
XII.0 American Recovery and Reinvestment Act Activities

In April 2009, the Department of Energy (DOE) announced the investment of \$41.6 million in American Recovery and Reinvestment Act (ARRA or Recovery Act) funding for fuel cell technologies. These investments were made to accelerate the commercialization and deployment of fuel cells and to spur the growth of 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 awarded to develop and deploy a variety of fuel cell technologies, including polymer electrolyte membrane, solid oxide, and direct-methanol fuel cells in auxiliary power, backup power, combined heat and power, lift truck, and portable-power applications. The cost share provided by the project teams is about \$54 million, more than 56% of the total cost of the projects.

The ARRA fuel cell projects are addressing the objectives stated above as well as the overall ARRA goals of creating new jobs and saving existing ones, spurring economic activity, and investing in long-term economic growth. Significant progress toward these goals has been made, including the deployment of more than 830 fuel cells by the end of FY 2011, out of the total planned deployment of up to 1,000 fuel cells. These deployments have required project teams to address key challenges, including siting and permitting, fueling infrastructure, and fuel cell lifetime and reliability. These deployments have also attracted significant attention, with media events taking place at three of the ARRA deployment sites.

All ARRA project teams submit quarterly reports, which are available to the public through the Recovery.gov website. These reports include technology and deployment status as well as data on jobs created and funds spent. Collection and analysis of operational data from the fuel cell deployments are being performed by the National Renewable Energy Laboratory's (NREL's) Hydrogen Secure Data Center (HSDC) to assess the performance and commercial readiness of the fuel cell technologies. Data are aggregated across multiple systems, sites, and teams, and are made available on a quarterly basis through Composite Data Products (CDPs), published on NREL's website. Eleven presentations containing all CDPs have been published thus far, with the latest CDPs including performance, reliability, maintenance, and safety data for material handling equipment and backup power.

The Hydrogen Safety Panel has made four deployment site visits and has reviewed each project's safety plan. In addition, Sandia National Laboratories (funded through the Safety, Codes & Standards sub-program) has obtained two types of high-pressure hydrogen tanks for testing, from two ARRA project fuel cell partner companies and from tank manufacturers. Tank testing and analysis, which began at Sandia National Laboratories in FY 2010¹, are being done to facilitate market entry for fuel cell-powered lift trucks. This effort continues to address fatigue crack initiation and growth in steel tanks used in high-cycle applications. Testing thus far has shown the engineering predictions to be conservative relative to the performance of the pressure vessels—i.e., the number of cycles to failure has been higher than predicted. The procedures for pressure testing with gaseous hydrogen are being included in Canadian Standards Association HPIT1 and SAE International J2579 working documents for performance testing.

ARRA Project Summaries

Auxiliary Power

Delphi Automotive (Troy, Michigan and Rochester, New York): Delphi is developing a 3- to 5-kW solid oxide fuel cell (SOFC) auxiliary power unit (APU) for heavy-duty commercial Class-8 trucks at their laboratory in Rochester, New York. Delphi will test and demonstrate the diesel APU in a high visibility fleet vehicle that will provide power for vehicle hotel loads and other vehicle needs under real-world operating conditions. There will also be a series of in-house tests, including on-vehicle testing, to validate the “road worthiness” of the diesel APU prior to installation on the demonstration truck. Delphi will provide a comprehensive system specification and—with original equipment manufacturer partner PACCAR—will define commercial requirements. System development efforts will improve Delphi's current-generation SOFC technology by increasing net output power and fuel processing efficiency, decreasing heat loss and parasitic power loss, and establishing diesel fuel compatibility. The primary focus will be accelerating the development

¹“Component Testing for Industrial Trucks and Early Market Applications,” Daniel Dedrick et al., this volume.

and acceptance of the APU by the Class-8 heavy-duty truck market. Partners include Electricore Inc., PACCAR Inc., and TDA Research Inc.

