
X.0 Market Transformation Activities

Introduction

The Market Transformation sub-program is conducting activities to help promote and implement commercial and pre-commercial hydrogen and fuel cell systems in real-world operating environments and to provide feedback to research programs, U.S. industry manufacturers, and potential technology users. One of the sub-program's goals is to achieve sufficient manufacturing volumes in emerging commercial applications that will enable cost reductions through economies of scale, which will help address the current high cost of fuel cells (currently the capital and installation costs of fuel cells are from five to six times higher than incumbent technologies¹). These early market deployments will also address other market acceptance factors, resulting in further expansion of market opportunities.

Current key objectives of the Market Transformation sub-program are to build on past successes in material handling equipment, such as lift trucks, and emergency backup power applications that were part of the Recovery Act, by exploring potential and emerging applications for market viability. Fiscal Year (FY) 2011 activities were primarily focused on initiating 10 diverse projects, using FY 2010 appropriations. These projects are highly leveraged, with an average of more than half of the projects' funds being provided by DOE's partners. Partners providing resources to these projects have shown a high level of interest in exploring these applications and markets, and this level of industry interest is very promising for the potential growth of the domestic fuel cell industry.

Goals

Market Transformation activities provide financial and technical assistance for the use of hydrogen and fuel cell systems in early market applications, with the key goals of achieving sales volumes that will enable cost reductions through economies of scale, supporting the development of a domestic industry, and providing feedback to testing programs, manufacturers, and potential technology users.

Objectives²

- Advance the knowledge and expertise regarding the use of fuel cells for waste-to-energy systems, shipboard auxiliary power units (APUs), and aviation applications through targeted testing and evaluation efforts in coordination with the Technology Validation sub-program and in partnership with Department of Defense (DOD) and civilian agencies such as the Department of Agriculture and the Federal Aviation Administration by evaluating design requirements for aircraft APUs by 2012, shipboard APUs by 2013, and waste-to-energy fuel cells by 2014.
- By 2013, establish baseline energy efficiency and reliability performance metrics for commercially available emergency backup power, material handling, and light commercial/residential power fuel cell systems and provide feedback to component suppliers regarding cost reduction opportunities.
- By 2014, test emerging approaches to grid management using renewable hydrogen storage and fuel cell systems, in coordination with the DOE Office of Electricity Delivery and Energy Reliability.
- By 2015, develop and launch energy efficiency and reliability certification programs for fuel cells.
- By 2016, Identify lessons learned from existing policies and regulations and promote the development of effective and applicable incentives for hydrogen and fuel cell technologies.
- By 2020, enable capital equipment cost of fuel cell-powered lift trucks and emergency backup power systems to be on a par with conventional technologies.

FY 2011 Status

Fuel cells have been enjoying growing success in key early markets, particularly in material handling (e.g., forklift) and backup power applications. The Program's early market deployment efforts—including Market Transformation funding and Recovery Act funding—have successfully catalyzed a significant level of market

¹ *Catalog of CHP Technologies*, U.S. Environmental Protection Agency, December 2008, www.epa.gov/chp/basic/catalog.html.

² Note: Targets and milestones are under revision; therefore, individual progress reports may reference prior targets.

activity in these areas, which has been accompanied by substantial reductions in the price of fuel cells. The sub-program is actively pursuing additional opportunities for effective stimulation of market activity. Ongoing activities and additional areas of interest include the following:

- **Backup Power:** A joint effort has been initiated by DOD's U.S. Army Corps of Engineers and the Program to install 18 emergency backup power fuel cell systems at eight DOD locations. Data will be collected and analyzed during a five-year period of operation.
- **Hydrogen Bus Deployment:** The Program is continuing to support the deployment of hydrogen-powered internal combustion engine buses produced by Ford Motor Company. The buses are being used at national laboratories and federal facilities, for special events, campus tours, new employee orientations, and as part of shuttle bus fleets.
- **Combined Heat and Power (CHP) Feasibility Studies:** Eleven technical, site-specific feasibility studies have been completed. The resulting reports, which assess the installation and operation of distributed power or CHP fuel cells at DOE locations, have been provided to U.S. fuel cell manufacturers; discussions about specific siting and financing options are underway at several sites, including Los Alamos National Laboratory and the National Renewable Energy Laboratory.
- **Material Handling Equipment (MHE):** As a complement to the hydrogen fuel cell forklift deployments currently underway, the sub-program is investigating the use of direct methanol fuel cell (DMFC) technologies. DMFC MHE will provide the same operational benefits as hydrogen-powered fuel cell MHE, with significant additional benefits from the use of a liquid fuel, including reduced infrastructure costs, high energy density, and low overall fueling costs. Other activities involving hydrogen-fueled lift trucks are ongoing, including collaboration with the Defense Logistics Agency (DLA). The DLA's Eastern Distribution Center now has 55 fuel cell-powered lift trucks. Recent deployments of fuel cell-powered stand-up lift trucks have completed the portfolio of MHE classes that have been retrofitted, which could lead to the complete elimination of battery infrastructure at DOD sites that fully convert to fuel cell power for their MHE needs.
- **Mobile Lighting:** The sub-program is exploring the potential for expanded use of fuel cells for mobile lighting, which is commonly used for road maintenance, general construction, and large outdoor events. Unlike conventional diesel-based systems, fuel cells offer the benefits of nearly silent operation, with no harmful exhaust emissions. Working with manufacturers of fuel cells and mobile lighting equipment, the Program has supported the design, construction, and testing of fuel cell power mobile lighting prototypes (Sandia National Laboratories). Demonstration and testing was conducted at a Boeing Manufacturing Plant, NASA Kennedy Space Center, Caltrans, Paramount Pictures/Saunders Electric, and the San Francisco International Airport.
- **Market Analysis and Deployment Tools:** The sub-program continues to pursue opportunities for collaboration through the DOE-DOD memorandum of understanding, including two projects that have analyzed the technical feasibility of using fuel cells for auxiliary power onboard commercial passenger airliners, addressing both low-temperature polymer electrolyte membrane (PEM) fuel cells (Sandia National Laboratories), and high-temperature ceramic-type fuel cells (Pacific Northwest National Laboratory).
- **Micro CHP:** To document market viability of fuel cells for small facilities, the sub-program is working with fuel cell manufacturers and their partners to demonstrate CHP systems at several light commercial facilities. Baseline technical performance models have been established, the most competitive projects have been selected, and a final contract has been issued with ClearEdge Power to provide up to 38 fuel cells at up to 10 locations. A key objective of this work is to obtain performance data on these systems over the course of several years.
- **Green Communities:** The sub-program is working to help communities incorporate hydrogen and fuel cell technologies into their existing energy efficiency, sustainable energy, and greenhouse gas reduction plans. A decision-matrix tool has been developed and has been used to identify five community types as having high potential benefits for deployment of hydrogen and fuel cells. Actual communities will be selected through the Sources Sought and Request for Proposal processes. The sub-program's efforts in this area also include identifying opportunities for education and outreach to increase the public's awareness of hydrogen and fuel cell technologies.
- **Big Island of Hawaii Hydrogen Energy Storage Project:** In partnership with the Naval Research Laboratory and the University of Hawaii's Hawaii Natural Energy Institute, the sub-program is supporting

the demonstration of using a hydrogen energy storage system as a grid management tool. While hydrogen produced from the system could be used for a variety of value-added products, the initial phase of the project will use the hydrogen to fuel two Ford E-450 shuttle buses operated by the County of Hawaii Mass Transportation Agency.

- **South Carolina Landfill Gas Purification Project:** The sub-program is demonstrating the business case and technical viability of using landfill gas (LFG) as a source of renewable hydrogen production, using BMW's assembly plant in South Carolina as the host site. Should such a scale-up operation prove viable, it would represent a first-of-its-kind LFG-to-hydrogen production project in the nation, and it would serve as a model for future adoption of renewable biogas as a feedstock for hydrogen production.

FY 2011 Accomplishments

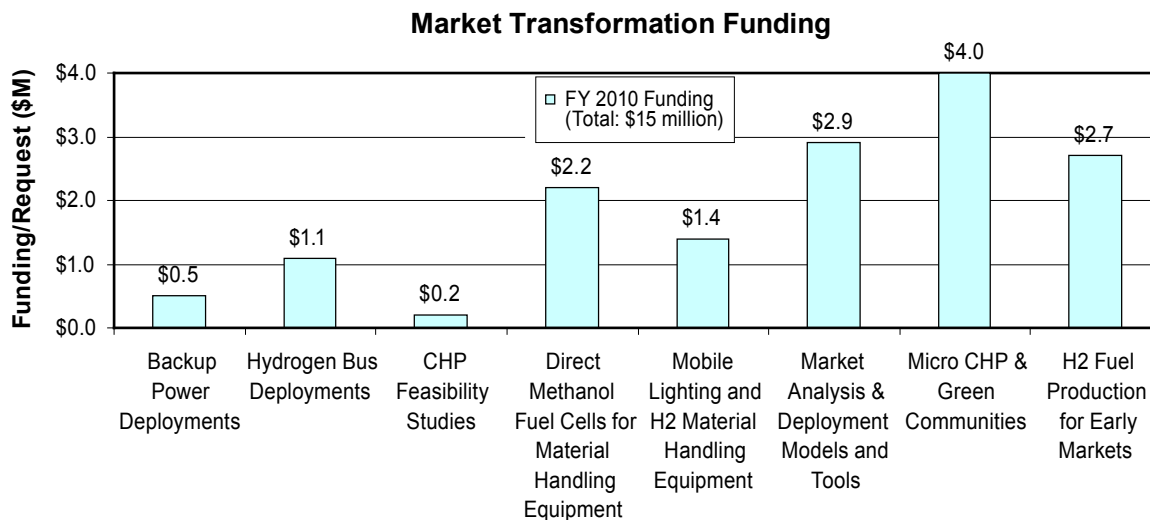
In FY 2011, the sub-program developed deployment tools and business cases for various fuel cell applications, conducted public outreach activities, and analyzed and tested potential new early markets in mobile lighting, DMFC-powered lift trucks, and auxiliary power. The following are some of the key milestones the sub-program achieved in FY 2011:

- Created a federal fuel cell user's forum for backup power fuel cells deployed at Army, Navy, NASA, and national laboratory sites.
- Completed design of a fuel cell mobile lighting system that combines high-pressure (5,000 psi) hydrogen storage, efficient plasma lighting, and a 5-kW PEM fuel cell; built five fuel cell mobile lights that are being field tested at industry and government installations; and expanded public awareness of the technology by using fuel cell mobile lighting at the 2011 Golden Globe Awards and 2011 Grammy Awards.
- Completed deployment and outreach activities for 22 hydrogen-powered buses at federal facilities and national laboratories. The buses were shown to thousands of attendees at several events such as the "Taste of Colorado" in Golden, Colorado; the Innovation for Green Advanced Transportation Excellence's National Energy Systems Technology Incubator opening in Livermore, California; the Southwest Region Fleet Transportation Regional Managers Conference in Camp Pendleton, California; "Expanding Your Horizons in Math and Science" in San Ramon, California; and at multiple Earth Day Celebrations in California, Hawaii, and South Carolina.
- Developed a decision matrix tool that highlights the most promising community types for hydrogen and fuel cell system deployment projects; and used this tool to rank 56 community types, with the top five identified as "high-potential" deployment sites for hydrogen and fuel cell systems.
- Published a business case for a utility with renewable resources, in which excess or "spilled" wind power is used to produce hydrogen via electrolysis for later use in fuel cell power generation; and updated utility energy storage model to include purchase of curtailed wind energy. A key conclusion is that hydrogen produced from un-dispatchable renewable power can be used for grid management and high-value products, such as transportation fuel.
- Developed overall system requirements, specifications, and a conceptual system design for a hydrogen energy storage system to be used as a grid management tool.
- Built, tested, and delivered 75 DMFCs to customer warehouse sites for use and testing in class-III material handling equipment.
- Completed a feasibility study of a LFG-to-hydrogen project. A key finding is that LFG-to-hydrogen production needs to be at a rate of more than 500 kg/day to be competitive with vendor-supplied hydrogen.
- For aircraft auxiliary power applications, analyzed the electrical system using a PEM fuel cell on a direct current bus that will reduce power conversion losses and reduce in-flight jet fuel consumption; obtained extensive information from Boeing on the 787 electrical system, including generation and distribution systems, load profiles, and fuel consumption. A key finding was that for some hotel power loads—such as galley and peak-power needs—the use of a PEM fuel cell APU could save up to 30% of the jet fuel these loads would normally consume (which would result in a reduction of 20,000 metric tons of CO₂ emissions annually, for a fleet of 1,000 airplanes).³

³ Pratt, J. W., et al., "Proton Exchange Membrane Fuel Cells for Electrical Power Generation On-Board Commercial Airplanes," Sandia National Laboratories, May 2011, http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pem_onboard_airplane.pdf.

Budget

No funding was requested for Market Transformation in FY 2011 or FY 2012. With the market successes that have been achieved by fuel cells in lift trucks and backup power applications as a result of FY 2009 and Recovery Act funding, the focus of FY 2010 funds was on new applications, such as micro CHP and mobile lighting applications.



FY 2012 Plans

In FY 2012, the sub-program will continue to document lessons learned associated with previously funded projects, including the strategies developed for market entry and for risk management with respect to safety, environmental, and siting requirements. Planning for business case analysis and case studies will be initiated. Collection and evaluation of data from these projects will provide the basis for verifying the business cases for various early market fuel cell systems, as well as providing an assessment of the performance of these integrated systems. Data will be made publicly available so that more customers will become aware of the benefits of integrated hydrogen and fuel cell systems. In addition, a near-term priority will be to continue collaborating with other federal agencies—in accordance with existing interagency cooperative agreements such as the DOE-DOD memorandum of understanding—to increase the use of fuel cells in market-ready applications and to increase awareness of the benefits of these deployments.

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