

2010

American Recovery and Reinvestment Act

Summary of Annual Merit Review of American Recovery and Reinvestment Act Activities

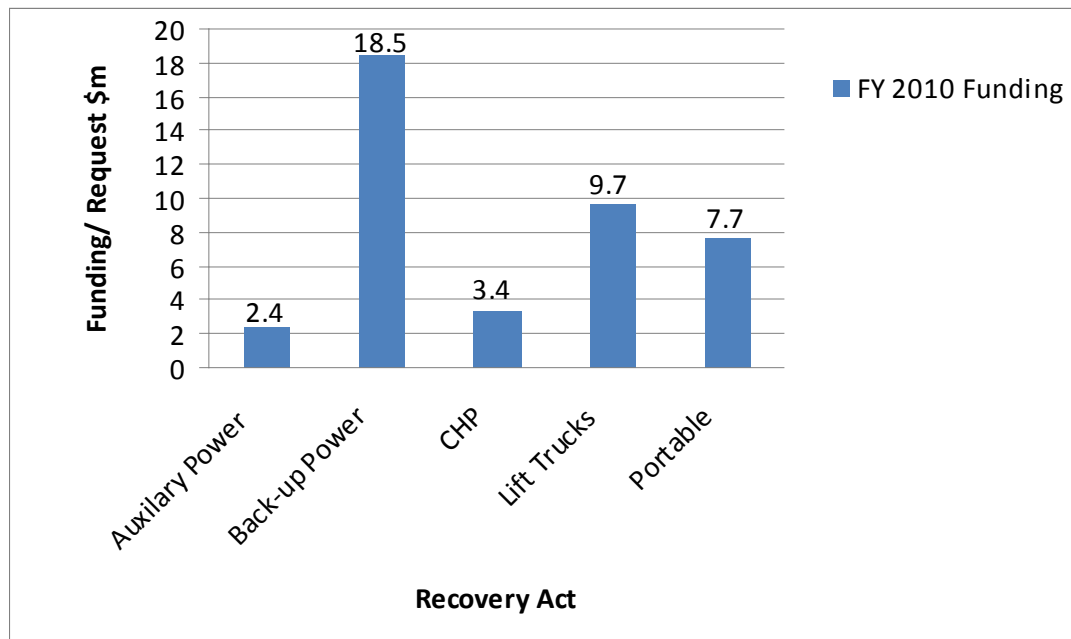
Summary of Reviewer Comments on American Recovery and Reinvestment Act Projects:

This review session evaluated fuel cell market transformation projects funded under the American Recovery and Reinvestment Act of 2009 (ARRA). The ARRA projects are generally considered to be well aligned with the goals and objectives of ARRA and the DOE Hydrogen Program.

The ARRA projects include the development and deployment of a variety of fuel cell technologies including polymer electrolyte, solid oxide, and direct-methanol fuel cells in auxiliary power, backup power, combined heat and power, lift trucks, and portable applications. Overall, the projects were judged to have made progress toward development and deployment goals. Reviewer concerns and recommendations varied by project and are summarized below.

ARRA Funding by Technology:

In April 2009, DOE announced the investment of \$41.9 million of ARRA funding to accelerate the commercialization and deployment of fuel cells and to build a robust fuel cell manufacturing industry in the United States, with accompanying jobs in fuel cell manufacturing, installation, maintenance, and support services. Twelve grants were competitively selected and awarded to develop and deploy a variety of fuel cell technologies. These projects address the objectives stated above as well as the overall ARRA goals to create new jobs and save existing ones, spur economic activity, and invest in long-term economic growth. The cost share provided by the project teams is approximately \$54 million, which represents over 56% of the total cost of the projects.



Majority of Reviewer Comments and Recommendations:

All twelve of the ARRA projects provided oral presentations. Three of the projects were not reviewed due to relatively late starts in FY 2010. The remaining nine were reviewed. In general, reviewer scores for the ARRA projects were very good, with scores of 3.6, 3.2, and 2.6 for the highest, average, and lowest scores, respectively. Six of the nine projects had a score of 3.1 or higher. The scores are indicative of the technical progress that has been made since the project grants were awarded in late FY 2009 and early FY 2010. Recommendations and major key concerns for each project category are summarized below.

Auxiliary Power: One project in this area was reviewed, and its collaborative efforts received favorable comments. The project is leveraging the Solid-state Energy Conversion Alliance (SECA) program to implement an aggressive on-road test program for an auxiliary power unit (APU). Reviewers commented that diesel APU systems are a key early market fuel cell technology with the potential for substantial impact on U.S. manufacturing and air quality. The reviewers recommended that deployment to the field test be accelerated since this will identify additional opportunities for product improvement. They also recommended that the project team involve the Department of Defense (DoD) in the demonstration phase to help identify other applications that could be beneficial for military use.

Backup Power: Two projects addressing 72-hour backup power for cell phone towers and DoD sites were reviewed, with both projects recognized for their statements on jobs retained and/or created with the ARRA funds. The reviewers recommended re-examining fuel choices for the various backup power applications, such as using alternative hydrogen delivery solutions (e.g., on-site methane reforming) depending on the site, and re-examining the possibility of operation on hydrogen for 72 hours; they also suggested that the economic trade-offs of using a battery for initial start-up versus using a hybrid hydrogen/LPG system should be considered. Additionally, project teams were advised to work on increasing public and market awareness of their products.

Combined Heat and Power (CHP): One project in this area was reviewed. The reviewers suggested that there is widespread opportunity for this application, particularly in California, and they remarked that a strong partnership has been assembled. The reviewers advised the team to focus on cost and performance and competitiveness with other CHP technologies, including other fuel cell CHP systems. The reviewers also suggested additional bench testing in addition to field tests, in order to accelerate the durability verification process.

Fuel Cell Powered Lift Trucks: The projects in this area were generally highly rated. At the end of the 3rd quarter of FY 2010, a total of 206 fuel cell lift trucks had been deployed into a significant cross-section of the U.S. economy. This achievement is well aligned with the ARRA objectives. These projects have the potential to accelerate the commercialization of fuel cell lift trucks—leading to large-scale market adoption—and to benefit the hydrogen fueling industry. Reviewers encouraged the project teams to continue to monitor and evaluate fuel cell lift truck performance, document lessons learned, and clearly identify the value proposition for future deployments. It was also recommended that the projects complete additional economic analyses to characterize fuel cell life and to validate or re-evaluate the estimate that a market deployment of 1000 units will drive fuel cell costs from \$3,600/kW to less than \$2,000/kW (David Greene, ORNL, 2008).

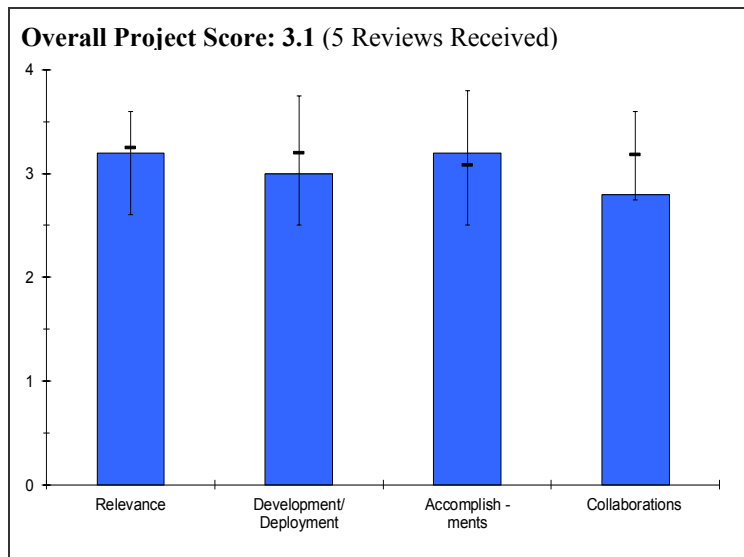
Portable Power: One project in this area was reviewed. The reviewers recognized the potentially large consumer market for portable fuel cell applications but advised that the technology be presented to niche markets first to gain acceptance. There is significant competition offered by incumbent technologies such as battery recharging. Additional performance analyses and lifetime predictions for comparison to batteries and other competing technologies were recommended.

Project # ARRA-01: Commercialization Effort for 1W Consumer Electronics Power Pack*Chuck Carlstrom; MTI Micro Fuel Cells, Inc.***Brief Summary of Project**

The overall objective of this project is to demonstrate and field test a commercially viable one-watt direct methanol fuel cell (DMFC) charger for consumer electronic devices. The objectives are to:, 1) reduce the cost to attain a competitively priced product, 2) complete design for manufacture and ease of assembly, 3) demonstrate performance across a range of environmental conditions, and 4) conduct a user field test of 75 fuel cell (FC)-powered chargers.

Question 1a: Relevance to overall ARRA objectives

This project earned a score of **3.2** for its relevance to ARRA objectives.



