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## XI.0 American Recovery and Reinvestment Act Activities

### Introduction

In April 2009, the DOE announced the investment of \$41.9 million in American Recovery and Reinvestment Act (ARRA) funding for fuel cell technologies 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 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 (CHP), lift truck, and portable applications. The cost share provided by the project teams is about \$54 million, over 56% of the total cost of the projects.

These projects are addressing 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. Deployment of nearly 1,000 fuel cells is planned in these applications. These efforts have required the DOE and ARRA project teams to identify and address key challenges in technology innovation and deployment, and also in reporting requirements, performance measurement and tracking, and safety and environmental management.

Reports addressing technology and deployment status and jobs and costing data are submitted quarterly by the project teams and are available to the public through the Recovery.gov Web site. Collection and analysis of operational and performance data from the fuel cell deployments are being performed by the National Renewable Energy Laboratory (NREL) 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 quarterly through composite data products (CDPs) available on the NREL Web site. In addition, detailed data products (DDPs), shared only with the project partner, are produced twice annually for each fuel cell system and site. Safety plans are being developed by all project teams and will be reviewed by the Hydrogen Safety Panel.

The Safety, Codes and Standards sub-program is facilitating market entry for fuel cell-powered lift trucks, through tank testing and analysis, which it initiated at Sandia National Laboratories in Fiscal Year (FY) 2010.<sup>1</sup> This effort addresses fatigue crack initiation and growth in steel tanks used in high-cycle applications. The test tanks were obtained from two ARRA project fuel cell partner companies and from tank manufacturers. Hydrogen pressure-cycle testing and engineering analysis of commercial Type-1 hydrogen pressure vessels are being performed under conditions similar to in-service environments for lift truck storage tanks. Results will be used to help inform design methodologies and code development processes for high-frequency refueling applications, and to provide the technical basis for Canadian Standards Association HPIT1.

### ARRA Project Summaries

#### Auxiliary Power

**Delphi Automotive (Troy, Michigan and Rochester, New York):** Delphi will develop 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 heavy-duty truck 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 and acceptance of the APU by the Class-8 heavy-duty truck market. Partners include Electricore Inc., PACCAR Inc., and TDA Research Inc.

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<sup>1</sup>“Hydrogen Safety, Codes and Standards R&D—Materials and Components Compatibility,” Daniel Dedrick et al., this volume.

## Backup Power

**ReliOn, Inc. (Spokane, Washington):** ReliOn is deploying over 150 fuel cell systems into the telecommunications and utility networks at AT&T and PG&E for backup power, across nine states, combined with the deployment of a refillable stationary hydrogen storage module unit 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 installation, fueling logistics, and operating data 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 Corp. (Reston, Virginia):** Sprint Nextel is planning to demonstrate the technical and economic viability of deploying 1-kW 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 [MPHSS] 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 to sites in California, Connecticut, New Jersey, and New York. In addition, 70 already in-service fuel cell systems at cell sites in Louisiana and/or Texas will be converted from a low-pressure storage solution (bottle swap) to the new MPHSS. 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<sup>®</sup> 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 for spikes in power demand. Partners include the Army Corp of Engineers' Construction Engineering Research Laboratory (CERL), Warner Robins Air Force Base, and Fort Irwin.

## Combined Heat and Power

**Plug Power Inc. (Latham, New York):** Plug Power is evaluating the performance of 12 high temperature, natural gas-fueled, 5-kW micro-CHP fuel cell units (GenSys Blue<sup>®</sup>). 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 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):** Over 350 fuel cell systems are being deployed 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 of 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 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 Power 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 battery power sources. 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 further integrating and miniaturizing the components of a portable power system for use in mobile computing, and analyzing failure modes to increase durability. The power system would be a DMFC that meets the requirements for power density, energy density, and operating lifetime. The university will also conduct a design for manufacturability and assembly review to ensure that the systems meet the cost targets for commercialization. Partners include the University of Florida, Gainesville.

