VII.10 Next Generation H2 Station Analysis

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

Fiscal Year (FY) 2012 Objectives

- Collect data from state-of-the-art hydrogen (H2) fueling facilities, such as those funded by the California Air Resources Board (CARB), to enrich the analyses and composite data products (CDPs) on H2 fueling originally established by the Learning Demonstration project.
- Work with codes and standards activities and fueling facility owners/operators to benchmark performance of the fueling events relative to current SAE International 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 in an interactive manner.
- 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 NREL's Alternative Fuels Data Center (AFDC) station locator, the Fuel Cell and Hydrogen Energy Association, the California Fuel Cell Partnership (CaFCP), and FuelCells.org.

Technical Barriers

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

- Verifying shorter fueling times for 700-bar fills using pre-cooling.

FY 2012 Accomplishments

- Created a set of 12 Spring 2012 CDPs from four stations reporting data.
- Updated NREL's internal database of stations and their locations and submitted updates to the AFDC.
- Presented station CDPs and metrics for station performance to the CaFCP working group.
- Participated in a CaFCP station implementation team and provided performance metrics for stations.
- Internally processed and analyzed quarterly infrastructure data in the Hydrogen Secure Data Center (HSDC) for later inclusion in CDPs.
- Created templates for infrastructure data collection.
- Updated NREL Fleet Analysis Toolkit (NRELFAT) code to accept data from stations in the new templates form for processing and analysis leading to CDPs.
- Participated with the California Energy Commission (CEC) in workshops and other discussions regarding hydrogen station funding.

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 original equipment manufacturers are ramping up FCEV bus, forklift, and car production, there is an effort to build additional stations, increase individual station fueling output, and cluster stations to cover the area where vehicles are located.

California has been a leader in supporting additional hydrogen infrastructure through multiple state agencies, including CARB and the CEC. Two separate actions by

CARB funded seven stations of which several are online with the remainder soon to be open in 2012. CEC is also working on funding stations, moving the state toward the CaFCP goal of 68 stations by 2015 when FCEVs will be introduced in larger numbers. These stations are expected to be included in subsequent evaluations.

Keys to success for improving hydrogen fueling availability are selecting the fueling location, ensuring public access, and providing adequate output to support the vehicles. Developing multi-use facilities that can serve cars, buses, and/or forklifts may help the economics and capacity utilization. Hydrogen output from existing and upcoming facilities varies from 12 to 140 kg/day, with most new fueling facilities being in the 100-kg/day range. There is an effort to focus on clusters of stations near population centers in the Los Angeles area. 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. As more vehicles come online, all fueling facilities will need to be accessible to anyone with a hydrogen vehicle. Long construction lead times need to be accounted for when planning for the upcoming vehicles. As these optimized 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 it will meet vehicle 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 will be evaluated with the available data to establish current status and research needs. Station locations will be evaluated within the context of both available vehicles and future vehicles and their fueling patterns. NREL will also use the analysis results to support DOE in identifying trends from the data that will help guide DOE's research and development (R&D) activities.

Data analysis will be performed on sensitive industry hydrogen fueling data in NREL's HSDC and recommendations will be 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 will be 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. We will continue exercising the fueling analysis functionality of the NRELFAT 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 HSDC.

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

The results presented in this section are from the Spring 2012 CDPs and pertain to four stations that reported data. The location of these hydrogen stations can be seen in Figure 1 along with locations of the other U.S. stations that are kept in the hydrogen station database. As stations are built or retired, updates are made to the database and shared with others including the AFDC. The stations reporting data included one where hydrogen was delivered to the station as a liquid, one with hydrogen pipeline delivery, and two that reformed natural gas or methane.

The total amount of fueling reported was 4,600 kg. Fueling times from the stations varied and on average took 4.72 minutes. More than half (61%) of the fuelings took less than 5 minutes, while 22% took less than 3 minutes. The average amount fueled at the stations was 2.95 kg. As can be seen in Figure 2, the average fueling rate was 0.72 kg/min with 20% of fills faster than 1 kg/min and 3% of fills faster than 1.67 kg/min. The 1.67 kg/min reference comes from a 2012 milestone of a 3-minute fill of 5 kg.

