2014 — Market Transformation
Summary of Annual Merit Review of the Market Transformation Sub-Program

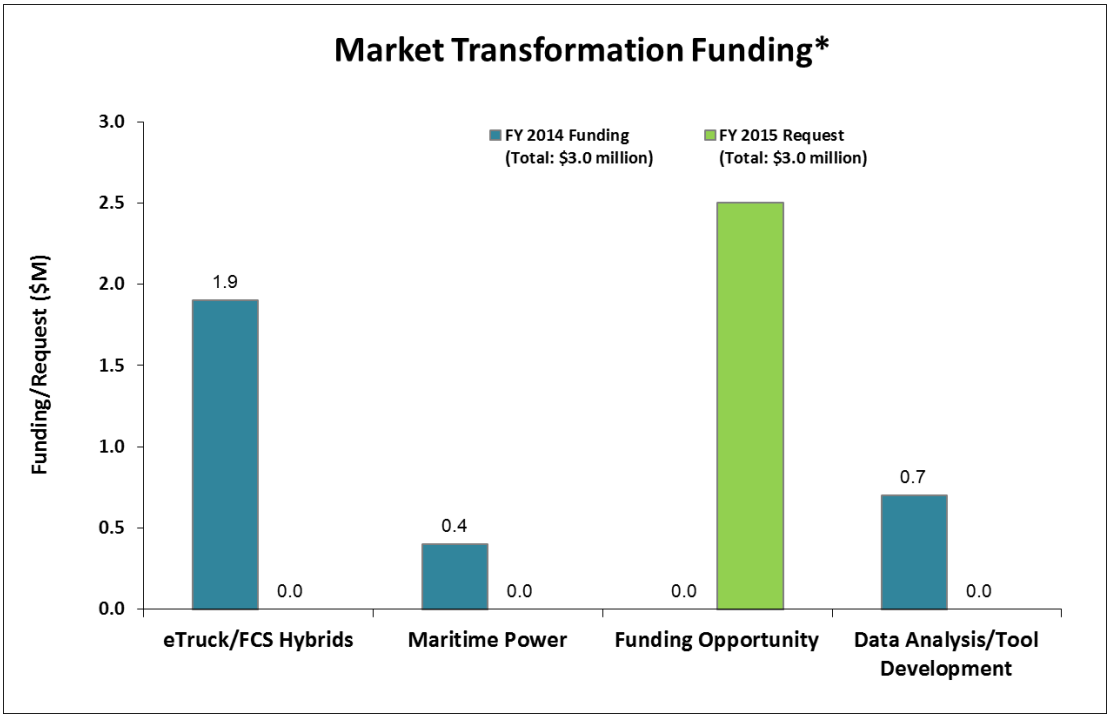
Summary of Reviewer Comments on the Market Transformation Sub-Program:

The purpose of the Market Transformation sub-program is to spur market introduction and growth for domestically produced hydrogen and fuel cell systems. By supporting initial commercialization in key early markets, this sub-program helps to identify and overcome nontechnical barriers to deployment and to reduce the life cycle costs of fuel cell power by helping to achieve economies of scale. The current focus of the Market Transformation sub-program is to build on past successes in lift truck and emergency backup power applications (part of the U.S. Department of Energy's [DOE's] American Recovery and Reinvestment Act of 2009 [Recovery Act] efforts) by exploring the market viability of other potential and emerging applications. Six projects were reviewed this year, and these projects are highly leveraged, with more than half of the funds provided by DOE's partners. This substantial commitment of external resources shows the high level of interest in exploring applications and markets where the hydrogen and fuel cell industry can expand and the technologies can play a valuable role.

Generally, reviewer comments about the sub-program were positive, noting that the focus on material handling equipment and emergency backup power has been extremely successful, as has the focused work in the state of Hawaii. The Market Transformation sub-program's coordination with agencies is commendable and allows the sub-program and the agencies to leverage funding to achieve mutual and individual goals, although it was suggested that increased collaboration with private companies could be beneficial. Some reviewers suggested that the sub-program could benefit from a general market transformation strategy that pinpoints longer-term niches. Reviewers also asked for insight into the process of deciding which markets are pursued and which are postponed.

Market Transformation Funding:

With the market successes that have been achieved by fuel cells in lift trucks and backup power applications as a result of prior fiscal years' and Recovery Act funding, the focus of FY 2014 funds was on a new application: battery/fuel cell medium-duty hybrid tucks that will demonstrate a value proposition for parcel delivery fleets, airport ground support, and specialty vehicles. As shown in the chart below, another application (i.e., shore power) will be a focus that will be leveraged through partnerships with other federal agencies and stakeholders. Although not reflected in the budget figure, DOE invested $42 million under the Recovery Act to enable the deployment of more than 1,000 fuel cells for early market applications, such as forklifts and backup power. The Market Transformation sub-program budget for FY 2014 was $3 million.



* Subject to appropriations, project go/no-go decisions, and competitive selections. Exact amounts will be determined based on research and development progress in each area.

Majority of Reviewer Comments and Recommendations:

The Market Transformation sub-program's projects were rated average to high, and overall ratings ranged from 3.0 to 3.6, with an average score of 3.3. The projects were judged to be relevant to DOE activities and employ good or adequate technical approaches. Reviewers recommended that future data collected and analyzed from all deployment activities be used to develop business case reports that can be used to support further market expansion.

Stationary Applications (Micro Combined Heat and Power): This project received an overall score of 3.3. Reviewers commented that this project was clearly relevant and could help build significant market share for hydrogen and fuel cells in the near term. They also observed that this project was well designed for collecting and analyzing data, and that the project had recovered well from failures of initial units. Some reviewers suggested that feedback should be solicited from host organizations about their experience with the system, cost/benefit, worthiness of using the system without DOE support, and what system changes are needed.

Airport Ground Support Vehicles: This project received an overall score of 3.1. Reviewers reported that the plan to complete this project is reasonable, with a number of go/no-go decisions that will help mediate the risk of this project. However, they mentioned that the summer 2014 schedule seems very aggressive and will need to be monitored. One important comment was that it is unclear how project partners have been integrated into the area of safety planning, and that the project also missed an opportunity to collaborate with the Hydrogen Safety Panel in early project design activities.

