VII.B.1 Hydrogen Station Data Collection and Analysis

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Project Start Date: October 1, 2011
Project End Date: Project continuation and direction determined annually by DOE

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) 2016 Objectives

- Obtain and 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 procedures.
- Perform analysis and provide feedback on sensitive data from hydrogen infrastructure for industry and DOE. Aggregate these results for publication.
- Participate in technical review meetings and site visits with industry partners to discuss results from NREL's analysis.
- Transition national database of location and status of hydrogen stations to the Alternative Fuels Data Center (AFDC) station locator and work with California and AFDC to keep the database up to date. Also work on adding fields and online status of the stations together with AFDC and the California Fuel Cell Partnership.

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 contributes 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 2016 Accomplishments

- Internally processed and analyzed quarterly infrastructure data in the NFCTEC for inclusion in CDPs every six months and created new Fall 2015 and Spring 2016 CDPs.
- Transitioned NREL's internal database of stations and their locations to AFDC. Worked with Pacific Northwest National Laboratory and California Fuel Cell Partnership to consolidate information and continue to work with California and AFDC to keep the list updated to the latest information.
- Updated the infrastructure data collection templates for the latest CEC grant funding opportunity.
- Analyzed data and provided updates on stations under DOE FOA 626-funded projects.
- Updated NREL Fleet Analysis Toolkit code to accept and analyze data in multiple formats from stations.
- Participated in the California Fuel Cell Partnership working group meetings and the H2USA hydrogen fueling station working group.

INTRODUCTION

In the past, 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 and into a commercialization environment, manufacturers are ramping up FCEV production alongside an infrastructure effort to build out a network of 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 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, are resulting in multiple stations opening in 2016. 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, which 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. Hydrogen output from existing and upcoming facilities varies from 50 kg/d to 350 kg/d, with most new fueling facilities being more than 100 kg/d. 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 hydrogen energy from landfills and wastewater treatment plants 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. NREL also uses the analysis results to support DOE in identifying trends from the data that will help guide DOE's R&D activities.

Data analysis is performed on sensitive industry hydrogen fueling data in the NFCTEC and recommendations are provided to DOE on opportunities to refocus 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 the NREL 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.

Using unique analysis capabilities and tools developed at NREL, researchers are providing valuable technical recommendations to DOE based on real-world experiences with the technology. NREL will continue to provide multiple outputs in the form of CDPs and presentations and papers at technical conferences.

RESULTS

As stations are built or retired, the AFDC station database is updated for public viewing. Currently, there are 29 public stations in the United States with 29 more planned in the near future. The newer stations are being built to be accessible to the public and most are located in California. Using the data reported to NREL by 11 of these stations, 61 CDPs were created by analyzing and aggregating the station data, and results were 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-use station shows an average of 35 kg/d on Wednesdays. A new CDP shows the historical failure rate

