XII.7 Analysis Results for ARRA Projects: Enabling Fuel Cell Market Transformation

Jennifer Kurtz (Primary Contact), Keith Wipke, Sam Sprik, Todd Ramsden, Genevieve Saur, and Chris Ainscough
National Renewable Energy Laboratory (NREL)
1617 Cole Blvd.
Golden, CO 80401
Phone: (303) 275-4061
E-mail: jennifer.kurtz@nrel.gov

DOE Manager
HQ: Sara Dillich
Phone: (202) 586-7925
E-mail: Sara.Dillich@ee.doe.gov

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Pacific Northwest National Laboratory, Richland, WA

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Objectives

- Independent technology assessment in real-world operation conditions focusing on fuel cell system and hydrogen infrastructure.
- Leverage data processing and analysis capabilities developed under the Fuel Cell Vehicle Learning Demonstration.
- Support market growth through reporting on technology status to key stakeholders and analyses relevant to the markets' value proposition.
- Study fuel cell systems operating in material handling equipment (MHE), backup power, portable power, and stationary power applications; includes up to 1,000 deployed fuel cell systems.

Technical Barriers

This project addresses the technical barrier of commercialization of fuel cells in key early markets and the associated performance capabilities and benefits.

Technical Targets

- Deployment of up to 1,000 fuel cell systems: By December 2010, 557 systems were delivered and 483 of those systems were in operation.

Accomplishments

- Expanded the NREL Fleet Analysis Toolkit (NRELFAT) to include MHE, backup power, and stationary power data processing, analysis, and reporting.
- Published three deployment focused Composite Data Products (CDPs), updated on a quarterly basis.
- Published two cycles of technical focused CDPs (42 CDPs for MHE and 10 CDPs for backup power data) and hundreds of detailed data results were shared with individual data providers, updated bi-annually. Key performance results include operation time, fill time, maintenance, reliability, safety, usage patterns, and durability.
- Created a website and maintained it for all published results and presentations.

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Introduction

The DOE has designated more than $40 million in American Recovery and Reinvestment Act (ARRA) funds for the deployment of up to 1,000 fuel cell systems. This investment is enabling fuel cell market transformation through development of fuel cell technology, manufacturing, and operation in strategic markets where fuel cells can compete with conventional technologies. The strategic markets include MHE, backup power, stationary power, and portable power, where the majority of the deployed systems are in the MHE and backup power markets. NREL is analyzing operational data from these key deployments to better understand and highlight the business case for fuel cell technologies and report on the technology status.

Approach

Data (operation, maintenance, and safety) are collected on site by the project partners for the fuel cell system(s) and infrastructure. NREL receives the data quarterly and stores, processes, and analyzes the data in NREL's Hydrogen Secure Data Center (HSDC). The HSDC is an off-network room with access for a small set of approved users. An internal analysis of all available data is completed quarterly and a set of technical CDPs are published every six months. The CDPs are aggregated data across multiple systems, sites, and teams in order to protect proprietary data and summarize the performance of hundreds of fuel cell systems and thousands of data records. A review cycle is completed before the publication of CDPs. The review cycle includes Detailed Data Products (DDPs) of individual system and site performance results provided to the individual data provider. DDPs also identify the individual contribution to CDPs. NRELFAT is an internally created tool for data processing and analysis structured for flexibility, growth, and applications. Analyses are created for general performance studies as well as application or technology specific studies.

Results

NREL created NRELFAT to efficiently process and analyze large amounts of data for the study of performance at the system, fleet, application, and across applications levels. Because the analysis results are created with multiple purposes and expected audiences, the set of results is varied and comprehensive of many aspects of the hydrogen and fuel cell deployments.

One result topic is where the systems are deployed and what some of the site specifications are. Each marker on the map in Figure 1 identifies the application, system(s) location, and deployment size at that site. There are 96 backup power sites (with more sites to be determined in the next few months), but most have only one to three systems installed at the site. There are eight MHE sites, but some of these sites have around 100 systems operating. Fuel cell systems are deployed in many regions of the United States, expanding the user base familiar with hydrogen and fuel cell technologies.

In the set of results published in the spring of 2011, 308 MHE systems were analyzed and had accumulated 307,433 operation hours in less than one year. Each site has a different system and operational conditions for the fuel cell MHEs. Figure 2 highlights the variation in average daily fuel cell system operation hours by fleet. (A fleet is a collection of same class MHEs and a site may have multiple fleets.) The range of average daily operation hours is between two and eight hours.

Refuel time is a critical performance metric for the operation of fuel cell MHEs and benefit over competing technologies. Figure 3 depicts the fueling rate for 38,795 hydrogen fills with an average of 0.33 kg/min. The inset graph highlights that all of the sites averaged very similar fill rates. The average fill time was just under two minutes per fill.

