
VII.11 Hydrogen Station Data Collection and Analysis

Sam Sprik (Primary Contact), Jennifer Kurtz, Chris Ainscough, Genevieve Saur, Matt Post, and Mike Peters

National Renewable Energy Laboratory (NREL)
15013 Denver West Parkway
Golden, CO 80401-3305
Phone: (303) 275-4431
Email: Sam.Sprik@nrel.gov

DOE Manager

Jason Marcinkoski
Phone: (202) 586-7466
Email: Jason.Marcinkoski@ee.doe.gov

Project Start Date: October 1, 2011

Project End Date: Project continuation and direction determined annually by DOE

- Participate in technical review meetings and site visits with industry partners to discuss results from NREL's analysis
- Maintain an accurate database (location and status) of all online hydrogen stations in the United States, and provide periodic updates to other online resources, specifically the Alternative Fuels Data Center (AFDC) station locator, the Fuel Cell and Hydrogen Energy Association, the California Fuel Cell Partnership (CaFCP), and Pacific Northwest National Laboratory (PNNL)

Technical Barriers

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

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

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to achievement of the following DOE milestone from the Technology Validation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 4.4: Complete evaluation of 700-bar fast fill fueling stations and compare to SAE J2601 specifications and DOE fueling targets. (3Q, 2016)

FY 2015 Accomplishments

- Internally processed and analyzed quarterly infrastructure data in the NFCTEC for inclusion in CDPs every six months, creating Fall 2014 and Spring 2015 CDPs:
 - Gathered and provided updates on stations under the DOE FOA 626-funded projects
 - Analyzed data from the CEC on their awarded stations
- Provided assistance in filling out and modifying templates for those providing infrastructure data
- Updated NREL's internal database of stations and their locations, submitted updates to AFDC, and synced with PNNL list
- Updated NREL Fleet Analysis Toolkit code to accept and analyze data in multiple formats from stations

Overall Objectives

- Analyze current, state-of-the-art hydrogen infrastructure using several metrics including efficiency, performance, cost, and reliability of station components and systems
- Perform an independent assessment of technology in real-world operating conditions, focusing on hydrogen infrastructure for on-road vehicles
- Leverage the data processing and analysis capabilities at the National Fuel Cell Technology Evaluation Center (NFCTEC), originally developed under the Fuel Cell Vehicle Learning Demonstration, as well as from forklift, backup power, and bus projects

Fiscal Year (FY) 2015 Objectives

- Obtain/collect data from state-of-the-art hydrogen fueling facilities that receive funding through DOE Funding Opportunity Announcement (FOA) 626 awards, California Energy Commission (CEC) awards, and others, to enrich the analyses and the set of publicly available composite data products (CDPs) on hydrogen fueling infrastructure
- Work with codes and standards activities and fueling facility owners/operators to benchmark performance of the fueling events relative to current Society of Automotive Engineers (SAE) procedures
- Perform analysis and provide feedback on sensitive data from hydrogen infrastructure for industry and DOE
 - Aggregate these results for publication

- Participated in the CaFCP working group meetings and H₂USA hydrogen fueling station working group
- Presented results at Fuel Cell Seminar 2014 and at the 2015 DOE Annual Merit Review



INTRODUCTION

In the past decade, approximately 60 hydrogen fueling stations supported a few hundred fuel cell electric vehicles (FCEVs) in the United States. Of these stations, 25 supported the 183 DOE Learning Demonstration vehicles. As we move out of a learning demonstration environment into a commercialization environment, manufacturers are ramping up FCEV production alongside an infrastructure effort to build additional consumer-friendly stations in a retail environment, upgrade existing stations to increase fueling output, and cluster stations to cover areas where vehicles are introduced.

