VII.D.2 Material Handling Equipment Data Collection and Analysis

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Project Start Date: October, 2012
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

- Perform independent technology assessment in real-world operation conditions.
- Focus on fuel cell system performance and operation.
- Leverage data processing and analysis capabilities developed under the fuel cell vehicle learning demonstration project.
- Evaluate material handling equipment (MHE).
- Support market growth.
- Provide analyses and results relevant to the markets' value proposition.
- Report on technology status to fuel cell and hydrogen communities and other key stakeholders like end users.

Fiscal Year (FY) 2016 Objectives

- Leverage existing data and results developed under the American Reinvestment and Recovery Act (ARRA) to continue the collection of MHE data on new systems, on a voluntary basis.
- Validate the status of the MHE market, which continues to expand and evolve.
- Develop at least 20 updated Composite and Detailed Data Products (CDPs and DDPs) on fuel cell MHE on durability, operation, and infrastructure performance.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

(A) Lack of Fuel Cell Electric Vehicle and Fuel Cell Bus Performance and Durability Data

(D) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

Contribution to Achievement of DOE Technology Validation Milestones

This project contributes to achievement of the following DOE milestones from the Technology Validation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

- Milestone 4.2: Updated composite data products for material handling and backup power published. (3Q, 2012)
- Milestone 4.3: Report safety event data and information from ARRA projects. (3Q, 2013)

FY 2016 Accomplishments

- Published the tenth set of technical CDPs on performance and operation for MHE, with 12 updated (and one new) results.[1]
- Negotiated access to the largest single set of technology validation data in the program's history for the second year in a row, including approximately 2,000 new-generation vehicles in different MHE classes, from private commercial sites receiving no direct government funding.
- Documented over 450,000 hydrogen fills.
- Validated mean fueling time of 2.2 min, which is key to the fuel cell MHE value proposition. This is a 13% decrease since last year.
- Validated average daily site hydrogen usage of 230 kg/d. Newer sites use much more than older sites, indicative of the penetration of fuel cells into distribution center operations.
- Validated mean vehicle operating times between fueling of 4.5 h, up from 3.7 h last year, a 22% increase.

[1] All results and publications are available on NREL's technology validation website, at http://www.nrel.gov/hydrogen/proj_fc_market_demo.html#cdp

INTRODUCTION

The U.S. Department of Energy designated more than $40 million in 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, and the majority of the deployed systems are in the MHE and backup power markets. NREL continues to analyze operational data from the MHE sector, because it is the market segment with the most rapid growth and technological evolution. MHE data are currently provided voluntarily by industry. The data collection has ended for backup power and stationary systems.

The project includes both end users and system developers: Air Products, FedEx, GENCO, Nuvera Fuel Cells, Plug Power, and Sysco Houston. The evaluation focused on fuel cell stack durability, reliability, refueling, safety, and value proposition. The deployment partners provided approximately $53 million in industry cost share [1]. In addition to the ARRA co-funded fuel cell backup power demonstrations, DOE supported additional demonstration projects with other federal agencies through interagency agreements. The Department of Defense and the Federal Aviation Administration are two agencies with fuel cell backup power demonstrations that also submitted operational and deployment data to NREL. All results covered in this report will include ARRA and private commercial sites that received no direct government funding. The degradation result, Figure 1, also includes interagency agreement data.

APPROACH

The project's data collection plan builds on other technology validation activities. Project partners collect operation, maintenance, and safety data for fuel cell system(s) and accompanying infrastructure. Then they send data to NREL in a manner consistent with security procedures. NREL receives the data quarterly, then stores, processes, and analyzes the data in NREL's National Fuel Cell Technology Evaluation Center (NFCTEC). The NFCTEC is a controlled-access, off-network analysis facility. An internal analysis of all available data is completed quarterly, and a set of technical CDPs is generally published every six months. Publications are uploaded to NREL's technology validation website [2] and presented at industry-relevant meetings. The CDPs present 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 CDPs are published. This review cycle includes providing DDPs of individual system and site performance results to the specific data provider. DDPs also identify the individual contribution to the CDPs. The NREL Fleet Analysis Toolkit is an internally developed tool for data processing and analysis structured for flexibility, growth, and simple addition of new applications. Analyses are created for general performance as well as application- or technology-specific studies.