- This project showed an excellent return rate on jobs sustained and/or created. However, keep in mind that at the moment it was presented, these jobs are not necessarily sustainable jobs because of the start-up nature of the company and the resulting product.
- This is an impressive product. I'm looking forward to seeing an operational unit (and data) at the 2011 AMR, together with an overview of user feedback, manufacturing ramp up (and additional generated work and/or jobs at supplying companies), additional attracted investment funding (from any source), and market sales.
- Charging of consumer electronics is an outstanding market, given the large numbers of personal digital assistants (PDA), cellular phones, and BlackBerry®-type devices being used. If FCs can penetrate that market to a significant degree, it will create skilled jobs and improve FC performance through scale production. It is still questionable whether FCs can compete with other chargers (i.e., lithium battery chargers). This is especially true regarding cost. All the job growth is predicated on FCs displacing a very attractive, incumbent technology, even if it takes longer to charge with batteries. Many people use the nighttime to charge these devices and don't experience a negative impact.
- This project evidently had a good effect on MTI's employment, and the portable charger appears to be a good potential business for the future.
- It's important for U.S. leadership to support development of a micro fuel cell product given activity by other countries.

Question 1b: Relevance to overall FCT ARRA objectives

- This research has definitely shown that ARRA funding sped up the development process of this product (and attracted outside investment). The process has not yet reached the mass or large-number manufacturing level. It's understandable that the product has not been introduced to the market based on the status of the product development process.
- Next time, there will hopefully be a large number of units either being manufactured or released in market!
- Next time (not applicable on 2010 AMR), show what jobs are created and /or maintained at suppliers and those companies that develop to support peripheral needs.
- This type of project focuses on large scale production of FCs, which is very important to this technology. It also addresses a market that, if successful, could translate into many jobs. Given the global use of these consumer electronics, it could also help grow the export of FC products. The fact that this project saved 14 jobs -- which

were probably all at MTI -- may have been the only thing to keep a domestic fuel cell technology development effort in this application area alive.

- One element could be strengthened, which is to enhance the acceptance of the FC as a portable charger. The presenter did not make clear how this acceptance was facilitated by the project. For example, there is a barrier that is the change of concept from charging to having to buy cartridges. It will be interesting to see if the consumer is willing to buy these in a store or online and keep them on hand. If they run out of cartridges, they are stuck; whereas a larger battery could be charged somewhere.
- The relatively small number of units (75 units) and the small power level (one-watt) will not achieve FC commercialization, but it's a small step in the right direction.
- While I strongly support the technology, I question that the consumer market is being targeted. The combination of a relatively low energy density in the DMFC product and the initial cost is going to make consumer market penetration difficult when going up against the incumbent battery charger products.

Question 2: Development and Deployment Approach

This project was rated **3.0** based on development and deployment approach.

- It is past the idea, seed, and prototype development phases, but there are still significant challenges ahead, which will become clearer when doing (or after) the field test of 75 units.
- For the 2011 AMR, make sure to compare this one-watt fuel cell power unit to products with competitors like all Li-ion (lithium-ion) products and regular battery packs for recharging.
- The technical and deployment milestones were sound ones. Having these 75 units used by people outside of MTI will give objective feedback on their performance. Testing the units before and after they go through their trial phase is also important and a good approach. The slides did not go into enough detail about who they were targeting, how long the testing is expected to last, or what type of MTI engagement with the customers will take place. One would think the customers would have been identified by now. Working with the Methanol Foundation is a wise plan, as there are clearly some codes and standards issues that need to be addressed.
- The project appears to be well managed and executed in a timely manner.
- The team had a good technical approach with a clear focus on achieving the objective.
- There was not much information on cost approach, such as the projections for manufacturability and reducing the cost down to what the market requires. The project could be a technical success, but it may not go anywhere beyond the limited demonstration units because of the cost of the product.
- The project is outstanding in terms of technical progress. However, there was not much discussion on the competitiveness of the product versus incumbent battery charging products in the consumer market.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **3.2** for technical accomplishments and progress.

- Next time, the PI should include jobs that are created and/or maintained by paying contractors to build specific parts for product. This translates into hours worked as contractors that can be credited to the funding your company received.
- The passing of the first go/no-go point was a good sign. The testing results appear to be very promising, both in the environmental testing and performance testing areas. The manufacturing maturity plan is also good; and will drive down cost.
- There could be a better definition of the cost progress in total and the comparative analysis to technologies such as batteries. Also, the effect of operating versus capital cost should be a bit clearer.
- The technical progress to date is good. The operating lifetime appears to be adequate, but the calendar or shelf life of the system is not certain.
- This is more of a product development project rather than an ARRA-type deployment project.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **2.8** for collaborations.

- It appears good, but perhaps they could consider reviewing rechargers.
- The PI should see if component suppliers can achieve additional reduction of labor cost and cost of components.
- The collaboration with the Methanol Foundation is fine, but there doesn't appear to be a lot of effort in recruiting the 75 users for these devices.
- The collaborators might consider companies (i.e., tool vendors) that know how to make high-volume consumer electronics.
- This project shows good collaboration with the Methanol Foundation and with component suppliers.

Strengths and weaknesses**Strengths**

- Several strengths include the power density, current performance of FCs, the packaging, and the fact it lasts as long as seven to ten mobile device recharges.
- This product has a potentially large consumer market. The testing regimens are very sound. Building quantities of 75 units provides a large enough data set from which to evaluate consumer acceptance.
- This project was executed in a timely manner, which saved several jobs.
- The project is clearly focused on a specific niche application.
- The technical progress in the micro market segment is strong. This is an area where the United States is behind the progress of other countries.

Weaknesses

- It is an unproven product.
- The PI should focus on finding the niche market that definitely will use the product, because the amount of power it provides is comparable to seven to ten recharges of mobile electronic devices.
- Logistics fuel distribution is a weakness.
- The PI could be up against a tough incumbent technology in battery recharging. MTI has not identified the 75 users of their devices as of yet.
- There is a lack of clarity with respect to cost, even on a percentage basis.
- Getting the costs down enough to make the device affordable to a widespread market is going to be a challenge.
- It is not clear how this project will continue after the ARRA subsidy is depleted. Venture capital investment may be a way to go to the next needed level of commercialization.
- Until the data are presented to show cost and performance competitiveness versus incumbent battery chargers, The PI might view a successful market entry for a consumer product with some skepticism.

Specific recommendations and additions or deletions to the work scope

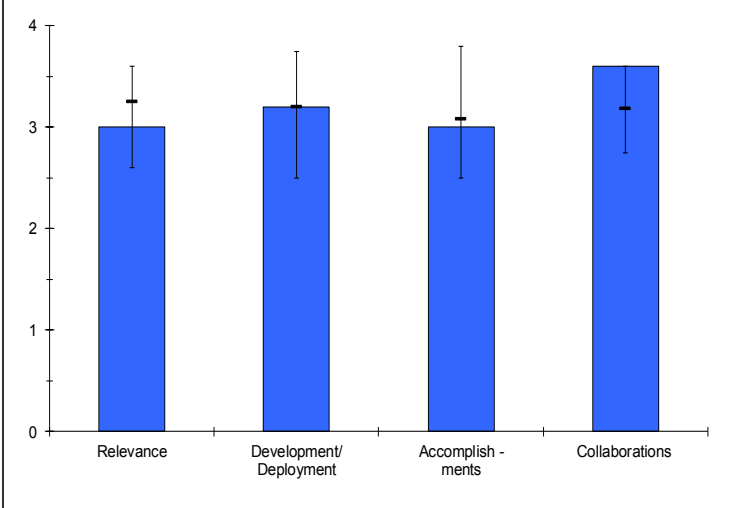
- The PI should work really hard (below the radar) on presenting this product to niche target markets and make sure that users have easy access to either rechargers or available refills. Even though the Li-ion brick doesn't last as long, it can be recharged in a hotel room or any other electric plug, assuming the price is similar or lower.
- Consider exploring the potential to make the unit even smaller.
- Based on degradation numbers, the PI should attempt to make a prediction of the unit's lifetime and compare that to batteries or competing products.
- Make clear how acceptance barriers are being addressed, and consider adding manufacturing prowess to the sub-tier team. Perhaps there are high-volume manufacturers in Michigan or other depressed areas that could help.
- Seek a partner in consumer electronics or public relations to help with the marketing side of the devices.
- The PI should continue to work towards Underwriter Laboratories (UL) or Canadian Standards Association International (CSA) certification and get the product on the U.S. General Services Administration (GSA) schedule.

RECOVERY ACT

- When the demo units are ready, get MTI invited to demonstrate the units to an inter-agency working group meeting. Not only could these agencies be customers, but they also may be able to identify commercial or military applications for this product, such as power packs for remote sensors or unmanned autonomous vehicles (UAVs).

Project # ARRA-02: Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration*Steven Shaffer; Delphi Automotive***Brief Summary of Project**

The overall objective of this project is to dramatically increase both the technical and commercial viability of fuel cell (FC) auxiliary power unit (APU) technology. Objectives are to: 1) define system specifications and commercial requirements, including subsystem requirements, and develop a subsystem requirements document, 2) design, build, and test the diesel APU system, including verification testing of APU subsystems, form and packaging redesign, plus APU system vibration analysis, and 3) perform a one-year vehicle demonstration and data analysis.

