranes. They noted that flux began decreasing after only 15 hours, so they suggested testing to failure to better understand flux stability. They also suggested working to reduce the palladium content of the project, in order to reduce cost. Long-term tests and testing in a real gasifier stream were recommended as key to future plans.
PD-085	Hour-by-Hour Cost Modeling of Optimized Central Wind-Based Water Electrolysis Production *Genevieve Saur; National Renewable Energy Laboratory*	3.0	X			While reviewers agreed that this project provides a good analysis of different wind classes, they disagreed as to how applicable the scenarios are. They felt that none of them may be realistic for a representation of the potential wind-to-hydrogen industry. They also found some of the assumptions to be overly optimistic. However, they felt that the models provide valuable wind data and cover a basic range of options.
PD-086	Pilot Water Gas Shift – Membrane Device for Hydrogen from Coal (Office of Fossil Energy) *Thomas Barton; Western Research Institute*	2.9	X			Reviewers noted that the membrane designed by this project team was unique, with immunity to hydrogen embrittlement under certain conditions. Key strengths of the project included the use of an actual gasifier to test the membrane and the small amount of palladium-alloy required for the membrane, which would lower the cost. Reviewers felt that considerably more development work may be needed before the system can be demonstrated. Membrane testing for stability, permeability, and resistance to contaminants was recommended.
PD-088	Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage *Wei Zhang; Oak Ridge National Laboratory*	3.5	X			Reviewers praised this project's approach, which optimizes the use of two low-cost materials, steel, and concrete. They commented that, although the project is still in its early stages, it appears that critical barriers for stationary storage are being addressed. It was suggested that the investigators consider collaboration with Sandia National Laboratory, which is doing a lot of work with tank qualification.

*Congressionally directed project (CDP)

Hydrogen Storage

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ST-001	System Level Analysis of Hydrogen Storage Options *Rajesh Ahluwalia; Argonne National Laboratory*	3.3	X			The reviewers commented that the project has provided useful quantitative storage system performance estimates and important insights into the systems analyzed. Reviewers praised the project team for its considerable expertise and background in hydrogen storage system modeling, trade-off analysis, and integration with fuel cell systems. They recommended that the project explain its system design choices and assumptions, and discuss areas of risk and potential showstoppers. They also recommended that future work should identify specific issues and problems to be explored and define plans to address them. Continued collaboration with the Hydrogen Storage Engineering Center of Excellence (HSECoE) was encouraged.
ST-002	Analyses of Hydrogen Storage Materials and Onboard Systems *Karen Law; TIAX, LLC*	3.0			X	Reviewers commented that the bottom-up cost methodology is effective, the sensitivity analyses are useful, and collaboration with Argonne National Laboratory for system design and specification ensures good external input. It was noted that there is a need to examine cost reduction at lower-tier supply chains. It was also observed that the application of a single cost learning curve from one component to all storage system balance-of-plant components is risky and oversimplifies the system being analyzed. This project will be completed in fiscal year (FY) 2012.
ST-004	Hydrogen Storage Engineering Center of Excellence *Don Anton; Savannah River National Laboratory*	3.2	X			Reviewers noted that the HSECoE's development of total materials-based system models and designs is an important function for the U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program. However, they observed that the lack of an existing material with all of the requisite properties limits the effectiveness of this work and requires the HSECoE to use surrogate materials with an insufficient emphasis on cost. This was identified as the primary weakness of the HSECoE work. However, the HSECoE's overall organization and management was thought to be effective and it was found to be making good progress through substantial, well-coordinated collaboration.

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ST-005	Systems Engineering of Chemical Hydride, Pressure Vessel, and Balance of Plant for Onboard Hydrogen Storage *Jamie Holladay; Pacific Northwest National Laboratory*	3.3	X			This project is part of the HSECoE. The reviewers found the project to be relevant to the Program, and they particularly appreciated the important role this project has played in down-selecting from eight chemical hydrogen storage materials. The approach used in the effort was thought to be well-structured and appropriate. Reviewers also observed that the laboratory is involved in a wide range of HSECoE activities with extensive collaborations; however, the project management was found to be strong, enabling the project to remain effective. It was recommended that additional analyses on thermal management and overall energy efficiency should be conducted.
ST-006	Advancement of Systems Designs and Key Engineering Technologies for Materials Based Hydrogen Storage *Bart van Hassel; United Technologies Research Center*	3.0	X			This project is part of the HSECoE. Reviewers felt that this project plays a crucial role in the HSECoE, observing that its work builds on previous experience and addresses a wide range of issues related to materials-based hydrogen storage systems. Reviewers commented that a clearer prioritization of the various program elements is needed. Overall they thought that good progress has been made in a number of research areas, including compaction, thermal management, fuel purification, and risk factors. While the future work plan appeared comprehensive, reviewers thought more detail and metrics should have been provided.
ST-007	Chemical Hydrogen Storage Materials Rate Modeling, Validation, and System Demonstration *Troy Semelsberger; Los Alamos National Laboratory*	3.1	X			This project is part of the HSECoE. Reviewers commented that this project is highly relevant to the Program and it was observed that even if chemical hydrogen storage materials and metal hydrides are not able to meet DOE targets for vehicles, the outcome of this project could still be useful to systems for other applications. The progress on development of a fluid-phase ammonia borane (AB) reactor and an acoustic fuel gauge was thought to be good. While the future work was thought to be appropriate, reviewers commented on the need for more emphasis on understanding the formation of key impurities and inclusion of other fluid-phase chemical hydrogen storage materials, such as alane (AlH_3). Reviewers felt that the respective roles of the project partners, with respect to impurity release/clean-up and AB slurry systems, were not sufficiently clarified and that strong coordination is needed.

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ST-008	System Design, Analysis, Modeling, and Media Engineering Properties for Hydrogen Energy Storage *Matthew Thornton; National Renewable Energy Laboratory*	2.9	X			This project is part of the HSECoE. Overall, the reviewers commented that the models integrating vehicle and fuel cell performance with the onboard storage system are useful for evaluating predicted system performance. However they were divided on the need to take the effort much further with incorporation of well-to-wheels efficiency and greenhouse gas emissions. With NREL's experience leading the prior Sorption Center of Excellence, reviewers thought that their input on sorbent materials and systems was valuable; however, it was observed that the proposed materials do not correspond with the HSECoE's down-selected materials. Reviewers recommended that the integrated storage system-vehicle model be made available to groups outside the HSECoE.
ST-009	Optimization of Heat Exchangers and System Simulation of Onboard Storage Systems Designs *Darsh Kumar; General Motors*	3.2	X			This project is part of the HSECoE. Reviewers observed that this project addresses the critical areas of design optimization of heat exchangers and system simulations, and they noted that overall the progress has been good. They praised the project's work plans and approach, and commented favorably on the team's capabilities. A key concern was raised regarding whether there will be sufficient time and how applicable the current data will be when the project moves from surrogate material (sodium alanate) to a more promising material.
ST-010	Ford/BASF/University of Michigan Activities in Support of the Hydrogen Storage Engineering Center of Excellence *Andrea Sudik; Ford Motor Company*	3.3	X			This project is part of the HSECoE. Reviewers commented that it contains a good combination of modeling and experimentation and is addressing key research areas for this stage of the project—compaction for improved volumetric density and improved thermal conductivity. Reviewers found the proposed future work to be appropriate and felt that the team is highly qualified for successfully carrying out the plans.
ST-013	Composite Materials for Hazard Mitigation of Reactive Metal Hydrides *Joseph Pratt; Sandia National Laboratories*	2.4			X	While the reviewers found the project objective to be highly relevant to the Program, they thought there were a number of weaknesses with the approach. Reviewers commented that the project scope was limited in investigating only one polymer, and insufficient concern was given to the impact of the polymer on other factors such as gravimetric capacity. Reviewers also commented that additional work should have been done to determine polymer stability on cycling before carrying out large syntheses, and that other polymer matrices should have been investigated earlier in the project. They also felt that the project should have involved more collaboration. This project was completed in FY 2011.

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ST-018	A Biomimetic Approach to Metal-Organic Frameworks with High H_2 Uptake *Joe Zhou;* *Texas A&M University*	3.1	X			Reviewers noted that the project has achieved high gravimetric results that have been independently validated for air- and water-stable polymers. Reviewers recommended that future work needs to balance progress in both gravimetric and volumetric capacity as well as improved surface area and improved heat of adsorption. Reviewers also noted that the project would benefit from more theoretical work to guide materials design, incorporating metal functions to increase the storage at higher temperatures, and eventually approaching ambient temperatures. This project will be completed in FY 2012.
ST-019	Multiply Surface-Functionalized Nanoporous Carbon for Vehicular Hydrogen Storage *Peter Pfeifer;* *University of Missouri*	3.0	X			The reviewers commented that the strength of this project's concept is low-cost materials that can form monoliths while retaining storage performance. The reviewers recommended that FY 2012 work should continue on material design, with incorporation of boron and metals to increase storage capability at temperatures approaching ambient. Continued collaboration is also needed for sample measurement verification. This project will undergo a phase I/II go/no-go decision in FY 2012.
ST-021	Weak Chemisorption Validation *Thomas Gennett;* *National Renewable Energy Laboratory*	3.2	X			Reviewers stressed the importance of this project's round-robin synthesis and testing effort on common samples, along with its material characterization efforts that help to illuminate the mechanisms of weak chemisorption, or "spillover." The reviewers noted that coordinated project management and characterization efforts will be essential for successfully completing this work. This project has been extended and will be completed in FY 2012.
ST-022	A Joint Theory and Experimental Project in the Synthesis and Testing of Porous COFs/ZIFs for Onboard Vehicular Hydrogen Storage *Omar Yaghi;* *University of California, Los Angeles*	2.4		X		The reviewers favorably commented on the project's focus on covalent organic framework materials, which have been found to be more stable than metal organic frameworks. They cautioned that the use of platinum group metals as the metal function to increase storage temperature has high cost implications and that lower-cost metals should also be investigated. They also commented that it was not clear whether the modeling portion of the project is contributing to the success of the material discovery efforts. Reviewers recommended that external collaboration should be increased to validate the performance of promising samples.

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ST-023	New Carbon-Based Porous Materials with Increased Heats of Adsorption for Hydrogen Storage *Randy Snurr; Northwestern University*	3.0	X			Reviewers praised the successful teamwork of the team's theorists and experimentalists, and they noted that the project has achieved high gravimetric results for the high-surface-area metal organic framework sample. Reviewers recommended that future work should balance gains in both gravimetric and volumetric capacities. They also recommended that the project should focus on increased heat of adsorption, with a sufficient degree of coverage, to enable storage at temperatures closer to ambient. It was suggested that promising samples be verified with outside groups. This project will be completed in FY 2012.
ST-024	Hydrogen Trapping through Designer Hydrogen Spillover Molecules with Reversible Temperature and Pressure-Induced Switching *Angela Lueking; Pennsylvania State University*	2.9	X			Reviewers stressed that this project is important for understanding the mechanism of spillover for hydrogen storage near ambient temperature. They commended the project for focusing on measurement reproducibility and for collaboration with external groups for verification. They also commented on the technical risks involved in the concept, including a lack of reproducibility of material synthesis and slow hydrogen refill rates of the materials. Reviewers recommended that future work should stress a broad understanding of the spillover mechanism and reproducibility both internally and with outside groups.
ST-027	Tunable Thermodynamics and Kinetics for Hydrogen Storage: Nanoparticle Synthesis Using Ordered Polymer Templates *Mark Allendorf; Sandia National Laboratories*	2.9			X	Reviewers noted that this project's work toward understanding the potential effect of nanochemistry on altering the thermodynamics and kinetics of simple and complex metal hydrides is important and highly relevant to the Program's goals. They commented that the approach is well-designed; however, they felt that more focus should be placed on evaluating the amount of materials in the nanoporous structure. The reviewers noted that the project has a high level of collaboration and has demonstrated an excellent use of theory to drive experimental efforts. They recommended that the effort should be further prioritized, to show more-complete progress in a fundamental area. This project was completed in FY 2011.