RESULTS

The initial ARRA funding for MHE kicked off rapid growth of the fuel cell MHE industry. This growth is reflected directly in the large amount of additional data NREL was able to secure from private commercial sites receiving no direct government funding.

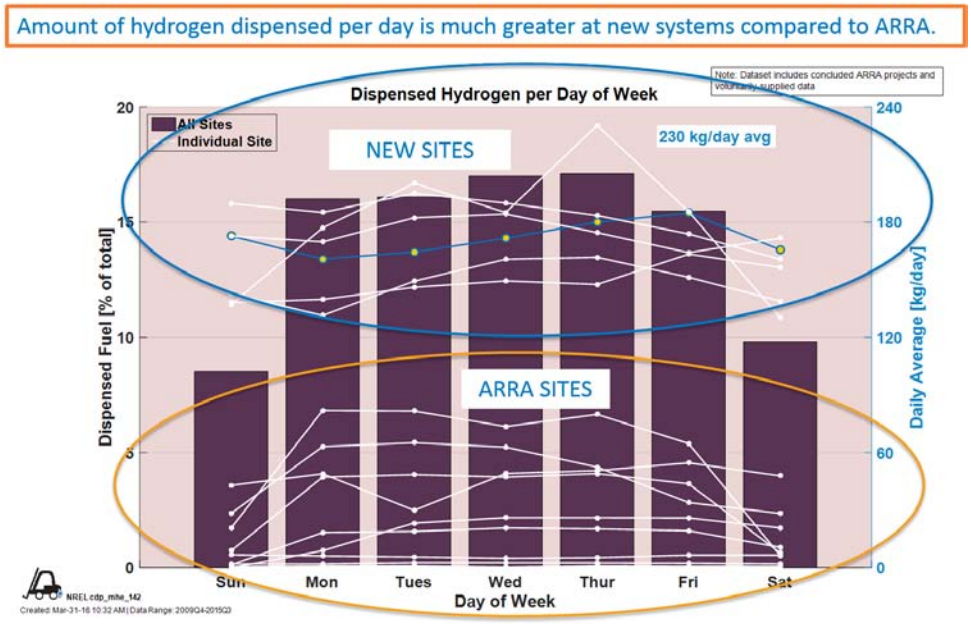
The new data set represents an increase in vehicles represented by approximately 2,000. This new data set dwarfs all other ARRA data combined. Yet, these data represent only a piece of the MHE fleet deployed in United States logistics warehouses. MHE are broken down into classes based on the capabilities of the vehicle. These data represent Class I (sit-down counterbalance), II (stand-up, high reach, narrow aisle), and III (powered pallet jacks and tow tractors) trucks.

The new fleet data represent newer systems, which are newer-generation technologies being deployed in ever-greater numbers. This can be seen in Figure 1, showing the average daily hydrogen usage at ARRA sites as a cluster well less than 100 kg/d. Newer sites cluster around 180 kg/d.

As reported earlier in this project [1], refueling time (i.e., fast fueling) is critical to the value proposition for MHE. Without fast fueling, the productivity improvements upon which distribution centers rely become much more difficult to achieve, with a corresponding increase in the difficulty of justifying fuel cells. Over the past year, fueling times have decreased 13% to an average of 2.18 minutes, down from 2.5 minutes (see Figure 2). This was achieved with an average fill amount of 0.61 kg.

Operation times have increased 22% from last year to an average of 4.5 h (see Figure 3). This does not necessarily represent the vehicle autonomy, as there are other human factors that dictate when fueling is convenient (e.g. breaks, shift changes, or proximity to a fuel dispenser).

One-third of fueling events take place within 5 min of one another, and 19% within 20 min (see Figure 4). This usage pattern has important implications for station design with respect to back-to-back fills, something that light duty vehicle stations currently struggle with. The shift from 250 bar fueling is complete, with 250 bar fueling only represented in the ARRA data.



avg – Average

FIGURE 1. Dispensed hydrogen by day of week showing ARRA and newer sites (cdp_mhe_142)