California has been a leader in supporting hydrogen infrastructure with a goal of 100 stations within a carefully planned network. Early efforts in California focus on clusters of stations near population centers in the Los Angeles and the San Francisco Bay areas. Through past funding efforts, eight non-private stations are in place in California with 18 more in near-term development. The most recent awards from the CEC through PON-13-607, which were announced in May of 2014, further support the rollout of FCEVs coming in 2015–2017 and beyond. That effort is funding the building of 28 new stations and a mobile fueler with \$46 million of state money through the CEC's Alternative and Renewable Fuel and Vehicle Technology Program. These stations will be included in subsequent evaluations and would bring the California public station count to 54. Besides California, there are efforts in other states, including the northeastern states that will establish hydrogen infrastructure for the upcoming FCEVs.

Keys to success for improving hydrogen fueling availability are selecting the fueling location, ensuring customer-friendly public access, and providing adequate and reliable output to support the vehicles. One concern is the underutilization of the stations while the vehicle market develops, which could be aided by fueling multiple applications such as buses and forklifts at a site. Another idea is to build stations smaller at first with the ability to upgrade the station to higher output once the market develops. Hydrogen output from existing and upcoming facilities varies from 50 kg/day to 350 kg/day, with most new fueling facilities being more than 100 kg/day. Although it is currently most economical to make hydrogen from natural gas, there are efforts and requirements to make hydrogen from renewable sources. Using available biogas from landfills and wastewater treatment plants to generate hydrogen is

one way to make use of a renewable feedstock and to lower greenhouse gas emissions. Another renewable pathway is to make hydrogen through electrolysis with the electrical energy coming from a renewable source such as wind or solar. As more vehicles come online, all fueling facilities will need to be accessible to anyone with a hydrogen vehicle. As these fueling facilities are developed, there is a need to continue data collection and analysis to track the progress and determine future technology development needs.

APPROACH

The emphasis of this project is documenting the innovations in hydrogen fueling and how well they meet customer needs. This includes analysis that captures the technology capability (such as back-to-back filling capability, impact of pre-cooling temperature, and radio-frequency identification of vehicles to allow unique fueling profiles) as well as the customer perspective (such as fueling times and rates, safety, and availability). Individual components, such as compressors, are evaluated with the available data to establish current status and research needs. Station locations are evaluated within the context of both available vehicles and future vehicles and their fueling patterns.

Data analysis is performed on sensitive industry hydrogen fueling data in the NFCTEC, supporting DOE in identifying trends from the data that will help guide or supplement R&D activities. Aggregation of the analyzed data allows for creation of composite results for public dissemination and presentation. Some existing CDPs from the previous learning demonstration are updated with new data, as appropriate. All this involves working with industry partners to create and publish CDPs that show the current technology status without revealing proprietary data. Feedback to industry takes form in detailed data products (protected results) and provides direct benefit to them from the NREL analysis performed on their data. NREL will continue exercising the fueling analysis functionality of its Fleet Analysis Toolkit to preserve and archive a snapshot of the analysis results from each quarter. This allows a deeper level of results to be stored in an easy-to-access form within the NFCTEC.

RESULTS

As stations are built or retired, the internal station database is updated and shared with others, including the AFDC. Currently, there are 51 stations in the United States with 46 planned in the near future. Most of the current stations are not available to all original equipment manufacturer customers (only a few are), while most of the future stations will be open to the public and located in California. Using the data reported to NREL by 10 of these stations, 43 CDPs were created by aggregating and analyzing the station data. These results were presented at the Fuel Cell

Seminar and at the DOE Annual Merit Review. Results were also published on NREL’s website.

Although the primary goal of the early stations is geographic coverage for FCEV customers to prevent range anxiety, the current analysis includes how these stations are being used. The amount of dispensed hydrogen per day of the week (Figure 1) shows more filling is happening Monday through Friday than on Saturday and Sunday. The highest station shows an average of 31 kg/day on Thursdays. The number of fills per day (Figure 2) at each station ranges from 3 to 11 on average with maximum daily fills at each

station ranging from 13 to 31 fills per day. The average amount of hydrogen dispensed per fill (Figure 3) is 2.63 kg ranging mostly between 1.5 kg and 3.5 kg. Some of the lower amounts in the histogram are due to interrupted fills. A look at maintenance by equipment type (Figure 4) shows that hydrogen compressors are the primary items needing maintenance both in terms of number of events and hours. Dispensers, safety items (e.g., false alarms and sensors), and thermal management are the next highest items in terms of number of maintenance events. These results and all the other CDPs are published on NREL’s website.