Overall Project Score: 3.1 (5 Reviews Received)**Question 1a: Relevance to overall ARRA objectives**

This project earned a score of **3.0** for its relevance to ARRA objectives.

- The program continues an important effort in the United States, which is, in fact, differentiated from other solid oxide fuel cell (SOFC) programs around the world. This is an application that the United States may be the technology leader in and the United States should pursue it aggressively. The number of jobs created and/or retained, albeit small ones, are good jobs in a part of the country where stimulus is very much needed.
- This project saved approximately five engineering jobs. Future manufacturing of this product could create jobs and improve the APU industry.
- This is a key, early market, FC product and technology. Success of this product would have a substantial impact on U.S. manufacturing and also mitigate a serious air quality issue.
- The effort has created approximately four full time equivalent (FTE) jobs and certainly has contributed to the maintenance of others. As the basis of a future commercial product, it contributes to long-term growth.
- The presentation didn't address the ARRA objectives. In the question-and-answer period, the PI responded that five jobs were created, which is low for \$2.4 million.

Question 1b: Relevance to overall FCT ARRA objectives

- From a technical point of view, focusing on vibration and successful operation in the actual application seems entirely appropriate.
- This project is creating a product that will fill a niche that supports both environmental needs and may have economic impacts on the trucking industry. This project is accelerating both the commercialization and installation of this type of FC technology.
- This project is directly impacting the speed of commercialization of the planar SOFC technology into a meaningful market. Furthermore, it's a demanding application. Success here will open up other markets for the technology.
- This market is challenging and may be difficult to enter near term, but this project will advance the technology.

Question 2: Development and Deployment Approach

This project was rated **3.2** based on development and deployment approach.

- There are some positives and some negatives to this, which balance the score. The weakness is the length of time to develop the required documentation. It doesn't seem like it should take that long. On the positive side, the one-year road test is potentially quite important. While things may break, this should be considered okay. The sooner the road test can start, the better – even if it requires iteration on the design. There is concern that trouble in the early demonstration could be perceived negatively, and it should not be.
- By December 2010, plan to have a unit on a truck.
- The project includes having a lab unit in development now. They are simplifying components and reducing the size and weight of the unit to fit on the truck.
- It is running on low-sulfur diesel.
- The heat exchanger will be revamped in the next phase.
- This is an aggressive development schedule. The demonstration phase will identify additional opportunities for product improvements.
- The milestones are clear. The project is focused appropriately: vibration, weight, packaging, cost, manufacturing, and reliability. The key is the use of commercial diesel APUs as the cost target for competitiveness.
- They employ a vague schedule. There is no real definition of risks and how to address them.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

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

- The total progress appears on track to a soft plan.
- There is a requirement for 3.5 million miles on the system. Shake table testing at ambient conditions is planned.
- They have modified the desulfurizer. They plan to replace the desulfurizer every six-to-twelve months during normal service of the truck.
- Solid oxide technology has presented several challenges that this project will have to successfully resolve in an aggressive development schedule.
- The project team shows excellent progress, and the plan is for limited fleet trials in FY11 and commercial roll-out in late 2012 or early 2013.
- They have significant management support. The shaker table work will yield valuable feedback on the design and is very important.
- There is a good list of accomplishments. The presentation was vague on system test hours. The Q&A indicated appropriate system test accomplishments.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.6** for collaborations.

- They made very good use of input from truck OEMs (original equipment manufacturer).
- They used a truck donated from PACCAR International (PACCAR). They collaborated with TDA Research in Colorado and ElectroCorp, both of whom assisted with report writing and project management.
- PACCAR is a great partner in terms of developing a new technology accessory product for trucks.
- Their effort relies on stack technology developed by the Solid State Energy Conversion Alliance (SECA), and they are working closely with OEMs via PACCAR. They're using vibration data from Peterbilt, and one of their trucks as a test bed. They are also working with well-known TDA to deal with sulfur.
- There is good involvement with this project and good leverage from SECA.

Strengths and weaknesses**Strengths**

- There is good focus on an aggressive on-road test program and good use of leverage with the SECA program.
- The technology seems to fill a niche in environmental air quality zones. It is assumed more regulations will be put in place that will further limit the idling of trucks. As these regulations increase, there will be a greater need for this product.

- This is a well thought out program development plan.
- The project as a whole reflects a serious intent towards commercialization with meaningful interactions between OEMs and realistic testing.
- The SOFC technology is very promising, but very challenging. Pushing an SOFC system for small power is a way to resolve issues and show capability.

Weaknesses

- The project plan appears to be a bit soft.
- This transportation application, in particular, is very challenging. An assessment of trade-offs between delivering a reliable system and product specifications is needed (What specifications drive risk up?).

Specific recommendations and additions or deletions to the work scope

- The PI should consider accelerating the deployment to the field test.
- The presentation did not address if users and potential users have been surveyed to see if this is a relevant need, and how they would utilize this technology.
- When units are ready for demonstration, bring Tank and Automotive Research, Development and Engineering Center (TARDEC) into the project so that DoD is involved in the demonstration phase. This may identify complementary products and applications in a military environment.
- The next review should have a better definition of schedule and actions taken against specific barriers.

Project # ARRA-03: Highly Efficient, 5kW CHP Fuel Cells Demonstrating Durability and Economic Value in Residential and Light Commercial Applications

Rhonda Staudt; Plug Power, Inc.

Brief Summary of Project

Plug Power believes that high-temperature proton exchange membrane fuel cell (PEMFC) technology creates a compelling value proposition in the residential and light commercial micro-combined heat and power (CHP) market. GenSys Blue is Plug Power's CHP fuel cell system (FCS). The objective of this demonstration program is to substantiate the durability and economic value of GenSys Blue and verify its technology and commercial readiness for the marketplace.

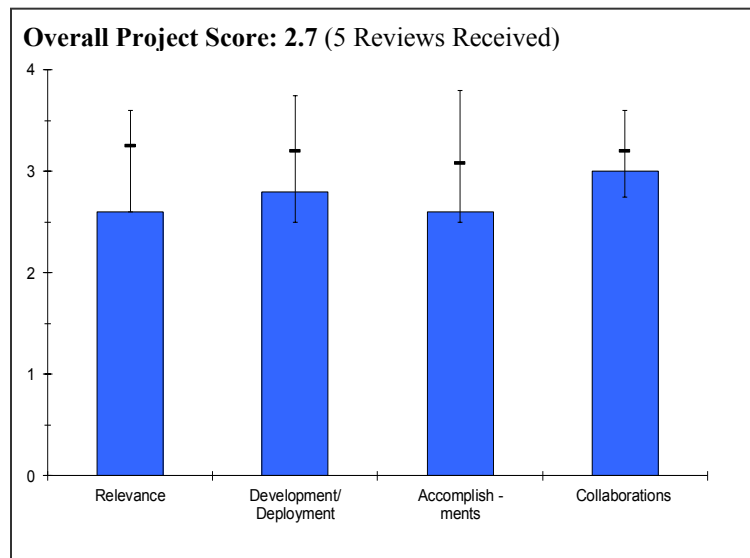
Question 1a: Relevance to overall ARRA objectives

This project earned a score of **2.6** for its relevance to ARRA objectives.

- It is not exactly clear how many jobs are created, sustained, and/or saved. Ten to 15 jobs is pretty general. Next year, the PI should better quantify this in the presentation according to the ARRA definition and what the expected impact is from ordering parts from suppliers for funded systems, contracted labor, etc.
- The long-term impact of this project is not completely clear.
- Creating green jobs is clearly part of the ARRA goals. Residential and/or commercial CHP using fuel cells (FC) clearly fits into that category. Having that said, it is tough to ignore the fact that Plug Power themselves have mothballed this capability to focus their resources more on the lift truck sector. This may not have much, if any, job growth associated with it in the near term.
- There were 10 to 15 workers on this project, plus there was leveraging across the company to retain other jobs.
- The project does not create many new jobs, nor does it seem likely to spur economic investment and growth.
- The project is all development, with very little deployment of only six units. This has limited jobs creation except a few R&D jobs.
- The presentation didn't address the ARRA objectives. In the question-and-answer period, the PI responded that between 10 and 15 jobs were created.

Question 1b: Relevance to overall FCT ARRA objectives

- It was clear how funding supported deployment of FCs, but it was not clear how ARRA funding accelerated commercialization, FC manufacturing, and lessons learned by organizations involved with installation, maintenance, and support services.
- This is an application with a lot of potential and could create stationary FC jobs. The fact that Bloom Energy is also in this market space and has received a lot of venture capital funding attests to the relevance of commercial and residential CHP. The ability to "harden the design" of this high temperature PEM technology throughout the course of this project and to have the University of California, Irvine (UCI), do a system model for product development are important for any FC product launch. However, it will not create a lot of jobs in the near term.
- There is a wide-open market for stationary residential FCs that not many companies are focusing on. Being cost competitive with large segments of the country will be difficult, but certain segments may be attainable.
- The project's cost goal is \$10,000 per kilowatt. Even if it succeeds in achieving its goals, its FCs will not be marketable at that price, even with subsidies and tax credits.
- This is a good application for the technology, assuming the market segmentation analysis is correct.