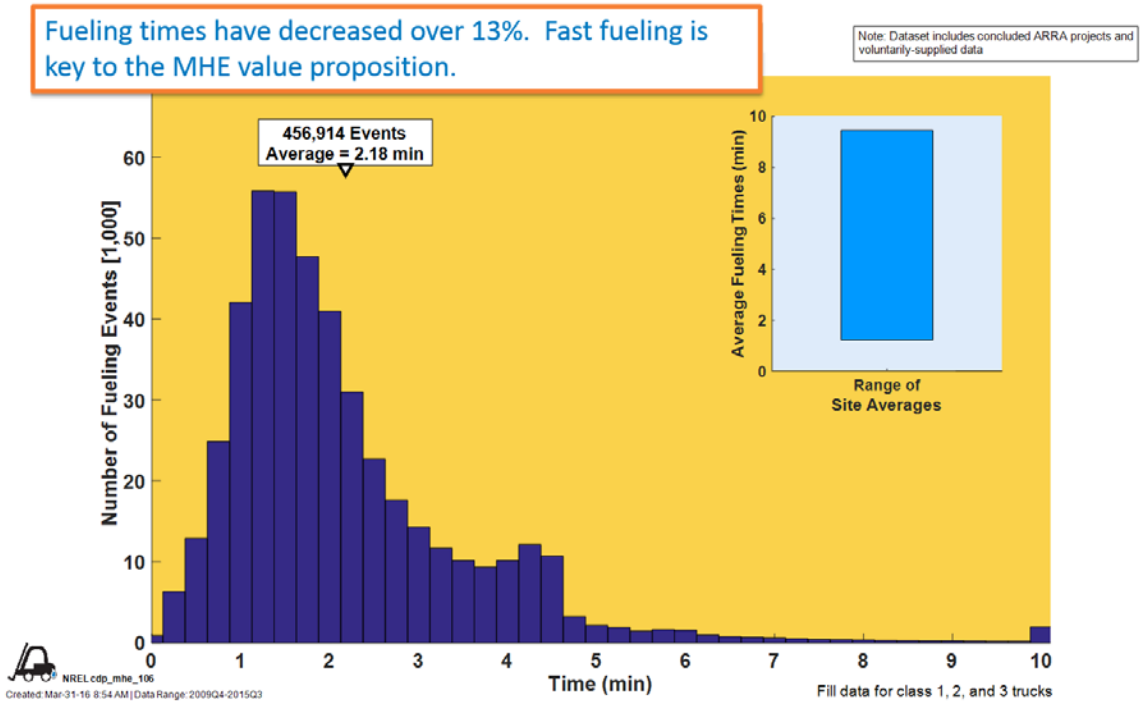


FIGURE 2. Histogram of fueling times, combined fleet (cdp_mhe_106)