Landfill Gas-to-Hydrogen: This project received an overall score of 3.2 for its efforts to validate the business case and technical feasibility of using landfill gas (LFG) for hydrogen production and to share lessons learned that may be applicable for other candidate waste streams. Several reviewers commented that this project showcases an opportunity to produce hydrogen that is viable for use in fuel cells from LFG, which is often an unrealized asset. However, a reviewer commented that the project lacks cost information on the impact of new gas cleanup equipment and system design.

Hydrogen Energy Systems as a Grid Management Tool: This project received an overall score of 3.6 for its efforts in modeling, testing, and validating potential applications for hydrogen energy systems to address grid

stability issues. Reviewers stated that the project is worth continuing. The reviewers made several suggestions: better align barriers addressed with the project's objectives and approach; seek more private industry participation; and document processes, challenges, and solutions so future projects can benefit.

Maritime Fuel Cell Generator Project: This project received an overall score of 3.6 for its efforts in developing, designing, and testing a first-of-its-kind hydrogen fuel cell power generator for maritime applications. Reviewers stated that the project has done an outstanding job of coordinating efforts between the fuel cell supplier, the fuel cell customer, the infrastructure support, and the relevant regulatory agencies. Also, reviewers stated that the project shows notable leveraging of other government agency funding and provides a meaningful deployment of hydrogen technologies. Reviewers commented that any schedule slip on the design review will surely result in a delay of the entire project.

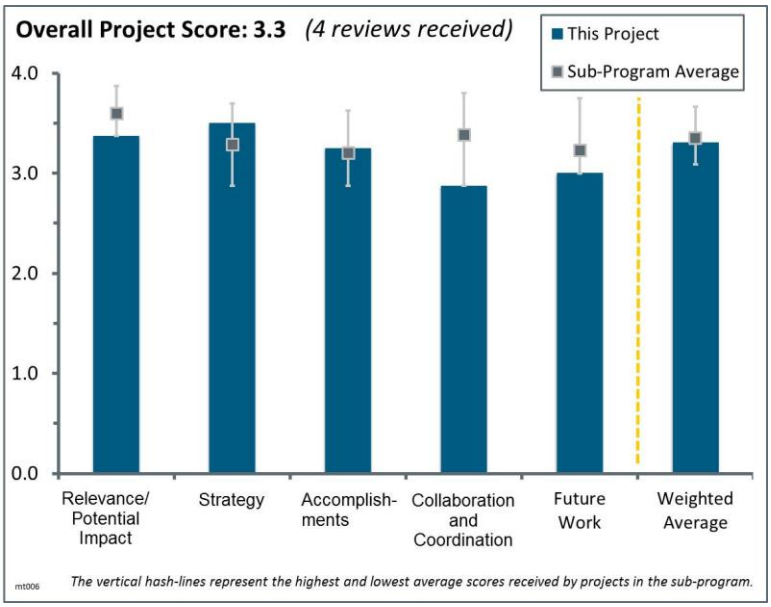
Fuel-Cell-Based Auxiliary Power Unit for Refrigerated Trucks: This project received an overall score of 3.0 for its efforts to design, develop, and demonstrate hydrogen fuel cell power for refrigerating trucks. Reviewers stated that the potential impact will be large, given the number of refrigerated trucks on the road and the number sold each year, if a business case can be realized. Reviewers stated that this project could meet a need of the trucking industry, save fuel, reduce greenhouse gases, and create a market for fuel cell technology. Also, it was stated that the funding and/or time does not seem sufficient for full integration (e.g., electrical integration with the transport refrigeration unit), and that the reason for 400-hour demonstrations was not defined.

Project # MT-006: Fuel Cell Combined Heat and Power Commercial Demonstration

Kriston Brooks; Pacific Northwest National Laboratory

Brief Summary of Project:

The overall objective of this project is to demonstrate combined heat and power (CHP) fuel cell systems, objectively assess their performance, and analyze their market viability in commercial buildings. Possible system improvements are identified through long-term data collection. The project provides independent assessment of operations, economics, and environmental impact and develops a business case for the continued use of CHP fuel cell systems.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.4** for its relevance/potential impact.

- The project is a very good demonstration of fuel cells installed in real-world applications. Great data are being collected that will help prove that fuel cells are ready for "prime time." The results of the project can help improve acceptance of fuel cells based on unbiased performance data collected.
- The project clearly showed the advantage of a phosphoric acid fuel cell (PAFC) versus BASF's polybenzimidazole (PBI) and the advantage of small CHP in various applications. The project showed which buildings were better than others for CHP applications.
- The project helped introduce CHP systems at consumer locations. One hopes the users will recognize the many benefits of these grid-independent systems. The data collected from these applications have provided valuable insight into their effectiveness, reliability, etc.

Question 2: Strategy for technology validation and/or deployment

This project was rated **3.5** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- This is a great showcase of the technology in an unbiased test, as well as a great mix of fuel cell applications/users to broaden the public's knowledge base on the fuel cell technology. The published results will be very useful to the community.
- The project was designed for four different sectors and sized to supplement existing utilities. Continuing the study over five years has been good since it allowed the inclusion of the M5 units.
- The project has a well-thought-out technical plan.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **3.3** for its accomplishments and progress.

- The demonstration was excellent. The project has overcome some industry problems to nearly complete the demonstration and keep many of the fuel cells operational. The project team found a way to get the most data available out of the fuel cells. The large number of data collected over the ~five-year demonstration is fairly unique, as most demonstrations are not this long. It is beneficial to the industry that the government was able to fund this long-term demonstration.
- Analysis of the data is very good, showing the efficiencies, availability, and cost in different markets. The environmental costs should be articulated through publications in journals as well as in mass media. It seems that the PBI-based stacks deteriorated faster than expected, while the PAFC stacks proved more reliable. It is somewhat disappointing that the PBI stacks were failing—it is indicative that the technology needs maturation. It would be desirable to document the weaknesses of the PBI stack so that corrective research and development can be pursued. Color coding of "M5" and the original "CE5" seems confusing. Per slide 20, the M5 (PAFC) are producing less power and less heat and are less available than the CE5. These findings seem at odds with the results in slide 21. Slide 28 shows the life cycle cost of ownership. It would be interesting to see the cash flow curve.
- The project has made excellent progress and shows good transformation from PBI to PAFC. This is a good recovery of a program.

