

## VII.B.2 Performance Evaluation of Delivered Hydrogen Fueling Stations

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Contract Number: DE-EE0005886

Subcontractor:

Linde Gas, LLC, Hayward, CA

Project Start Date: March 1, 2013

Project End Date: April 30, 2018

### Overall Objectives

- Integrate non-intrusive data collection systems at five 100 kg/d delivered liquid hydrogen fueling stations located in California for a 24-month performance period.
- Submit complete sets of the National Renewable Energy Laboratory (NREL) Hydrogen Station Data Templates to the National Fuel Cell Technology Evaluation Center (NFCTEC).
- Provide useful data to accurately benchmark and characterize station capacity, utilization, maintenance, and safety.

### Fiscal Year (FY) 2016 Objectives

- Installation and commissioning of the second system at San Juan Capistrano, CA site location.
- Produce the complete sets of data for the first two project sites at the end of each quarter after startup and commissioning is completed.
- Obtain approval to continue project efforts into Budget Period 2.
- Monitor progress on other three planned hydrogen fueling stations to ensure data acquisition systems are prepared for installation.

### 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 will contribute to the achievement of the following DOE milestones from the Technology Validation section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan.

- Milestone 3.2: Validate novel hydrogen compression technologies or systems capable of >200 kg/day that could lead to more cost-effective and scalable (up to 500 kg/day) fueling station solutions for motive applications. (4Q, 2014)
  - The stations currently being constructed will incorporate Linde's patented ionic fluid compressor. This technology utilizes a liquid piston to compress gas rather than a diaphragm or metal piston used in conventional compressor technologies. Linde is optimistic that this technology can be cost effectively scaled to larger capacity stations in the future.
- Milestone 3.4: Validate station compression technology provided by the delivery team. (4Q, 2018)
  - See Milestone 3.2.
- Milestone 3.8: Validate reduction of cost of transporting hydrogen from central production to refueling sites to <\$0.90/gge. (4Q, 2019)
  - This project will yield data directly aiding to develop baseline benchmarking and measure improved cost of delivery of liquid hydrogen to fueling stations in California.
- Milestone 4.4: Complete evaluation of 700-bar fast fill fueling stations and compare to SAE J2601 specifications and DOE fueling targets. (3Q, 2016)
  - This project will supply data to the NFCTEC that aid the program in the characterization of the stations' storage and delivery capacities, compression

performance, fueling transactional data, operational cost, maintenance, and safety. Data supplied will provide points of direct comparison to SAE fueling standards and DOE fueling targets.

## FY 2016 Accomplishments

- Completed installation of the GTI-designed data acquisition system at San Juan Capistrano and data submitted to NREL.
- Data submitted to NREL each quarter for West Sacramento station.
- Tasks under Budget Period 1 were completed and approval to move to Budget Period 2 was received.
- A root cause failure analysis was completed and a permanent solution was found for a data logger error that was caused by network issues. Solution has allowed for continuous data collection.
- All equipment ordered and assembled for installation at third station, Bishop Ranch. The Bishop Ranch station began construction June 20, 2016.



## INTRODUCTION

The objective of this project is to collect, organize, and report on operational, transactional, safety, and reliability data for five hydrogen fueling stations located in California. Goals of the project are as follows. (1) The data collected will be statistically meaningful and the stations will have sufficient throughput and vehicle fueling frequency to minimize data aberrations. (2) The data collected will be accurate. (3) The data collected will be comprehensive and timely.

This project will directly assist DOE in assessing the readiness level of current infrastructure and state of the art technologies utilized to support planned fuel cell vehicle deployment within the next five years. The data and observations collected during the performance period of this project will provide NREL with information detailing the operational costs, efficiencies, and reliability of the delivered hydrogen fueling station design. Furthermore, the Linde design utilizes the patented IC90 ionic fluid compressor package; through this project GTI will provide the performance data which will enable DOE and original equipment manufacturers to evaluate real-world efficiencies further gauging the technology's adequacy in this application. This system is a first of its kind utilized for hydrogen fueling applications in the United States.

## APPROACH

Hydrogen station data will be submitted quarterly to the NCFCTEC at NREL using the appropriate Hydrogen Station Data Templates. GTI's project partner, Linde, is currently developing delivered hydrogen fueling stations under programs sponsored by the California Energy Commission. The sites will be accessible to the public for fueling consumer fuel cell vehicles, commercial vehicles, or government-owned vehicles. All five of the sites will be developed at existing or at new sites along with, conventional gasoline stations operated by major, branded fuel providers. This provides the project with vehicle fueling data from a broad, cross-section of real-world vehicle applications. The station sites were selected to provide convenient, consumer-friendly vehicle fueling for drivers of fuel cell vehicles. Development of each of these stations has the support of vehicle original equipment manufacturers and each site has passed stringent location selection requirements of the California Energy Commission to ensure the stations will be utilized by a high volume of fuel cell vehicle operators.

The data collection system will utilize a variety of methods in order to provide the entire data requirements set forth by NREL. This system will utilize the existing control architecture of the compressor and dispenser equipment as well as monitor and record signals from a set of installed instrumentation that will supplement information required that is not already captured inherently by the stations' operating system. There are multiple descriptive (opposed to measured data) deliverables that will be taken manually and submitted to GTI for processing and formatting prior to delivery to NREL. Manually collected data templates include:

- NREL Site Log: recording safety drills, training, or public meetings
- Storage and Delivery: compiling liquid hydrogen supplies delivery quantities and cost
- Fuel Log: transferring transactional data from monthly reports emanating from fuel management system
- Maintenance: station maintenance and operations reporting
- Hydrogen Cost: collection of utility bills
- Safety: station environmental, health, and safety reporting
- Hydrogen Quality: SAE quality analysis completed annually and submitted

GTI will collaborate with Linde and create a reporting/submittal process to collect this type of data required to populate the NREL templates.