The backup power deployments have a very different operating metric than the fuel cell MHE sites. In certain locations a backup system may not operate because of a grid outage for many months. Figure 4 depicts the number of attempted and successful starts by calendar month as well as conditioning starts. A conditioning start is an automated operation for regular system checks and hydration after long periods of no operation (typically a month). Conditioning starts account for 59% of the start attempts and 408 out of 409 starts were successful.

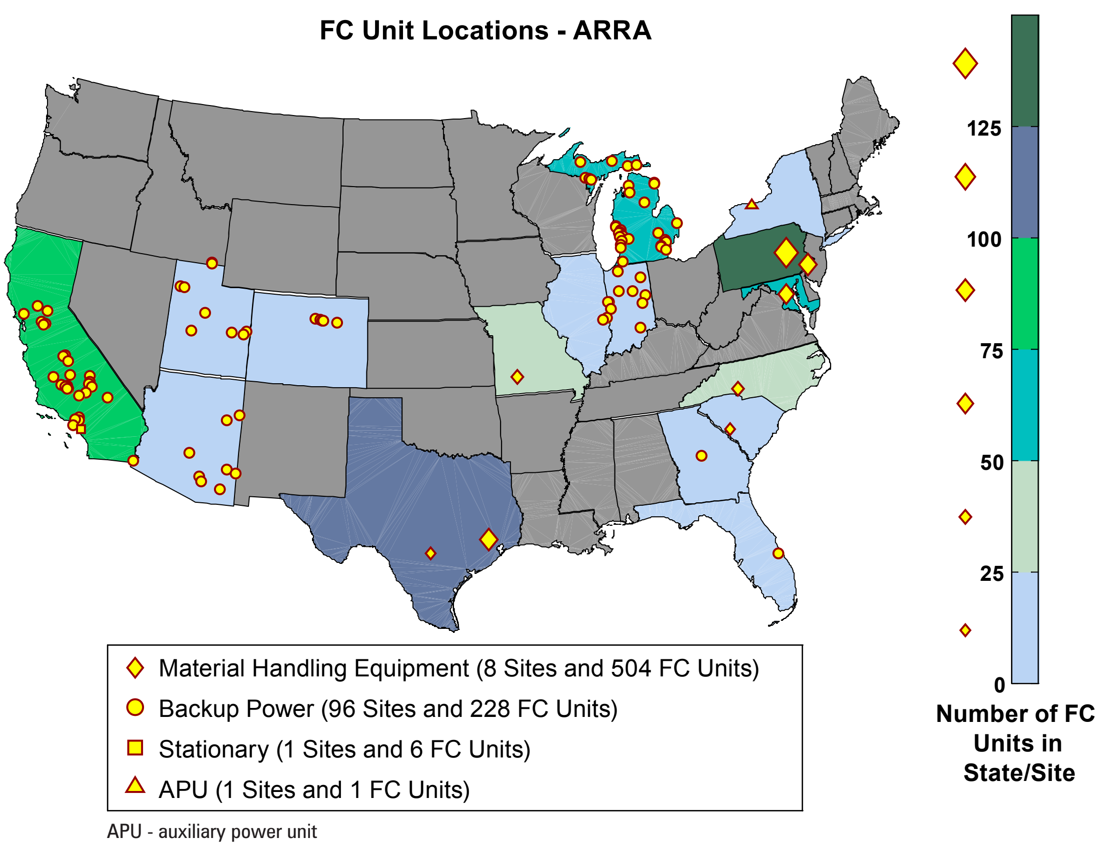

FIGURE 1. Fuel Cell (FC) System Locations by Application and Deployment Size

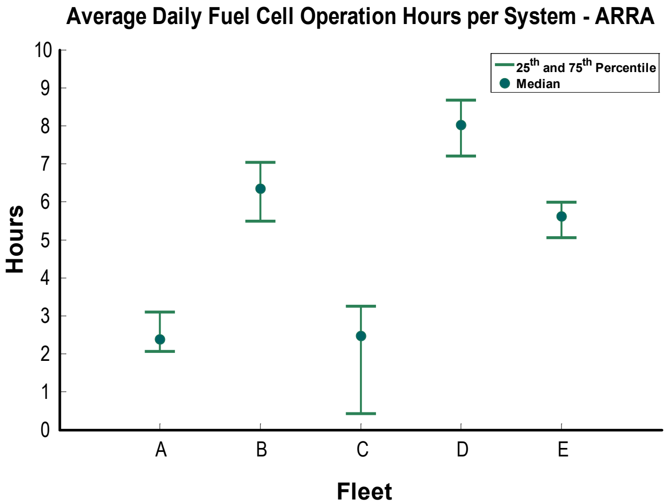

FIGURE 2. Average Daily Fuel Cell System Operation Hours by Fleet

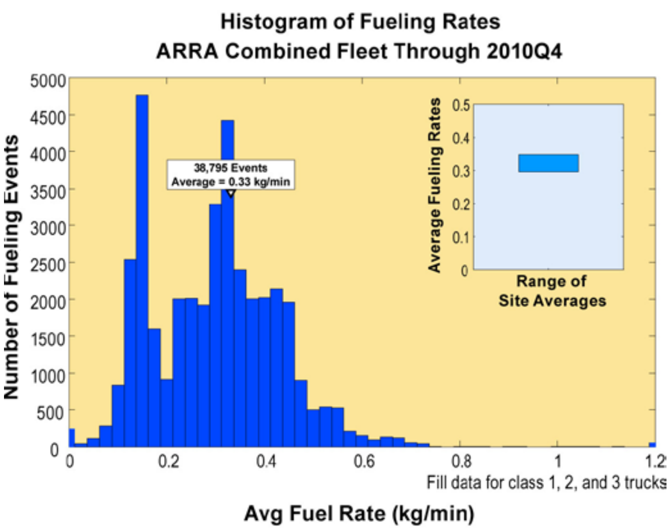

FIGURE 3. MHE Histogram of Fueling Rates and Range of Site Average Fueling Rates

Conclusions and Future Direction

This project has seen rapid deployment of hundreds of fuel cell systems in markets where the technology is ready to compete with incumbent technologies. Many aspects of the deployment and operation are analyzed and reported on via the CDPs. The CDPs have highlighted the magnitude of operation in operation hours (over 307,600 hours combined) and hydrogen fills (over 38,800 combined). These systems are demonstrated the capability to meet end user demands while learning lessons to integrate into future products and the operations are proving to be safe.

Planned future work includes:

- Quarterly publication of deployment focused CDPs.

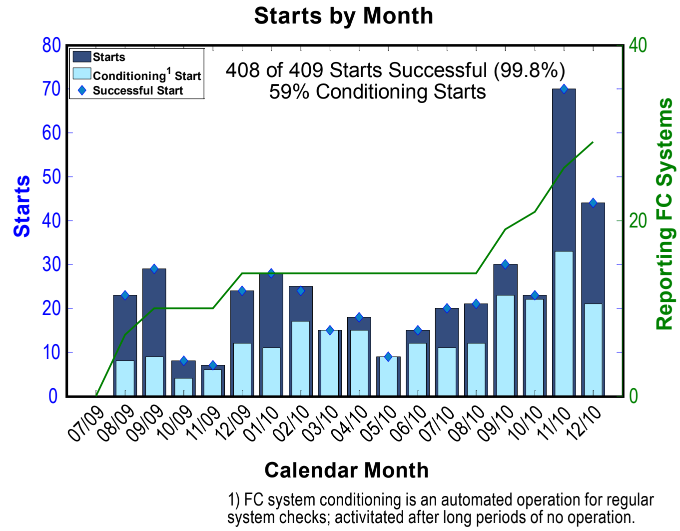

FIGURE 4. Count of Backup Power Attempted and Successful Starts by Month

- Bi-annual publication of technical focused CDPs and DDPs.
- Technical monitoring and coordination of hydrogen safety panel reviews and site visits.