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ST-028	Design of Novel Multi-Component Metal Hydride-Based Mixtures for Hydrogen Storage *Christopher Wolverton; Northwestern University*	3.1	X			Reviewers found that this project demonstrates a good use of theory and experimental efforts to predict and demonstrate new hydride materials, but they felt that more focus was needed on meeting automotive targets. They also noted that the computational effort should be expanded to cover release mechanisms and support catalyst development. Reviewers praised the quality of the team and its collaborations; however, they felt that there was a lack of focus between the collaborators' efforts. For future efforts, reviewers recommended more emphasis on regeneration.
ST-031	Advanced, High-Capacity Reversible Metal Hydrides *Craig Jensen; University of Hawaii*	3.4			X	The reviewers found that this project is closely aligned with the Program's goals and that it is examining very practical materials that could have a large impact. They observed that the project is focusing its efforts on materials with mild cycling conditions and high capacity, which are critical. They also noted that the project has leveraged many well-coordinated collaborations for materials development and characterization, which are key for achieving a fundamental understanding of barriers. This project was completed in FY 2011.
ST-032	Lightweight Metal Hydrides for Hydrogen Storage *J.-C. Zhao; Ohio State University*	3.3			X	The reviewers commended the project for its focus on high-capacity materials that could meet DOE targets, noting that aluminoboranes are some of the most promising materials for high-capacity, reversible hydrogen storage. They noted, however, that emphasis on hydrogen cycling should be balanced with characterization. They found that the project's theoretical work complemented the experimental characterization effort very well, and the collaboration between the teams seemed to be well-coordinated. Reviewers suggested that the project's main focus in the future should be on reversibility. This project was completed in FY 2011.
ST-034	Aluminum Hydride *Jason Graetz; Brookhaven National Laboratory*	3.5	X			Reviewers found this project, which is focused on alane, a material with high gravimetric and volumetric capacity, to be highly relevant to the Program. They felt that its efforts on investigating alane performance as a slurry and on regeneration processes are being well carried-out and that they are improving the outlook of alane as a practical storage material. However, reviewers considered the lack of collaborations to be a weakness. It was recommended that more modeling should be incorporated into the effort.

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ST-038	Hydrogen Storage by Novel CBN Heterocycle Materials *Shih-Yuan Liu; University of Oregon*	2.9	X			Reviewers commented that the project's approach is innovative and worth pursuing. They commended the project for the significant progress it has made in material synthesis, and they noted the benefit of a low temperature system that is liquid both before and after the release of hydrogen. However, they commented that the capacities of materials under consideration are low compared with the vehicular hydrogen storage targets, and they emphasized the need to focus on higher-capacity materials. Reviewers also observed the noise in the desorption curve and stressed the need to identify its source.
ST-040	Liquid Hydrogen Storage Materials *Anthony Burrell; Los Alamos National Laboratory*	3.2	X			The reviewers commended the project for its well-thought-out synergistic approach that combines its strength in material science with engineering expertise, through collaboration with the HSECoE. Reviewers commended the project for having identified several ionic liquids that are thermally stable up to 400°C. It was recommended that the project consider theoretical guidance for catalyst development and minimization of borazine production.
ST-044	SRNL Technical Work Scope for the Hydrogen Storage Engineering Center of Excellence: Design and Testing of Metal Hydride and Adsorbent Systems *Ted Motyka; Savannah River National Laboratory*	3.1	X			This project is part of the HSECoE. Its focus on reversible metal hydrides and sorbents for onboard storage was considered by the reviewers to be appropriate and relevant to the Program. They considered the team to be well organized and observed that the work has a strong fundamental basis. Reviewers felt that the approach taken in compiling materials properties and developing comprehensive models for heat and mass transfer appear to be well-designed and effective. The key issue identified was the lack of existing materials with all the required properties to allow a system to meet DOE targets. The future work plans were considered to be logical and appropriately based upon past results.
ST-045	Key Technologies, Thermal Management, and Prototype Testing for Advanced Solid-State Hydrogen Storage Systems *Joseph Reiter; NASA Jet Propulsion Laboratory*	3.1	X			This project is part of the HSECoE. Reviewers considered the Jet Propulsion Laboratory to have made considerable progress over the past year. They observed that a particularly good example of progress was the development of a Kevlar suspension design for a cryogenic multilayer vacuum super-insulated vessel to minimize vacuum inefficiency and conductive heat transfer. Reviewers commented that, while there appear to be significant collaborations within the HSECoE, there should be stronger collaborations with some groups, such as Lincoln Composites and Lawrence Livermore National Laboratory, to better utilize their related expertise.

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ST-046	Microscale Enhancement of Heat and Mass Transfer for Hydrogen Energy Storage *Kevin Drost;* *Oregon State University*	2.8	X			This project is part of the HSECoE. While the reviewers commented that improved heat transfer and combustion technologies with reduced weight and size are critical development areas for materials-based storage systems, they were not uniformly convinced that microchannel technology is the best approach or that it will offer benefits over more conventional technologies. In general the reviewers expressed concern that the work to date hasn't accomplished as much as expected and that the proposed future work would not proceed at a sufficient pace to meet the HSECoE timeline for prototypes. Reviewers also thought that feasibility testing needs to be carried out—under conditions closer to expected operating condition—earlier than proposed.
ST-047	Development of Improved Composite Pressure Vessels for Hydrogen Storage *Norman Newhouse;* *Lincoln Composites*	2.7	X			This project is part of the HSECoE. The development of high-pressure vessels that are lighter and cost less was considered by the reviewers to be highly relevant and critical to the Program. While most of the individual elements that the project is investigating might have minimal impact, reviewers commented that in total, they could add up to significant improvements and cost reductions. Reviewers suggested that the project should consider low-temperature operation and the impact that this will have on Type-IV tanks.
ST-048	Hydrogen Storage Materials for Fuel Cell Powered Vehicles* *Andrew Goudy;* *Delaware State University*	2.5			X	This project involves high-capacity metal hydrides. The reviewers thought that the quality of the work was good, although most of the effort was retracing old work. The reviewers commented that the effort could be focused on providing useful information on destabilized metal hydrides to the HSECoE. Reviewers suggested that the investigators should begin collaborating with the HSECoE and focus on understanding the role of catalysts.
ST-050	Hydrogen Storage through Nanostructured Porous Organic Polymers (POPs) *D.J. Liu;* *Argonne National Laboratory*	3.2			X	Reviewers noted that porous polymers are important materials to study and that the team has synthesized a wide range of materials using a large number of chemistries. Reviewers noted that the porous polymers had high thermal stability. They also observed that the link between synthesis chemistries was not clear and that surface area is not yet sufficient for high capacity, even though a large number of materials have been synthesized to date. They recommended that remaining work should balance gravimetric and volumetric capacity and promising samples should be verified by external groups. This project was completed in FY 2011.

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ST-052	Best Practices for Characterizing Engineering Properties of Hydrogen Storage Materials *Karl Gross; H2 Technology Consulting LLC*	3.4			X	Reviewers emphasized that a widely available document on best practices for hydrogen storage performance measurements is critical to reduce the amount of false claims based upon faulty measurements. Reviewers had mixed feedback on the need for the planned engineering property measurement chapters. All reviewers felt that the baseline material property chapters should be completed promptly, peer reviewed, and published widely. This project will be completed in FY 2012.
ST-053	Lifecycle Verification of Polymeric Storage Liners *Barton Smith; Oak Ridge National Laboratory*	3.0	X			Reviewers noted that this project is well aligned with DOE targets and very important to understanding the cycling and aging effects of high-pressure tanks. While 4,000 thermal cycles and diffusion measurements on one sample have been completed, reviewers commented that the project should move on to measuring additional samples as quickly as possible. Reviewers also commented that the addition of a polymer expert to assist in the interpretation of the morphological changes observed on cycling would strengthen the team. It was recommended that the project should pursue extending the temperature range of cycling down to -40 °C.
ST-063	Electrochemical Reversible Formation of Alane *Ragaiy Zidan; Savannah River National Laboratory*	3.1	X			Reviewers commented that the project's electrochemical approach for the generation and re-generation of alane is highly relevant to the Program. Reviewers suggested focusing on improving efficiencies and yields and scaling-up with an ultimate goal of commercializing the process. Reviewers observed that the project is involved in a number of collaborations, but some of their contributions to the project were not clear. They suggested that the project collaborate with industrial chemical stakeholders and strengthen its collaboration with Brookhaven National Laboratory (BNL), especially regarding BNL's recent work on particle size for slurrying.
ST-070	Amide and Combined Amide/Borohydride Investigations *Don Anton; Savannah River National Laboratory*	3.2			X	Reviewers considered the team's approach to be well-designed and logical, and they commented that good progress has been made on demonstrating and advancing the potential of the Li-Mg-N-H system. However, they observed that kinetics is still an issue. Reviewers commented that the project could benefit from stronger collaborations and incorporation of guidance from theory. They also stated that a more focused effort on improving sorption kinetics at lower temperatures is needed. This project was completed in FY 2011.

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ST-085	HGMS: Glasses and Nanocomposites for Hydrogen Storage* *Kristina Lipinska-Kalita; University of Nevada, Las Vegas*	1.6			X	This project focuses on fundamental R&D of glass for hydrogen storage applications. Reviewers noted the theoretical basis for using nanocrystals to store hydrogen had not been demonstrated. Developing a model for identifying the potential characteristics of modified glass that could meet DOE's hydrogen storage targets was recommended. They also recommended that the project include hydrogen adsorption and release experiments in the tasks and that it examine the energy efficiency of this storage approach.
ST-093	Melt Processable PAN Precursor for High Strength, Low-Cost Carbon Fibers *Felix Paulauskas; Oak Ridge National Laboratory*	3.2	X			The development of lower-cost processes for producing high-strength carbon fiber precursors was considered by reviewers to be of critical relevance to the Program. Reviewers commented that progress has been considerable, in light of the project's budget. However, additional collaborations, especially with industrial carbon fiber producers, were encouraged. Reviewers also recommended converting the melt-spun precursor fiber to carbon fiber soon, in order to determine the properties of the carbon fiber earlier in the project rather than later.
ST-096	Analysis of H_2 Storage Needs for Early Market Non-Motive Fuel Cell Applications *Lennie Klebanoff; Sandia National Laboratories*	2.9			X	Reviewers noted the importance of this project's work toward understanding the hydrogen storage needs for early market, non-motive applications of fuel cells. However, they felt that portable power (less than 2 kilowatts) was an important application area that was not included in this project. It was noted that the approach used was valid but that the Kano method of analysis may be too detailed for the quality of data received. Reviewers also felt that, while storage system requirements for these applications were addressed, the project did not identify or discuss the gaps in current storage systems and their performance. This project was completed in FY 2011.
ST-097	Analysis of Storage Needs for Early Motive Fuel Cell Markets *Jennifer Kurtz; National Renewable Energy Laboratory*	3.4			X	Reviewers noted the importance of this project's work toward understanding the hydrogen storage needs of fuel cells in early-market, motive-power applications. The reviewers noted that the approach used to gather data was appropriate and that exceptional progress has been achieved to date. However, they felt that the use of the Kano method of analysis may be too detailed for the quality of data received. The reviewers recommended that future work should stress quantifying the required performance of the existing fuel-storage or energy-storage mechanism for a targeted application. This project was completed in FY 2011.

*Congressionally directed project (CDP)

Fuel Cells

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
FC-001	Advanced Cathode Catalysts and Supports for PEM Fuel Cells *Mark Debe;* *3M*	3.5			X	Reviewers felt that this project is relevant to the U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program, is well managed and productive, and incorporates excellent participation from academia, national labs, and industry. The project was commended for its progress towards reducing platinum loading while improving catalyst activity. In addition, the reviewers identified the 3M team's willingness to discuss experimental details as an asset to the Program. Some reviewers were concerned that the best anode and cathode compositions and structures would not match when combined in a cell/stack. The project is in the validation phase and most reviewers felt that the remaining work was appropriate; however, some reviewers expressed a preference for using the remaining time to address technical issues, such as the stability of more promising alloys developed earlier in the project.
FC-002	Highly Dispersed Alloy Catalyst for Durability *Vivek Murthi;* *UTC Power*	2.3			X	The reviewers commented that the project was relevant, well-managed, and has collaborated effectively. Reviewers commended the project for involving key industrial partners to develop novel catalytic systems for end-product demonstrations and for involving academia in fundamental modeling to further guide the research. The reviewers felt that the choice of iridium tied the catalyst to an element with low abundance and increased the risk of making the catalyst too expensive. In addition, it was noted that the project did not appear to be able to meet the activity goals set and had no plans to address this issue. The project is near completion, and there was disagreement among the reviewers about the value of validating the catalyst in a fuel cell stack.
FC-006	Durable Catalysts for Fuel Cell Protection During Transient Conditions *Radoslav Atanasoski;* *3M*	3.2	X			According to reviewers, the project addresses DOE targets and is making good technical progress. Reviewers observed that key strengths of the project included the use of the nanostructured thin film catalyst, with its inherent resistance to corrosion, and the team's proactive approach towards developing new test protocols. Reviewers noted that the use of precious metals will require lower catalyst loading. It was suggested that more focus should be placed on understanding the source of the apparent onset of degradation at 1.6 volts and that additional modeling would be useful for optimizing the catalyst configuration and materials.