For comparison, fuelings at 350 bar and 700 bar were analyzed and their average rates were 0.77 kg/min and 0.71 kg/min, respectively. Final pressures in the vehicle tanks were also compared and found on average to be 376 bar for the nominally 350-bar fills and 707 bar for the nominally 700-bar fills.

The amount of hydrogen dispensed by each station was analyzed by day of the week and can be seen in Figure 3. The highest average for a station was 30 kg/day and occurred on Thursday. The highest average for the combined stations was dispensed on Fridays.

A new analysis was created to start to quantify time between fills and provide some insight into how long a customer may have had to wait for a back-to-back fill. Figure 4 shows a histogram of the times between fills. For times less than 5 minutes, it is assumed that the customer had to wait for the previous customer. From the data, 6% of the fills were within 0 to 5 minutes of each other, and these were considered back-to-back fills. The final pressures are

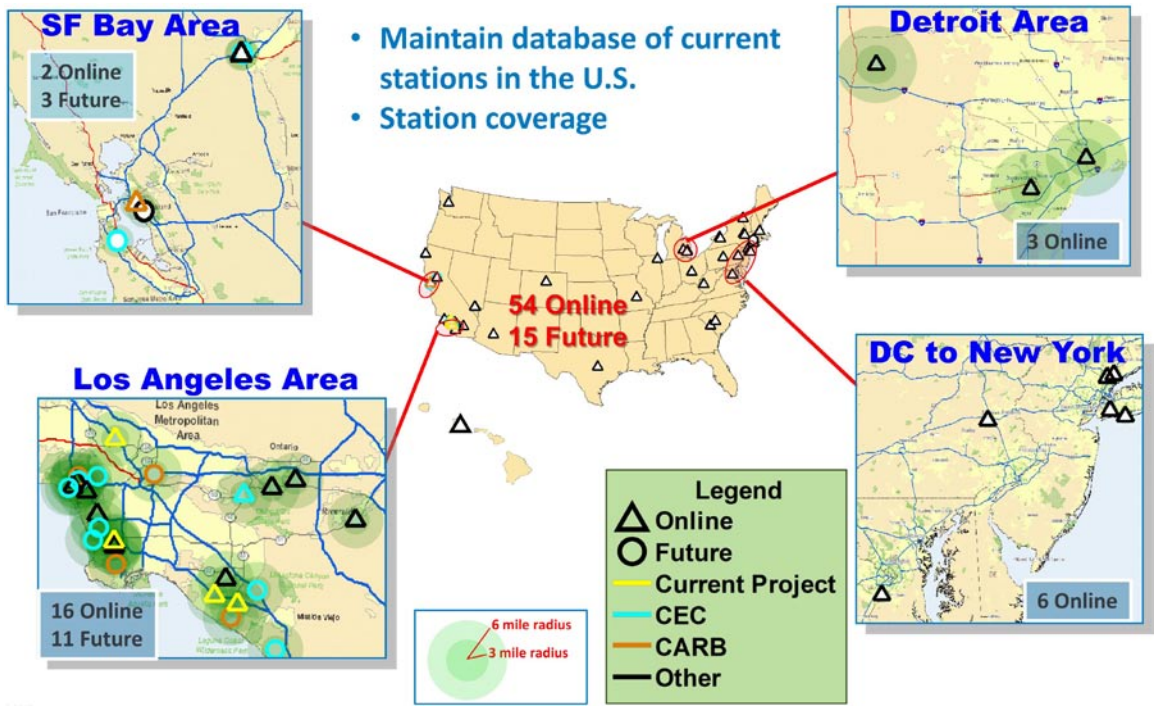

FIGURE 1. Hydrogen station locations

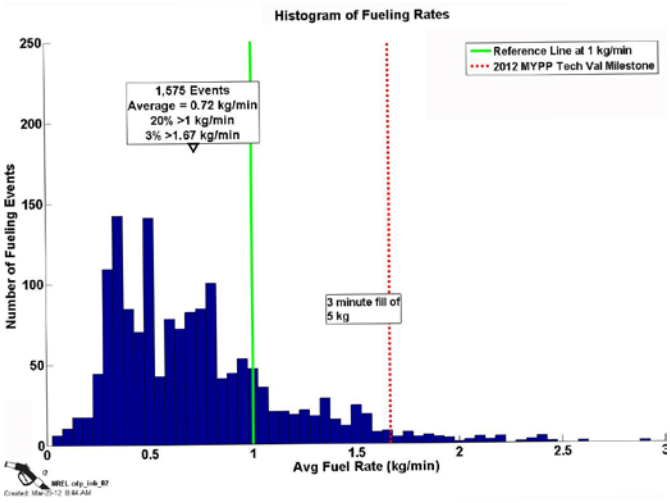

FIGURE 2. Histogram of fueling rates

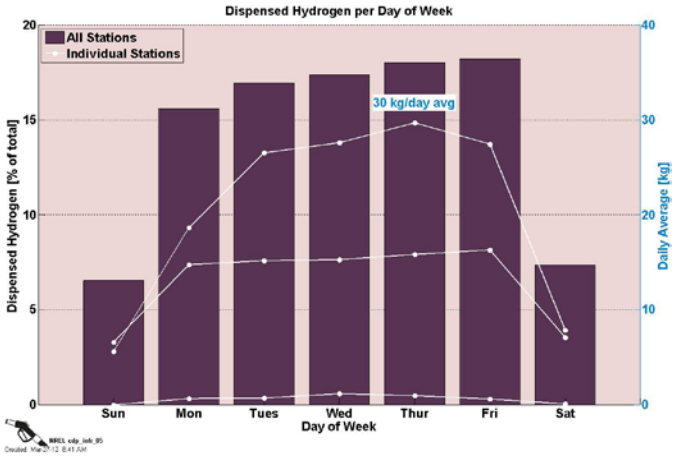