### FY 2010 Status and Accomplishments

As of the end of September 2010, 276 fuel cell lift trucks and 24 fuel cell backup systems for communication cell towers had been deployed and 51% of the ARRA project funds had been spent by the projects. A total of 36 direct jobs have been created or retained as a result of the Fuel Cell Technologies ARRA projects (excluding supply chain and other indirect jobs). NREL's HSDC has set up data reporting protocols with each of the project teams. CDPs and DDPs showing progress to-date have been prepared. The CDPs are available on the NREL HSDC Web site, [www.nrel.gov/hydrogen/news/2010/807.html](http://www.nrel.gov/hydrogen/news/2010/807.html).

#### Auxiliary Power

Delphi Automotive Systems has completed initial system specifications and system design and layout for their SOFC APU, and they have identified its commercial requirements. Initial system and subsystem vibration testing and analysis have been completed, as has initial on-vehicle testing and demonstration; component fabrication is underway. Over the next year, Delphi will complete and test the APU system/subsystem build. Delphi will also complete the integration and characterization of the system and begin their full-scale demonstration.

#### Backup Power

Plug Power is working with CERL to identify deployment sites at Warner Robins Air Force Base in Warner Robins, Georgia, and Fort Irwin in Barstow, California, for 20 GenCore<sup>®</sup> fuel cells. It was determined that a system that starts quickly with hydrogen and runs for extended periods with LPG or natural gas is more favorable, economically, than a pure hydrogen system. The first fleet is currently being built and module testing and qualification are being performed.

ReliOn, Inc. has completed the site qualification stage for over 150 communications sites. They have fabricated, integrated, and delivered fuel cell equipment to AT&T for 132 sites, and hydrogen storage modules for 69 sites. Fuel cell equipment has been fabricated and integrated for all nine PG&E sites. ReliOn had installed fuel cells at 24 sites as of the end of September 2010. Technology and methodology for remote monitoring and collection of operational data have been developed.

Sprint Nextel is addressing siting and permitting requirements necessary for the deployment of hydrogen fuel cell systems at their communications sites. Design of the MPHSS is being completed. The project team plans to benchmark the life-cycle costs, performance, and operational characteristics of the hydrogen fuel cell systems against incumbent technologies (batteries and diesel generators).

#### Combined Heat and Power

Plug Power has built and commissioned an internal GenSys Blue<sup>®</sup> micro-CHP test fleet and is conducting durability tests. Control and efficiency of the units have been improved, resulting in faster start-ups and thermal response time, improved heat modulation, and increased total efficiency. Manufacturability improvements have reduced build time by over 55%, and material costs for low-volume production of the fuel cell units have been reduced. Site selection has been initiated for external customer testing in California.

#### Fuel Cell-Powered Lift Trucks

FedEx Freight East deployed 35 fuel cell-powered lift trucks in June 2010 at their distribution center in Springfield, Missouri. These fuel cell systems will serve as battery replacements for the complete fleet of Class-I electric lift trucks in their 53,000-square-foot facility. A permanent hydrogen fueling infrastructure has been built and installed by Air Products & Chemicals, Inc., including liquid hydrogen handling and gaseous compression, storage, and dispensing (for two indoor dispenser stations) equipment. Success in this project may lead to additional fleet conversions at some or all of FedEx's other 470 centers.

Sysco of Houston has deployed 98 hydrogen fuel cell-powered pallet trucks and forklifts at Sysco Corporation's new 585,000-square-foot food distribution facility in Houston, Texas, and a permanent hydrogen fueling infrastructure has been built and installed by Air Products & Chemicals Inc. In the first quarter of 2010, 2,664 fills were logged. On June 17, 2010, business leaders and government representatives attended an official ribbon cutting and media event at this facility.

GENCO has deployed 59 GenDrive<sup>®</sup> fuel cell lift trucks at a Wegmans' distribution facility in Pottsville, Pennsylvania. The units logged over 24,000 operating hours during the first quarter of 2010. The Wegman's fueling station completed almost 2,000 hydrogen fills during the first quarter of 2010. By the end of September 2010, 61 GenDrive<sup>®</sup> fuel cell lift trucks were delivered to Whole Foods in Landover, Maryland, and nine fuel cell lift trucks were delivered to Kimberly Clark in Graniteville, South Carolina. Deployment of an additional 228 fuel cell lift trucks is planned for four different distribution facilities.