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FC-007	Extended, Continuous Pt Nanostructures in Thick, Dispersed Electrodes *Bryan Pivovar; National Renewable Energy Laboratory*	3.1	X			According to the reviewers, this project is highly relevant and led by a team with solid technical skills utilizing an effective approach. Reviewers praised the project for evaluating a diversity of supports and for evaluating bulk properties of the platinum catalyst. According to the reviewers, there is a lack of clarity between the modeling and experimental work. They suggested using modeling to narrow the scope of materials being evaluated experimentally.
FC-008	Nanosegregated Cathode Catalysts with Ultra-Low Platinum Loading *Nenad Markovic; Argonne National Laboratory*	3.4	X			The reviewers felt that this project was highly relevant and that the team is appropriately applying fundamental and applied research to develop viable membrane electrode assemblies (MEA). According to reviewers, one strength of the project is its comprehensive approach—using modeling to inform highly controlled synthesis, processing, and analytical testing. The reviewers felt that nickel leaching could be a barrier to commercial application. It was suggested the team work less on developing new catalytic materials and more on characterizing and diagnosing existing catalyst formulations.
FC-009	Contiguous Platinum Monolayer Oxygen Reduction Electrocatalysts on High-Stability, Low-Cost Supports *Radoslav Adzic; Brookhaven National Laboratory*	3.3	X			Reviewers commented that this work—including the modeling activities—supports the main objectives of the fuel cells sub-program and that the approach is sound, rigorous, and excellent. They commended the project for excellent results in terms of stability and performance with very low platinum loadings. The reviewers noted that results were only shown for pure oxygen and that the catalysts should be assessed in air as well. They encouraged the principal investigator (PI) to concentrate on the more promising nanoparticles that have demonstrated they can meet the targets, unless there is some direct evidence that the palladium nanowires can be made thin enough to meet DOE's overall platinum-group-metal loading targets.
FC-010	The Science and Engineering of Durable Ultralow PGM Catalysts *Fernando Garzon; Los Alamos National Laboratory*	2.8	X			Reviewers noted that the project addresses DOE goals to reduce the cost and improve the durability of fuel cells. They observed that this project's modeling work has significantly increased understanding of ultra-low platinum group metal catalysts. Reviewers also commended the project for very strong collaboration and coordination with other institutions. However, they said the project would benefit from a clearer discussion of how (and when) theoretical methods will be validated. They encouraged the PI to enhance the specific activity (on a real surface area basis), and they noted that no effort has been made to show how they could be scaled up.

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FC-011	Molecular-Scale, Three-Dimensional Non-Platinum Group Metal Electrodes for Catalysis of Fuel Cell Reactions *John Kerr; Lawrence Berkeley National Laboratory*	2.4		X		Reviewers felt that the project is very relevant to DOE goals; however, they noted that progress has been slow. It was observed that the current level of catalyst activity is well below where it needs to be, even relative to targets for non-platinum-group-metal-based materials. Reviewers felt that MEA testing was premature, and that catalysts with higher activity need to be found. They commented that the turnover frequency and catalyst density should have been evaluated for their ability to meet performance and durability targets earlier in the project, instead of in the third year.
FC-012	Polymer Electrolyte Fuel Cell Lifetime Limitations: The Role of Electrocatalyst Degradation *Deborah Myers; Argonne National Laboratory*	3.5	X			Reviewers identified degradation as the most critical issue that still must be resolved, and they praised this project as the most comprehensive effort addressing degradation mechanisms. They also praised the project highly for the progress it has made. It was recommended that, when appropriate, the project should also assess the impact of electrode architecture and microlayer composition and chemistry. Reviewers also suggested that the project determine whether the gas diffusion layer has an impact on degradation.
FC-013	Durability Improvements through Degradation Mechanism Studies *Rod Borup; Los Alamos National Laboratory*	3.4	X			Reviewers noted that durability is one of the critical challenges to overcome for the commercialization of fuel cells. They commended this project for the significant progress made toward all project milestones as well as its extensive collaboration with relevant partners. Reviewers noted that conductivity of ion-conducting membranes only appears to have been studied indirectly as was given in iR-free fuel-cell plots, and they suggested a direct correlation of conductivity to failure modes.
FC-014	Durability of Low Platinum Fuel Cells Operating at High Power Density *Olga Polevaya; Nuvera Fuel Cells*	3.3	X			Reviewers praised the project team, and they commended the project for the progress it has made and for its balanced combination of modeling and experimental validation of the models. Some reviewers were concerned that the work may only be applicable to Nuvera's single cell open flow field design. Reviewers recommended additional sharing of information.
FC-015	Improved Accelerated Stress Tests Based on FCV Data *Timothy Patterson; UTC Power*	3.0	X			Reviewers commended the project team for its expertise in catalyst degradation post-mortem characterization, as well as for using real-world data and comparing it with accelerated stress tests (ASTs). However, reviewers were concerned that the information gained from the project may be too specific to UTC Power. Reviewers recommended that materials, design, and operating condition information should be shared as much as possible to make the reported data more meaningful.

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FC-016	Accelerated Testing Validation *Rangachary Mukundan; Los Alamos National Laboratory*	3.2	X			Reviewers stated that studies of catalyst degradation are important to meeting DOE's fuel cell goals for all applications and that buses are an important early application. They observed that very good progress has been made by this project. However, reviewers were concerned that automotive real-world drive data are not included in the project even though ASTs for automotive fuel cells are generated based on the automotive drive cycles. It was suggested that automotive original equipment manufacturers should be included in the project.
FC-017	Fuel Cells Systems Analysis *Rajesh Ahluwalia; Argonne National Laboratory*	3.6	X			Reviewers felt that the modeling tool developed by Argonne National Laboratory (ANL) is critical for benchmarking progress achieved in the Program and for providing input to cost analyses. They noted that the project is highly collaborative, as ANL interacts with leading fuel cell component providers, the standards community, other DOE laboratories, the PIs involved in cost analysis projects, and many others. They recommended that better documentation should be provided regarding how the design choices were made and what the implications of alternate designs might be.
FC-018	Manufacturing Cost Analysis of Fuel Cell Systems *Brian James; Directed Technologies, Inc.*	3.5	X			Reviewers observed that the project is highly relevant and uses well-developed analytic experience to perform detailed cost estimates of fuel cell systems. They noted that the PI has good collaboration with ANL and industry. It was recommended that the project expand its collaborations to include solid-oxide fuel cell developers and additional automotive fuel cell developers.
FC-020	Characterization of Fuel Cell Materials *Karren More; Oak Ridge National Laboratory*	3.0	X			Reviewers felt that most aspects of this project align with DOE objectives, that extensive data have been produced, and that this project's team is one of the best in the sub-program's portfolio. The project was specifically commended for its innovative experimental techniques and analytical facilities. Reviewers suggested that the project should either provide users with analysis services or pursue research such as material characterization using its own analysis techniques.

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FC-021	Neutron Imaging Study of the Water Transport in Operating Fuel Cells *David Jacobson; National Institute of Standards and Technology*	3.1	X			Reviewers commented that water management in the fuel cell stack is one of the most critical processes for meeting performance targets and that the neutron imaging technique provides very powerful analysis capabilities for addressing this issue. They noted that significant improvement of imaging resolution has been demonstrated; however, reducing the response time (frame time) is still a challenge. Reviewers felt that the technical path and odds of success for the new goal of 1 micron resolution were not sufficiently explained and that it is not clear how knowledge gained through these imaging studies is transferred to the developers of the systems to be improved. They suggested that investigation at low temperatures should be used to determine where the onset of ice formation takes place and that the project identify possible mitigating actions.
FC-023	Low Cost PEM Fuel Cell Metal Bipolar Plates *Conghua Wang; TreadStone*	2.7			X	Reviewers considered the project to be relevant and observed that the technology shows promise. They expressed concern, however, that plate testing data is lacking, and that testing should be conducted to prove the stability of the plates in aggressive cycling conditions. Reviewers also expressed concern that, because the project is approaching completion, time is limited for developing and testing chromium-plated aluminum plates. The project is coming to completion.
FC-024	Metallic Bipolar Plates with Composite Coatings *Jennifer Mawdsley; Argonne National Laboratory*	2.7			X	Reviewers noted that development of low-cost, durable coatings for metal plates is very relevant to DOE objectives. They were concerned that the coatings are very thick and will not lead to thin plates. They recommended that the fuel cell testing include EIS studies and HFR results. Reviewers also suggested making a conductivity measurement of the filler powder after it had been through the acid-exposure test since the formation of surface oxide layers would electrically insulate one particle from another as well as from the plates.
FC-025	Air Cooled Stack Freeze Tolerance *Dave Hancock; Plug Power, Inc.*	2.5			X	Reviewers felt that the project was relevant to the near-term implementation of fuel cells for material-handling equipment, but perhaps of less general relevance. Overall, they felt that that the progress achieved was good, with experiments supported by modeling, and with a sound demonstrated commercial collaboration between the teams. However, they also felt that the project is too specific to one stack model, and they questioned the degree to which lessons learned from this project can be translated to other fuel cell technologies.

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FC-026	Fuel-Cell Fundamentals at Low and Subzero Temperatures *Adam Weber; Lawrence Berkeley National Laboratory*	2.9	X			Reviewers felt that this project has used a very solid and complete approach to addressing issues around freeze-starting and that it has employed a very good team to thoroughly investigate water management and freeze-starting. The reviewers disagreed on the importance of studying freeze-starting and on whether the project should focus on nanostructured thin film catalyst or include conventional platinum on carbon. They suggested correlating gas transport with freezing phenomena to help determine pore size and channeling changes during freezing and during the onset of freezing.
FC-027	Development and Validation of a Two-Phase, Three-Dimensional Model for PEM Fuel Cells *Ken Chen; Sandia National Laboratories*	2.9		X		The reviewers appeared to disagree on the relevance and approach of this project. Some reviewers felt that it is relevant, with the proposed approach allowing for the objectives to be reached, while others questioned the predictive capability of the models and expressed concern over the degree of complexity needed for the three-dimensional models. The reviewers strongly encouraged further improvement in achieving agreement between modeling and validation.
FC-028	Transport Studies Enabling Efficiency Optimization of Cost-Competitive Fuel Cell Stacks *Robert Dross; Nuvera Fuel Cells*	3.2	X			The reviewers had differing opinions on the project's approach. One reviewer suggested that the project should engage in further discussion with the U.S. DRIVE fuel cell tech team regarding its approach. Recommendations included additional model verification and adding a durability aspect to the project because transport is closely related to durability.
FC-030	Water Transport in PEM Fuel Cells: Advanced Modeling, Material Selection, Testing, and Design Optimization *Vernon Cole; CFD Research Corp.*	2.3			X	Reviewers noted that the project addresses a key aspect for polymer electrolyte membrane (PEM) fuel cell performance optimization. They praised the project's overall approach of combining modeling with experimental validation. They also observed that the project's effective collaborations help to support this approach. However, they felt that the project has made only marginal progress—they observed that the model it has developed lacks experimental validation, with poor quantitative agreement between the model and experimental data. Some reviewers suggested that, in the limited time remaining, the project should include water balance measurements and controlled variation of specific material properties to validate the model.