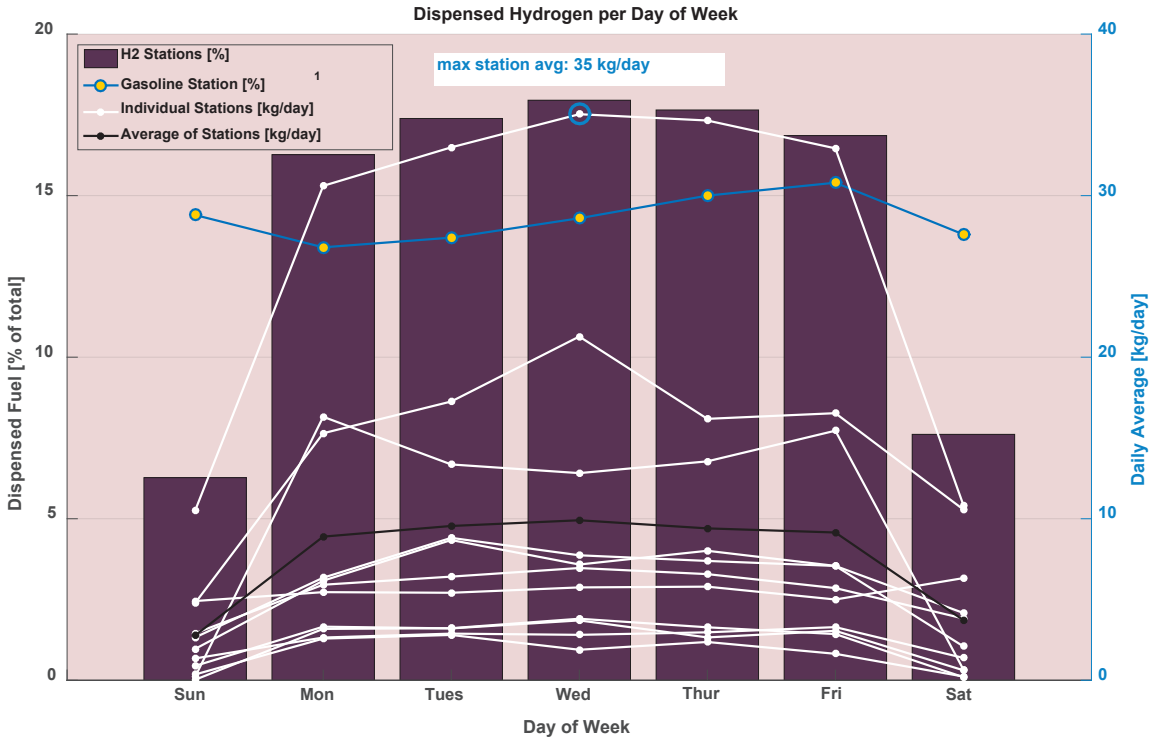

FIGURE 1. Dispensed hydrogen per day of week

by the amount dispensed (Figure 2) and shows the left and mid part of a typical "bathtub" curve where the right side, if projected out, would be expected to go back up as failures due to aging equipment ramp up. The average fueling rates, times and amounts for new stations (Figure 3) is for fills greater than 1 kg with precooling at -40°C. For these fills the average rate is 0.87 kg/min, time to fill is 3.7 min, and the average amount is 2.8 kg. A look at maintenance by equipment type (Figure 4) shows that hydrogen compressors are the primary items needing maintenance both in terms