- Quarterly analysis of operation, maintenance, and safety data for fuel cell systems and hydrogen infrastructure.
- Collaboration with key stakeholders to identify valuable analyses for technology status updates and metrics important to the value proposition.

FY 2011 Publications/Presentations

1. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Analysis Results of ARRA Fuel Cell Early Market Projects." Presented at Hydrogen + Fuel Cells 2011 conference May 17, 2011.

2. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Analysis Results for ARRA Projects: Enabling Fuel Cell Market Transformation." Presented at DOE's Annual Merit Review February 16, 2011.

3. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Early Fuel Cell Market Deployments: ARRA and Combined - May 2011." Published May 10, 2011.

4. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "ARRA Fuel Cell Deployments: Operation Data Overview." Presented at Hydrogen Safety Panel Meeting February 16, 2011.

5. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Spring 2011 Composite Data Products - ARRA Material Handling Equipment." Published April 6, 2011.

6. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Spring 2011 Composite Data Products - Backup Power." Published March 29, 2011.

7. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Analysis Results for ARRA Fuel Cell Deployments." Presented at Fuel Cell and Hydrogen Energy Association February 16, 2011.

8. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Early Fuel Cell Market Deployments: ARRA and Combined - February 2011." Published February 10, 2011.

9. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T.; Saur, G.; Ainscough, C. "Early Fuel Cell Market Deployments: ARRA and Combined - November 2010." Published November 30, 2011.

10. Kurtz, J.; Wipke, K.; Sprik, S.; Ramsden, T. "ARRA Fuel Cell Deployment and Operation." Presented at 2010 Fuel Cell Seminar October 20, 2011.