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FC-031	Development and Demonstration of a New Generation, High Efficiency 10 kW Stationary PEM Fuel Cell System *Durai Swamy; Intelligent Energy*	2.5			X	The reviewers commended the project for demonstrating a working system for stationary combined-heat-and-power applications to achieve targets—particularly the durability target of 40,000 hours for stationary PEM fuel cells. It was observed that the project has made some progress toward these targets, but has not achieved them. In particular, the reviewers noted that the project was unlikely to achieve the stated durability targets. Some reviewers recommended that additional work be done. This project concludes in August 2011.
FC-032	Development of a Low Cost 3–10 kW Tubular SOFC Power System *Norman Bessette; Acumentrics Corporation*	3.2	X			Reviewers believe the project has made significant progress—in terms of improving performance and durability and reducing cost—in developing and demonstrating a tubular solid oxide fuel cell system for stationary applications. They noted that advances have been made at the cell, stack, and system level. Reviewers observed that further reductions in cost are needed for commercialization. Some reviewers also mentioned the need for further development of current collection and interconnect materials.
FC-036	Dimensionally Stable Membranes *Cortney Mittelsteadt; Giner Electrochemical Systems, LLC*	2.8			X	Reviewers stated that this project was relevant to the Program's goals because dimensionally stable membranes have the potential to improve fuel cell durability, especially at elevated temperatures. Reviewers praised the investigator's versatility in response to setbacks regarding issues with the developed materials' durability and performance. They also stated that this project provided a valuable data set, with functioning membranes showing properties comparable to Nafion 211 and approaching DOE targets. However, they expressed a lack of confidence in any further developments meeting DOE's membrane targets in the time remaining for the project.
FC-037	Rigid Rod Polyelectrolytes: Effect on Physical Properties: Frozen-in Free Volume: High Conductivity at Low Relative Humidity *Morton Litt; Case Western Reserve University*	3.0	X			Reviewers praised the novelty and quality of the technical approach pursued by this project. They felt that the project has made progress by achieving very good conductivity at 120°C at low relative humidity, with slight improvements in mechanical properties. However, the reviewers noted that additional improvements in MEA performance are needed—particularly for improving stability and mechanical properties.

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FC-038	Nanocapillary Network Proton Conducting Membranes for High Temperature Hydrogen/Air Fuel Cells *Peter Pintauro; Vanderbilt University*	3.1			X	The reviewers commended the project for applying novel electrospinning processes to generate perfluorosulfonic acid and polypheylsulfone nanofibers. According to the reviewers, the technical approach is strong and excellent progress has been made. Reviewers remarked that this project's approach can be applied to membranes as well as electrodes; however, it was suggested that these aspects be separated. Reviewers noted that performance characteristics of the novel composite membrane and MEA at 120°C and low relative humidity have not been demonstrated. Reviewers recommended additional testing, including durability protocols, with the time remaining in the project.
FC-039	Novel Approaches to Immobilized Heteropoly Acid Systems for High Temperature, Low Relative Humidity Polymer-Type Membranes *Andrew Herring; Colorado School of Mines*	2.7			X	Reviewers commended this project for its collaboration with industry. Some reviewers praised its novel approach on unconventional materials, while others questioned the approach and the materials investigated. Reviewers noted that the project has met the initial conductivity milestone and go/no-go decision point. Reviewers observed that the ultimate technical targets have not all been achieved, but an understanding of the materials and synthesis methods has been acquired and disseminated.
FC-040	High Temperature Membrane with Humidification-Independent Cluster Structure *Ludwig Lipp; FuelCell Energy, Inc.*	2.7			X	According to the reviewers, the project's technical goal of developing stable, low-resistance membranes directly addresses the Program's goals. Reviewers commented that the project team is strong and has provided materials to make highly conductive membranes. However, reviewers felt that the approach to company sensitive information resulted in important details missing from the Annual Merit Review (AMR) presentation, such as the precise nature and composition of the water retention additive and the proton conductivity enhancer. Reviewers recommended that the team provide more details at next year's AMR regarding the membrane composition, so that reviewers can better evaluate the potential of this new membrane material in fuel cells.
FC-041	Novel Approach to Advanced Direct Methanol Fuel Cell Anode Catalysts *Huyen Dinh; National Renewable Energy Laboratory*	2.7			X	According to the reviewers, the project's goal of improving the performance of the anode catalyst in direct methanol fuel cell systems is critical to achieving the DOE technical targets. The reviewers noted that the test data presented appears to indicate improved catalyst activity; however, they felt that the presentation lacked data on MEA testing. The reviewers recommended that cost analysis, MEA testing, and cell degradation analysis be conducted. They also recommended more dissemination of information.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
FC-042	Advanced Materials for Reversible SOFC Dual Mode Operation with Low Degradation *Randy Petri;* *Versa Power*	3.3			X	The reviewers felt that the project has made significant progress on improving the efficiency and durability of reversible solid oxide fuel cell stacks. They observed that the project involves a good mix of modeling and experimentation. They also praised the project for progress made in improving power density and degradation. However, they observed that much more work is needed before the technology will be commercially viable. Reviewers also felt that an economic analysis is an important aspect of this project's future work.
FC-043	Resonance-Stabilized Anion Exchange Polymer Electrolytes *Yu Seung Kim;* *Los Alamos National Laboratory*	3.2			X	According to reviewers, the project is well-thought-out and well-planned, and anion exchange PEM for fuel cells are an important technology that could meet the Program's goals for performance and cost reduction through non-platinum catalysts. The reviewers felt that the project would benefit from closer collaboration with industrial partners. They observed that, while good progress has been made in both non-platinum-group-metal catalyst and membrane development, more progress on membrane stability is critical for success. The reviewers recommended that the project focus on a mechanistic understanding of alkaline fuel cell performance and durability, rather than work toward a set of targets for a specific application.
FC-044	Engineered Nanoscale Ceramic Supports for PEM Fuel Cells *Eric Brosha;* *Los Alamos National Laboratory*	3.0	X			According to the reviewers, this project's approach is well-designed and is focused on achieving DOE goals. It was noted that the project has made significant progress towards synthesis of high-surface-area, durable supports and towards synthesis of high-loaded platinum catalyst on Mo_2N support. However, reviewers commented that the project suffers from poor electrochemical characterization and too much emphasis on ex-situ x-ray diffraction, which is not a particularly useful tool for oxygen reduction reaction catalysts. The reviewers felt that the project's future plans are on track. They recommended that future work should focus on using the standard perchloric acid technique for rotating disk electrode measurements and then use surface characterizations to understand why activity may be low.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
FC-048	Effect of System and Air Contaminants on PEM Fuel Cell Performance and Durability *Huyen Dinh; National Renewable Energy Laboratory*	3.1	X			The reviewers commended the project for its overall approach of selecting a few key balance-of-plant-derived contaminants to understand effects on stack durability. They observed that this approach covers many of the required aspects of an impurity project. They also observed that there has been good progress in benchmarking methods between various labs, in establishing and validating analytical methods, and in demonstrating reproducibility across the different collaborator sites. The reviewers felt that the benchmark MEA performance at the three organizations should have been a higher priority. They also commented that the plan for future work is good and has clear benefits to industry.
FC-049	Development of Micro-Structural Mitigation Strategies for PEM Fuel Cells: Morphological Simulations and Experimental Approaches *Silvia Wessel; Ballard*	3.4	X			According to the reviewers, this study of catalyst durability at low platinum loading addresses key barriers defined by the Program. The reviewers identified the value of this project's approach, which includes: focusing on degradation of the cathode catalyst and catalyst layer; modeling, with an extensive experimental component for validation; and statistical sensitivity analysis of the modeling results. The reviewers expressed concern, however, that agreement between the model and experimental test data on cell voltage versus cathode platinum loading was not as good as it should have been. For future work, the reviewers suggested that the researchers need to further refine the base model before conducting sensitivity studies and statistical analysis.
FC-051	Fuel Cell Testing at the Argonne Fuel Cell Test Facility: A Comparison of US and EU Test Protocols *Ira Bloom; Argonne National Laboratory*	2.2		X		Reviewers felt that the project appears to naturally align with the Program's priorities and plans. They felt that the project's approach is reasonable, but they stated that there should be a more in-depth assessment of how the industry should test stacks to improve throughput and maintain accuracy. They also noted that support of the standards activities seems good. The reviewers suggested that this project would benefit from having an automotive fuel cell that can work in many circumstances, which could be used to do this kind of work on EU tests methods and on U.S. test cycles in order to obtain more useful information.

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FC-052	Technical Assistance to Developers *Tommy Rockward; Los Alamos National Laboratory*	3.1	X			Reviewers praised this project for providing valuable testing and evaluation services, which would otherwise be unavailable to some organizations. They noted that the project's approach seems to be effective for developing an understanding of the issues being examined. Reviewers observed that the project seems to have good collaboration with a wide range of institutions. Reviewers felt that it would be beneficial to the industry as a whole, and DOE-funded projects in particular, if more of the results could be shared. They also suggested adding mechanical property testing capabilities.
FC-054	Transport in PEM Fuel Cell Stacks *Cortney Mittelsteadt; Giner Electrochemical Systems, LLC*	3.0	X			Reviewers felt that the project could improve PEM fuel cell transport properties, with a focus more on improving stack component performance. Reviewers felt that the project has a strong team, and they noted that solid progress has been made, with good experimental capabilities demonstrated, especially regarding determination of fundamental membrane-related parameters. Some reviewers raised a concern that the project may be too focused on components, without enough focus on the overall stack.
FC-063	Novel Materials for High Efficiency Direct Methanol Fuel Cells *Chris Roger; Arkema*	2.8	X			Reviewers observed that the project is addressing both membrane and cathode catalyst development to improve the performance and lower the cost of MEA for direct methanol fuel cells. They felt that the project team is strong and that good progress has been made with a promising set of membrane materials. Some reviewers were concerned with the relevance of the comparisons with existing materials. The reviewers agreed with the project's plan to test materials for durability, and they also recommended testing at lower methanol concentrations.
FC-064	New MEA Materials for Improved DMFC Performance, Durability, and Cost *Jim Fletcher; University of North Florida*	2.7		X		Reviewers observed that the project is relevant to DOE objectives for the development of MEA for portable power fuel cells. Some reviewers found the use of a barrier layer to modify water transport characteristics interesting and commented on the project's good progress in implementing this concept. Others felt that it was unclear whether improvements with this architecture would clear the path toward commercialization. Reviewers praised the technical expertise and experience of the project partners. They also stressed the importance of addressing durability in order for this project to be successful.

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FC-065	The Effect of Airborne Contaminants on Fuel Cell Performance and Durability *Jean St-Pierre; Hawaii Natural Energy Institute*	3.2	X			Reviewers felt that this project's activities are aligned with DOE's goals and that the project could have valuable results for the end users of systems operating in an industrial or hostile environment. However, they also noted that the study on the air side seems to be off to a slow start, perhaps due to the systematic approach to impurity selection. The downselect from 187 airborne contaminants, 68 indoor pollutants, and 12 roadside species that may have potential adverse effects on fuel cell performance was lauded. Reviewers recommended that the fuel cells be cycled repeatedly to failure and that the project carry out post mortem diagnostics of the MEA.
FC-067	Materials and Modules for Low-Cost, High Performance Fuel Cell Humidifiers *Will Johnson; W.L. Gore*	3.5	X			Reviewers felt that Gore's partners, materials, and strong technical competence have enabled solid progress toward the development of improved humidification materials. Reviewers expressed confidence that the project is on track to meet its goals. Reviewers suggested that the relevance of this work to stationary applications should be considered and that the project should ensure durability is sufficient for both automotive and stationary applications.
FC-070	Development of Kilowatt-Scale Fuel Cell Technology* *Steven Chuang; University of Akron*	2.0			X	The reviewers believe that the project is not relevant to the Program's goals, as it is using coal as a potential fuel for fuel cells. They further stated that, while the right topics are addressed, additional work is required to allow for scale-up of the developed technology.
FC-071	Alternative Fuel Membranes for Energy Independence* *Kenneth Mauritz; University of Southern Mississippi*	2.4			X	Reviewers observed that the project has demonstrated good polymer synthesis work, but they felt that conductivity results have not been impressive. They suggested that the project should move toward membrane fabrication upon down-selection of the current best available polymer.
FC-072	Extended Durability Testing of an External Fuel Processor for SOFC* *Mark Perna; Rolls-Royce Fuel Cell Systems (US) Inc.*	2.9			X	Reviewers felt that the project's focus on developing durable fuel-processing subsystems for solid oxide fuel cells aligns well with DOE objectives. They also observed that project milestones have been met or are on-schedule. It was suggested that the processor subsystem should be integrated with a fuel cell to run as a complete system.