Question 4: Collaboration and coordination with other institutions

This project was rated **2.9** for its collaboration and coordination.

- The project team found a good mix of users including collegiate, commercial, and recreational users. The publishing of the results will further the industry as a whole.
- Collaboration was mainly with ClearEdge and the host organizations. It is not clear what the host organizations think about their experience with the system, nor whether the cost versus benefit is worthwhile to repeat with their own dollars. If not, it is not clear what would need to change.
- The project needed better cooperation with ClearEdge to identify stack technical issues earlier.

Question 5: Proposed future work

This project was rated **3.0** for its proposed future work.

- The project will be ending this year, but the team has an exit strategy to wrap up the data collection and publish the results.
- PAFC systems have been studied over many years and have a good reliability record. Other fuel cell types should be included— polymer electrolyte membrane fuel cell- or solid oxide fuel cell-based, even if the scales are different. Quantifying down-time contributors is worthwhile. Cash flow curves would be interesting, along with identifications for system improvements with the greatest impact.
- The project needs to highlight more "good" applications versus "bad" applications and publish these.

Project strengths:

- This is a solid demonstration of CHP fuel cells that is yielding important data on the performance and degradation of fuel cells over a ~five-year time period. This information could be used to raise awareness of the feasibility of fuel cell systems for commercial use.
- CHP systems have been deployed and are generating data for public dissemination. Good analysis is coming from the data.
- The project had a good recovery from failures of initial units.

Project weaknesses:

- Other fuel cell types are needed in the study. Feedback from host organizations would be good.
- The project should have identified issues earlier.

Recommendations for additions/deletions to project scope:

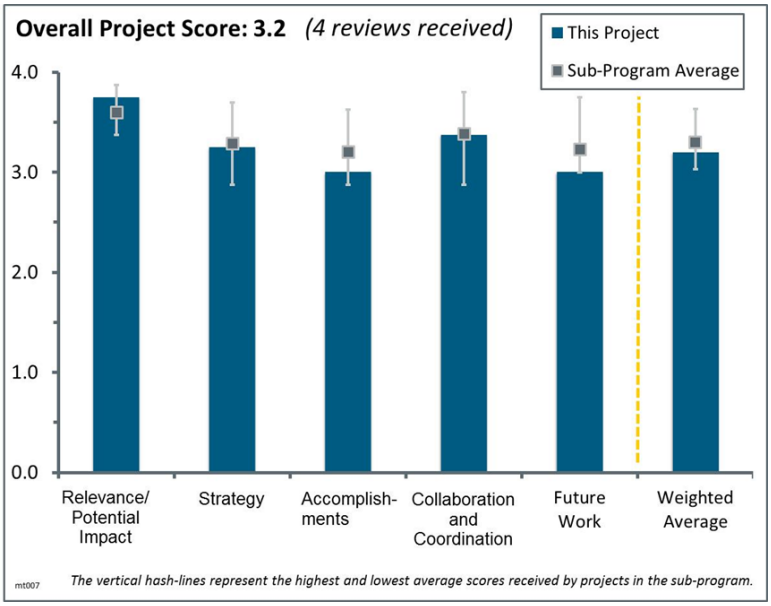
- This is an excellent project, and as long as the reports capture the data that was presented, the final reports will be very useful to the industry.
- Mass media collaboration would be beneficial. Other types of fuel cells should be included in the study.
- The project should evaluate cost versus benefit of avoided food spoilage costs due to power outages.

Project # MT-007: Landfill Gas to Hydrogen

Shannon Baxter-Clemmons; South Carolina Hydrogen and Fuel Cell Alliance

Brief Summary of Project:

The objective of this project is to validate the business case and technical feasibility of using landfill gas (LFG) as a "distributed generation" option for hydrogen production. The project will survey commercially available equipment to draw conclusions regarding economic viability of the LFG-to-hydrogen approach for potential end users, demonstrate technical viability of current systems to produce sufficiently pure hydrogen for use in motive or other applications, and confirm that there is no adverse impact on fuel cell systems that operate on LFG-sourced hydrogen.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.8** for its relevance/potential impact.

- LFG is a source of renewable energy and a terrific source for hydrogen and fuel cells, provided the gas can be cleaned up cost-effectively. This project serves to demonstrate the use of LFG for a business that has committed to the use of fuel cell-powered forklifts. Successful operation and the business case study are a benefit to the host company as well as to the U.S. Department of Energy, which is sponsoring this project as a business case study.
- The effort to solve the LFG-to-hydrogen approach is an important endeavor to harness current wasted assets. This solves an environmental issue and an energy issue. Doing so in an operational environment such as BMW is noteworthy.
- This project showcases an opportunity to produce hydrogen viable for use in fuel cells from LFG, which is many times an unrealized asset. If successful, this technology could create a hydrogen source from garbage, which could allow for hydrogen stations to be built at landfills.
- This process could provide renewable hydrogen from a variety of sources for a variety of transportation and other applications.

Question 2: Strategy for technology validation and/or deployment

This project was rated **3.3** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- SCRA has used commercial equipment for the clean-up and conversion of the LFG to hydrogen. The facilities have been set up and will be tested at an existing plant where fuel cells are already used with delivered hydrogen. The clean-up equipment is designed to deal with siloxane-free LFG. Problems with nitrogen removal have been addressed by bringing in a new vendor and equipment. Funding issues due to unanticipated clean-up needs have been resolved. Project stall because of inadequate nitrogen removal points to underestimated challenges in clean-up process design.