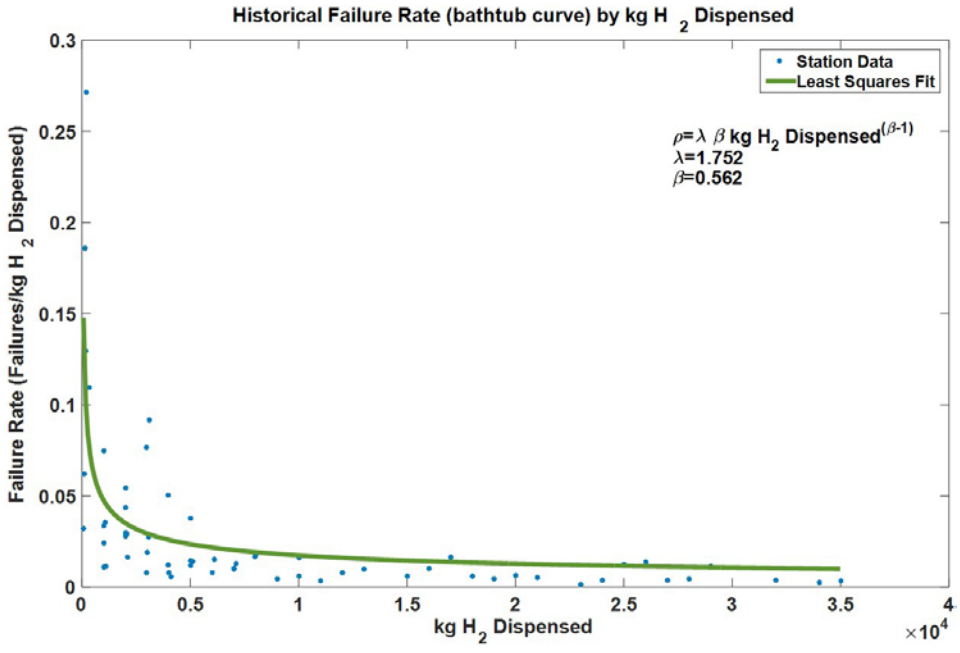

FIGURE 2. Historical failure rate by kilogram hydrogen dispensed

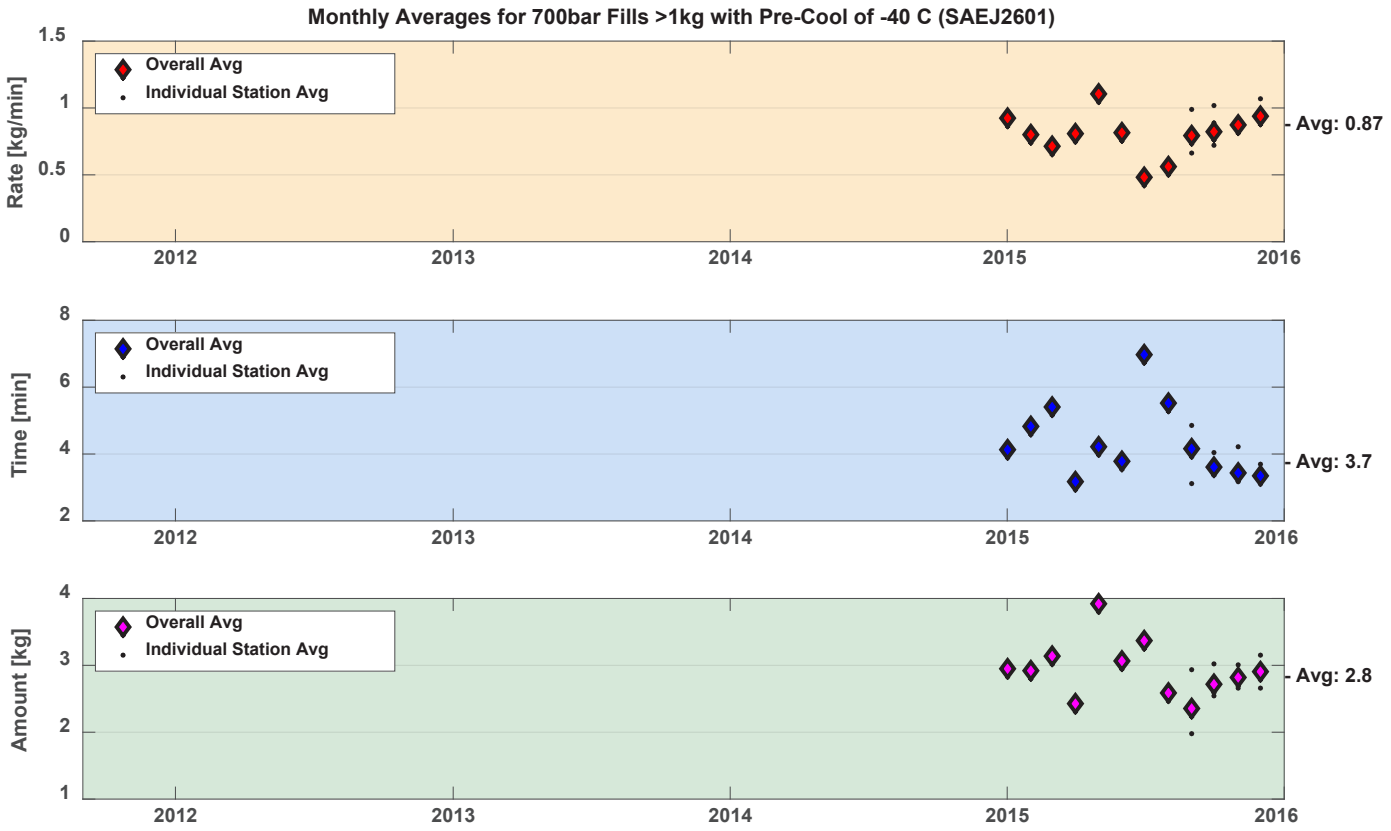

FIGURE 3. Monthly fueling rates, times, and amounts for new stations

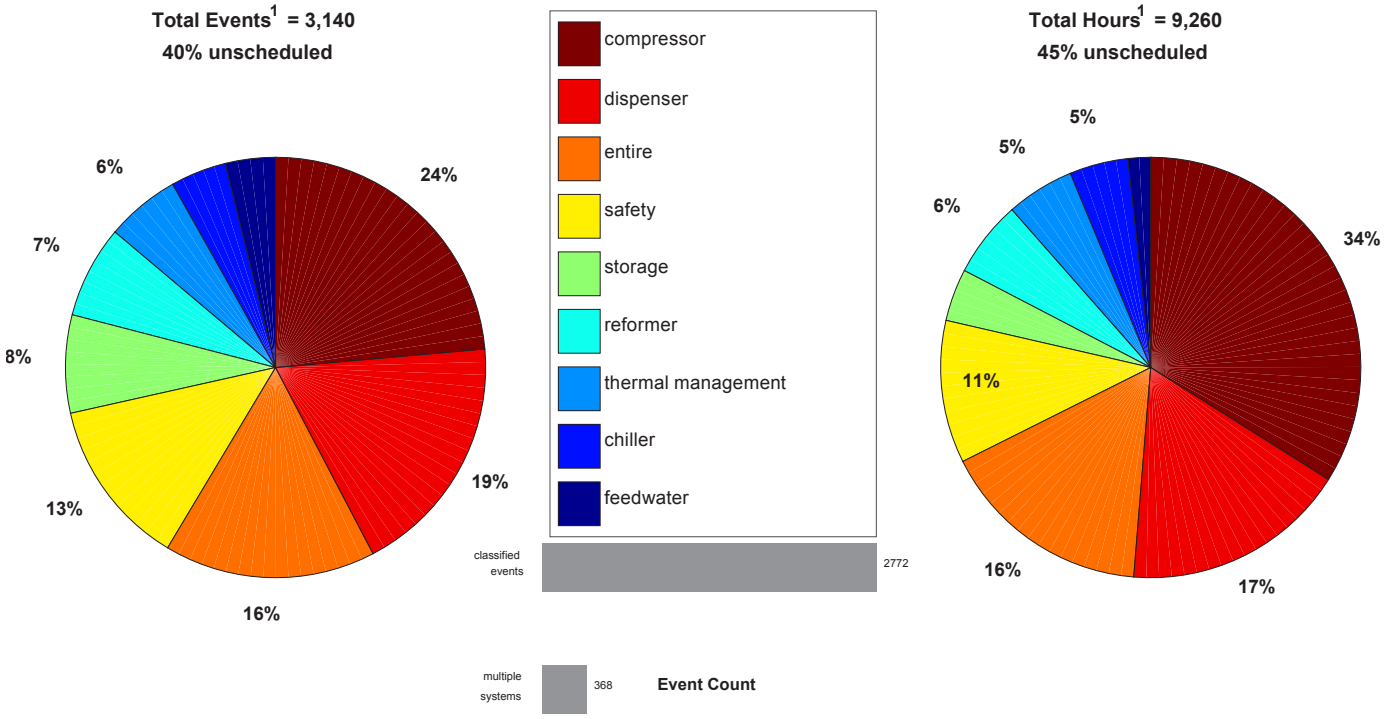

FIGURE 4. Maintenance by equipment type

of number of events and in hours. Dispenser maintenance, entire system inspections, safety items (e.g., false alarms and sensors), and storage 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.

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 coming online 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 2016 PUBLICATIONS/PRESENTATIONS

1. Sam Sprik, Jennifer Kurtz, Chris Ainscough, Matt Jeffers, Genevieve Saur, and Mike Peters, "TV017: Hydrogen Station Data Collection and Analysis," presented at the 2016 DOE Annual Merit Review and Peer Evaluation Meeting, Washington, D.C., June 2016.

2. Sam Sprik, Jennifer Kurtz, Chris Ainscough, Mike Peters, Matt Jeffers, and Genevieve Saur, "Performance Status of Hydrogen Stations and Fuel Cell Vehicles," presented at 2015 Fuel Cell Seminar IND32-3, Los Angeles, CA, November 2015.

3. "Hydrogen Fueling Infrastructure Analysis: Composite Data Products," National Renewable Energy Laboratory, http://www.nrel.gov/hydrogen/proj_infrastructure_analysis.html.