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FC-075	Fuel Cell Balance of Plant Reliability Testbed* *Vern Sproat; Stark State College*	2.2			X	Reviewers expressed concern that this project has made little progress since last year's AMR. The reviewers also expressed concern about the level of collaboration. It was recommended that the investigators should focus testing on a few critical components that have been identified as needing more reliability testing. In addition, they suggested that the project should develop a feedback mechanism to communicate its results to industry.
FC-076	Biomass Fuel Cell Systems* *Neal Sullivan; Colorado School of Mines*	3.2			X	Reviewers observed that the project is focused on a key fuel cell component, the micro-channel reactor. Reviewers commended the project for its strong modeling and design capabilities and its collaboration with CoorsTek. Reviewers observed that the project has a broad scope, but they noted that the PI has responded to prior year comments and focused the project's efforts. Reviewers recommended that the project accelerate the thermal modeling, the validation of modeling results through experimentation, and the demonstration of heat exchanger durability. In addition, they suggested that a cost analysis should be conducted.
FC-077	Fuel Cell Coolant Optimization and Scale-Up* *Satish Mohapatra; Dynalene*	2.9			X	Reviewers praised this project for its progress toward developing a coolant that meets or exceeds operational lifetime requirements. They also commended the project for its good approach to scale-up and process control. Reviewers felt that involving a fuel cell company in the evaluation of the coolant would have been useful. They recommended that tests on these materials should be run at higher temperatures (105°C –120°C) and that thermal management system data from power plants should be obtained, particularly regarding long-term stability.
FC-078	21st Century Renewable Fuels, Energy, and Materials Initiative* *Joel Berry; Kettering University*	2.0			X	Reviewers stated that portions of the project are outside the scope of the Program, although they do align with overall DOE objectives. They proposed narrowing the scope down to the most relevant and promising areas, such as membranes and reforming.
FC-079	Improving Fuel Cell Durability and Reliability* *Prabhakar Singh; University of Connecticut Global Fuel Cell Center*	2.5			X	The reviewers found the overall scope to be broad for the relatively small amount of time for this multi-faceted project. They stated that the approach is rational and good progress has been made considering the relatively short duration of the sub-projects. A key strength of the overall project is the involvement of different industrial partners with a wide range of expertise. The reviewers also recommended that each sub-project focus on specific targets.

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FC-080	Solid Oxide Fuel Cell Systems Print Verification Line (PVL) Pilot Line* *Susan Shearer; Stark State College*	3.0			X	Reviewers found the project to be relevant to Program goals, with a good approach of moving test systems from cell to block level and providing a basis for future manufacturing decisions. Reviewers felt that the project was executed in a timely manner. They also noted that the project has a relatively short testing time.
FC-081	Fuel Cell Technology Status - Voltage Degradation *Jennifer Kurtz; National Renewable Energy Laboratory*	3.3	X			Reviewers commended the project team for providing a single consolidated comparison of life data and projections as well as for conducting comparative analyses of different applications and laboratory data versus field data. The project was also praised for its collaborations and its protocols for protecting sensitive information.
FC-083	Enlarging the Potential Market for Stationary Fuel Cells through System Design Optimization *Darlene Steward; National Renewable Energy Laboratory*	2.9	X			Reviewers noted that this new project has a broad scope and should be useful for planning and forecasting purposes. However, they expressed concern that the focus is unclear and that high-level results do not provide guidance for designing and manufacturing fuel cells.
FC-084	WO_3 and HPA Based System for Ultra-High Activity and Stability of Pt Catalysts in PEMFC Cathodes *John Turner; National Renewable Energy Laboratory*	2.8	X			Reviewers commended the project for the strength of its team, its strong materials component, its characterization capabilities, and for investigating new fabrication methods. However, they questioned the hydrolytic stability of heteropoly acids, the metal-support interactions, and the role of electronic conduction in supports.
FC-085	Synthesis and Characterization of Mixed-Conducting Corrosion Resistant Oxide Supports *Vijay Ramani; Illinois Institute of Technology*	2.9	X			The project team was commended for its novel ideas, its collaboration with Nissan, and its progress on conductivity. Some reviewers questioned the choice of RuO_2. Reviewers recommended catalyzation of the materials to see rotating disk electrode results and possibly fuel cell results. It was also recommended that the project address the stability of the materials.
FC-086	Development of Novel Non-Pt Group Metal Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications *Sanjeev Mukerjee; Northeastern University*	2.8	X			The reviewers noted the high quality of the project team and commended the project for its balance of experimental and theoretical components, as well as for its strong characterization techniques. Reviewers recommended that the project not focus on mass transport issues until adequate durability is demonstrated, and they recommended down-selecting the approaches and materials earlier in the project.

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FC-087	High-Activity Dealloyed Catalysts *Fred Wagner;* *General Motors*	3.4	X			Reviewers commented on the good, well-planned, approach of the project, and they observed that the project team is excellent, with strong capabilities for scaling-up the materials developed. They also praised the project for the amount of work it has demonstrated in a short period of time. However, concern was expressed regarding whether the developed materials could meet both activity and durability targets. Some reviewers suggested that the scope should be expanded beyond well-studied alloy systems.
FC-088	Development of Ultra-Low Platinum Alloy Cathode Catalyst for PEM Fuel Cells *Branko Popov;* *University of South Carolina*	3.0	X			The reviewers observed that the approach is novel and interesting, as it aims to incorporate advances in non-platinum-group-metal work with those made in platinum alloy catalysts to make a hybrid catalyst with higher activity and durability. They noted that good progress has been made toward development goals. However, they expressed concern that reported high-current performance values were low, and they suggested that plans be adjusted to address this.
FC-089	Analysis of Durability of MEAs in Automotive PEMFC Applications *Randy Perry;* *Dupont*	2.2		X		The reviewers commended the project for its strong team, which included Nissan as a partner; for its sound, comprehensive approach; for its use of modeling to support experiments; and for the materials used. However, reviewers expressed concern about the very limited progress that has been made due to delays in getting subcontracts in place. It was recommended that the ASTs are run with the same MEA as those Nissan used. Furthermore, it was recommended that, for modeling purposes, the researchers should begin planning how durability cycle events will relate to the stresses in ASTs.
FC-090	Corrugated Membrane Fuel Cell Structures *Stephen Grot;* *Ion Power*	2.7		X		Reviewers recognized the relevance of the project to DOE objectives and praised the novelty and innovation of the approach. They also noted that, while assessment of the project is difficult at this early stage, progress has already been demonstrated. However, some reviewers expressed concern with the challenges and risks involved in the project concept.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
FC-091	Advanced Materials and Concepts for Portable Power Fuel Cells *Piotr Zelenay; Los Alamos National Laboratory*	3.5	X			Reviewers noted that this project directly addresses DOE's durability, cost, and performance goals for non-hydrogen-fueled portable fuel cells. They felt that excellent progress has been made during the short time that the project has been active. They also noted that the project team is strong, with complementary expertise that covers the full scope of the project. The reviewers stated that it would be helpful to understand the nanotube fabrication processes better in order to assess the potential for making thinner nanotubes. They also suggested that more testing of MEA should be done, and testing should be done at lower temperatures and in multi-cell stacks.
FC-092	Investigation of Micro- and Macro-Scale Transport Processes for Improved Fuel Cell Performance *Jon Owejan; General Motors*	3.7	X			The reviewers praised this project for its relevance, approach, and progress achieved. They felt that the project's modeling for baseline and next-generation material sets was a key strength of the project, and they observed that the modeling was appropriate and the results of the validation experiments were good. They also noted that the development of a database for public dissemination of data was a valuable aspect of the project.

*Congressionally directed project (CDP)

Manufacturing R&D

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
MN-001	Fuel Cell MEA Manufacturing R&D *Michael Ulsh; National Renewable Energy Laboratory*	3.3	X			Reviewers felt that defect identification is an important aspect of cost reduction for membrane electrode assemblies and gas diffusion layers and that the progress made by this project is appropriate for the expenditures to date. They commented that the infrared/direct current technique appears valuable but needs further validation, and they expressed uncertainty regarding how the segmented cell testing will help with manufacturing. The reviewers recommended that the National Renewable Energy Laboratory determine the size of the smallest detectable defect and also the minimum size defect that would affect fuel cell performance.
MN-002	Reduction in Fabrication Costs of Gas Diffusion Layers *Jason Morgan; Ballard Material Products*	3.7			X	Reviewers praised this activity for directly supporting the U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program's cost-reduction goals and for addressing key issues with gas diffusion layers (GDLs) by concentrating on the ink mixing and coating processes. They noted that collaborators are making significant contributions toward the project's accomplishments. The reviewers recommended that the investigators examine GDL performance with higher performing membrane electrode assemblies, where the GDL performance is more critical.
MN-003	Modular, High-Volume Fuel Cell Leak-Test Suite and Process *Hugh McCabe; UltraCell Corporation*	2.9		X		Reviewers felt that this project's approach to developing an automated leak test apparatus is sound but that cost-analysis elements are lacking. They found it hard to discern progress that has been made and whether adequate testing for high-volume processes could be carried out. Reviewers suggested that potential cost savings be analyzed to assess the usefulness of the effort.
MN-004	Manufacturing of Low-Cost, Durable Membrane Electrode Assemblies Engineered for Rapid Conditioning *Colin Busby; W.L. Gore*	3.7	X			Reviewers noted that Gore has a very strong technical approach to accomplishing the work proposed and that significant progress has been made to minimize the waste of materials. It was not clear to the reviewers that modeling done by the University of Delaware or the University of Tennessee-Knoxville has anything to do with the manufacturing process. Reviewers suggested that Gore identify when the results of this effort will enter the marketplace.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
MN-005	Adaptive Process Controls and Ultrasonics for High Temperature PEM MEA Manufacture *Raymond Puffer; Rensselaer Polytechnic Institute*	3.1	X			Reviewers felt that reductions in manufacturing time and improvements in membrane electrode assembly (MEA) properties were relevant to DOE objectives. They noted that adaptive process control efforts indicate improved cycle times with no loss in part performance, and that ultrasonic sealing can greatly reduce cycle time. Reviewers expressed concern that pressing individual MEAs is not a low-cost process compared with coating rolled goods. They suggested a thorough investigation of the seals as a function of process control and verification of the seals for large-active-area MEAs.
MN-006	Metrology for Fuel Cell Manufacturing *Eric Stanfield; National Institute of Standards and Technology*	3.0	X			Reviewers noted that the National Institute of Standards and Technology employs a sound engineering approach and that progress to date has been good. They commented that some of the work being done seems to be less critical to near-term commercial success. Reviewers observed that the flow field plate manufacturing variability task is limited in its current form and they suggest expanding on the channel design and operating conditions.
MN-007	High Speed, Low Cost Fabrication of Gas Diffusion Electrodes for Membrane Electrode Assemblies *Emory De Castro; BASF*	3.4	X			Reviewers commended this project for its solid approach to address key technical barriers and the good overall progress that it has made. According to the reviewers, the proposed work is clearly defined and should lead to further cost reductions and improved materials. Reviewers identified higher coating speeds with uniform loadings as a critical need, and they added that quantifying potential cost reductions would be helpful.
MN-008	Development of Advanced Manufacturing Technologies for Low Cost Hydrogen Storage Vessels *Mark Leavitt; Quantum Fuel Systems Technologies Worldwide, Inc.*	2.9	X			Reviewers noted that this project is relevant to the DOE's goal of reducing the cost of onboard hydrogen storage systems, as process optimization will affect cost to some degree. However, they commented that there is an evident lack of understanding of structural materials, especially in relation to controlling the interface between the automated fiber placement and lay-up, and that the interface needs to be much better controlled.