- The original strategy to complete the tasks was excellent, but the project has hit several barriers over the course of the project. The team has been able to overcome those barriers, and if the demonstration is successful, the entire project will be a success.
- The approach is sound and logical. What the reviewer would have liked to see coming from this project is a "return" to the feasibility study/business case analysis done in fiscal year 2012 and an update with actual information and costs for an "actual" business case versus the projected case.
- The only reason for a not-perfect score is lack of concrete information on the impact of new revised gas cleanup on cost-effectiveness.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **3.0** for its accomplishments and progress.

- The project has been turned around from what appeared to be a show stopper. A new vendor has set up equipment to deal with the nitrogen removal. Two tests have shown that the quality of the hydrogen meets the specifications for most contaminants, including sulfur. The levels of halogens, ammonia, and siloxanes in the gas should also have been analyzed to determine suitability for the fuel cell application. Data collection was limited, perhaps as a result of time constrained by problem resolution and fund exhaustion.
- The project has had great progress on all fronts. The reviewer was totally surprised, after many years in gas cleanup, with the excellent removal of gaseous impurities.
- The project has hit several barriers over the course of the project, but the team has been able to overcome those barriers. Unfortunately, creating solutions for those barriers has had an impact on the timeliness, and the demonstration period has been shortened. The timeline has slipped during the project, and the final demonstration will be close to the original end date of the project. A no-cost extension may be necessary to get useful data if any more milestones are missed. It seems that 2014 was a better year for the project, and a number of obstacles were overcome. The government point of contact needs to keep a close eye on the project during the month of August to ensure a successful demonstration.
- The main barrier of this project is to overcome the LFG cleanup. Progress has been made, but there still does not appear to be a universal or simple solution for cleanup prior to steam methane reforming.

Question 4: Collaboration and coordination with other institutions

This project was rated **3.4** for its collaboration and coordination.

- There is great collaboration with private and not-for-profit entities. During the past year, the team reached out to the Gas Technology Institute to obtain expertise to overcome barriers affecting the project. The team has also been able to get significant non-government funding to support this project, which is very beneficial.
- Multiple partners and collaborators have contributed to the project. Resolving the clean-up problem by the partners and collaborators is indicative of their commitment to successful demonstration of the project. Sign-up of an investor and potential adopter of the technology is a plus.
- The involvement of industry and government is quite impressive—a really strong attribute for the project.
- The project needs to operate more closely with gas cleanup suppliers.

Question 5: Proposed future work

This project was rated **3.0** for its proposed future work.

- The equipment will be tested over the next couple of months, with only two to three weeks of tests. This is very tight considering that unforeseen events have tripped up the operations before, but it is acceptable considering the constraints of the vendors and funds.
- Future work includes determining timing results in a limited trial of hydrogen production and use in forklifts. Outside the scope, business case work ideally would have been an output of this project.

- The project will be closing out, and the success of the project hangs on a successful demonstration/refueling of the hydrogen vehicles.
- The project must redo business with new gas cleanup system.

Project strengths:

- The team has overcome a number of the barriers that occurred during the research. The team has been able to assemble a number of collaboration partners that have the correct skills to complete the project.
- Strengths include support from two potential technology adopters. Cleanup solutions and reforming are achieved with commercial equipment. Sulfur and carbon monoxide have been managed to meet quality specifications.
- Strengths include project collaboration and use within a real-world manufacturing environment.
- The project is well-planned and well-thought-out.

Project weaknesses:

- The process design was faulty, which led to time and funding inadequacies. Siloxane removal should be part of the cleanup calculations considering the feedstock is LFG. There was a lack of cost or energy use data presented at the review.
- A number of technical barriers affected the timeline and shortened the demonstration period of the project.
- A weakness is the inability to deal effectively with the gas cleanup problem.

Recommendations for additions/deletions to project scope:

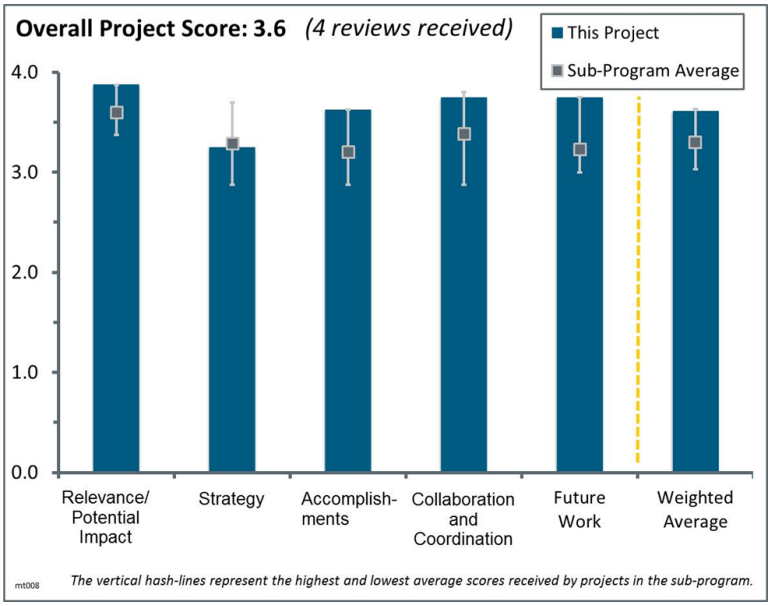
- It is strongly recommended that the project acquire overall plant performance data to permit detailed technical analysis (e.g., energy input/output, energy consumed at each component, utilities such as water, electricity, heat, etc.), as well as a business case study (capital and operating expenditures).
- The project should make sure the demonstration period for August 2014 is on track and good data are collected.
- The project should have been redoing the business case constantly.

Project # MT-008: Hydrogen Energy Systems as a Grid Management Tool

Mitch Ewan; Hawaii Natural Energy Institute

Brief Summary of Project:

Objectives of this project are to demonstrate the ability of electrolyzers to mitigate the impacts of intermittent renewable energy; to supply hydrogen to shuttle buses operated by County of Hawaii Mass Transit Agency and Hawaii Volcanoes National Park; to conduct performance and cost analyses to identify the benefits of an integrated system, including grid ancillary services and off-grid revenue streams; and to support the development of regulatory structure for permitting and installation of commercial hydrogen systems in Hawaii.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.9** for its relevance/potential impact.

