VI.A.5 California Hydrogen Infrastructure Project*

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

Project Start Date: August 1, 2005
Project End Date: September 30, 2008

*Congressionally directed project

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 (NDC)
  - Hydrogen Based Unit (HBU)
  - High pressure/high purity clean up equipment

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(C) 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 Technology Validation milestones from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure 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).

Accomplishments

- First permanent station (350 and 700 bar gaseous hydrogen) opened at UCI
- First mobile station (HF-150) being installed in Long Beach, CA
- Continued development of hydrogen pipeline fueling station in Torrance, 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. Air Products is leading this project in collaboration with four automakers: Toyota, Honda, and Nissan, who are providing fuel-cell vehicles, and BMW who is supplying hydrogen internal combustion engine (ICE) vehicles. By encompassing a variety of fuel cell vehicles, hydrogen ICEs, 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 familiar retail fueling experience at traditional gasoline station sites to foster public acceptance of hydrogen.

Approach

Work over the past year 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' eRAM 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 was brought onstream 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 on-stream 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 six cars per day. When starting with full storage, four to five cars can be filled in succession. An opening ceremony was held at the station on 27 February 2007. A photograph of the gaseous dispensing system is provided in Figure 1. During a third phase of work at UCI, a liquid hydrogen dispensing system is planned; this part of the project is currently in the procurement phase.

Air Products and Long Beach Gas & Oil agreed on the terms of the equipment lease agreement that will place an HF-150 mobile fueler on their property at 2400 E. Spring Street. The HF-150 (shown in Figure 2) is ideal for small fleet fueling and offers the advantages of being a highly reliable, cost-effective, and automated fueling system that can be easily installed. The HF-150 maintains about 150 kg of gaseous hydrogen at 6,600 psig. It can dispense approximately 80 to 90 kg before needing to be refilled. The contract was approved by the city council of Long Beach in October 2006. All project permits were obtained by the local authorities, including an exemption from the California Environmental Quality Act. The contract between Air Products and the City of Long Beach was executed

FIGURE 1. UCI 350/700 Bar Gaseous Hydrogen Dispenser

FIGURE 2. Air Products HF-150 Hydrogen Fueler

in April 2007. Following the completion of minor site work, the station is expected to be on-stream in June 2007.

The world's first fueling station supplied by a hydrogen pipeline is being developed to demonstrate a low-cost, reliable supply of hydrogen. A site in the Torrance, CA area in proximity to an existing Air Products 800 psig hydrogen pipeline is being considered. Pipeline permits are in place, and the plans for the permit to construct the fueling station were submitted in January 2007. Comments have been received, and revisions are expected to be submitted in July 2007. A 4 kg/hr compressor skid and a total of 50 kg of high-pressure hydrogen storage are being provided; accommodations are provided to double storage capacity in the future. A dual dispenser for both 350 and 700 bar hydrogen is being provided, and the future upgrade to 700 bar will require a booster compressor and minimal site work. 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, six cars can be filled in succession.

As part of this project, a novel high-pressure, high-purity hydrogen purifier has been developed, and a 4 kg/hr unit will be installed upstream of the fueling station. Hydrogen from the pipeline will be purified to ultra-high purity using a physical adsorption system. The process cycle (patents pending) utilizes a rapid regeneration cycle to yield high hydrogen recovery. There is no need for thermal regeneration, which reduces the capital, operating, and maintenance costs.

Two new technologies are being deployed under this project. The NDC trailer is a new method of hydrogen distribution capable of supplying low, medium, and high pressure systems using a single liquid hydrogen trailer (Figure 3). The NDC trailer provides a tenfold increase in the amount of transported hydrogen compared with traditional tube trailers. This delivery system can be utilized to supply existing merchant bulk hydrogen and liquid hydrogen supply chains as well as hydrogen fueling stations, resulting in greater equipment utilization. Delivery pressures as high as 8,000 psig are achieved, and no utilities are required from the receiving stations. Individual process components have been tested, and the first of the NDC trailers is under fabrication. Deployment to California is expected in late-summer 2007.

The HBU (patents pending) is a new approach to reduce costs associated with stationary fueling stations. The HBU requires minimal space and can be located remotely from storage (including underground). No compression is required, as the NDC trailer delivers the hydrogen at the desired pressure (up to 7,000 psig). The design capacity of the HBU is 150 to 200 kg of hydrogen. Fabrication of the first HBU was completed in April 2007, and a photograph is provided in Figure 4. Discussions with potential station operators are ongoing, and this unit can be deployed in conjunction with the roll-out of the NDC as early as late-summer 2007.

Conclusions and Future Directions

Planned future work includes:

- UCI Fueling Station – Continue operation of gaseous dispensers, and finalize liquid hydrogen dispensing system.
- Torrance Pipeline Fueling Station – Complete agreement with station operator, then install and commission both 350 and 700 bar systems.
- Hydrogen Fuelers (HF-150) – Begin operation at Long Beach, and identify other locations and station operators.
- NDC – Complete fabrication of NDC #1 and deploy; fabricate NDC #2 and deploy.
- HBU – Fabricate HBU #2; identify locations and station operators.
- Infrastructure Data Acquisition, Analysis and Delivery – Report Data to DOE.

FIGURE 3. Air Products New Delivery Concept (NDC) Trailer

FIGURE 4. Air Products Hydrogen Based Unit (HBU)

FY 2007 Publications/Presentations

1. A presentation regarding the overall project status was given at the DOE Annual Merit Review Meeting (May 2007).