Backup Power

ReliOn Inc. (Spokane, Washington): ReliOn is deploying backup-power fuel cell systems at approximately 190 telecommunications and utility network sites operated by AT&T and Pacific Gas & Electric (PG&E). These deployments span nine states, and they include the deployment of a refillable stationary hydrogen storage module and accompanying refueling logistics platform for AT&T sites. This effort will add reliability to communications networks where no backup power was previously available. ReliOn will provide DOE with data on installation, fueling logistics, and operations for fuel cells in voice and data communications networks in mountain, desert, and urban locations. Partners include Air Products & Chemicals Inc., AT&T, and PG&E.

Sprint Nextel Inc. (Reston, Virginia): Sprint Nextel is planning to demonstrate the technical and economic viability of deploying 1- to 10-kW polymer electrolyte membrane (PEM) hydrogen fuel cells with 72 hours of on-site fuel storage (using a new Medium Pressure Hydrogen Storage Solution with on-site refueling) to provide backup power for critical code division multiple access cell sites on the Sprint Wireless network. Over 200 new hydrogen fuel cell systems will be deployed at sites in California, Connecticut, New Jersey, and New York. Partners include Air Products & Chemicals Inc., Altery Systems, Black & Veatch Corporation, Burns & McDonnell Engineering Co. Inc., Ericsson Services Inc., and ReliOn Inc.

Plug Power Inc. (Latham, New York): This project will demonstrate the market viability of low-temperature, 6-kW PEM GenCore[®] fuel cells fueled by liquid petroleum gas (LPG) to provide clean and reliable primary power and emergency backup power (72 hours or more). Plug Power will install and operate 20 fuel cell systems at Fort Irwin in Barstow, California, and Warner Robins Air Force Base in Warner Robins, Georgia. These units will run continuously on LPG, providing power to the grid and will switch to emergency backup power during a grid failure. A small battery pack will be used to accommodate spikes in power demand. Partners include IdaTech, the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory, Warner Robins Air Force Base, and Fort Irwin.

Combined Heat and Power (CHP)

Plug Power Inc. (Latham, New York): Plug Power is evaluating the performance of up to 12 high-temperature, natural gas-fueled, 5-kW micro-CHP fuel cell units (GenSys Blue[®]). The objective of the project is to validate the durability of the fuel cell system and verify its commercial readiness. Six units will undergo an internal Plug Power test regime to estimate failure rates, and up to six units will be installed and tested in real-world residential and light commercial end-user locations in California. Partners include Sempra Energy and the National Fuel Cell Research Center at the University of California, Irvine.

Fuel Cell-Powered Lift Trucks

FedEx Freight East (Harrison, Arkansas): FedEx is deploying 35 fuel cell systems as battery replacements for a complete fleet of electric lift trucks at FedEx's service center in Springfield, Missouri. Success at this service center may lead to further fleet conversions at some or all of FedEx's other 470 service centers. Partners include Air Products & Chemicals Inc. and Plug Power Inc.

GENCO (Pittsburgh, Pennsylvania): GENCO is deploying 357 fuel cell systems as battery replacements for fleets of electric lift trucks at five existing distribution centers (Coca-Cola in Charlotte, North Carolina; Kimberly Clark in Graniteville, South Carolina; Sysco Foods in Philadelphia, Pennsylvania; Wegmans in Pottsville, Pennsylvania; and Whole Foods in Landover, Maryland). Success at these distribution centers may lead to further fleet conversions at some or all of GENCO's other 109 distribution centers. Partners include Air Products & Chemicals Inc., Linde North America, and Plug Power Inc.

Nuvera Fuel Cells (Billerica, Massachusetts): Nuvera is deploying 14 fuel cell forklifts in H-E-B Grocery Company's distribution facility in San Antonio, Texas. Fuel will be supplied by Nuvera's natural gas reformer and its storage and dispensing system. Partners include H-E-B Grocery Co.

Sysco Houston (West Houston, Texas): Sysco is deploying 98 fuel cell systems as battery replacements for a fleet of lift trucks at Sysco's new distribution center in Houston, Texas, opened in March 2010. This

installation is the first-ever greenfield installation without prior battery infrastructure for a pallet truck fleet. Success at this distribution center may lead to further fleet conversions at some or all of Sysco's other 169 distribution centers. Partners include Air Products & Chemicals Inc. and Plug Power Inc.