- Proving the use of electrolyzers to stabilize the utility grid will have a significant impact on utility grid reliability and could help the implementation of more renewable power being injected into the energy mix. This aligns very well with the U.S. Department of Energy (DOE) mission.
- The project could have a tremendous impact on the availability to use renewables by mitigating the grid instability caused by those renewables.
- The principal investigator is spearheading a monumental effort in Hawaii—akin to work done by the California Fuel Cell Partnership. The Hawaii Natural Energy Institute's work is opening the market acceptance of hydrogen for an island that needs both energy security and environmental sustainability.
- This is relevant and useful for the program goals, but there is some discord between the identified barriers and the project objectives. The Barriers appear to revolve around a lack of knowledge, standards, and funding, while the objectives listed are more about the benefits of using fuel cells, electrolyzers, and hydrogen in various applications. Both are important and relate to DOE goals, but they do not seem to line up within the project. The project should review these and be more focused on one or the other—or both in a clearer manner.

Question 2: Strategy for technology validation and/or deployment

This project was rated **3.3** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- The strategy presented to accomplish the tasks is excellent. The analysis justifying the electrolysis approach is useful by itself. The path to implementation in Hawaii will be the first of its kind, and the methodology and results should make future implementation easier.
- If barriers, objectives, and approach are more closely aligned, this project will receive a much higher score in this category. It would be good to know that the process of setting up the project/equipment is being well documented. It is not clear whether the objective of "supporting development of regulatory structure for permitting & installation" is being met by outlining the challenges, solutions, and details of the project

along the way. If this information is being recorded, then it cannot just meet this objective but also address the noted barriers. Similarly, it is unclear how the process of setting up the program and gaining additional funders and stakeholders has been recorded to meet and overcome that stated barrier. It appears progress is being made, but there is not clarity about documenting it for sharing and lessons learned.
- The success of the program is based on the ability to cycle electrolysis cells. If there are data to show this is not an issue, they should be shown; if not, data should be collected early, even if at the cell level.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **3.6** for its accomplishments and progress.

- There was an announcement during the presentation that the Puna Geothermal Venture go/no-go is a go. The analysis justifying the electrolysis approach is useful by itself and should be shared throughout the industry. Documenting the path to get this far is a great case study example for others trying to implement hydrogen and electrolyzers in the utility grid system.
- This is excellent work in navigating local politics and procedures. Nothing talks louder than the demonstrated results.
- There has been great progress, particularly getting all the approvals.
- This strongly ties to several DOE goals, but it is not clear whether the project is really about demonstrating technology and applications or about improving knowledge and process for future projects. Most of the "guts" of the presentation was about the technology demonstration, getting it up and running, not on the process and knowledge improvements listed as barriers. It appears the project is doing both—and seemingly well, despite inevitable real-world challenges and obstacles. However, it would be good to see better clarification of what the main objectives really are and ensure documentation is taking place to help others in the future. This project could easily be accomplishing both of these (demonstration and process), but it is not clearly being laid out that way.

Question 4: Collaboration and coordination with other institutions

This project was rated **3.8** for its collaboration and coordination.

- The project has a strong list of partners. It would be nice to tie in more private sector partners somehow.
- There is excellent collaboration. The project team has pulled together many strong players in Hawaii and has kept this project moving forward.
- It may be prudent to increase leverage of existing installations on the mainland. For example, learning and demonstration of electrolyzer systems could be expedited by leveraging National Renewable Energy Laboratory electrolyzer installations.
- Great cooperation has been achieved, particularly with Ormat Technologies and investors.

Question 5: Proposed future work

This project was rated **3.8** for its proposed future work.

- The project seems to be on track for completion in 2015. This is a newer revised schedule and seems reasonable to accomplish the tasks that are remaining.
- The score is high as it relates to overcoming the listed objectives (technology demonstration), not the listed barriers, as it does appear to address barriers for setting up the equipment and related future work milestones.
- The project needs to get electrolysis cell data as soon as possible.

Project strengths:

- Collaboration between many entities keeps this project moving forward. The success of this project will be the first of its kind in Hawaii and will be a model for implementation at other sites. This success could lead to future implementation in other areas, with large amounts of renewables being connected to the grid.
- This appears to be a good project for demonstrating electrolyzers and renewable energy potential. It has gone through expected challenges and delays of real-world implementation but is showing progress and potential. The reviewer looks forward to reaching the full operation and analysis phase of the project.
- The project quickly identified the difficulty of getting all approvals.

Project weaknesses:

- It is not clear why the barriers are not more aligned with the objectives, as they do not appear to be directly linked nor addressed. The technology demonstration is impressive, but in further review and consideration, this misalignment is troubling. The solution may be as simple as reviewing the barriers to be addressed and editing them to reflect what the project really is seeking as its outcome.
- The project needs to have an alternative use for by-product hydrogen in case fuel cell electric buses (FCEBs) are not economic in the long term.

Recommendations for additions/deletions to project scope:

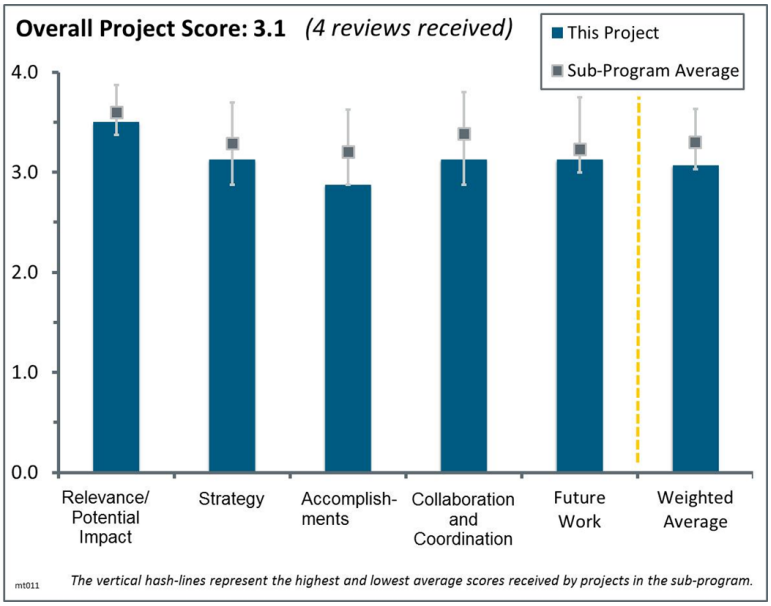
- The summary slide provides the best overview of what and why this project is important. It is worth continuing the project and seeing it through with the following notes:
    - Better aligning barriers addressed with objectives and approach of the project
    - Seeking more private industry participation
    - Documenting process, challenges, and solutions so future projects can benefit
- It would be beneficial to work with the utility companies to monetize grid benefits from electrolysis and install electrolyzers in distributed locations (e.g., Hilo, Kona). As renewables are distributed on the grid, benefits could be derived to the grid from distributed electrolysis. Such electrolyzers could operate during non-congested grid times and possibly receive lower electricity prices. It may be prudent to examine a utility-owned model for the electrolyzers.
- The project should continue on with the revised scope of work.
- Identify alternative use for hydrogen besides FCEBs.

Project # MT-011: Ground Support Equipment Demonstration

Jim Petrecky; Plug Power

Brief Summary of Project:

The overall objective of this project is to create a cost-competitive and energy-efficient fuel cell for airport baggage tow tractors to reduce consumption of fossil fuels, lower carbon emissions, and decrease energy expenditure. Specifically for 2013/2014, the project is working to develop the 80-V fuel cell product for baggage tow tractors to be tested in the Charlatte CT5E cargo tractor, perform a factory acceptance test to demonstrate equivalent tractor operation for battery versus internal combustion, and install and implement hydrogen at Memphis–Shelby County Airport in Tennessee.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.5** for its relevance/potential impact.

- The project appears to be aimed at a good market and is worthy of the resources to explore this area further. The identified barriers should be correlated to specific elements of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.
- The project is looking for opportunities to displace incumbent technologies. This is a necessary endeavor. Most of the discussion is about displacing diesel, but a comparison against battery-powered units is also needed, assuming that is viable as well.
- This project can help develop a new product area for the fuel cell industry that can help grow the industry and manufacturing in the United States. This new project may also help reduce greenhouse gas emissions in areas of concern.
- This is a great project that continues to expand the scope and value of fuel cells for material handling equipment.

Question 2: Strategy for technology validation and/or deployment

This project was rated **3.1** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- This is a perfectly designed project, with first obtaining requirements, then teaming up, design, alpha testing, beta testing, and deployment.
- The plan to complete this project is reasonable with a number of go/no-go decisions that will help mediate the project risk, but the summer 2014 schedule seems very aggressive and will need to be monitored. The barriers seem to be mainly engineering and manufacturing hurdles that the project team should be able to overcome.
- The project has a sound and logical approach.
- It does not appear that the project has worked through what requirements apply to this new application but is instead taking a figure-it-out-as-we-go approach. Without an early understanding of the applicable requirements, the project risks approval delays and/or potential safety issues. Additionally, there could be

significant value for a first-of-its-kind project to identify the applicable requirements to help future ground support equipment projects avoid delays or having to develop the list from scratch.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **2.9** for its accomplishments and progress.

- The progress seams steady but slow. The beta builds will begin the summer with commissioning in September. That seems to be an aggressive schedule but should be able to be accomplished. Careful tracking of the progress should be performed to make sure production is on track.
- There has been good progress with alpha and beta testing remaining.
- The project is 50% through its schedule but has completed only 20% of the work.
- It would appear that the project should have been in deployment or nearing it at this point. The project is still awaiting the final go decision, which frankly could be delayed even further.

Question 4: Collaboration and coordination with other institutions

This project was rated **3.1** for its collaboration and coordination.

- The project team has an excellent group of collaborators. If the demonstration is successful, the correct players are involved with opportunities for wide-scale implementation. Fedex Express and Charlatte are leaders in their respective industries, and if the project is successful, these two companies should be able to pull the fuel cell technology into the market.
- There is a solid list of partners. The project team might consider involving the Federal Aviation Administration in some role as the project moves forward.
- There is great teaming. The project perhaps could add some airlines to the team.
- The project has a number of partners. However, it is unclear how Plug Power has integrated these partners into the project in the area of safety planning. The project also missed an opportunity to collaborate with the Hydrogen Safety Panel in early project design activities. This could have been beneficial for the project and DOE program as a whole.

Question 5: Proposed future work

This project was rated **3.1** for its proposed future work.

- A good project is based on scheduled alpha and beta testing and deployment.
- The schedule should be closely monitored. The work seems reasonable, but there has been some slow progress to date, and there needs to be much progress between now and September to keep the project on track. This project could be very successful if the schedule is kept.
- On Slide 22, Future Work – Budget Period 1, Task 1 is identified as “Definition of Requirements.” The presentation did not identify any specific details on this activity. Priority should be given to formally identifying all of the applicable requirements for this type of activity.
- The project will be “stressed” to complete all objectives within the current timeline. Developing a beta unit has taken longer than anticipated, resulting in the demonstration phase being squeezed.

Project strengths:

- This appears to be a good fit for the technology.
- The project is looking for a captured fleet-type market. Dealing with weather factors is an important consideration for this technology in this environment.
- This project is developing a product that could fill a need and be implemented at a number of sites across the country. A successful project could lead to a new fuel cell market opportunity. The fuel cell could fill a need in the fuel cell industry.
- This is a well-designed project, particularly the pretesting before deployment.

Project weaknesses:

- The presenter stated that one of the goals of the project was ultimately to support similar activities in California. However, the California location was dropped as part of this project. The presenter suggested that this was due to siting and timing issues (requiring a two- to three-year permitting process). It is not clear how the issues that prevented this deployment in California will limit the application at other airports. It is important for the project to identify (and DOE to understand) the impediments to the adoption of fuel cells in this market.
- Compression of schedule due to the long design phase is a weakness.
- It may be challenging to meet the September goals based on the current schedule.
- The project needs to get air quality quickly, including dust and sulfur compounds at the airport. There is also a need for more market analysis and economics.