Question 2: Development and Deployment Approach

This project was rated **2.8** based on development and deployment approach.

- It's good to work the California market, because they have good incentives for this technology. It was also a good choice to team with the UCI National Fuel Cell Research Center (NFCRC), since they can give Plug Power valuable input for the local California market. Sempra Energy is also a good partner to work with.
- June 2010 is a go/no milestone for deciding on building the units for the field trial. The systems will be built and installed starting in September 2010. The units for the field test will be control-optimized versions of the units they are currently testing in their lab. The lab units have increased efficiency and reliability and have had material cost reduction since the program started.
- This is more of a demonstration than a deployment.
- The modeling effort does not seem to contribute much to this project.
- The stated objective is "to substantiate the durability and economic value of GenSys Blue and verify its technology and commercial readiness for the marketplace", and yet no business case is presented.
- This project has a good layout of schedule and metrics.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **2.6** for technical accomplishments and progress.

- The impact of jobs created was not quantified.
- There was some inconsistency in the presentation on how the cost per unit is reduced, even though there is a reduction in material cost, build time, etc.
- Plug Power's decision to back away from GenSys Blue's product support at this time can't help the technical progress, because they are not currently committed to this product line. They also had some issues finding locations on the UCI campus to host the CHP systems. There were other issues associated with converging the UCI dynamic performance model into the Plug Power system architecture.
- There was large improvement in unit build times to approximately two workers per week to build out a unit.
- The project shows a reduction in material costs of approximately \$40,000 per unit.
- The units have had 8,000 hours run in the lab with the newest version, and about 1,000 hours of lab time with no degradation of the cell stack.
- The lab experienced 76% unadjusted CHP reliability, which is low for a lab unit. It can be assumed that this reliability will decrease in the first field units because it will be outside of the laboratory. Since this is early on in the project, the low reliability is acceptable, but should be monitored throughout the project.
- The technical accomplishments are good, but progress seems a little slow, and the future of the company is on shaky ground. The go/no-go decision should be examined closely; if the company can produce the number of units needed and can fulfill the requirements of the project.
- There is no clear answer on the status of life testing.
- The project provides a clear statement of metrics and test results including a long list of technical improvements.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.0** for collaborations.

- They have strong partners in UCI and Sempra.
- They presented a paper at the FC seminar on this project and highlighted high-temperature PEM technology for residential and/or commercial CHP. They held a ribbon cutting for the deployment at Union College Schenectady, New York. Participation on the Ballston Spa High School field trip also shows good collaboration. Their teaming with Sempra and the UCI NFCRC provides further information dissemination. South Coast Air Quality Management District (AQMD) and NREL are also participating to some degree in this effort, which is a good sign.

- There is coordination among several significant organizations. UCI, Sempra Energy, LPA, AQMD, and NREL. This seems to be a good cross section of partners, as they could each play a significant part in development and market acceptance of this product. Partnering with Sempra and AQMD could improve the ability to install these units in California. The appropriate partners seem to be involved in this project.
- The project would be better served by replacing the university collaborator doing modeling with an industrial organization experienced in controls development and system integration with an eye towards cost reduction.
- There is good, broad involvement.

Strengths and weaknesses

Strengths

- The units appear to be competitive based on efficiency, reliability, and durability potential.
- A new, potential widespread opportunity for stationary FCs is the centerpiece of this effort. Plug Power is teamed with two California-based entities (UCI and Sempra) that can help them work into this market. Also, having AQMD involved is another positive.
- There is good coordination among the partners.
- The technical progress looks good based on what was revealed. They need to get a true customer-based test going to report that the product design and engineering are good and something that DOE should be funding.

Weaknesses

- It is not clear how the cost compares with existing solutions (i.e. per kWh of heat or of electricity).
- It's uncertain how reliability of this system compares with existing technologies.
- It's a new product in the market.
- Plug Power shows a lack of commitment to the GenSys Blue product line. This is not going to be a job-creator anytime soon.
- Progress seems a little slow, and the go/no-go decision will be extremely important for the project.
- This project appears to be a bridge to nowhere. Its cost goal is \$10,000 per kilowatt. Even if it achieves its goals, it will not be marketable at that price, even with subsidies and tax credits.
- The value of the modeling is not certain. Perhaps next year this can be presented in the form of how it will help product engineering. The cost analysis and market price target are critical but were only addressed on a superficial level. Maybe it can be addressed more fully next year.

Specific recommendations and additions or deletions to the work scope

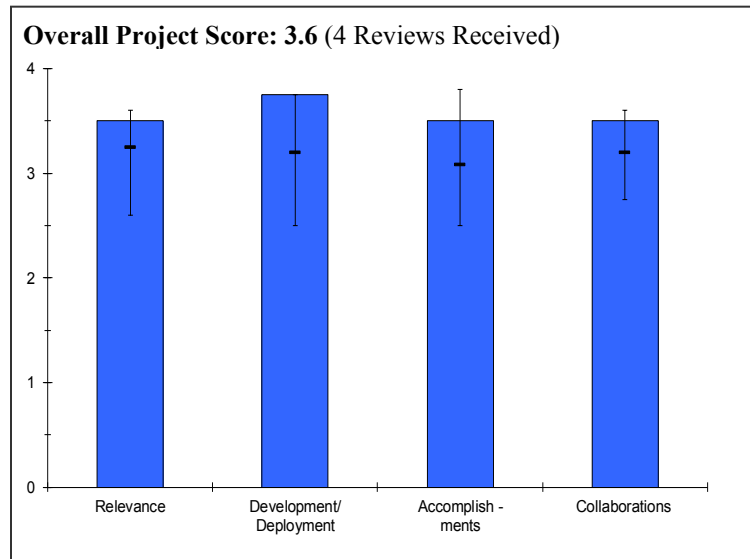
- Plug Power should compare this technology with existing systems, like what Japan is doing, and competing products such as Bloombox. It would be good to know whether Sempra or PG&E is testing this in California.
- California AQMD doesn't exist – South Coast AQMD does.
- Field testing is ideal, but bench testing may be quicker. The verification of thousands of hours of durability is going to take more than a few years. This could potentially slow down the development process.
- The PI should monitor this project closely to see if the company can still support the product build out and installation of the units. If the company will not be able to support this product line, the project scope may need to be reduced.
- This is a good project. Plug Power should strengthen the market assessment and drive product reliability.

Project # ARRA-06: PEM Fuel Cell Systems Providing Backup Power to Commercial Cellular Towers and an Electric Utility Communications Network

Mike Maxwell; ReliOn, Inc.

Brief Summary of Project

The goal of this project is to install and operate hydrogen fuel cells (FC) as critical emergency reserve power for cell sites operated by AT&T and as back-up power equipment for communications sites in use by California-based Pacific Gas & Electric (PG&E). Up to 189 sites will be served. The goals of the first year were to identify specific sites based on power load and fueling access and then begin deployment. The manufacturing and installation of up to 189 fuel cell systems (FCS) creates and retains direct and indirect jobs at ReliOn and indirect jobs through the service supply chain, and it develops growth in new service industries to install and refuel these systems.



Question 1a: Relevance to overall ARRA objectives

This project earned a score of **3.5** for its relevance to ARRA objectives.

- The team provides a good explanation of jobs created according to ARRA definition, but it would be nice to see what other impacts this project has. For example, Air Products developing a more feasible method (four lighter, smaller trucks with composite tanks) for hydrogen delivery to the sites would generate more business for them, as more sites will be accessible.
- It's already a commercially available product.
- This project directly supports ARRA goals including job creation at ReliOn's FC production, for its FC installation, and at its hydrogen fueling.
- Their general statement on jobs is good.

Question 1b: Relevance to overall FCT ARRA objectives

- The impact of bringing down the cost of FCs is not clear.
- It seems apparent that the number of units deployed is increasing because of funding assistance!
- Their support services could be better described.
- This project directly supports FC technology (FCT) ARRA goals with deployments of FCs in substantial amounts and in substantial numbers that make an impact.
- This project has done well in planning its wide spread installations and multiple host user sites.

Question 2: Development and Deployment Approach

This project was rated **3.8** based on development and deployment approach.

- The PI should pay more attention to how the commercial risks are addressed.
- The project is managing risks well in regards to hydrogen delivery.
- This presentation provided a thorough discussion of approach and criteria.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **3.5** for technical accomplishments and progress.

- What does it take to make this product competitive for any site proposed? The PI should consider using a different solution for hydrogen delivery to FC, such as methanol and reforming.
- The project is currently on schedule with some installations completed, and they are likely to finish all installations on time.
- The project's work to modify delivery trucks to reduce delivery costs is good.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.5** for collaborations.

- The team reported good collaboration with telecoms and with hydrogen fuel suppliers.
- There is a geographically broad set of installations that should be excellent exposure of FCs.

Strengths and weaknesses**Strengths**

- This is a commercially available product.
- The timeliness in getting FCs deployed early is a strength.
- FC size and the number of units are large enough to make a difference towards commercialization.
- There is broad involvement of gas suppliers, customers, and regulators to gain a foothold in the market and to chart a pathway to wider adoption.