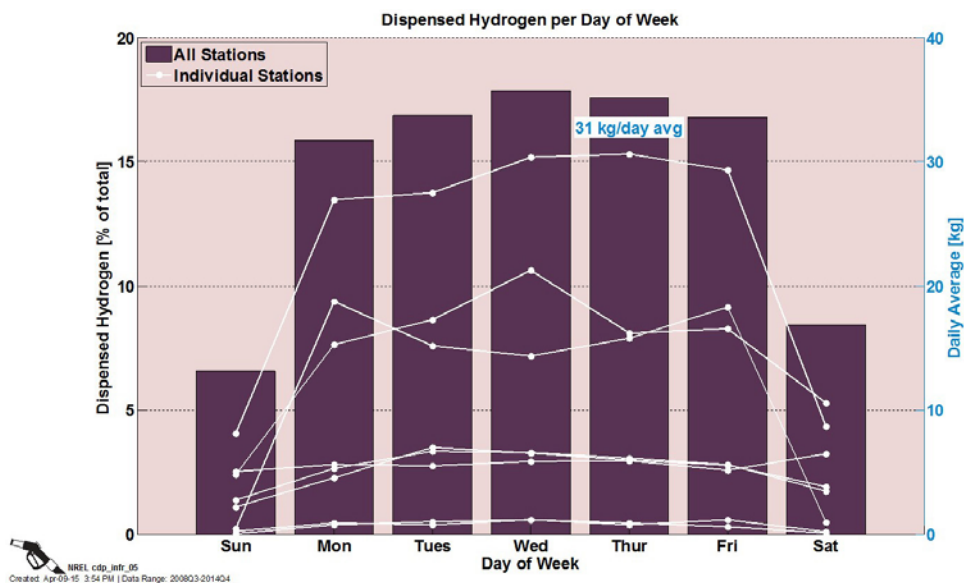


FIGURE 1. Dispersed hydrogen per day of week

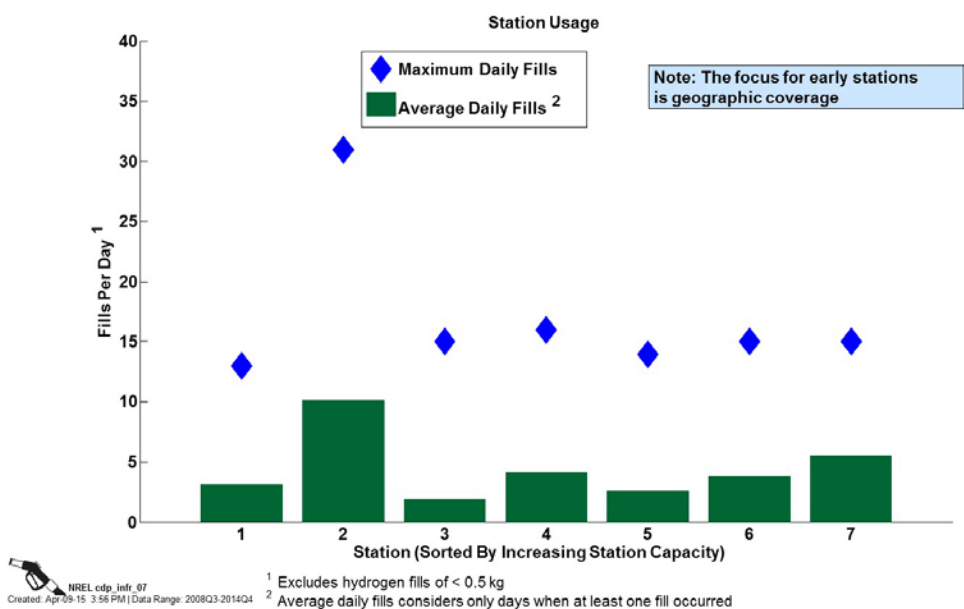


FIGURE 2. Station usage—number of fills per day

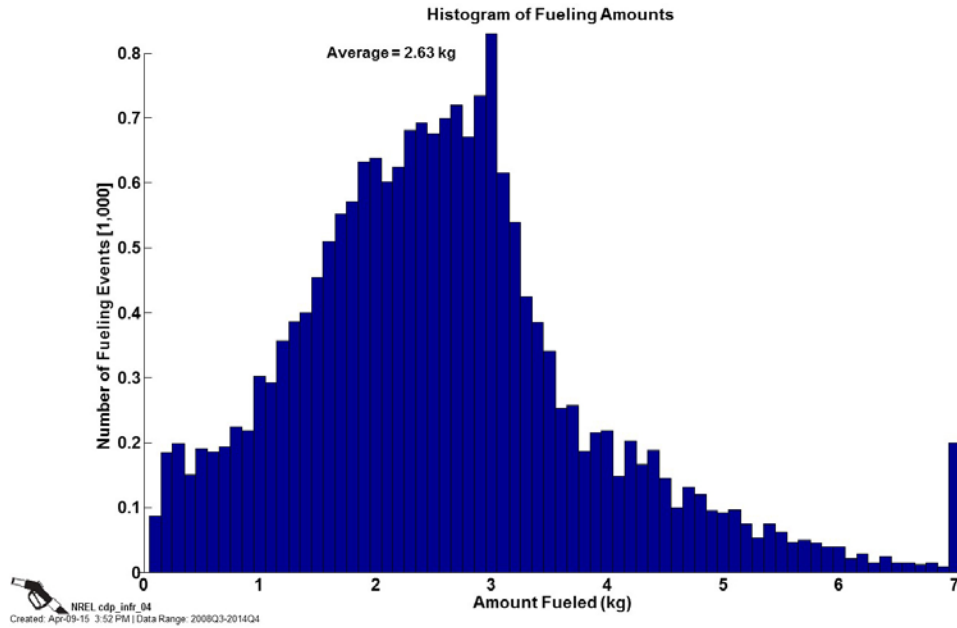


FIGURE 3. Histogram of fueling amounts

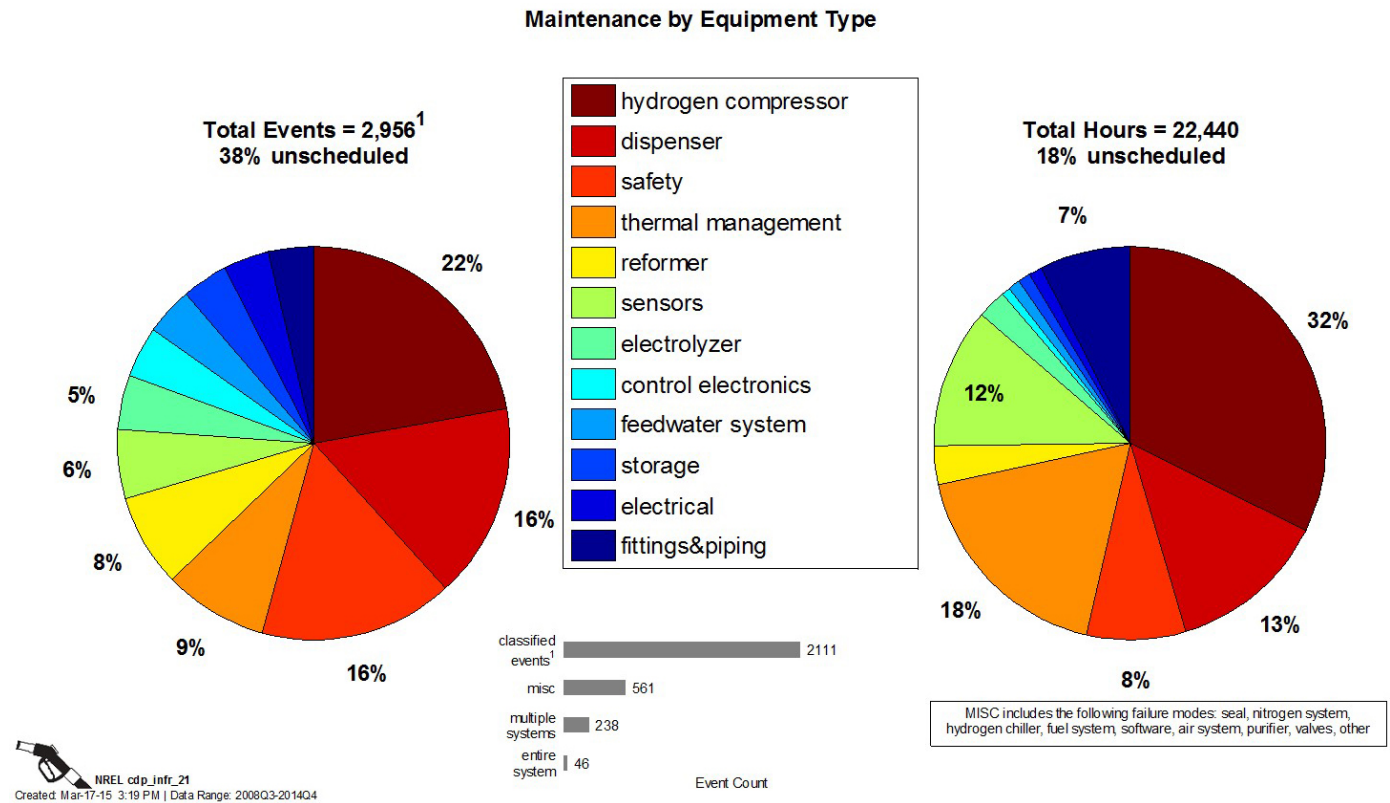


FIGURE 4. Maintenance by equipment type

CONCLUSIONS AND FUTURE DIRECTIONS

As new stations come online or are updated, their performance and availability will affect how successfully they support the current and upcoming fleet of fuel cell vehicles. Continual data collection, analysis, and feedback will provide DOE and the hydrogen and fuel cell community with awareness of the technology readiness and identify areas for improvement that could be research topics. Many new stations are planned to be built and start operating in 2015 and 2016, and will be included in the data set as they report data. Their data will be aggregated and published in CDPs without revealing individual station identity and will help identify general trends for the latest stations. As more data become available from newer stations and as more FCEVs enter the market, there will be an increase in data analysis possibilities to validate the technology for hydrogen infrastructure including focusing on trends over time for usage, reliability, and performance of the stations.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. Sam Sprik, Jennifer Kurtz, Chris Ainscough, Genevieve Saur, and Mike Peters, “TV017: Hydrogen Station Data Collection and Analysis,” (presented at the 2015 DOE Annual Merit Review and Peer Evaluation Meeting, Washington, DC, June 2015).
2. Sam Sprik, Jennifer Kurtz, Chris Ainscough, Mike Peters, Matt Post, and Genevieve Saur, “Technology Validation of Fuel Cell Vehicles and Infrastructure,” (presented at 2014 Fuel Cell Seminar FCS#222, Los Angeles, California, November 2014).
3. “Hydrogen Fueling Infrastructure Analysis: Composite Data Products,” National Renewable Energy Laboratory, http://www.nrel.gov/hydrogen/proj_infrastructure_analysis.html.