Recommendations for additions/deletions to project scope:

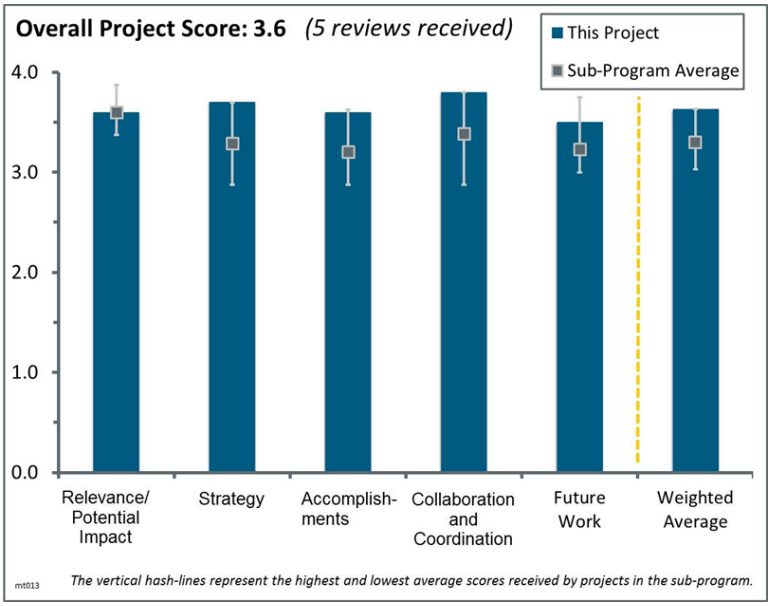
- The project should identify a requirements basis for implementing fuel cell technologies in ground support equipment and provide recommendations for how the California barriers could be addressed to open up that market.
- The project should add economics.

Project # MT-013: Maritime Fuel Cell Generator Project

Joe Pratt; Sandia National Laboratories

Brief Summary of Project:

The objectives of this project are to lower the technology risk of future port fuel cell deployments by providing performance data of hydrogen-powered polymer electrolyte membrane fuel cell technology in this environment, to lower the investment risk by providing a validated business case assessment for this and future potential projects, to enable easier permitting and acceptance of hydrogen-powered fuel cell technology in maritime applications by assisting the United States Coast Guard and the American Bureau of Shipping in developing hydrogen and fuel cell codes and standards, to act as a stepping stone for more widespread shipboard fuel cell auxiliary power unit deployments, and to reduce port emissions with this and future deployments.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.6** for its relevance/potential impact.

- This is an outstanding project that can be leveraged to develop applications for many and varied but similar applications. Right now, today, diesel generators might be cheaper than maritime fuel cell generators, but this project might be that first pathfinder activity.
- This is a great project that leverages other government agency funding and provides a meaningful deployment of hydrogen technologies. The application has the potential to spill over into the general goods shipping industry, which is vast in globalized world commerce.
- Seeking mobile power solutions is an interesting niche.
- It is not certain that this application has a particularly wide market.

Question 2: Strategy for technology validation and/or deployment

This project was rated **3.7** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- The approach is solid. Working with the state of Hawaii to advance the technology in many applications is very worthwhile. Building out from a single infrastructure makes economic sense for early adoption.
- The project is outstanding all the way around and a very well-planned effort.
- The project has a good approach to getting the requirements for hydrogen safety, but the team needs to do more quickly on the environmental requirements for the fuel cell, salt, water, drop, tilt, vibration, etc.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **3.6** for its accomplishments and progress.

- A complete and professional project through and through; the team's written and oral presentations were top-notch.
- There has been good progress on hydrogen safety issues, but the project needs to move quickly on fuel cell environmental requirements.
- To date, the project appears on track. The critical element is the detailed design forthcoming this summer. Any delays in it or the project build will create future problems.

Question 4: Collaboration and coordination with other institutions

This project was rated **3.8** for its collaboration and coordination.

- The project has done an outstanding job of coordination among the fuel cell supplier, the fuel cell customer, the infrastructure support, and the relevant regulatory agencies (not an easy job).
- The team is absolutely perfect and inclusive.
- The project has an impressive mix and apparently very strong collaboration to date. The project might consider talking to the U.S. Federal Emergency Management Agency (FEMA) about the utility of this power solution for their emergency and disaster response planning and support.
- There are numerous role players, each with key assignments delineated in the presentation.
- Hydrogenics is a fantastic company, but their focus is mostly electrolysis and not so much fuel cells. It is unclear that Hydrogenics is the right partner for this. Ballard already has a number of similar systems—hydrogen fuel cells in a container. They have been produced for Ballard itself as well as for DanTherm in Denmark. It may be prudent to include them in the program, as they have already gone down a significant cost reduction curve. If not, the project team should comment on the selection process.

Question 5: Proposed future work

This project was rated **3.5** for its proposed future work.

- The project has a good work plan.

Project strengths:

- The project is working on portable and distributed power generation, which, conceptually, has many potential applications.
- The whole effort is a project strength. This reviewer enjoyed the presentation to the point of taking minimal notes. No comments are necessary.
- The project is quickly addressing hydrogen safety issues and involving required stakeholders.

Project weaknesses:

- The timing is a weakness. The late award to Hydrogenics has put the schedule in jeopardy.
- This reviewer can identify no weaknesses whatsoever.
- The project needs to get fuel cell requirements.

Recommendations for additions/deletions to project scope:

- Liquid hydrogen should be considered as a fuel. The boil-off could be used directly in the fuel cell, and longer trips could be covered by this power generation type—potentially months in length, getting the interest of Pacific shipping. The technology could also be used by forward bases in U.S. Department of Defense applications—if liquid were used.