Portable Power

Jadoo Power (Folsom, California): Jadoo is developing portable, propane-fueled SOFC generators and an electro-mechanical propane fuel interface as a potential replacement for traditional gas/diesel generators and lead-acid batteries. Two portable fuel cell generators will be deployed in this project. One of them will be used in a demonstration with police and fire first-responders in the City of Folsom, California, to power equipment in emergency and off-grid situations; both units will then be used to power media production equipment at automobile racing events at multiple locations throughout the United States. Partners include Delphi Inc., NASCAR Media Group, and the City of Folsom, California.

MTI MicroFuel Cells (Albany, New York): MTI is demonstrating a 1-watt consumer electronics power pack. The project is focused on improving reliability to meet the standards required by the electronics market and includes testing of individual components, subsystems, and complete direct methanol fuel cell (DMFC) systems. MTI is also developing manufacturing processes to improve product yields and reduce overall costs.

University of North Florida (Jacksonville, Florida): The University of North Florida is continuing work on a portable power system for use in mobile computing, further integrating and miniaturizing the components and analyzing failure modes to increase durability. The power system would be a DMFC that meets their initial commercial entry requirements for power density, energy density, and lifetime. The University will also conduct a design-for-manufacturability-and-assembly review to ensure that the systems meet their cost targets for commercialization. Partners include the University of Florida, Gainesville.

Data Collection & Analysis

National Renewable Energy Laboratory (Golden, Colorado): NREL is analyzing operational data (operation, maintenance, and safety) from the ARRA fuel cell deployments to better understand and highlight the business case for fuel cell technologies. Data collected by the project partners will be stored, processed, and analyzed in NREL's HSDC. Reports on the technology status will be generated on a quarterly basis, while technical CDPs will be published every six months.

FY 2011 Status and Accomplishments

As of the end of September 2011, more than 460 fuel cell lift trucks and more than 370 fuel cell backup-power systems for cellular communications towers and stationary backup-power systems had been deployed, and over 80% of the ARRA project funds had been spent by the projects. A total of 46 direct jobs have been created or retained as a result of these ARRA projects. Supply chain and other indirect jobs are not included—if it is assumed that at least three indirect jobs are created for each direct job, this would indicate that over 180 total jobs were created or retained as a result of these ARRA projects. NREL's HSDC has established data reporting protocols with each of the project teams. CDPs and detailed data products showing progress to date have been prepared. The CDPs are available on the NREL HSDC website, http://www.nrel.gov/hydrogen/proj_fc_market_demo.html. The Fuel Cell Technologies Program's ARRA projects were also included in a recent assessment of the impacts of government policy on the fuel cell industry.²

Auxiliary Power

Delphi Automotive Systems has initiated the system and subsystem vibration analysis and has completed over 20% of their planned thermal cycle testing on their A-Level SOFC APU. They have also conducted initial road testing, driving >3,000 miles with the unit mounted on a Peterbilt Class 8 truck. A new stack with improved system efficiency and new endothermic reformer with improved heat transfer and lower cost have been integrated into the B-Level, next-generation system. Over the next year Delphi will begin monitoring the SOFC APU performance in an on-road, real-world demonstration.

² *Status and Outlook for the U.S. Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities*, David Greene et al., May 2011, http://www.cta.ornl.gov/cta/Publications/Reports/ORNL_TM2011_101_FINAL.pdf.

Backup Power

ReliOn Inc. has completed the site qualification stage for the entire project. As of the end of June 2011, they have installed and commissioned over 270 fuel cells at 118 sites (109 for AT&T and nine for PG&E). Fourteen additional AT&T sites are undergoing construction, and nine more are pending. In 2011 ReliOn will construct and commission all remaining sites, and they will continue to obtain and report operational data to NREL's HSDC.

Sprint Nextel has completed over 580 site surveys at potential deployment sites for their fuel cell backup-power systems. They have installed and commissioned 32 new PEM backup-power fuel cells as of June 2011, with an additional 190 planned over the next year.