*Congressionally directed project (CDP)

Technology Validation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
TV-001	Controlled Hydrogen Fleet and Infrastructure Analysis *Keith Wipke; National Renewable Energy Laboratory*	3.9	X			The reviewers commented that this project provides a valuable and relevant service to the Technology Validation sub-program by collecting and documenting vehicle and fueling infrastructure performance data. Reviewers noted that the approach has been proven and continues to improve over the course of the project. They observed that the process of providing specific, proprietary data to participants, while releasing general, nonproprietary data in the public domain, is very effective and useful. They also praised the valuable contributions of collaborators and commented that collaboration has been vital to the success of the project. The reviewers felt that this project should continue in some form and they recommended that future work should focus on disseminating information to key automotive decision-makers, and that analysis of material handling equipment should be added to the portfolio.
TV-006	Validation of an Integrated Hydrogen Energy Station *Ed Heydorn; Air Products*	3.8	X			The reviewers commented that this project fully supports the U.S. Department of Energy's (DOE) objectives and addresses the need to validate the use of fuel cells for cogenerating hydrogen. They noted that this approach has good potential for being an early hydrogen production pathway and that this project in particular will provide an excellent source of renewable hydrogen. Several reviewers commented there is a need for process and techno-economic analysis. Some questioned whether molten carbonate fuel cells are the best choice and it was suggested that solid oxide fuel cells be considered in the analysis. The reviewers recommended that the Hydrogen Analysis (H2A) or an equivalent model be used to determine the cost of electricity, heat, and hydrogen.
TV-007	California Hydrogen Infrastructure Project* *Ed Heydorn; Air Products*	3.8	X			The reviewers noted this project involves a good variety of refueling stations in terms of vehicle needs, site selection, permitting, operations, and data collection. Additionally, it was observed that the project is incorporating technical innovations, including the use of pipelines to supply hydrogen. Reviewers praised the project for its collaborations among a wide range of industry, auto original equipment manufacturers, local government, and university partners. It was recommended that Air Products consider broader collaborations in other areas, such as Hawaii, including possible collaboration with the Hawaii Hydrogen Initiative.

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TV-008	Technology Validation: Fuel Cell Bus Evaluations *Leslie Eudy; National Renewable Energy Laboratory*	3.7	X			The reviewers commented that this project directly addresses DOE's objective of obtaining and analyzing real-world operating data from fuel cell buses. They felt that it is an excellent source of valuable information, which is useful to DOE, the U.S. Department of Transportation, and other stakeholders involved with transit buses. The reviewers praised the investigator for excellent work overall and for working well with transit companies. Reviewers noted that the final reports will be essential for future decision makers to determine the value of using fuel cells in transit buses.
TV-009	Hawaii Hydrogen Power Park *Richard Rocheleau; Hawaii Natural Energy Institute*	3.2	X			The reviewers observed that this project is very relevant to the Hydrogen and Fuel Cells Program, addressing fuel cell electric vehicles, hydrogen refueling infrastructure, and fuel cell buses, and they felt that the lessons learned from this project will be very important. Reviewers also commented that there have been solid accomplishments to date, but progress has been hampered by delayed deliveries of buses and legal issues with the National Park Service. It was suggested that the project may have to be extended in order for all of the various demonstrations to have sufficient time for operation and data collection.
TV-012	Florida Hydrogen Initiative* *David Block; University of Central Florida*	2.4			X	The reviewers commented that progress on this project has been slow due to restructuring and a change in principal investigators. They observed that much progress has been made over the last year and that the project currently appears to be back on track with all funding committed and all subprojects underway. They also felt that its collaborations are good—each subproject is required to have an industrial partner—and there has been an increase in collaboration during last 12 months.

*Congressionally directed project (CDP)

Safety, Codes and Standards

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
SCS-001	National Codes and Standards Template *Carl Rivkin; National Renewable Energy Laboratory*	3.2	X			According to reviewers, good progress has been made and the team has established excellent coordination and collaboration with standards development organizations and code development organizations. Reviewers felt that the project has a talented team and strong interaction with domestic and international regulations, codes, and standards (RCS) activities. However, they thought that the National Renewable Energy Laboratory's specific contributions need to be more clearly defined. Reviewers suggested incorporating gap analyses into the RCS efforts and minimizing duplicative efforts in the development process.
SCS-002	Component Standard Research and Development *Robert Burgess; National Renewable Energy Laboratory*	3.4	X			The reviewers commented favorably on the technical focus and progress of this project, particularly its round-robin sensor testing. Specific strengths cited by reviewers included the direct working relationship with sensor manufacturers for testing and evaluating technologies and the development of a hydrogen sensor testing protocol. However, reviewers felt that the project relies too much on the national labs and that a metric is needed for assessing how useful these technical studies are for the standards development organizations and code development organizations. Reviewers suggested several research topics for further investigation including mesowire sensors and impact tolerance.
SCS-003	Codes and Standards Outreach for Emerging Fuel Cell Technologies *Carl Rivkin; National Renewable Energy Laboratory*	3.5	X			Reviewers praised the accomplishments and progress made by this project and highlighted its strong regional collaborations. They also praised the quality of the technical team and the strength of the project's communication plan. However, reviewers felt that this project's scope is too limited and that its potential impact is too small. Reviewers suggested more national collaborations and increased use of industry to broaden the reach of these education and outreach activities.

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SCS-004	Hydrogen Safety, Codes and Standards: Sensors *Eric Brosha; Los Alamos National Laboratory*	3.1	X			According to reviewers, this project employs an excellent, logical approach and has achieved adequate progress, but it still needs to demonstrate long-term stability and operability of the test stand from the National Renewable Energy Laboratory. Reviewers commended the project for its quality staff and approach, with particular praise for the modification of the lambda sensing platform. However, they felt that not enough field testing has been done to demonstrate the potential of the final product. Reviewers recommended more focus on commercialization and identification of target market applications.
SCS-005	Materials and Components Compatibility *Brian Somerday; Sandia National Laboratories*	3.3	X			Reviewers noted that this project has excellent collaborations and technical talent. They commended the project for its strong analytical and experimental approach and for its solid links with standards development organizations. However, the reviewers would have liked to see more clearly defined accomplishments and a better flow of information to industry. The reviewers suggested looking at the effect of a "V" notch on fatigue and crack growth in future tests and providing more details on welding requirements.
SCS-006	Hydrogen Safety Knowledge Tools *Linda Fassbender; Pacific Northwest National Laboratory*	3.6	X			Reviewers praised this project for the progress it has made in maintaining a critical hydrogen community resource and for its development of valuable materials on indoor refueling, basic hydrogen information, and storage. Specific strengths they identified include strong project organization and expansion of the lessons learned to other relevant technologies, which has widened the audience. However, reviewers felt that the project showed an inability to capture the percentage and significance of incidents reported—they also noted that there is limited funding to expand this work. The reviewers suggested developing a stronger analytical and evaluative component to this project.
SCS-007	Hydrogen Fuel Quality *Tommy Rockward; Los Alamos National Laboratory*	3.2	X			Reviewers observed that this project is making steady progress with complicated testing through a methodical and rigorous approach. They cited good collaboration with industry and persistent effort as project strengths. However, reviewers observed that there is much work left to be done and they felt that it takes too long for results to be made publicly available. More work on the effects of combinations of impurities was recommended.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
SCS-008	Hydrogen Safety Panel *Steven Weiner; Pacific Northwest National Laboratory*	3.4	X			According to reviewers, this project continues to provide a valuable resource for the hydrogen community and has effectively incorporated feedback from prior reviews. They noted that the project has established solid collaborations and shows a strong interest in promoting a culture of safety. Specific strengths cited include the technical expertise of the panel, its practice of conducting multiple site visits, and its exertion of continuous effort. However, reviewers felt that the panel seems to have a certain "comfort level" regarding its role. They suggested that the panel expand its role to more dynamically utilize the full value of a panel of safety experts. They also suggested pursuing international collaboration and developing a format to provide information on the value of project activities.
SCS-010	Research and Development Program for Safety, Codes and Standards *Daniel Dedrick; Sandia National Laboratories*	3.3	X			Reviewers observed that this project has made good progress and that the models it uses and the approach it employs to acquire sound technical data are excellent. Key strengths cited include the project's validated engineering models of hydrogen dispersion and ignition, its materials testing, and its direct involvement with code development and standards development organizations. The reviewers also felt that the project needs to move to real systems in order to have more impact and they believed that some duplication with work that others have done has occurred. They suggested that increased collaboration, potentially with more international partners, may help address this issue. They also recommended expanding the scope of materials and applications studied beyond steel tanks for forklifts.
SCS-012	Forklift Tank Testing and Analysis *Chris San Marchi; Sandia National Laboratories*	3.6	X			The reviewers commented favorably on this project's comprehensive approach, the significant progress it has made in providing data critical to standards development, and its strong collaborations with industry and standards development organizations. The experiment design and actual testing as well as the talent of the technical team were cited as project strengths. It was observed that the failure of some test equipment delayed the project and should have been included in the H2Incidents database. Reviewers suggested that, if additional funding were available to continue this work, there should be increased international collaboration and continuation of work on correlating engineered and as-manufactured flaws that lead to failures.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
SCS-014	Safe Detector System for Hydrogen Leaks* *Robert Lieberman; Intelligent Optical Systems, Inc.*	2.8	X			According to reviewers, good progress has been made in the development of this sensor, but there are still some concerns particularly relating to cost and algorithm development. Reviewers felt that the project's strengths lay in the development of a robust, novel optical platform sensor without any poisons. Reviewer concerns were focused on the cross reactivity of the device and whether there is sufficient potential for cost reduction. Reviewers recommended conducting a detailed cost analysis and risk assessment, establishing reliability and availability targets for the unit, and performing field tests.
SCS-015	Hydrogen Emergency Response Training for First Responders *Monte Elmore; Pacific Northwest National Laboratory*	3.6	X			Reviewers commended this project for the progress it has made and they recognized that it is maintaining a resource that could play an important role in the public acceptance of hydrogen. They highlighted the quality of the training and the project's excellent, enthusiastic staff as key strengths. However, reviewers felt there should be more outreach and virtual training and they considered the lack of a plan for expanding training to other regional markets a weakness. Reviewers suggested collaborating more with organizations outside California and offering the Continuing Education Units as part of the training.
SCS-017	Hydrogen Safety Training for Researchers and Technical Personnel *Salvador Aceves; Lawrence Livermore National Laboratory*	3.2	X			According to reviewers, this project has made good progress and developed several training packages. They observed that the project team has excellent expertise, capability, and experience, and the project is employing a thorough, well-thought-out approach. Reviewers noted, however, that some procedures have not been consistent with ASME piping codes and they felt that more collaboration would have been helpful. They also felt that there is a need for more evaluation of project effectiveness and value. While this project is currently winding down, reviewers suggested that, if additional funds were available to allow it to continue, more emphasis should be put on online classes and additional classes on other topics, including welding requirements and different joint types.