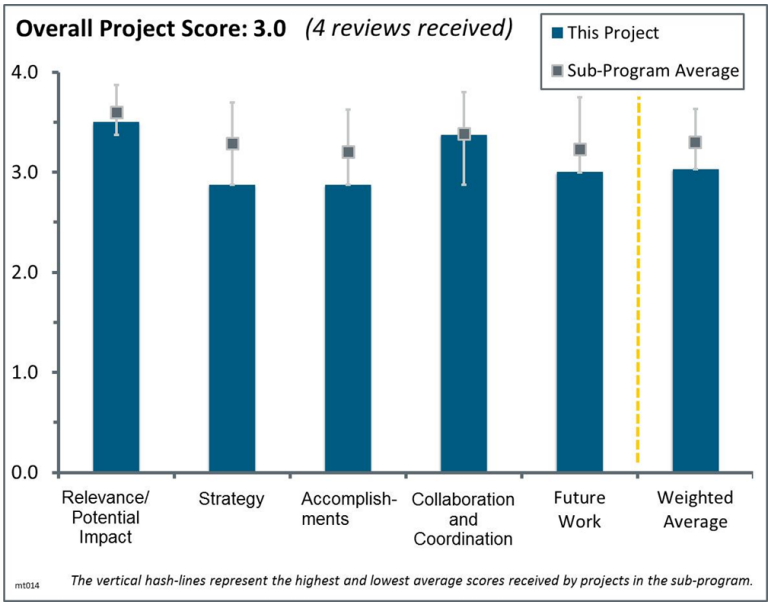
- Once the unit is built and operating, the project might reach out to FEMA for some late project collaboration.

Project # MT-014: Fuel-Cell-Based Auxiliary Power Unit for Refrigerated Trucks

Kriston Brooks; Pacific Northwest National Laboratory

Brief Summary of Project:

The overall objective of this project is to demonstrate the viability of fuel-cell-based transport refrigeration units (TRUs) for refrigerated Class 8 trucks. This project will demonstrate the value of a fuel-cell-based auxiliary power unit to replace diesel as the power source for the TRU to address environmental mandates, operate quietly, and be cost-competitive and energy-efficient.



Question 1: Relevance/potential impact on supporting and advancing progress toward the Hydrogen and Fuel Cells Program goals and objectives delineated in the Multi-Year Research, Development, and Demonstration Plan

This project was rated **3.5** for its relevance/potential impact.

- This project could meet a need of the trucking industry, save fuel, reduce greenhouse gases, and create a market for fuel cell technology.
- Looking for displacement of conventional fueled generators continues to be the best path for fuel cell introduction. This is already a winner on the emissions front, so getting the cost and value proposition remains a challenge for deeper adoption.
- The potential impact is huge *if* there is a business case, given the number of reefer trucks on the road and the number sold each year.
- This application seems to be a good extension of all the positive gains from the fuel cell material handling equipment market.

Question 2: Strategy for technology validation and/or deployment

This project was rated **2.9** for its project design, approach to addressing barriers, feasibility, and integration with other efforts.

- There is a well-laid-out plan, and with the two subcontracts, the project will be able to compare and contrast the performance of two major U.S. manufacturers. The competition between the two companies may result in better products.
- The approach is sound, but as always, the cycle time to get these types of items ready for market introduction could and should be accelerated.
- Either funding and/or time does not seem sufficient for full integration (e.g., electrical integration with the TRU). The reason for 400-hour demonstrations was not defined in the slides. The timeline in the backup section does not seem to match with the approach timeline. And if the approach timeline is to scale, the section for defining the power rating of the system seemed too long.
- There is not enough being done to develop and demonstrate a convincing business case. The project seems more like a one-off (or two-off) demonstration that is unlikely to go anywhere unless the business case can be developed.

Question 3: Accomplishments and progress toward overall project and U.S. Department of Energy (DOE) goals

This project was rated **2.9** for its accomplishments and progress.

- In the first year of the project, subcontracts have been awarded, power requirements have been defined, and the business case has been developed. These actions will lead to a strong foundation for the out-years of the work. This seems like significant progress for the first year of the project and puts the project on a good track for the future work.
- With respect to accomplishments, the project is still in early stages. Getting the prototype testing completed is very good. The slides did not sufficiently describe why and how the systems were under development. Perhaps technology readiness levels could have been added to explain the development phase needed or the similarities to/differences from other products such as a fuel cell forklift power plant. The proprietary nature of the business case is understood, but perhaps there are assumptions that make a two-year payback period possible and what the size is of a "large" fleet that makes this feasible. It would have been good to see more definition on the data logging and power definition accomplishment (i.e., whether the sample profile was taken from the number of trips and averaged). The difference between alpha prototype testing and Level 1 prototype testing is not clear. It would have been helpful to see more which partner was leading the accomplishments.
- Within the first year, the project appears on course.

Question 4: Collaboration and coordination with other institutions

This project was rated **3.4** for its collaboration and coordination.

- Two of the major U.S. fuel cell providers are sub-contractors on this project. The sub-contractors each have partners as part of their teams, which consist of the progressive companies that will help create a market for a successful product.
- The list of contributors and industry leaders makes this a very attractive team. Having two producers also ups the nature of the work.
- Key players are participating, with strong industry/end user involvement.
- The project is coordinating well with two sets of customers.

Question 5: Proposed future work

This project was rated **3.0** for its proposed future work.

- The upcoming work consists of developing the fuel cell auxiliary power unit and testing the units in the field with the project partners. The schedule seems reasonable, and the barriers seem to be overcome through engineering and manufacturing techniques.
- The actual demonstration and analysis was not included in the future work slide, but that seems like a critical aspect of this project. It would have been helpful to know what other value propositions were expected.

Project strengths:

- A strength of the project is system developers and customers. Another strength of this project is the logical (and important) extension from a forklift application to the refrigerated truck market.
- This project has good project partners working on achievable development and demonstration goals. The first year of progress has been successful, with no major barriers slowing down the research.
- The project is finding ways to displace incumbent technology.

Project weaknesses:

- There is still a distributed generations in the auxiliary power unit because it needs to be there for backup. This is not a strong indicator for the technology.
- A weakness of this project is that either the time or schedule is prohibitive of a fully developed solution. The demonstration and analysis aspect of this project was not discussed as much as expected.

Recommendations for additions/deletions to project scope:

- There are no recommendations for additions or deletions to project scope at this time.