VII.13 Stationary Fuel Cell Evaluation

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Project Start Date: October 2011
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

- Independently assess, validate, and report operation targets and performance under stationary fuel cell (FC) system real operating conditions

Fiscal Year (FY) 2015 Objectives

- Develop more voluntary data partners, especially for operations data
- Analysis of quarterly data as available
- Publication of 33 technical stationary fuel cell composite data products (CDPs) biannually
- Update of a public website for dissemination of CDPs

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:

(B) Lack of Data on Stationary Fuel Cells in Real-World Operation - Address gaps in knowledge as stationary fuel cell installations have increased.

(E) Codes and Standards - Provide data and context to codes and standards activities.

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute 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 1.1: Complete validation of residential fuel cell micro combined heat and power (CHP) systems that demonstrate 40% efficiency and 25,000 hour durability. (4Q, 2015)
- Milestone 1.2: Complete validation of commercial fuel cell CHP systems that demonstrate 45% efficiency and 50,000 hour durability. (4Q, 2017)

FY 2015 Accomplishments

- Published an updated and expanded set of CDPs (http://www.nrel.gov/hydrogen/proj_fc_systems_analysis.html) in April 2015; these included five new CDPs, four of which were for operational criteria, for a total of 33 CDPs
- Validated that commercial stationary fuel cells (>100 kW) exceeded the 2015 DOE technology validation target for electrical efficiency of 43% based on the lower heating value of hydrogen (39% higher heating value of hydrogen)

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INTRODUCTION

This project aims to provide status on stationary fuel cell systems to inform DOE, the public, fuel cell manufacturers, and other stakeholders. This is the only technology validation project working directly on Technical Barrier (B): Lack of Data on Stationary Fuel Cells in Real-World Operation.

APPROACH

The project's data collection plan builds on other technology validation activities. 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 National Fuel Cell Technology Evaluation Center (NFCTEC).

The NFCTEC 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 is published every six months. 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.

A review cycle is completed before the publication of CDPs. The review cycle includes providing detailed data products of individual system and site performance results to the individual data provider. Detailed data products also identify the individual contribution to 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 studies as well as application- or technology-specific studies.

RESULTS

In April 2015, a set of 33 CDPs were published, which included updates to 28 CDPs and five new CDPs. The set includes four new operations CDPs to go along with three updated operations CDPs, which cover stoppages, availability, electrical efficiency, load profiles, and cumulative output. The operations CDPs have now been segmented into fuel cells that are less than 100 kW and greater than 100 kW. New load profile CDPs for fuel cell units greater than 100 kW show the frequency of operation time at different load fractions and the ratio of electrical output per rated capacity of the fuel cell unit, separately, for both base load and load following units (Figure 1 and Figure 2). The load profiles show that base load units operate mostly in the 90–100% load fraction as expected, load following units have operation time at a wider range, and some units spend time above 100% rated capacity. We have also validated that the electrical efficiency for fuel cells greater than 100 kW has exceeded the 2015 DOE Technology Validation target of 43% based on the lower heating value of hydrogen (39% higher heating value of hydrogen) (Figure 3).

California's Self-Generation Incentive Program (SGIP) has helped deploy 397 fuel cell systems, for a total of 161 MW, since 2001. The fuel cell deployment increased 25% in 2014. These fuel cell deployments have shown that fuel cells may be applied with a wide variety of fuels, including renewable biogas from landfill, biomass, and digester sources. Natural gas is the dominant fuel type, accounting for 79% of projects and 69% of the capacity. Since 2011, electric-only fuel cell projects have been increasing at a rate (number and capacity) greater than other competing technologies, which include gas turbines, internal combustion turbines, microturbines, and pressure reduction turbines. The fuel cell electric projects now equal the number of internal combustion engines at 279 projects. Deployment numbers have increased even in a climate of declining incentive. Also, in 2014 fuel cell CHP systems neared the cost per kilowatt of gas turbines, and beat the cost when incentives were applied (Figure 4).

The average unit costs in the SGIP are significantly higher than the DOE target of $1,500/kW; however, SGIP costs may include additional costs that are not included in the DOE target. The average range, when differentiating by capacities (0–50 kW, 51–200 kW, 201–400 kW, 401+ kW), is $9,537–$11,275/kW without incentives and $5,620–$8,782/kW with incentives. Generally, larger projects (those with larger capacities) have lower unit costs and also receive more incentives.

