VII.4 California Hydrogen Infrastructure Project

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Working Partners/Subcontractors:
- University of California Irvine (UCI), Irvine, CA
- National Fuel Cell Research Center (NFCRC), Irvine, CA

Project Start Date: August 1, 2005
Project End Date: December 31, 2011

Fiscal Year (FY) 2012 Objectives

Demonstrate a cost-effective infrastructure model in California for possible nationwide implementation:

- Design, construct and operate seven hydrogen fueling stations
- Collect and report infrastructure data
- Document permitting requirements and experiences
- Validate expected performance, cost, reliability, maintenance, and environmental impacts

Implement a variety of new technologies with the objective of lowering costs of delivered H_2:

- New Delivery Concept
- High pressure/high purity clean up equipment

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section (3.6.4) of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(C) Hydrogen Refueling Infrastructure

Contribution to Achievement of DOE Technology Validation Milestones

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

- Milestone 23: Total of 10 stations constructed with advanced sensor systems and operating procedures. (1Q, 2008).

FY 2012 Accomplishments

- Began operation of the hydrogen pipeline fueling station (350 and 700 bar) in Torrance, CA.
- Installed, commissioned and began operation of a renewable hydrogen fueling station and a gas clean-up system for anaerobic digester gas in Fountain Valley, CA.
- Continued high-reliability operation of the hydrogen fueling station in Irvine, CA.

Introduction

Air Products and Chemicals, Inc. is leading a comprehensive, multiyear project to demonstrate a hydrogen infrastructure in California. The specific primary objective of the project is to demonstrate a model of a "real-world" retail hydrogen infrastructure and acquire sufficient data within the project to assess the feasibility of achieving the nation's hydrogen infrastructure goals. The project will help to advance hydrogen station technology, including the vehicle-to-station fueling interface, through consumer experiences and feedback. By encompassing a variety of fuel cell vehicles, customer profiles and fueling experiences, this project is obtaining a complete portrait of *real market needs*. The project is also opening its stations to other qualified vehicle providers at the appropriate time to promote widespread use and gain even broader public understanding of a hydrogen infrastructure. The project is engaging major energy companies to provide a fueling experience similar to traditional gasoline station sites to foster public acceptance of hydrogen.

Approach

Work over the course of the project was focused in multiple areas. With respect to the equipment needed, technical design specifications were written, reviewed, and

finalized. Both safety and operational considerations were a part of this review. After finalizing individual equipment designs, complete station designs were started including process flow diagrams and systems safety reviews. Material quotes were obtained, and in some cases, depending on the project status and the lead time, equipment was placed on order and fabrication was started. Consideration was given for expected vehicle usage and station capacity, standard features needed, and the ability to upgrade the station at a later date.

In parallel with work on the equipment, discussions were started with various vehicle manufacturers to identify vehicle demand (short- and long-term needs). Discussions included identifying potential areas most suited for hydrogen fueling stations, with focus on safe, convenient, fast-fills. These potential areas were then compared and overlaid with suitable sites from various energy companies and other potential station operators. Work continues to match vehicle needs with suitable fueling station locations. Once a specific site has been identified, the necessary agreements can be completed with the station operator and expected station users. Detailed work can begin on the site drawings, permits, safety procedures and training needs. Once stations are brought online, infrastructure data will be collected and reported to DOE using Air Products' Enterprise Remote Access Monitoring system. Feedback from station operators will be incorporated to improve the station user's fueling experience.

Results

The first of the hydrogen fueling stations within the California Hydrogen Infrastructure Project continued operation at the NFCRC at UCI. The capability for fueling vehicles with gaseous hydrogen at 350 bar, involving the installation of a 1,500 gallon horizontal liquid hydrogen tank, 2 kg/hr compressor skid, storage for 50 kg of hydrogen, and a dual dispenser for both 350- and 700-bar hydrogen was brought onstream in August of 2006. The 700-bar system, including the installation of a booster compressor, was commissioned in February of 2007. Based on a 50% compressor on-stream factor, the station has the capacity to dispense 24 kg/day or approximately 6 cars per day. The station continues to see high usage, with daily throughput often reaching 50 kg/day. Table 1 shows the growth in usage of the station over time.

A proposal by Air Products to expand the station to 100 kg/day capacity was selected for support by the California Energy Commission. A photograph of the dispensing system is provided in Figure 1.

The world's first fueling station supplied by a hydrogen pipeline completed construction in early 2011 to demonstrate a low-cost, reliable supply of hydrogen. A site in the Torrance, CA area in proximity to an existing Air Products hydrogen pipeline was developed by Shell Hydrogen. A 4 kg/hr compressor skid and a total of 100 kg of 7,777 psig storage and 20 kg of 15,000 psig storage have been provided. This station dispenses hydrogen according to SAE International specification TIR-J2601. Hydrogen purification technology has been deployed for the first time in this application to demonstrate the production of an ultra-pure hydrogen stream from the industrial-grade pipeline supply. Two dual dispensers for both 350- and 700-bar hydrogen have been installed, and 4 vehicles can be filled simultaneously. Based on a 50% compressor on-stream factor, the station will have the capacity to dispense 48 kg/day or approximately 12 cars per day. When starting with full storage, 6 cars can be filled in succession. An opening ceremony was held on 10 May 2011. Station usage has been high since start-up, with