*Congressionally directed project (CDP)

Education

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
ED-003	Hydrogen and Fuel Cell Education at California State University, Los Angeles *David Blekhman; California State University, Los Angeles, University Auxiliary Services, Inc.*	3.3			X	Reviewers noted that this project has developed an impressive variety of materials, including courses, modules, and labs. They also observed that the materials cover a wide array of subjects in hydrogen, fuel cells, and general sustainability. However, reviewers expressed concern about the lack of an assessment plan or a feedback mechanism to evaluate and improve the education materials that were developed under this project. They recommended that regular assessments be integrated with the project's implementation plan. This project is fully funded and will be completed in 2011.
ED-004	Hydrogen Energy in Engineering Education (H2E3) *Peter Lehman; Humboldt State University Sponsored Programs Foundation*	3.7			X	Reviewers looked very favorably upon this project and noted the wide variety of materials, instructional tools, and teacher-training resources it has developed for pre-college and undergraduate audiences. Reviewers also noted that the project has effectively integrated assessments and improvements into its efforts. One weakness identified was that the materials are primarily being used in partner schools in California; the reviewers recommended that methods for disseminating these materials to a wider region should be considered. This project is fully funded and will be completed in 2011.
ED-005	Hydrogen Education Curriculum Path at Michigan Technological University *Jason Keith; Michigan Technological University*	3.7			X	Reviewers were very impressed with the content developed by this project, and particularly with its use of active learning techniques and its leveraging of long-standing engineering texts with updated problem and laboratory sets. They also praised the project for its use of members of industry to review and test the materials. Reviewers suggested that the project should seek additional input from other educational institutions that are also using this set of materials, in order to improve the materials and help expand their reach. This project is fully funded and will be completed in 2011.
ED-006	Hydrogen and Fuel Cell Technology Education Program (HFCT) *David Block; University of Central Florida*	3.0			X	Reviewers noted that this project has been transferred successfully to the University of North Carolina-Charlotte. They commented that it is demonstrating effective collaboration with industry to help direct student research, and that it has done a good job developing partnerships. Recommendations included developing a mechanism for distributing curricula and materials to others in the fuel cell and hydrogen educational 'network' and to a wider range of engineering schools. This project is fully funded and will be completed in 2011.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
ED-007	Development of a Renewable Hydrogen Production and Fuel Cell Education Program *Michael Mann; University of North Dakota*	3.5			X	Reviewers favorably noted this project's mix of laboratory and lecture materials and its targeting of three levels of students and teachers. The use of masters-level graduate students to help conduct the program was viewed positively. Reviewers noted that collaboration outside the University of North Dakota and neighboring communities could be improved to extend the impact of the U.S. Department of Energy (DOE) investment. Additional effort to reach more industry and stakeholders in North Dakota was also recommended. This project is fully funded and will be completed in 2011.
ED-008	Dedicated to the Continued Education, Training, and Demonstration of PEM Fuel Cell Powered Lift Trucks in Real-World Applications *Tom Dever; Carolina Tractor and Equipment Co. Inc.*	3.5			X	Reviewers observed that this project serves a valuable purpose by getting fuel cells and hydrogen out in front of a relatively non-technical audience of early adopters and end-users. Reviewers noted that the project's joint market transformation, communication, and education approach appears to be effective. They also noted that that there has been good outreach to fire and other emergency response personnel. This project is fully funded and will be completed in 2011.
ED-010	Development of Hydrogen Education Programs for Government Officials *Shannon Baxter-Clemmons; South Carolina Hydrogen and Fuel Cell Alliance*	3.4			X	Reviewers commended this project for taking a "whole state" approach to interfacing with government and leaders from the business community on the use of hydrogen and fuel cells. They also praised the project for incorporating the economic, environmental, and energy benefits of hydrogen and fuel cells into their messaging to these decision-makers. In addition, they complimented the project for its economic impact approach including highlighting energy and environmental benefits and for using an economic impact approach in addition to highlighting energy and environmental benefits. The reviewers commented on the strength of including a combination of industry, government policy makers, and the general public as target audiences, as well as the relationships with solar, wind, and biomass groups. They agreed with the approach of using the lessons already learned in South Carolina to help neighboring states develop their education plans for hydrogen and fuel cells. This project is fully funded and will be completed in 2012.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
ED-011	Virginia, Maryland, and Washington, D.C., Hydrogen Education for Decision Makers *Chelsea Jenkins; Commonwealth of Virginia, Virginia Clean Cities*	2.8			X	The reviewers stressed that the National Capital Region is a critical area for outreach to key policy- and decision- makers. The reviewers lauded the use of new media and the *Motorweek* videos to reach diverse audiences. However, they noted that the workshops at James Madison University and the University of Richmond were limited in impact and were not sufficiently coordinated and broad-based enough to have significantly impacted decision makers in the Capital region. This project is fully funded and will be completed in 2011.
ED-012	State and Local Government Partnership *Joel Rinebold; Connecticut Center for Advanced Technology, Inc.*	3.5			X	Overall, reviewers commented that this is a high value project and that the goals of informing state government and business decision makers about the use of hydrogen and fuel cells is critical. Reviewers praised the project for including economic, technical, and ecological aspects, and for helping states develop plans to implement the technology. Reviewers observed that good progress has been made through the use of road maps, financial tools and models, and analysis. They suggested that improving tracking of affected stakeholders and including better feedback from the use of roadmaps and models would be useful to improve future outreach efforts. This project is fully funded and will be completed in 2011.
ED-013	Raising Hydrogen and Fuel Cell Awareness in Ohio *Pat Valente; Ohio Fuel Cell Coalition*	3.5			X	Reviewers noted that the Ohio Fuel Cell Coalition has benefited from strong participation of state-based companies that are developing fuel cell products. Reviewers agreed with the project's approach of using forums and business-to-business networking and matchmaking, and they remarked that this approach provides traction for the project's activities to continue beyond the DOE funding. This project is fully funded and will be completed in 2011.
ED-014	H2L3: Hydrogen Learning for Local Leaders *Patrick Serfass; Technology Transition Corporation*	3.6			X	Reviewers noted that the project supports the DOE's objectives of providing unbiased information about hydrogen and fuel cells and learning opportunities for local leaders. They supported the project's use of detailed market analyses and its leveraging of existing curricula, such as Hydrogen 101, and they praised the student design contest. They suggested an expansion of focus to include broader audiences that are less familiar with the technologies. They also suggested increased use of webinars, but cautioned that relying solely on webinars may not provide optimal impact of reach to local leaders. This project is fully funded and will be completed in 2011.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
ED-015	Hydrogen Education State Partnership Program *Warren Leon; Clean Energy States Alliance*	2.9			X	Reviewers observed that this project targets a broad national audience and that the multi-state alliance can leverage resources and provide tools for other states to use. Reviewers agreed with the project's use of webinars, email listservs, and white papers for outreach. However, they recommended more collaboration with organizations that represent potential end-user customers, and with organizations that represent the hydrogen and fuel cell industry. In addition, the reviewers noted that there has been limited engagement with groups such as first responders, where a large impact could be achieved with outreach and education activities. This project is fully funded and will be completed in 2011.
ED-016	Hydrogen Technology and Energy Curriculum (HyTEC) *Barbara Nagle; Lawrence Hall of Science at University of California, Berkeley*	3.8			X	The reviewers commended this project for using a solid process to develop, field test, modify, and assess hydrogen and fuel cell curricula that can be financially sustainable after DOE funding. The reviewers noted that the project's collaboration model could be extended to other institutions, including museums. In addition, it was noted that significant progress has been made in addressing regional differences that might be barriers to broad dissemination of the curricula. All planned funds have been provided to this project and it will be completed in 2012.
ED-017	H2 Educate! Hydrogen Education for Middle Schools *Mary Spruill; National Energy Education Development Project (NEED)*	3.8			X	Reviewers noted that the project team has accomplished a lot through their workshops, with a relatively limited amount of funding since 2004, including reaching more than 8,500 teachers. They commended the project for being extremely well-planned, and they noted that its strong partnerships and effective collaboration have supported the expansion of the program. They also felt that the project team recognizes the importance of continual assessment and evaluation. All planned funds have been provided to this project and it will be completed in 2011.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review Completed or CDP*	Summary Comments
ED-019	Employment Impacts of Early Markets for Hydrogen and Fuel Cell Technologies *Marianne Mintz; Argonne National Laboratory*	3.0	X		Reviewers agreed with the purpose of the model, recognizing that understanding economic impact will be critical to advancing industry deployment. They also noted that the project meets objectives of both the Education and Systems Analysis sub-programs. They cautioned that this model should be tuned to a specific audience, because it will be weakened if it tries to serve too many diverse audiences with varying needs. Reviewers recommended that future work should address the economic impacts of individual installations of products for end-users. They also noted that it is important to benchmark the model versus other economic impact and employment studies. This project involves coordination between DOE's Education and System Analysis sub-programs.

*Congressionally directed project (CDP)

Market Transformation

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
MT-001	Assessment of Solid Oxide Fuel Cell Power System for Greener Commercial Aircraft *Larry Chick; Pacific Northwest National Laboratory*	3.0			X	Reviewers commented that it is important to examine all areas where fuel cells might provide benefits and gain market share; therefore, they felt that this project's investigation into the use of fuel cells for aircraft was a worthwhile study. However, reviewers commented that the likely uses for fuel cells on aircraft have a small potential for achieving reductions in petroleum use and greenhouse gas emissions.
MT-002	PEM Fuel Cell Systems for Commercial Airplane Systems Power *Lennie Klebanoff; Sandia National Laboratories*	3.2			X	Reviewers commended the project for its effective approach to understanding current aircraft architecture, developing models to analyze potential applications for fuel cells, and then testing via demonstrations. Reviewers noted that thermal integration may increase efficiency, but also noted that it adds to the complexity, cost, and weight of the system. Reviewers concluded that the overall weight of fuel and electrical systems could be reduced, given the right operating conditions, but they also felt that there does not seem to be much of a difference in parameters of interest (e.g., fuel requirements and total weight) between the baseline design and the fuel cell scenario. Based on these observations, some reviewers commented that this project indicates that this application should not be considered until critical in-flight power can be included.
MT-003	Green Communities *John Lewis; National Renewable Energy Laboratory*	3.4	X			Reviewers commended this project for taking an integrative approach toward a whole community. They felt that this work can help fuel cells enter the market by providing insights that will serve as good guidelines for future efforts by other communities that would like to integrate the use of fuel cells for stationary power with energy conservation measures in a comprehensive community plan. Some reviewers commented that a good outreach plan was needed to fully meet project objectives.
MT-004	Direct Methanol Fuel Cell Material Handling Equipment Demonstration *Todd Ramsden; National Renewable Energy Laboratory*	3.3	X			Reviewers commented that this real-world demonstration of battery-powered material handling equipment with fuel cell range-extenders will provide useful operating and durability data, which will help guide future research and development (R&D). Reviewers noted that the lack of understanding of the current economics of this application needs to be addressed immediately in order to effectively compare this approach with other technologies.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
MT-005	Bus Fleet and Infrastructure Deployment *Bob Glass; Lawrence Livermore National Laboratory*	2.7		X		Several reviewers noted that this project helps national labs showcase the technology to a wide variety of stakeholders, helping overcome misconceptions and aiding in education/outreach. However, one reviewer commented that the project seemed mostly inaccessible to the general public and that the vehicles were idle for a significant part of the project period. It was suggested that the project's visibility could be improved if the buses were used for public transit.
MT-006	Fuel Cell Combined Heat and Power Industrial Demonstration *Mike Rinker; Pacific Northwest National Laboratory*	2.9	X			Generally, reviewers' comments were positive in terms of this project's relevance; they noted that this application could be a significant market for fuel cells in the near term and could help fuel cells gain market traction, resulting in manufacturing cost reductions. It was noted by reviewers that having more diverse vendors and fuel cell products would have made the project more effective.
MT-007	Landfill Gas-to-Hydrogen *Shannon Baxter-Clemmons; South Carolina Hydrogen and Fuel Cell Alliance*	3.2	X			Reviewers felt that an this project is a strong example of a way to determine if there is a viable business case for producing hydrogen from landfill gas, and to potentially lay the groundwork for establishing business cases for many more deployments. While reviewers agreed that it is a strong project team, they also said that more technical planning details are needed to be successful.
MT-008	Hydrogen Energy Systems as a Grid Management Tool *Richard Rocheleau; Hawaii Natural Energy Institute*	2.9	X			Reviewers agreed that the project objectives are relevant and valuable and that the project has engaged with high-quality collaborative partners. However, reviewers also felt that the project team needs to put an immediate focus on addressing delays in some initial project tasks.
MT-009	Economic Analysis of Bulk Hydrogen Storage for Renewable Utility Applications *Susan Schoenung; Longitude 122 West, Inc.*	3.0			X	Reviewers commented that the tasks are appropriate and address the critical costs and benefits of using hydrogen for energy storage. However, they felt that the efficiency assumptions may be too optimistic. They also observed that the assumptions were relevant for longer-term scenarios, after R&D targets for cost and efficiency have been met, but they felt that the current or near-term equipment costs should be used to make the business case more relevant in the near term in order to facilitate adoption.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
MT-010	Fuel Cell Mobile Lighting *Lennie Klebanoff; Sandia National Laboratories*	3.6			X	Reviewers commented very positively on this project, stating that it is an excellent example of taking existing technologies (efficient lighting technologies and fuel cells for backup power) and combining them to create a new market with multiple advantages over the incumbent technology. Reviewers felt that this project is well-planned and that it involves a good variety of partners.