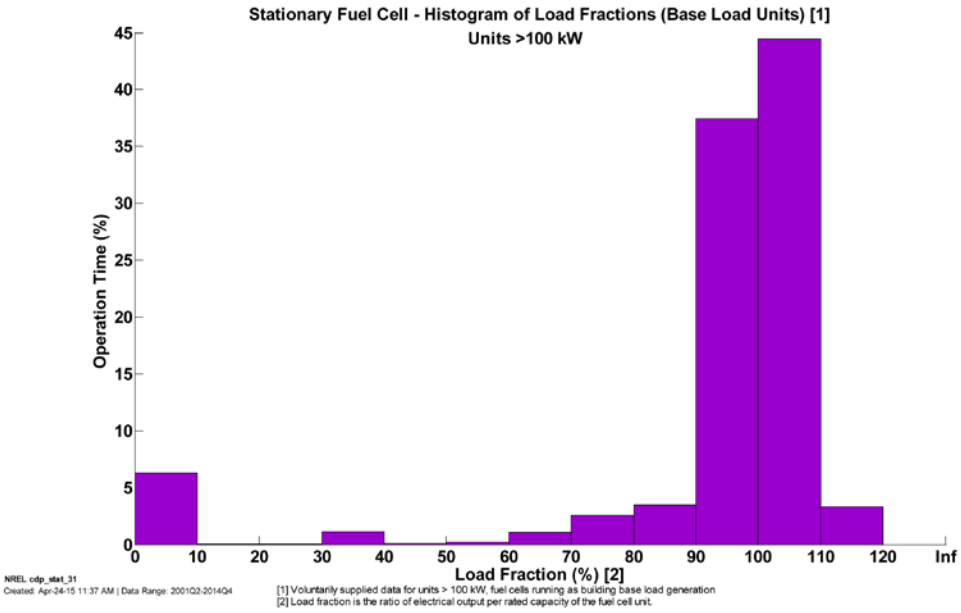

FIGURE 1. Histogram of load fractions for base load units >100 kW

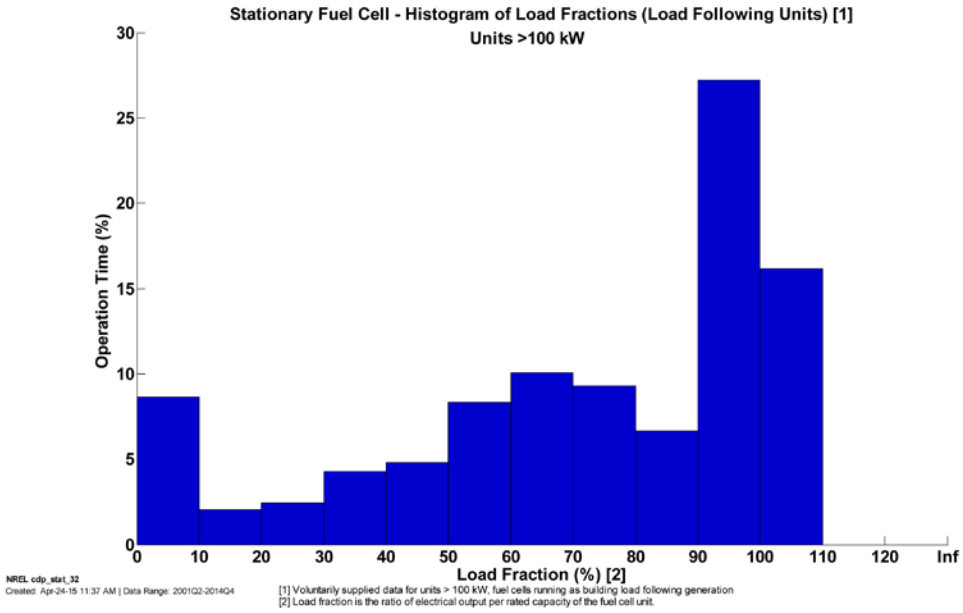

FIGURE 2. Histogram of load fractions for load following units >100 kW

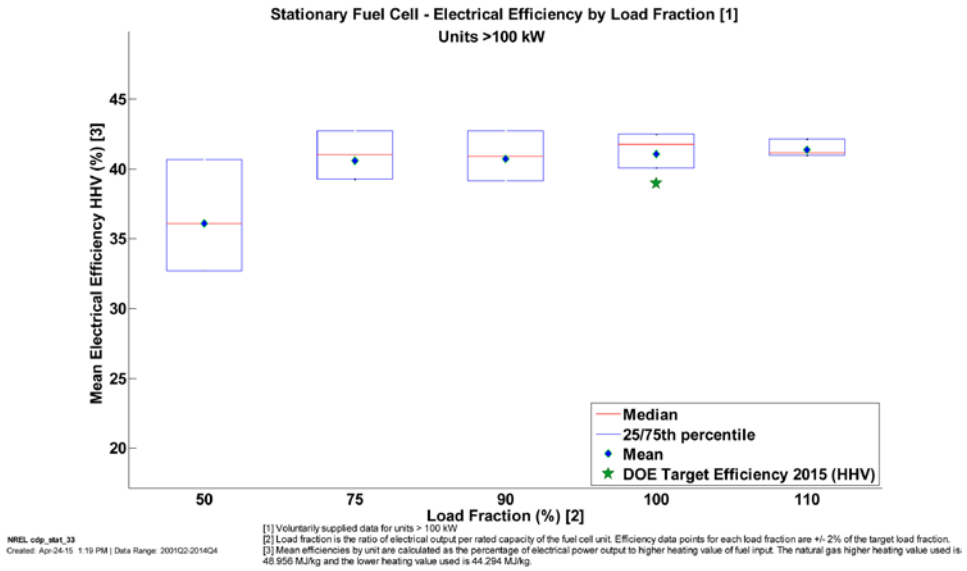

FIGURE 3. Electrical efficiency by load fraction for units >100 kW

All CDPs are available at http://www.nrel.gov/hydrogen/proj_fc_systems_analysis.html.