Nuvera has installed 14 PowerEdge<sup>™</sup> fuel cells in lift trucks and completed installation of their PowerTap<sup>™</sup> hydrogen infrastructure technology at the H-E-B Grocery Co. distribution center in San Antonio, Texas. At this site, fuel cell forklifts and battery forklifts are operating in parallel to allow direct comparison. An initial productivity gain of 10% from the use of fuel cells instead of lead-acid batteries has been reported.

#### Portable Power

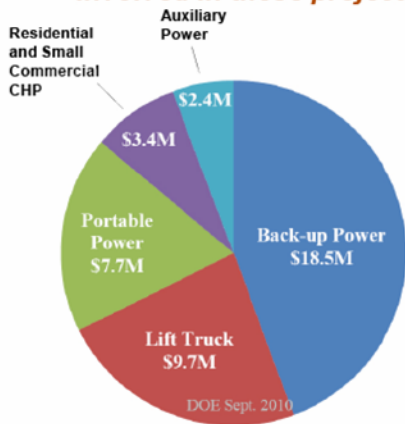
Jadoo has developed preliminary requirements for the portable generator and fuel interface. Desulfurizer hardware has been delivered from Delphi and reformer testing has been initiated. Existing technologies and methodologies applicable to a portable SOFC propane fueling system have been compared and evaluated. Site specific baseline load data on media equipment power requirements have been collected.

MTI MicroFuel Cells has demonstrated reduced cost, manufacturability, and assembly for a redesigned one-watt DMFC charger for consumer electronics. System level testing has verified that the charger is capable of operating well during transients such as start-up and shut-down and at all specified temperatures, humidity, and orientations. High power density, high fuel efficiency, and low stack degradation rates exceeding product requirements have also been demonstrated. Seventy-five fuel cell charger systems are being deployed to organizations and individuals for evaluation and feedback.

The University of North Florida has completed component design requirements for the DMFC portable power system and started analysis of design failure modes. The university will continue component development and testing and will demonstrate that component performance meets system requirements. Subsequently, they will integrate components and subsystems into a packaged unit and conduct extensive system tests to evaluate performance, robustness, and durability.

**Budget**

**FROM the LABORATORY to DEPLOYMENT:**  
 DOE funding has supported R&D by all of the fuel cell suppliers involved in these projects.



Approximately \$54 million in cost-share funding from industry participants—for a total of about \$96 million.

COMPANY	AWARD	APPLICATION
Delphi Automotive	\$2.4 M	Auxiliary Power
FedEx Freight East	\$1.3 M	Lift Truck
GENCO	\$6.1 M	Lift Truck
Jadoo Power	\$2.2 M	Portable
MTI MicroFuel Cells	\$3.0 M	Portable
Nuvera Fuel Cells	\$1.1 M	Lift Truck
Plug Power, Inc. (1)	\$3.4 M	CHP
Plug Power, Inc. (2)	\$2.7 M	Back-up Power
Univ. of N. Florida	\$2.5 M	Portable
ReliOn, Inc.	\$8.5 M	Back-up Power
Sprint Nextel	\$7.3 M	Back-up Power
Sysco of Houston	\$1.2 M	Lift Truck

**FY 2011 Plans**

Completion of all project safety plans and National Environmental Policy Act compliance reviews are priorities for early FY 2011. The Fuel Cell Technologies Safety Panel will review the project safety plans and submit formal written assessments to DOE and the project teams. In addition, safety panel members will visit at least four project sites to discuss project-specific safety issues, as well as findings that may have broader impact on the fuel cell community.

In FY 2011, deployment of over 500 additional fuel cell systems for backup power, CHP, and lift truck applications is planned. It is anticipated that the NREL HSDC will be able to report performance and productivity data in FY 2011, beginning with the first-quarter FY 2011 CDP.

Finally, in FY 2011, DOE will begin documentation of lessons-learned associated with the ARRA projects, including the strategies developed for risk management with respect to safety, environmental and siting requirements, and market entry. Planning for business case analysis and case studies will be initiated.

Sara Dillich

Lead for Fuel Cell Technologies ARRA Activities and  
Hydrogen Production & Delivery Team Lead (Acting)  
Fuel Cell Technologies Program  
Department of Energy  
1000 Independence Ave., SW  
Washington, D.C. 20585-0121  
Phone: (202) 586-7925  
E-mail: Sara.Dillich@ee.doe.gov