Weaknesses

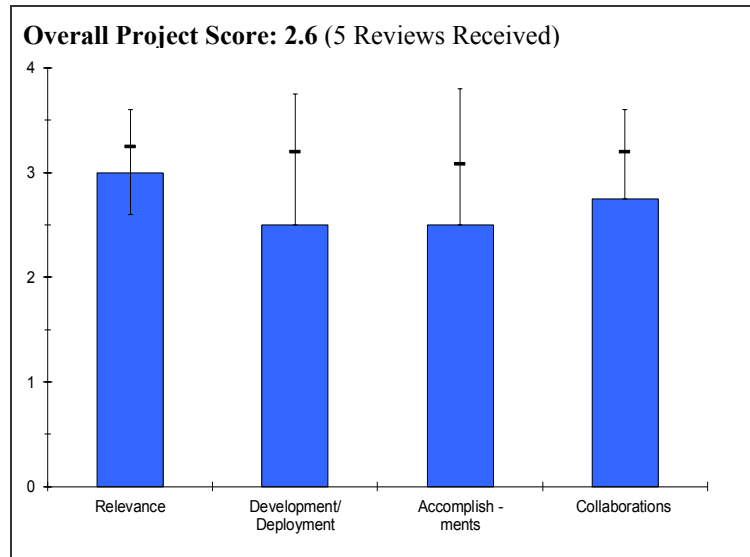
- The product cannot be used for every site.
- It is a new product.
- There was no business plan shown for a sustainable path forward in commercialization after ARRA subsidy ends.
- None.

Specific recommendations and additions or deletions to the work scope

- Compare this technology's cost with existing technology costs, including external costs.
- As soon as data is available, develop a public outreach plan to increase public and market awareness of the benefits and value proposition of this product. This plan can include presentations at industry conferences and web-based materials. In addition to ReliOn and its collaborators, groups with education program experience could disseminate such communication.
- This is a good project. Next year, the team should share lessons learned and an assessment of the economics.

Project # ARRA-07: Accelerating Acceptance of Fuel Cell Backup Power Systems*Rick Cutright; Plug Power, Inc (7A).***Brief Summary of Project**

The objectives of this project are to: 1) demonstrate market viability and increase market pull of hydrogen and fuel cell systems (FCS) within our government customers and partners, 2) support 15%-30% of Plug Power's technical staff through this funding effort, 3) establish a large automotive supply base delivering stack, reformer, and balance of plant (BoP) components, 4) deploy 20 GenSys hybrid hydrogen start/liquefied petroleum gas (LPG) or natural gas run units that provide economically viable backup power in excess of 72 hours.

Question 1a: Relevance to overall ARRA objectives

This project earned a score of **3.0** for its relevance to ARRA objectives.

- Assuming the 12 to 15 jobs mentioned are calculated using the ARRA formula, this is good. The three to five additional in-company jobs are also good.
- It would be good to note whether the jobs are sustainable or not.
- The presenter explained that jobs have been preserved. The product being developed, should costs be reasonable, appears to have future growth potential.
- This is not a conventional, "shovel-ready" project. There is still a lot of product development to do.
- Most of the jobs so far have been primarily in analysis and project management, yet it was indicated that 15%-30% of its employees were technical staff.

Question 1b: Relevance to overall FCT ARRA objectives

- The key to relevance is if the reliance on fossil fuel for the power generation is really reduced.
- It is too early in the project timeline to give a good evaluation.
- The deployment of significant numbers of units supports DOE's goal of accelerating deployment.
- The deployment of 20 units of good size (six kW) will help advance the market, if field operation is successful.
- This market is a good entry point with well understood, controlled requirements.

Question 2: Development and Deployment Approach

This project was rated **2.5** based on development and deployment approach.

- The PI should find out if increased maintenance costs are caused by new, unproven preventative maintenance or other problems.
- There was little discussion of cost requirements and progress to reduce cost through the early deployment of FCs. The project plan also appears to be a bit soft, meaning not very aggressive.
- It is not clear why operation on hydrogen for 72 hours has been ruled out when many other backup power deployments are successfully using hydrogen fuel.
- The alternative hybrid approach that they have changed to (hydrogen/LPG) seems unnecessarily complicated because of the use of two different fuels, extra controls, etc. There was no analysis presented, technical or economic, to show why they chose this approach instead of simply using a battery during initial startup.

- They needed a better discussion of barriers and risks.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **2.5** for technical accomplishments and progress.

- Everything appears to be on target.
- The specific goals, product lifetime, and cost analysis are relatively vague. The progress is okay but is running against a plan that is not terribly aggressive.
- For a project that started more than a year ago (June 1, 2009), progress has been slow. The site selection still isn't completed for Warner Robins.
- The bulk of the effort to date appears to have been devoted to economic analyses, but no results on economic analyses were presented.
- This project shows good technical accomplishments and progress overall, but reporting accomplishments against target metrics would be very helpful.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **2.8** for collaborations.

- The DoD partners appear to be value added. However, there is no commercial partner, a relationship that should be developed to ensure a marketplace exists. Also, there is a statement of "automotive suppliers" being used for stacks, fuel processors, etc., in the opening section, but little follow-up on that fact.
- There are good collaborations, but they are on the weak side relative to some other ARRA projects.

Strengths and weaknesses**Strengths**

- The potential benefits of the product are a strength.
- It seems like a good application. The demonstration should start early enough in the project to be useful.
- It draws on an existing technology base, which may minimize the technical barriers.

Weaknesses

- It is a new project.
- There are limited partnerships with commercial entities. There is also no clarity on cost performance and reduction over time.
- The definition of market and technical barriers needs to be better described, and specific approaches need to be more fully described.

Specific recommendations and additions or deletions to the work scope

- One needs to know the history of this unit, if there were any other units deployed in the past, and, if so, how those units performed.
- The PI should review the weaknesses listed here and work to address those areas.
- The team should re-examine the possibility of operation on hydrogen for 72 hours, since many other backup power deployments are successfully using hydrogen fuel. If that is not possible, examine the technical and economic trade-offs of using a battery for initial start-up versus going to a hybrid hydrogen/LPG system.
- This project needs to strengthen their economic justification and provide more detail on technical approach to specific barriers.

Project # ARRA-08: HEB Grocery Total Power Solution for Fuel Cell Powered Material Handling Equipment- Fuel Cell Hybrid Power Packs and Hydrogen Refueling

William Mitchell; Nuvera Fuel Cells.

Brief Summary of Project

The objectives of this project are to install one PowerTap hydrogen generation system with indoor refueling and 14 PowerEdge fuel cell systems (FCS) at an H-E-B (Here Everything's Better) grocery facility in San Antonio, Texas. Expected outcomes include: 1) periodic reports documenting system performance and any issues, 2) enable widespread adoption of hydrogen and fuel cell (FC) technology by employing this across the H-E-B fleet of 1,000 forklifts once verification of economic and/or operational advantages is determined, and 3) validation of the DOE market transformation activities.

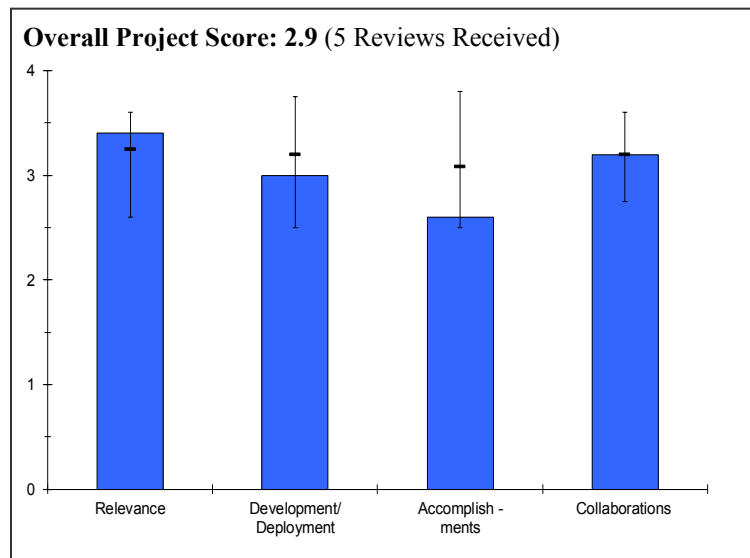
Question 1a: Relevance to overall ARRA objectives

This project earned a score of **3.4** for its relevance to ARRA objectives.

- Making the conversion based on ARRA definition of jobs created and/or sustained is praised.
- The PI should continue to speak about additional economic impacts as well. It's good to hear what economic activity is stimulated outside the ARRA definition.
- Is there an ARRA definition of "economic activity" that has been spurred through this project?
- This will help FC volume for domestic manufacturers, which will lead to further cost reductions and commensurate market share in this new, growing technology. Indirectly, this also benefits the light-duty vehicle FC market since these are proton exchange membrane fuel cell (PEMFC) manufacturers.
- This project indicates that job saving is modest, one to two jobs. However, the prospect of stimulating long-term economic growth is viable.
- This project will definitely create or sustain jobs in one of the emerging commercial applications of FCs.
- Application of this project in a refrigerated warehouse environment will be a good test of FCs in this challenging project.