FIGURE 3. Dispensed hydrogen per day of week

also shown in a histogram comparing the previous fill final pressure to the next fill final pressure as a check to see if the equipment would have trouble performing a full fill in a back-to-back filling scenario. From the small set of data, no obvious trends were identified in that regard.

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 research areas for improvement. With so few stations providing data at the present, it is difficult to aggregate the data without revealing individual station identity, and to identify general trends in the industry. As more data become available from more stations, there will be an increase in data analysis possibilities to validate the technology for hydrogen infrastructure.

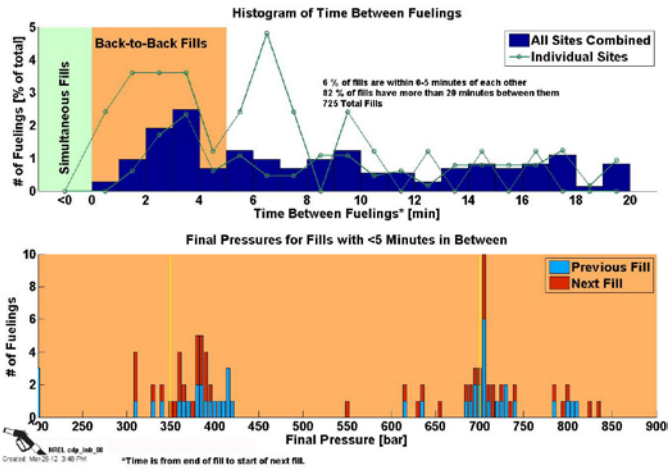

FIGURE 4. Time between fueling

FY 2012 Publications/Presentations

1. "Next Generation H2 Station Analysis," poster presented at the 2012 DOE Annual Merit Review and Peer Evaluation Meeting, May 14–18, 2012, Washington, D.C.

2. CDPs and other publications available on the Hydrogen Infrastructure section of NREL's Technology Validation website, http://www.nrel.gov/hydrogen/proj_tech_validation.html.