Plug Power has installed 10 GenCore[®] fuel cells at the Warner Robins Air Logistics Center, at Warner Robins Air Force Base. The units are providing backup power for lighting within the building. Plug Power also plans to install 10 additional fuel cells at an engineering building at Fort Irwin in Barstow, California, in FY 2012.

Combined Heat and Power

Plug Power is continuing durability tests on its six internal GenSys Blue[®] micro-CHP test systems, which were commissioned in January 2010. Since then, they have logged over 30,000 hours of stack operation, averaging over 30% electrical efficiency and over 85% thermal efficiency. In May and June 2011, three systems were installed at the National Fuel Cell Research Center at the University of California, Irvine, for real-world testing in a light commercial environment. The National Fuel Cell Research Center has also continued its dynamic modeling work of the GenSys Blue[®] system. Over the next year, Plug Power will install fuel cell systems in at least one Sempra Energy customer site in California. A customer site has already been recommended for the first installation.

Fuel Cell-Powered Lift Trucks

FedEx Freight East deployed 35 Class-1 fuel cell-powered lift trucks in June 2010, at their 53,000 square-foot distribution center in Springfield, Missouri. Due to the favorable operational results, they purchased an additional five fuel cell lift trucks, *without any additional DOE funding*. As of April 2011, the lift trucks have accumulated over 28,000 hours of operation and used 13,500 kilograms of hydrogen. FedEx has already seen 30–60% more operating hours in between repairs for fuel cell lift trucks than for propane-powered internal combustion engine lift trucks. Over the next year they will continue to monitor the performance of their fuel cell lift truck fleet, and they plan to work with Plug Power on resolving issues related to cold-weather operation.

GENCO has deployed over 270 GenDrive[®] fuel cells in lift trucks across five distribution facilities as of May 2011. The lift trucks at Wegmans in Pottsville, Pennsylvania, Whole Foods in Landover, Maryland, and Kimberly Clark in Graniteville, South Carolina, are fully deployed and operational. Some of the power units at the Wegmans site have already accumulated over 5,000 hours of operation. Coca-Cola and Sysco Philadelphia have initiated deployments of fuel cell lift trucks, and over the next year, GENCO will deploy the remaining fuel cells to Coca-Cola and Sysco Philadelphia.

Nuvera Fuel Cells installed 14 PowerEdge[™] fuel cells in lift trucks and installed their PowerTap[™] hydrogen infrastructure technology at the H-E-B Grocery Co. distribution center in San Antonio, Texas. As of May 2011, Nuvera's on-site reformer had generated 5,570 kilograms of hydrogen and had maintained 100% hydrogen availability at the pumps. Their lift trucks have accumulated nearly 22,900 hours of operation and have demonstrated a 10% productivity gain over battery-powered lift trucks. Based on the success of this deployment site, H-E-B plans to purchase 28 additional PowerEdge[™] fuel cell units, requiring two additional PowerTap[™] systems—*with no additional DOE funding*.

Sysco Houston has deployed 98 hydrogen fuel cell-powered Class-3 pallet trucks and Class-2 forklifts at their 585,000 square-foot food distribution facility in Houston, Texas. As of February 2011, the lift trucks had accumulated over 300,000 hours of operation and used 17,620 kilograms of hydrogen (from 31,000 fueling events). While Sysco Houston is currently not experiencing any difference in cost between charging batteries and fueling with hydrogen, they are saving nearly \$100,000 annually in fewer man-hours spent refueling

lift trucks compared with swapping batteries. Based in part on the success of this deployment site, Sysco Corporate is planning to replace about 1,000 batteries with 500 or more fuel cells at seven sites over the next 24 months—with no additional DOE funding.

Portable Power

Jadoo Power has completed a detailed analysis of the power needs of NASCAR’s cameras. Desulfurizer hardware from Delphi has been fully tested, and the reformer testing is near completion. Jadoo’s propane fuel interface has been developed and is ready for system integration testing. They have also created preliminary designs for the overall system packaging. Over the next year, Jadoo plans to deploy the systems for the field trial and begin to collect data on the units.