Question 1b: Relevance to overall FCT ARRA objectives

- It could be challenging to develop a 10-year life cycle within the first two years of this project. It would be interesting to note what they plan on doing for the next eight years. Hopefully, they are not completely dependent on what H-E-B decides!
- This is the hottest early market for FCs, but it still has a long way to go, both because of unfamiliarity and hydrogen infrastructure costs. Working with a grocery chain is a wise choice since they have a great chance for further adoption across the company and, ultimately, across the sector. They cite a 10% productivity gain.
- The proposed effort is consistent with the acceleration of these efforts. The question is whether the plan makes a significant impact. It would be useful to see more information on life cycle and durability, and how these results will be used to reduce customer risk of acquiring these devices.
- If H-E-B has a good experience with FC forklifts as a result of this project, the project team expects the grocery chain to employ up to 1,000 forklifts across its fleet.



Question 2: Development and Deployment Approach

This project was rated **3.0** based on development and deployment approach.

- The PI should make sure to consider how larger power demand (more than 5kW capacity) on FC forklifts – because of larger demand in a particular section of the warehouse – will be addressed in a next project or contract. Moving all forklifts to another section is not always an option, especially when a larger fleet is ordered.
- The PI should consider reviewing how they evaluate the power needs for the forklifts. Moving the forklifts to another part of the warehouse could have been avoided.
- Installing 25 units is a large enough number from which to make an informed judgment on this technology from H-E-B's standpoint. H-E-B estimates they have 1,000 lift trucks, so there is room to grow. Nuvera's POWERAP natural gas-to-hydrogen reformer allows for a turnkey solution. Two dispensers show the ability (compared to batteries) to reduce refueling trips and distances for the lift trucks. Two 10-hour shifts of employees provide enough operational tempo to make hydrogen FC lift trucks competitive. Texas is a good target market because they have low natural gas prices.
- The latter portion of the project plan could use a bit more detail to show data analysis cycles and lessons learned.
- The initial results of 10% total productivity gain versus batteries are impressive.
- Validating these findings with additional data will provide increased confidence in the added value of FC forklifts compared to batteries.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **2.6** for technical accomplishments and progress.

- Showing a numerical comparison with battery forklifts would be helpful in evaluating the significance of improvements and setting benchmarks.
- Input from H-E-B would help determine the project's progress, especially comments on what decision variables they will use to make the decision to keep the FC forklifts in continued operation.
- There is pretty good progress, although somehow the hydrogen FC lift trucks were unable to work the produce warehouse, and they had to move them to the grocery section. It wasn't clear what the specific issue was. The assumption is the FC power pack was undersized for the heaviest and highest of lifts (the presenter was a "pinch hitter" and quite unqualified to give the presentation).
- The presentation was not clear as to what has actually been accomplished to date from a technical point of view.
- There was no actual information about jobs created or sustained provided.
- The PI said that an example of measuring 10% of productivity could be described as starting with ten people, firing one person, and still getting the job done. This is definitely not the best way to argue that this project is creating jobs.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.2** for collaborations.

- It doesn't appear there are additional university or research organizations involved.
- There was little discussion about collaborations beyond H-E-B and providing NREL data. On the other hand, it would be challenging to suggest a list of collaborators in this area.
- They produced a good mix of partners to address the project tasks.
- H-E-B is a highly regarded grocer. Its progress with FCs will be keenly observed by the grocery industry. H-E-B may also have potential to be a customer of other FC products such as primary power. It is important to be developing a presence for FC products in Texas.
- The PI showed good collaboration with NREL in sharing (and then publishing) the data to be aggregated with other FC forklift projects.
- H-E-B appears to be an excellent project partner to grow the market share of FC forklifts, if this project is successful.

Strengths and weaknesses**Strengths**

- It is valuable to have the H-E-B grocery stores involved.
- The potential to inform many more people (i.e., truckers and peripheral stakeholders) about FC forklift and related station projects is very beneficial.
- The involvement of a company that normally maintains battery- powered forklifts is extremely beneficial.
- This project helps a new technology move forward in a market well suited for it. Site selection in Texas where natural gas costs are low, client selection that utilizes a distribution warehouse with multiple shifts, and a turnkey approach, such as one-stop shopping for FC and hydrogen training and/or issues, increases the odds for success.
- The project is in a good market, and they are collaborating with good partners.
- The real world demonstration of the benefits of FC forklifts in a very demanding, critical-path application of moving groceries is useful.

Weaknesses

- The size of FC forklift fleet, presented as a percentage of total forklift fleet, which is 1,000, is a weakness.
- Another weakness is the limited project life. It is somewhat challenging to hear what the potential financial losses are if H-E-B decides not to continue this project.
- The presenter was not specific enough on details, and questions asked were generally not answered.
- There was a lack of focus on durability in a detailed way.
- There was no clear tabulation of jobs impact, which is key for ARRA activities.

Specific recommendations and additions or deletions to the work scope

- Nuvera needs to make sure that cost of fuel projections are made for larger fleets of FC forklifts, in addition to the 10-year life cycle plan.
- A 10% productivity gain doesn't show how this translates in H-E-B's overall warehouse benefits, jobs and productivity gains.
- The PI should specify how the fleet data will be analyzed. It is implied that NREL would do that.
- Nuvera should seek out opportunities for public outreach. For example, the Fuel Cell Seminar will be held this year in San Antonio, Texas, where H-E-B is headquartered. This would be a good opportunity for the grocery store chain to discuss publicly its interest in FCs.
- Questions about the details of the project could be more effectively answered if Nuvera had sent a technical presenter rather than a financial presenter. Many basic questions went unanswered.

Project # ARRA-09: 7B: Fuel Cell-Powered Lift Truck FedEx Freight Fleet Deployment*Curtis Cummings; FedEx Freight East***Brief Summary of Project**

The objectives of this project are to: 1) convert an entire material handling equipment (MHE) fleet at the Federal Express (FedEx) facility in Springfield, Missouri, with fuel cell (FC)-powered forklifts, 2) demonstrate safe and reliable operations of hydrogen MHE, 3) demonstrate the economic benefits of conversion, 4) provide cost effective and reliable hydrogen, 5) spur further lift truck fleet conversions, and 6) establish proving ground for hydrogen MHE.

Question 1a: Relevance to overall ARRA objectives

This project earned a score of **3.6** for its relevance to ARRA objectives.

- If FedEx adopts FC-powered forklifts, even to a moderate degree, this could be a “shot in the arm” for the fledgling FC companies in this market space.
- The project could spur economic activity by creating a market for FC forklifts. The project will retrofit 35 FCs. Having a major third party evaluating this technology could open up a large market for FCs.
- They didn't address the relevance to overall ARRA objectives.

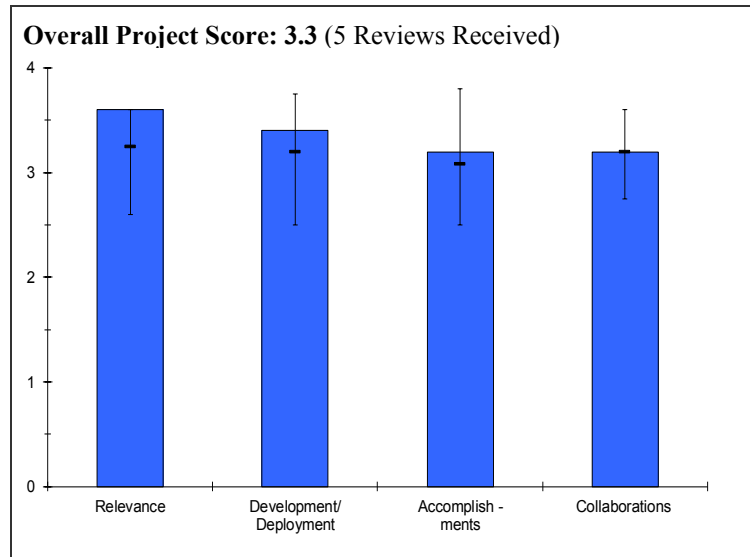
Question 1b: Relevance to overall FCT ARRA objectives

- FedEx is serious about exploring this technology. They clearly aren't doing it for the ARRA cost share. The fact that they want to convert their entire fleet of Class I forklifts in Springfield, Missouri, and are targeting a “greenfield” site speaks volumes.
- This project could be the first step in a large deployment of this technology. If the testing is successful in this project, a large market segment could be opened up for FC technology.
- This is a good application to use this technology.

Question 2: Development and Deployment Approach

This project was rated **3.4** based on development and deployment approach.

- Working with Plug Power, arguably the leader in the FC lift truck market, and Air Products is a solid team. Thirty-five Class I lift trucks is sufficient volume from which to make an evaluation for future use within FedEx. Two indoor dispensers will keep the lift trucks from having to travel far for refueling purposes. The Plug Power units should last the entire shift, as they have at the New Cumberland Defense Depot Susquehanna. The 10-12 kW range is a good power range. FedEx will use this deployment to compare hydrogen fuel cell (HFC) lift trucks versus electric- and propane-powered lift trucks.
- There was a delay because of getting internal approval to lease the technology, because the status quo previously had been to purchase equipment outright. This delay is acceptable, because business procedures had to be changed to accept the new technology.
- It would be beneficial to know if there are any plans to release an economic analysis. It wasn't identified as a milestone or deliverable.
- They had a vague schedule and overall plan. The emphasis on training operators is commended.



Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **3.2** for technical accomplishments and progress.

- There is good progress being made, despite a few bumps in the road. National Fire Protection Association standards versus international standards that the Springfield Fire Department uses caused adaptive process control (APC) to have to put in different dispensers than originally envisioned. FedEx had to put in a temporary battery charging infrastructure and use battery forklifts until hydrogen infrastructure was ready. As a result, HFC lift trucks were not in service at the time of the AMR. There does not appear to be any issues with Plug Power's GENDRIVE units being ready on time. They just need hydrogen in place to operate.
- They are making good progress toward their milestones. Units will be installed shortly and operation will begin.
- Much appears to have been accomplished in the last nine months. It would help if there were a schedule to judge against.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.2** for collaborations.

- There were only 10 slides in the briefing, and they didn't cover this area very well. They are sending data to NREL. It's difficult for a for-profit company putting up a lot of their own cost share to spread the word in this sector since that would be telling their competitors.
- There are three partners: Fedex, Plug Power, and Air Products. These are three effective partners that are likely to succeed in this type of project.
- Their stated cost of delivered hydrogen (\$5/kg) seems unrealistic, especially considering that it is trucked in from either New Orleans or Sarnia, Ohio, to Springfield, Missouri.
- This was a good, but predictable, cast of characters.

Strengths and weaknesses**Strengths**

- This project targets a major company with great potential for demand. A strong team was put together for this effort. Greenfield site selection and high operational tempo is an ideal deployment scenario. A company with a reputation as strong as FedEx would really boost the credibility of the HFC lift-trucks if they were to embrace them.
- A third-party evaluation of FC technology could jump start the FC market, if this test is successful.
- This is a real industrial test bed, and the project is making good technical progress.

Weaknesses

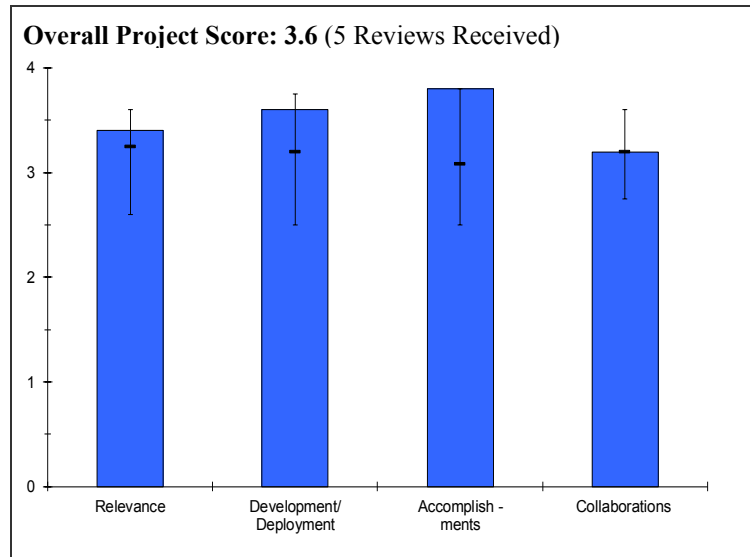
- None.
- None to mention.
- This is a good project. It will be interesting to hear an unbiased assessment of these systems in operation from the user and customer perspectives.

Specific recommendations and additions or deletions to the work scope

- See if FedEx will share their comparison between FC forklifts with electric and propane. In particular, there is not a lot of comparison that has been done between HFC lift trucks and propane-powered lift trucks. The briefer said propane tends to have the most down time.
- It is recommended to continue the project as planned. It seems to be on track.
- It would be useful to show some economic analysis, with and without ARRA grant subsidies. Examine cases on both expected FC life and for the warranty life of the FC. Validate (or re-evaluate) the David Greene model that predicts that a market deployment of 1,000 units will drive FC costs from \$3,600 per kilowatt to less than \$2,000 per kilowatt.

Project # ARRA-10: Fuel Cell-Powered Lift Truck Sysco Houston Fleet Deployment*Scott Kleiver; Sysco of Houston***Brief Summary of Project**

The objectives of this project are to: 1) support American Recovery and Reinvestment Act goals of long-term economic growth by successfully demonstrating a new technology, 2) establish a proving ground for expanded use of hydrogen fueling technology at Sysco and promoting future adoption of fuel cells (FC) in other applications to help drive their use in the U.S., and 3) promote the economic and environmental benefits of hydrogen fuel cell (HFC) technology. The tactics used are to: 1) convert the entire Class II and Class III lift truck fleet at Sysco Houston's greenfield distribution center to FC use, 2) demonstrate the economic benefits of large fleet conversions of lift trucks from lead-acid batteries to FC power units by measuring, analyzing, and reporting on the performance, operability, and safety of the systems, 3) demonstrate freezer operation, and 4) obtain affordable and reliable hydrogen.

**Question 1a: Relevance to overall ARRA objectives**

This project earned a score of **3.4** for its relevance to ARRA objectives.

- This project indicates good timing for the implementation of a hydrogen station and FC forklifts that are lined up. This is good to know for all potential future distribution centers beyond Sysco's Greenfield site. Lessons learned to be shared.
- There is a significant number of new jobs created compared to several of the other projects. This could also be because of new implementation instead of the replacement of a technology.
- They show good quantification of jobs impact and the financial benefit of the forklifts in the operation.
- The PI reported that 5.5 jobs are created. The cost savings have already been realized by the host site. This savings may affect other aspects of the business and keep additional jobs viable.
- The project stated that throughout the life of the project, 5.5 jobs have been created.

Question 1b: Relevance to overall FCT ARRA objectives

- Commercialization and deployment were shown, but the impact on the company that provided the fuel cells was not. It would also help if we knew what they learned from this project.
- The company appears to be genuine in looking to this application for more widespread deployment. The project could facilitate further expansion of FC use.
- This project can accelerate the commercialization and deployment of FCs and could open a large market for FC fork trucks. It also could affect the hydrogen fueling industry.
- Because of the size and reach of Sysco, a successful demonstration through this project could lead to large-scale adoption of FC forklifts at many sites.

Question 2: Development and Deployment Approach

This project was rated **3.6** based on development and deployment approach.

- The freezing capability was well addressed.
- Avoiding drive offs was well addressed by Plug Power. This should be required of all FC forklifts, because it saves significantly on cost and creates a safer work environment. A truck being driven away could require hose replacement that creates labor hours, costing up to several thousands of dollars to repair and/or replace it.
- They provided a good definition of key milestones, most of which are completed. The data collection intervals are crucial, and they are defined.
- The project is on track with FC forklifts operating at the site. The cost savings and productivity increases have been realized.
- This is a very large scale deployment, so it is great to see the contractor so well organized.
- The contractor appears to be ideally suited for a commercial evaluation of whether FC forklifts will assist their bottom line.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **3.8** for technical accomplishments and progress.

- The technical accomplishments and progress have both been excellent.
- The project is on track, and the plan is fairly aggressive.
- The units are in place and operating at a high level. Productivity has been increased.
- This project has moved very rapidly to deployment, with more than 2,500 hydrogen fills and a conversion of an entire fleet of Class II and Class III lifts to run on hydrogen at the Greenfield site.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.2** for collaborations.

- The involvement of a research institution (NREL) will hopefully result in the development of better models that can be used by the rest of the industry (i.e., the H2A Model or hydrogen delivery).
- There is no involvement of an academic institution.
- The project has good interactions with a FC manufacturer, a hydrogen supplier, and the FC customer interactions.
- Sysco, Plug Power, Air Products, and Big-D Construction are the appropriate players to participate in this project.
- It appears as though a good partnership has been forged with Air Products, who could easily support H-E-B, a Texas-based grocery store chain, as they move beyond the demonstration phase into a more full-blown commercial purchase and/or deployment without government incentives.

Strengths and weaknesses

Strengths

- Implementation of this project from a start facility is promising.
- They have a good number of FC forklifts.
- There is a good market for this application, an aggressive schedule, and a strong focus on life data.
- The schedule is on track and units are in the field. They are operating well.
- The project is being rapidly executed with many activities, such as fire marshal approval, ahead of schedule.