*Congressionally directed project (CDP)

Systems Analysis

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
AN-001	Infrastructure Analysis of Early Market Transition of Fuel Cell Vehicles *Brian Bush; National Renewable Energy Laboratory*	3.3	X			According to reviewers, good progress has been made and a useful modeling tool, the Scenario Evaluation and Regionalization Analysis model, has been developed and successfully integrates other data analysis tools. Specific project strengths highlighted by reviewers include the scenario analysis capability of the model and improved data flow from other data analysis tools. However, reviewers felt that more coordination with industry stakeholders was needed. It was suggested that the project focus more on the impact of using curtailed renewable power for hydrogen production in different regions of the country—in terms of both integrating renewables and developing a hydrogen infrastructure.
AN-002	Analysis of the Effects of Developing New Energy Infrastructures *Dave Reichmuth; Sandia National Laboratories*	2.9		X		Reviewers noted that this project has made good progress in developing a model to provide understanding of the factors that will influence the market penetration of fuel cell electric vehicles. They commented that the project has excellent international collaboration and they identified the sensitivity analysis and the ability to expand regionally and to other countries as project strengths. Reviewers recommended making the model available to the research community and suggested this project coordinate with related Hydrogen Demand and Resource Assessment (HyDRA)and Macro-System Model efforts.
AN-006	Cost and Greenhouse Gas Implications of Hydrogen for Energy Storage *Darlene Steward; National Renewable Energy Laboratory*	3.1	X			The reviewers observed that this project has made adequate progress in providing analysis of the use of hydrogen for energy storage. Reviewers praised the project for its careful utilization of historical data from four geographically dispersed wind sites. They noted, however, that further work—including collaboration with a geologist—is needed to determine appropriate geologic storage sites. They also suggested that the project increase its collaboration with utilities, wind turbine producers, and electroylzer manufacturers and that it publish its results and make its assumptions clearer.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
AN-010	Fuel Quality Effects on Stationary Fuel Cell Systems *Shabbir Ahmed; Argonne National Laboratory*	3.2			X	Reviewers commented positively on the overall progress of this project and its critical relevance to the performance, durability, and cost of stationary fuel cell systems. A specific strength that was observed was the project's comprehensive evaluation of impurities. Reviewers felt that the project should have a clearer timetable and that it should establish greater collaboration with industry partners and other researchers. Reviewers also recommended that a cost estimate of the gas cleanup system should be obtained and trade-off analysis should be incorporated into the project. This project has been completed.
AN-011	Macro-System Model *Mark Ruth; National Renewable Energy Laboratory*	3.1	X			Reviewers believed that this project has made good progress. Specific strengths cited include the successful integration of other analysis models into the Macro-System Model and the increased detail and transparency concerning model inputs and outputs. Reviewers felt, however, that the value of the project may be obscured by acronyms and complex language and that it should be more simply explained. Reviewers also commented that it was unclear how the results from these analyses could be used. It was suggested that the project add more effort to interpreting the results and that it should highlight the sensitivity analyses.
AN-012	GREET Model Development and Life-Cycle Analysis Applications *Michael Wang; Argonne National Laboratory*	3.6	X			Reviewers commended this project for the ongoing progress it is demonstrating and for the inclusion of new analysis and additional case studies. Reviewers thought this project had significant strengths, operating as the "gold standard" for greenhouse gas emissions calculations. However, reviewers expressed concern regarding issues in obtaining consistent, reliable data and the potential for the project to continue indefinitely. Reviewers suggested greater specificity on costs and timelines for future work and more focus on the range of diverse energy pathways possible in the future.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
AN-013	Emissions Analysis of Electricity Storage with Hydrogen *Amgad Elgowainy; Argonne National Laboratory*	2.8	X			According to reviewers, this project has made adequate progress in studying the key issue of using hydrogen for energy storage, but they felt that some significant gaps remain. Specific strengths cited by reviewers include the comparison of competing technologies, investigation of the impacts on different regions of using hydrogen to store electrical energy, and investigation of the effects of capturing and using by-product oxygen. Reviewers felt, however, that the project was too limited in its consideration of competing technologies and needed more quantitative data on emissions. Reviewers suggested increased collaborations, which they felt would be helpful in verifying data analysis.
AN-014	Energy Informatics: Support for Decision Makers through Energy, Carbon, and Water Analysis *A.J. Simon; Lawrence Livermore National Laboratory*	2.7			X	Reviewers believed this project generated informative graphics and helped visualize the current state of energy sources and use, but they questioned its relevance to the Program. Reviewers cited extensive data compilation and clear visual depictions on a variety of scales as strengths. However, they felt that the project needed to better explain how their work benefits the hydrogen and fuel cell community and assists decision-making. Reviewers suggested making the tool available to the general public and estimating water and energy use by fuel and vehicle type. This project has been completed.
AN-015	Non-Automotive Fuel Cells: Market Assessment and Analysis of Impacts of Policies *David Greene; Oak Ridge National Laboratory*	3.4	X			Reviewers observed that this project has demonstrated good progress in addressing non-automotive fuel cell markets and policies and has successfully established close interactions with industry. They commended the project for obtaining real-world insights from fuel cell original equipment manufacturers and praised the talents and effective planning of the project team. The difficulty of predicting markets was noted by reviewers and they questioned whether policy-makers would use this analysis. Reviewers suggested adding 100- to 500-kW backup-power units to the analysis and incorporating issues concerning hydrogen supply.
AN-016	NEMS-H_2: Hydrogen's Role in Climate Mitigation and Oil Dependence Reduction *Marc Melaina; National Renewable Energy Laboratory and Frances Wood; OnLocation, Inc.*	3.2			X	Reviewers responded favorably to the high-quality work and analyses resulting from this project in the past year, but they noted a lack of collaboration. Specific strengths cited by reviewers included the use of the existing National Energy Modeling System for analysis and the variety of scenarios examined. The major weakness noted by reviewers was the insular nature of the project. Reviewers suggested adding an industry partner to strengthen the review process and increase feedback. This project has been completed and the analysis delivered to DOE.

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
AN-017	Developments in the Hydrogen Demand and Resource Assessment (HyDRA) Model: Improvements in Data Interoperability, Availability, and Querying *Dan Getman; National Renewable Energy Laboratory*	3.2			X	According to reviewers, this project has demonstrated good progress in data exchange and adding functionality. They also noted the project's excellent coordination efforts with academia, industry, and government. Reviewers identified the organization and visualization of complex geospatial data as a key strength of the project. However, they believed that the project needs to more clearly articulate how the outputs of HyDRA might affect decision-making. Reviewers suggested identifying how to increase the usability of this model and raising awareness of the model with potential external users.
AN-018	Hydrogen Infrastructure Market Readiness Analysis *Marc Melaina; National Renewable Energy Laboratory*	3.0	X			Reviewers commended the project for the progress it has made in developing a station-cost calculator and for its successful use of workshops. Reviewers felt that the project's strength stems from the combined qualitative and quantitative approach in gathering knowledge and insights. However, they believed that greater collaboration with more industrial partners is required. Reviewers suggested that the project should coordinate closely with other analysis activities, routinely engage with stakeholders, and regularly utilize workshops.
AN-019	Rethinking U.S. Hydrogen Infrastructure Transition Scenarios: What comes next? *Marc Melaina; National Renewable Energy Laboratory and David Greene; Oak Ridge National Laboratory*	2.6	X			Reviewers commented that this project employs a sound approach to a critical research area in infrastructure development, but they felt it is too early to gauge the progress of the project. They also praised the capabilities of the research teams involved. However, they thought that the project should make sure its objectives and milestones are more clearly defined. Reviewers recommended comparing results from different cities, states, and regions and incorporating all competing vehicle types.

*Congressionally directed project (CDP)

American Recovery and Reinvestment Act

Project Number	Project Title *PI Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
H2RA-002	Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration *Dan Hennessy; Delphi Automotive*	3.1	X			Reviewers found that this project is well-focused, with efforts directed towards Class 8 sleeper trucks, which have on average almost 1,500 hours of idling time per year. They observed that progress has been made in desulfurization and in the development of the compact heat exchanger and reformer. However, it was noted that the demonstration has been delayed by development issues. Reviewers felt that the team's collaboration with PACCAR Inc. increases the probability of success and that it has the potential to create clean energy jobs. It was suggested that the project work on development of a business case and a commercialization plan.
H2RA-003	Highly Efficient, 5 kW CHP Fuel Cells Demonstrating Durability and Economic Value in Residential and Light Commercial Applications *Donald Rohr; Plug Power Inc.*	3.1	X			Reviewers observed that this project is on track for completion, meeting or nearly meeting most of its targets. However, they expressed concerns that further delays could jeopardize the success of the project. They noted that the durability test was successful and that there has been good progress, considering the resource issues and delays. They also observed that there were some failures during testing, but these were not related to the fuel cell stack. In addition, some reviewers have expressed concern over the fact that the original equipment manufacturer is dropping its product line of combined-heat-and-power fuel cells.
H2RA-004	Advanced Direct Methanol Fuel Cell for Mobile Computing *Jim Fletcher; University of North Florida*	3.2	X			Reviewers observed that good progress has been made on this project and it appears to be on schedule. It was observed that the novel direct methanol fuel cell (DMFC) design with fewer parts should help reduce cost, although it may still be difficult to reach target costs. It was also noted that the team has a thorough approach to evaluating the different components of the DMFC. However, reviewers commented that, despite many hours of testing and data analysis, there are still issues with degradation. Reviewers suggested additional collaborations with DMFC developers.
H2RA-005	Jadoo Power Fuel Cell Demonstration *Ken Vaughn; Jadoo Power*	2.4	X			According to reviewers, some progress has been made towards product development, but the project is behind schedule. It was observed that the mechanical design of the generators appears to be sound and that the analysis of the power needs for NASCAR's camera equipment has been completed. Reviewers felt that collaborating with NASCAR will provide good visibility for the technology, but it is confined to a limited market. Reviewers would have liked to see more cost data and suggested identifying other potential markets.

Project Number	Project Title *PI Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
H2RA-006	PEM Fuel Cell Systems Providing Backup Power to Commercial Cellular Towers and an Electric Utility Communications Network *Mike Maxwell; ReliOn Inc.*	3.2	X			Reviewers indicated that this project has great potential to spur market growth for fuel cell backup power for cellular communications towers. They felt that partnering with AT&T maximizes chances for market growth and project success. While the project is slightly behind schedule due to permitting delays, reviewers believed that it will achieve all of its goals. Reviewers also made note of the project's thorough site selection process and its development of a 72-hour hydrogen storage solution. They recommended that the project provide more operational and technical information, including a full description of a typical installation.
H2RA-007	Accelerating Acceptance of Fuel Cell Backup Power Systems *Donald Rohr; Plug Power Inc.*	2.5	X			Reviewers observed that this project has made solid progress, increasing efficiency through development and testing. However, they noted that it has been delayed and is not meeting milestones. Reviewers recommended that collaboration with partners be increased. They also suggested that additional field data be collected, and that a failure analysis be conducted.
H2RA-011	GENCO Fuel Cell Powered Lift Truck Fleet Deployment *Jim Klingler; GENCO*	3.3	X			According to reviewers, the project addresses a large potential market and has the potential to create additional jobs and accelerate commercialization. They noted that it appears to be on schedule and is approaching a significant level of deployment. They also observed that the project's collaboration with five different host-site companies could lead to widespread adoption of the technology. Reviewers praised the technical progress and installations by the team and suggested an additional focus on identification of performance metrics needed to facilitate the economic sustainability of fuel cell forklifts.
H2RA-012	Use of 72-Hour Hydrogen PEM Fuel Cell Systems to Support Emergency Communications *Kevin Kenny; Sprint*	2.9	X			Reviewers observed that this project has a large potential market and that it will accelerate the deployment of fuel cells in the telecom industry. They commented that progress is being made toward overcoming barriers, such as permitting issues and environmental and safety approvals. They also noted that the project has made progress in its education efforts. However, some reviewers thought that too much time and effort was spent on site screening—noting that only 10% of initial sites have been approved for installation and that actual installation has yet to begin. Reviewers felt that the project has achievable milestones but stated that they expected to see the project more than 15% complete as it nears its halfway point.

Project Number	Project Title *PI Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed or CDP*	Summary Comments
H2RA-013	Analysis Results for ARRA Projects: Enabling Fuel Cell Market Transformation *Jennifer Kurtz; National Renewable Energy Laboratory*	3.4	X			Reviewers indicated that this project provides valuable information to both the public and private sectors. They commented that it supports long-term growth of the technology and will enable other projects to succeed. Reviewers also noted that the project has no visible obstacles to success and is meeting its goals and milestones. It was suggested that the team provide data comparing fuel cell products with existing technologies.

*Congressionally directed project (CDP)

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