TABLE 1. UCI 350/700 Bar Hydrogen Fueling Station Usage Growth over Time

Period	# of Fills	Period	# of Fills	Period	# of Fills
Q1 FY2007	88	Q1 FY2009	326	Q1 FY2011	544
Q2 FY2007	60	Q2 FY2009	368	Q2 FY2011	605
Q3 FY2007	111	Q3 FY2009	450	Q3 FY2011	608
Q4 FY2007	107	Q4 FY2009	507	Q4 FY2011	616
Q1 FY2008	257	Q1 FY2010	527	Q1 FY2012	643
Q2 FY2008	198	Q2 FY2010	455		
Q3 FY2008	313	Q3 FY2010	531		
Q4 FY2008	385	Q4 FY2010	549		

Q - quarter

FIGURE 1. UCI 350/700 Bar Hydrogen Fueling Station

daily throughput often exceeding the station's nameplate capacity. Table 2 shows the increase in activity over time.

TABLE 2. Torrance, CA Hydrogen Pipeline Fueling Station Increase in Activity over Time

Period	# of Fills	Period	# of Fills
April 2011	163	September 2011	261
May 2011	193	October 2011	270
June 2011	261	November 2011	298
July 2011	247	December 2011	284
August 2011	203		

A photograph of the dispenser area is provided in Figure 2.

Air Products was selected under a 2006 California Air Resources Board solicitation with additional funding from South Coast Air Quality Management District to install a renewable-based hydrogen fueling station and cleanup system for anaerobic digester gas (ADG) at Orange County Sanitation District (OCSD) in Fountain Valley, CA. Hydrogen was produced utilizing the Hydrogen Energy Station concept being developed under a second DOE project. The statement of work for this project was modified to include procurement and installation of a hydrogen fueling station (sized at 100 kilograms per day) and of a gas cleanup skid to remove contaminant species such as sulfur from the ADG that will be fed to the Hydrogen Energy Station. The fueling station includes compression, storage, and dispensing of hydrogen at 350 and 700 bar according to SAE TIR-J2601. Hydrogen use at the fueling station was limited as automakers continued to negotiate access and payment agreements related to station use. As of December 31, 2011, three automakers have executed the access agreement and were in discussions with UCI (who was managing operation of the hydrogen fueling station) regarding the payment agreement. A photograph of the fueling station area, with the dispenser in the foreground and the balance of fueling station equipment in the background, is provided in Figure 3.

FIGURE 2. Torrance, CA Hydrogen Pipeline Fueling Station

FIGURE 3. Fountain Valley Renewable Hydrogen Station

The ADG clean-up system was delivered to the site in May of 2011, and initial performance of the system has been excellent. One of the features of this system was the use of hydrogen from the Hydrogen Energy Station to assist in the removal of sulfur species. As shown in Figure 4, performance of the ADG clean-up system has met the requirements for supply to the fuel cell.

The formal opening of the Hydrogen Energy Station and hydrogen fueling station at OCSD was held on August 16, 2011.

Conclusions and Future Directions

This project has ended, but operation will continue at Irvine, Torrance and Fountain Valley under a variety of funding mechanisms.

FY 2012 Publications/Presentations

1. A presentation regarding the overall project status was given at the DOE Annual Merit Review Meeting (May 2012).

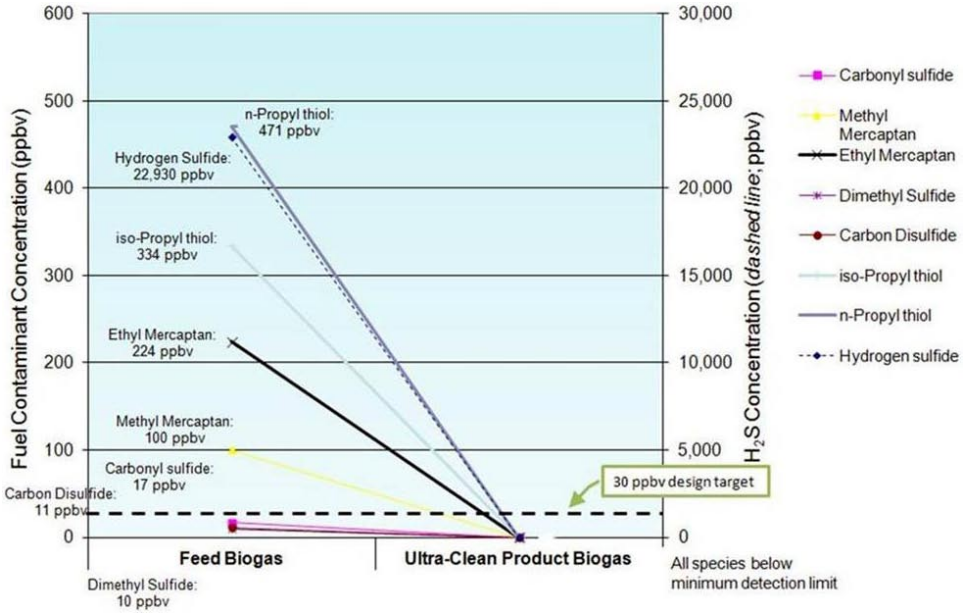

FIGURE 4. Performance of ADG Clean-Up System, Fountain Valley (2/23/12)