CONCLUSIONS AND FUTURE DIRECTIONS

The California SGIP has been very successful in installing fuel cell systems. In recent years, fuel cell projects have been installed in greater numbers than other competing technologies, despite generally higher installed costs and decreasing incentive spending. This early market rollout is important for the stationary fuel cell industry in terms of real-world experience and the fuel cell deployments benefit that the SGIP has been extended to run through at least January 1, 2019.

We are exploring more avenues to acquire operations data that will help us expand the analyses and validate other technology validation targets.

Activities for the remainder of FY 2015 will include the following:

- FY 2015 Q4: Update all CDPs with current data from the SGIP and voluntary operations data submissions

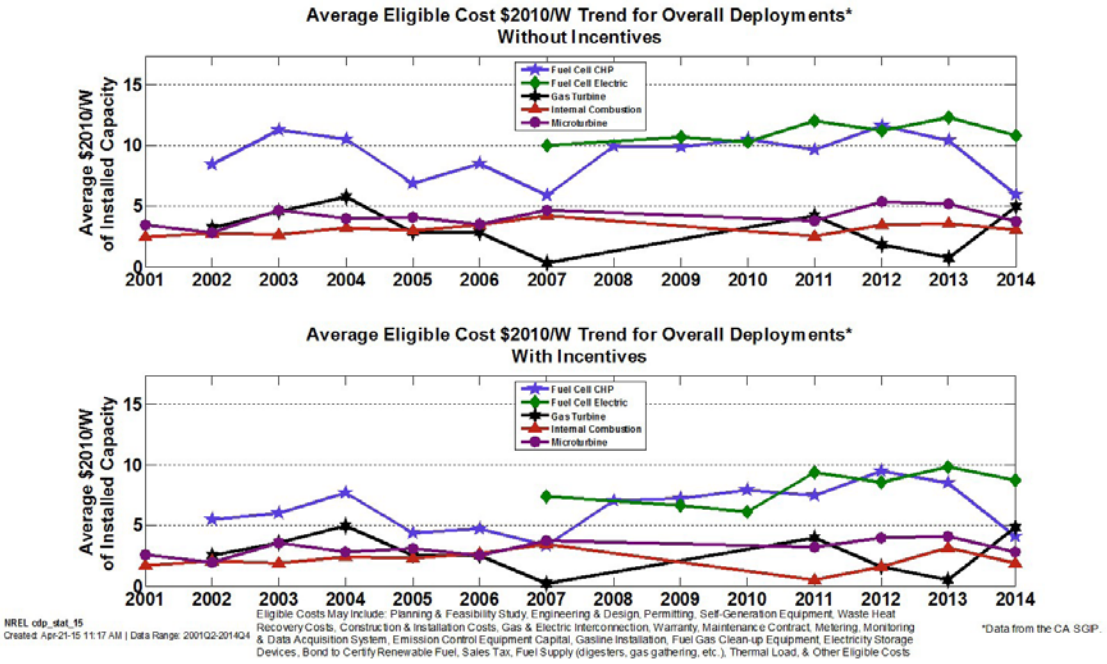

FIGURE 4. Average eligible cost by equipment type, including other distributed generation

- Expand analysis to include new CDPs that address availability and capacity factor of stationary fuel cells
- Look into other data partners (state and federal programs, original equipment manufacturers) for additional data relevant to DOE targets.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. Saur, G., Kurtz, J., Ainscough, C., Sprik, S. "Stationary Fuel Cell Evaluation." DOE Annual Merit Review meeting, June 2015. (presentation)

2. "Stationary Fuel Cell Systems Analysis Project: Partnership Opportunities." Golden, CO: National Renewable Energy Laboratory, published June 2015. (fact sheet)

3. Saur, G., Kurtz, J., Ainscough, C., Sprik, S., Post, M. "Stationary Fuel Cell System Composite Data Products: Data through Quarter 4 of 2014." Golden, CO: National Renewable Energy Laboratory, published April 2015. (report)

4. Saur, G., Kurtz, J., Ainscough, C., Peters, M. "VII.2 Stationary Fuel Cell Evaluation." DOE FY 2014 Annual Merit Review Proceedings. Washington, D.C., published November 2014. (report)