Weaknesses

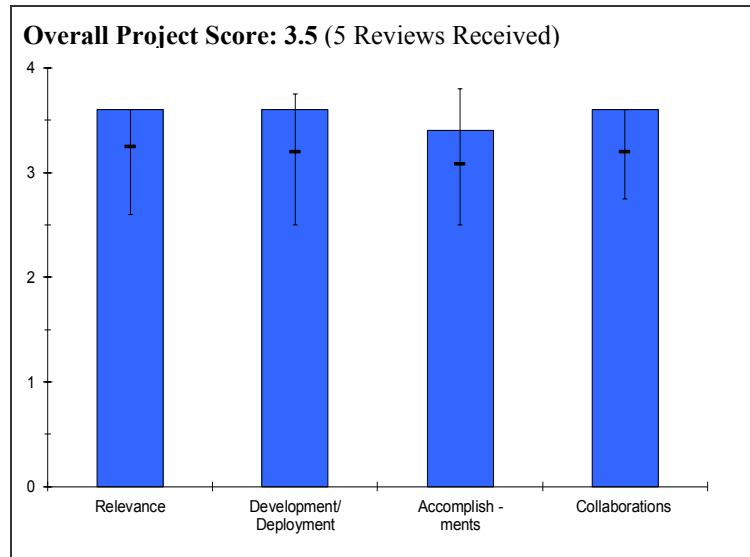
- The distance to transport liquid hydrogen is a weakness.
- There are no warranties of FCs for the user.
- There is no indication that hydrogen cost per kilogram will come down. The hydrogen supplier appears to make profit on the sale of hydrogen. It would be interesting to know if that was the case.
- There are no obvious weaknesses here.
- No major project weaknesses were identified.

Specific recommendations and additions or deletions to the work scope

- Sysco's liability when something happens with the hydrogen station needs to be addressed.
- It is recommended that the team evaluate and/or consider what alternatives they have that would bring down the cost of hydrogen. If Sysco considers putting in similar fleets at other locations, the cost could come down significantly if the same station design is reproduced at each site.
- The PI should ensure that the data analysis is very robust. There will likely be some failures, and they should be reported in some detail in the future.
- It's good to continue operating the FC fork trucks and monitoring the progress.
- They could coordinate this project with the overall public outreach effort as part of the Education Subprogram. For example, invite Sysco to participate in a panel on market transformation at the 2010 Fuel Cell Seminar in nearby San Antonio, Texas.
- The PI should make sure that the project clearly identifies the value proposition for future deployments, based on the evaluation of costs and data from this project without future incentives being required.
- They are ready to publicly broadcast the success of this project at trade conferences so the word gets out beyond the community already aware of this technology.

Project # ARRA-11: 7B: GENCO Fuel Cell-Powered Lift Truck Fleet Deployment*Jim Klingler; GENCO.***Brief Summary of Project**

The objectives of this project are to: 1) support American Recovery and Reinvestment Act goals of long-term economic growth by successfully demonstrating a new technology, and 2) promote the economic and environmental benefits of hydrogen fuel cell (HFC) technology. The tactics used are to: 1) demonstrate the economic benefits of large fleet conversions of lift trucks from batteries to fuel cell (FC)-powered units by measuring, analyzing, and reporting on the performance, operability, and safety of the systems that will spur further FC lift truck fleet conversions, 2) convert electric-drive fork lift truck fleets to FC use in five large distribution centers and manufacturing facilities, 3) provide affordable and reliable hydrogen, and 4) establish a proving ground for hydrogen fueling technology that will promote the future adoption of FCs in other applications, such as cars, and help drive the use of FC technology in the U.S.

**Question 1a: Relevance to overall ARRA objectives**

This project earned a score of **3.6** for its relevance to ARRA objectives.

- GENCO is a third-party distribution warehouse manager that can bring this technology to many major retailers who employ their services. These include Target, Best Buy, Johnson & Johnson, and Kimberly-Clark. The deployment itself will cover multiple original equipment manufacturers (OEMs): Wegmans Food Markets, Whole Foods Market Stores, Coca-Cola, and Sysco Food Services of Philadelphia. The productivity increases through use of these FC lift trucks should increase jobs at both the FC OEM level and the company that hires GENCO to operate the warehouses. Productivity precipitates lower costs, increasing profitability that should allow for further expansion and more jobs.
- This project could spur economic activity by investing in this new technology, and cost savings could be realized by these companies that, in turn, could save jobs and increase long-term economic growth.
- This project has the potential for many jobs to be created and/or saved given the large scale deployment of 357 lifts.
- Specifically, two jobs were maintained in the first quarter of 2010.

Question 1b: Relevance to overall FCT ARRA objectives

- GENCO is asking the question: "Can we run our customers' facilities more efficiently?" By exploring the use of FCs versus batteries in their lift trucks, GENCO is trying to become even more competitive. This underscores the relevance of this technology to this market.
- This deployment project gets this technology in the hands of the users, which could create a cascading effect for implementation of these FC fork lifts across the country. Projects like this are needed for commercialization of this technology.
- The number of FC units in this project is a large enough number to make a significant impact. With 357 lifts, this project has gravitas.
- The broad introduction to multiple users is commended. Trained operators and controlled conditions will help to achieve technical success.

- The large-scale potential of a nationwide rollout among GENCO partners is huge, which makes this project extremely relevant toward accelerating commercialization.

Question 2: Development and Deployment Approach

This project was rated **3.6** based on development and deployment approach.

- By having multiple warehouse and company deployments, GENCO is maximizing the impact that a successful pilot would have. As a third-party warehouse operator, GENCO can claim credit for a clean energy deployment and pass that credit on to their customers. Using two hydrogen suppliers – Air Products and Linde for the Whole Foods deployment – spreads out the risks and adds competition for hydrogen supply and infrastructure. Other great features of this project include the fact that these are multiple shift operations, and they are employing Class I, II and III lift trucks in the pilots.
- The deployment plan is well laid out, and good progress has been made toward the milestones. They have deployed 59 units and have logged significant run hours.
- It would be helpful to know if there is any plan to show and/or publish their economic analysis. It was not identified as a milestone or deliverable in the presentation.
- They offered a good definition of their approach. The reviewer recommends providing a better definition of what go/no-go means.
- Having two hydrogen suppliers, Linde and Air Products, is great because it will actually start to trigger some competition, resulting in lower hydrogen cost and increased choices in the marketplace.
- The location, type, and quantity of lifts to be deployed were clearly articulated.

Question 3: Technical accomplishments and progress toward project and ARRA objectives and milestones

This project was rated **3.4** for technical accomplishments and progress.

- Everything seems to be going pretty much on schedule. They are using the hydrogen station in Aiken, South Carolina, which lowers hydrogen costs at that site. They did have delays getting on contract and receiving all the environmental permits.
- Some of the units are in the field, and the remainder of the units are on schedule to be placed at the locations.
- Their technical progress to date has been good.
- There are 59 units already operating successfully.
- To date, there has been more than 2,000 hydrogen refuelings.
- The progress appears to be outstanding.
- They already have 59 GenDrive systems delivered – two months ahead of schedule – and have logged 24,000 operating hours.
- Good progress appears to be made at the other four sites on schedule.

Question 4: Collaborations with industry, universities and other laboratories

This project was rated **3.6** for collaborations.

- GENCO is doing a good job relaying information about this pilot to their customers. Their customers say they "want to be leaders, but not pioneers". This means a cautious, deliberative approach is in order, but it also means they want GENCO to keep them on the forefront of more productive and cleaner technologies. GENCO mentioned there have been no "Hindenburg references," as they have done their operator training and familiarization education with permitting officials. This suggests that they are collaborating early enough with these employees and officials to enable the project to go forward in a timely and effective fashion.
- The project has multiple partners including Plug Power, Linde, Air Products, and customers at each host site: Wegmans, Whole Foods, Coca-Cola, Sysco, and Kimberly-Clarke. These units are being evaluated by large and diverse companies that could create a significant market pull if this project is a success.
- Their collaboration includes two suppliers of hydrogen.
- Their stated cost of delivered hydrogen at \$11 per kilogram seems realistic.
- The large number of users should really help accelerate and evaluate FCs in this marketplace.

- This project has assembled an excellent team with a cross-section of partners representing many different sectors of the U.S. retail economy.
- Important lessons will be learned from the execution of this project.

Strengths and weaknesses

Strengths

- Through strong collaborations, GENCO has a great target market to which they can deploy this technology.
- Many of GENCO's customers will see the benefits of this technology and take credit for having it used in their facilities.
- There are multiple hydrogen suppliers.
- The units have been deployed, and significant run hours have been logged. Multiple partners and hosts are involved in this deployment. The technology is performing as expected.
- The fact that they are going to deploy 357 units is impressive.
- This project provides for a relatively large quantity of delivered product, something that can help bring down production costs. The introduction of the product to multiple users and customers is commended.
- This project enables penetration of FC forklifts into a good cross-section of the U.S. economy, reflecting the intent and potential of the ARRA activity.

Weaknesses

- None.
- Set at one year, the warranty on the FC units is very limited. From the users' viewpoint, this could be a problem if the FCs start failing early.
- No weaknesses identified here.

Specific recommendations and additions or deletions to the work scope

- GENCO should continue monitoring progress until all units are sited and operating.
- The team can show some economic analysis, with and without ARRA grant subsidies, and examine cases on both expected FC life and warranty on FC life.
- The project should validate, or re-evaluate, the David Greene model that predicts a market deployment of 1,000 units that will drive FC costs from \$3,600/kW to less than \$2,000/kW.
- This is a good project. The PI should provide an unbiased account of lessons learned and feedback from the operators and customers.
- Keep completing milestones on time so that all of the project partners have a good experience with hydrogen and FCs.

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