## RESULTS

The past year has shown substantial progress including installing the data acquisition system and retrieving data from the two hydrogen stations and making progress toward installing the system at the third station. Figures 1 and 2 show the monthly dispensed hydrogen data collected from the operational sites. This is just a small subset of the large amount of data that is being reported to NREL each quarter. Other data collected includes the energy used in compression and precooling of the hydrogen, maintenance and safety logs, and hydrogen control quality results.

The West Sacramento station was completed and commissioned in December 2014. The data collection portion of this project has continued and six quarters of data have been collected from the site and submitted to NREL. The San Juan Capistrano station was completed and commissioned in September 2015. The data collection portion of this project has continued and three quarters of data have been collected from the site and submitted to NREL. The Bishop Ranch station began construction June 20, 2016. Installation of the GTI panel will likely occur in September or October of this year. The GTI-supplied hydrogen gas flow meter for the system (longest lead item) has been delivered to the Linde

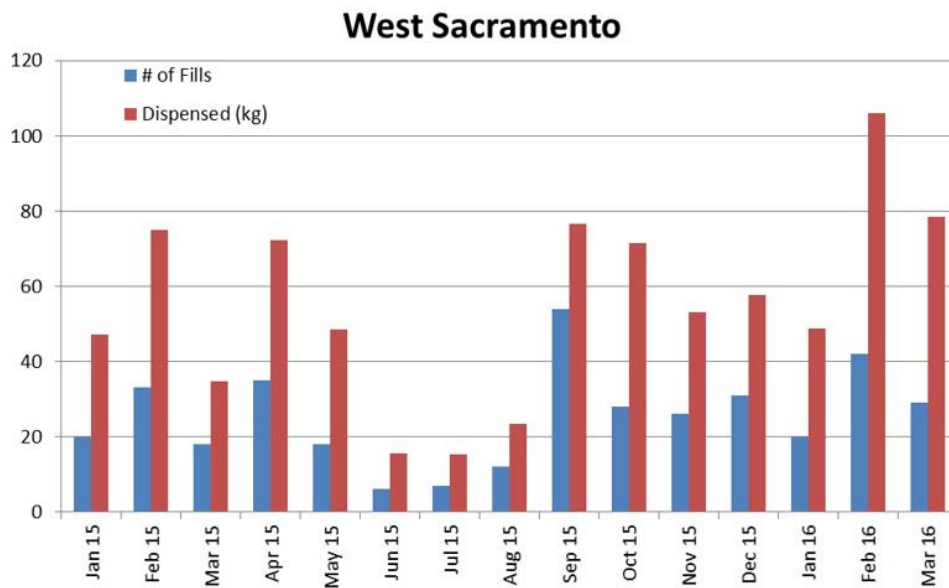


FIGURE 1. West Sacramento usage data

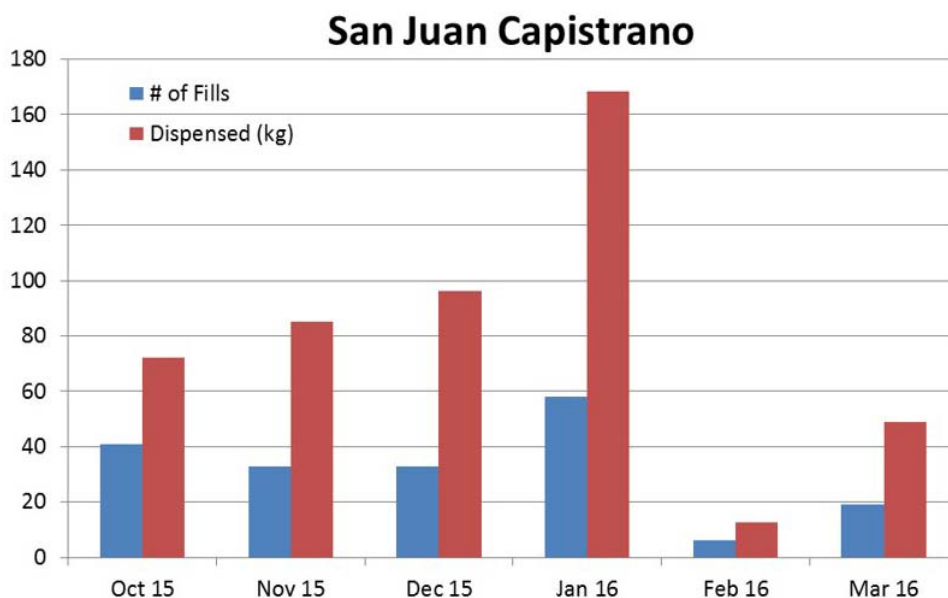


FIGURE 2. San Juan Capistrano usage data

staging area for integration into the compressor skid prior to the skid being installed at the site. The GTI data logger panel was assembled in early 2016 and is ready for installation whenever site construction progress allows. Lastly, progress continues to be made on the installation of the remaining two stations though these installations have progressed slowly due to permitting issues. Sites have all been identified and early engineering has been initiated. These sites are each in various stages of city planning discussions with the local authorities. The major equipment for each site has already been built and is awaiting installation.

## CONCLUSIONS AND FUTURE DIRECTIONS

- Complete construction panel installation at Bishop Ranch.
- Produce the complete sets of data for three project sites at the end of each quarter after startup and commissioning is completed.
- Continue progress on remaining two sites.

## FY 2016 PUBLICATIONS/PRESENTATIONS

1. “tv025\_barnes\_2016\_p.pptx” – Poster Presentation 2016 AMR.