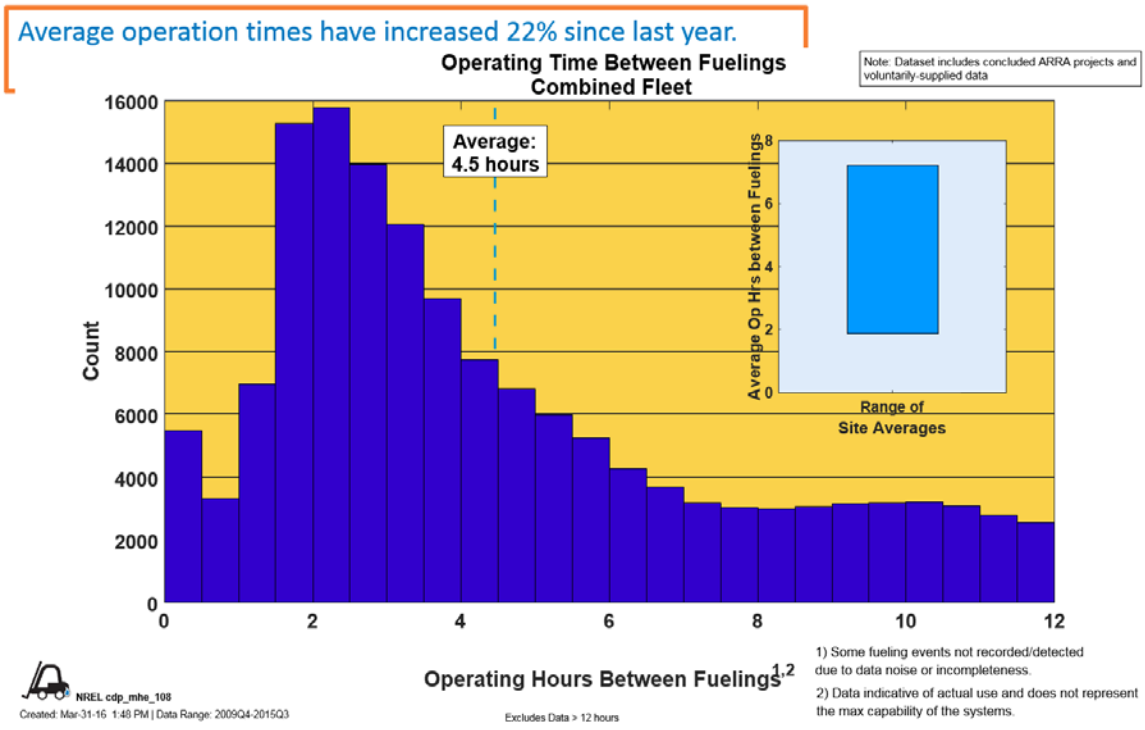


FIGURE 3. Operating time between fuelings, combined fleet (cdp_mhe_108).

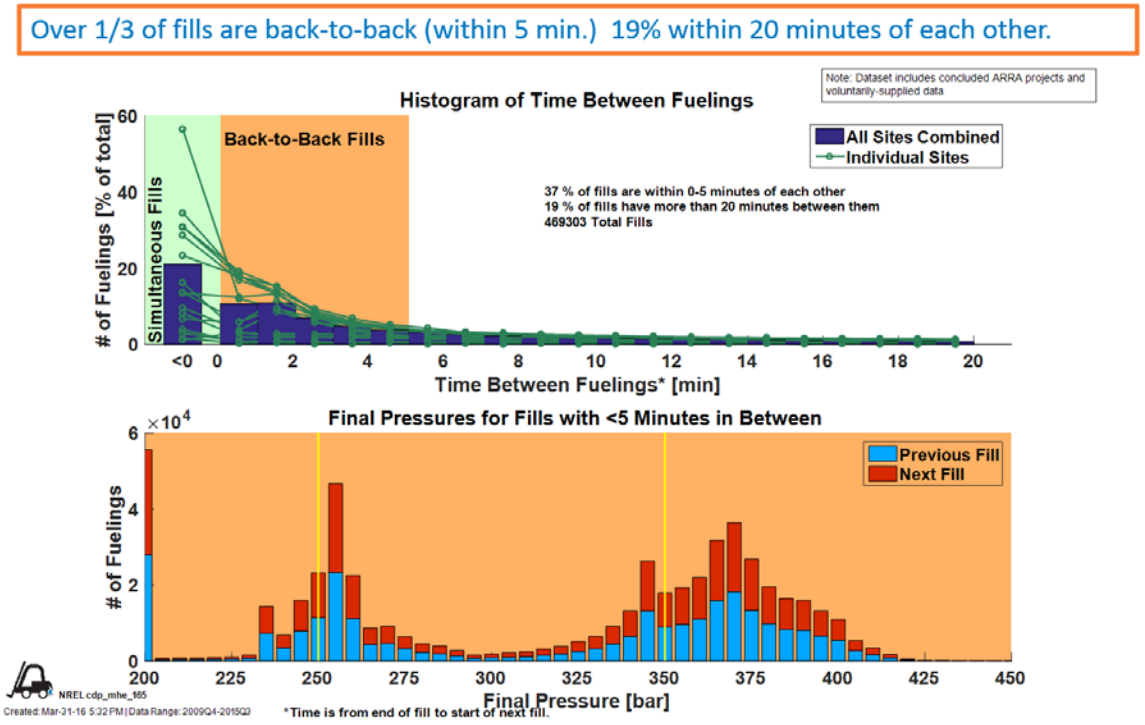


FIGURE 4. Histogram of time between fuelings, relative to the dispensers (cdp_mhe_165).

CONCLUSIONS AND FUTURE DIRECTIONS

The project is concluded.

FY 2016 PUBLICATIONS/PRESENTATIONS

1. Ainscough, C., Kurtz, J., *ARRA Material Handling Equipment Composite Data Products: Data through Quarter 2 of 2015*, Golden, CO: The National Renewable Energy Laboratory, 2016.

2. Ainscough, C., *Material Handling Equipment Data Collection and Analysis,* Washington, DC: U.S. Department of Energy, 2016.

REFERENCES

1. Ramsden, T., *An Evaluation of the Total Cost of Ownership of Fuel Cell-Powered Material Handling Equipment*. Golden, CO: National Renewable Energy Laboratory, April 2013.