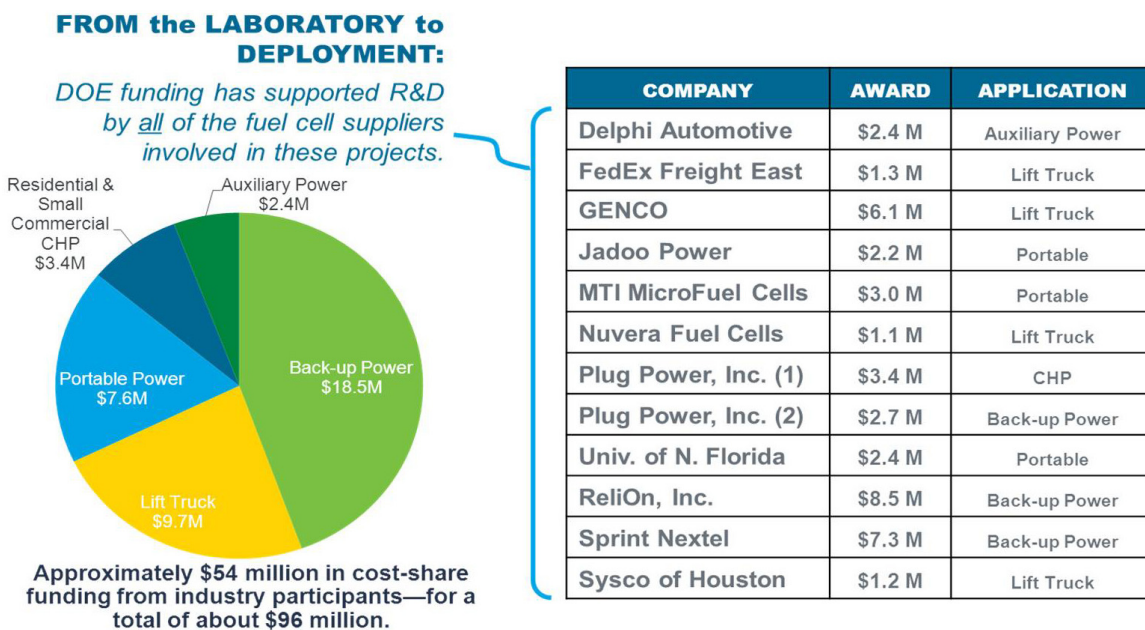
MTI MicroFuel Cells has demonstrated high performance, high fuel efficiency, and low degradation for a one-watt DMFC charger for consumer electronics. They have achieved or exceeded all their technical metrics for the project. MTI sent out 75 complete systems to be tested in real-world environments by individuals, original equipment manufacturers, and government and military personnel. Overall feedback from the field tests has been very positive, and MTI plans to use the data gathered to guide future product development.

The University of North Florida has nearly completed component and subsystem testing for the DMFC portable power system. As of June 2011, three brassboards have been tested, with over 500 hours of operation on each system at multiple locations. The design for the packaged system is complete, with the subassemblies in the manufacturing and assembly phase. The University will assemble multiple packaged systems and test them extensively to evaluate performance, robustness, and durability.

Data Collection & Analysis

NREL has published six deployment-focused CDPs and three cycles of technical CDPs—composed of 42 CDPs for material handling equipment and 10 CDPs for backup power. In addition, they have provided hundreds of detailed data results to the individual projects. NREL has created a website to host these published results and presentations. Over the next year, they plan to continue collecting and analyzing ARRA deployment data and publishing the results on their website.

Budget



FY 2012 Plans

Continued data collection on performance and productivity at the various deployment sites is a priority for FY 2012. In FY 2012, deployment of over 250 additional fuel cell systems for backup power, combined heat and power, and lift truck applications is planned. Five projects are expected to end in early FY 2012. All projects will conclude by the end of FY 2013.

Finally, in FY 2012, DOE will continue to document the lessons learned associated with the ARRA projects, including strategies developed for market entry and management of risks relating to safety, environmental, and siting requirements. Energy Efficiency and Renewable Energy will initiate an evaluation in FY 2012, focused on early-stage “market change” impacts (for the period of 2010 through the end of 2012), of the Recovery Act fuel cell deployments.

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