VIII.3 Hydrogen Fuel Cell Vehicle & Infrastructure Demonstration Program Review

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Subcontractor:
BP America Inc., Naperville, IL

Start Date: November 17, 2004
Projected End Date: April, 2010

Objectives

Ford:

- Gain vehicle operational data in differing climate conditions, to direct and augment future design efforts.
- Provide input to the industry-government efforts to define a future hydrogen economy.

BP:

- Provide safe, reliable user friendly hydrogen infrastructure.
- Install technology to meet cost targets.
- Test a variety of hydrogen delivery options.

Technical Barriers

This project addresses the following technical barriers identified in the Technology Validation section (3.6.4) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan (October 10, 2007, update April 2009):

(A) Lack of Fuel Cell Vehicle Performance and Durability Data

(B) Hydrogen Storage

(C) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

(D) Maintenance and Training Facilities

(E) Codes and Standards

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 (3.6.6) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 2**: Demonstrate FCVs that achieve 50% higher fuel economy than gasoline vehicles (3Q, 2005).
- **Milestone 4**: Operate fuel cell vehicle fleets to determine if 1,000 hours fuel cell durability, using fuel cell degradation data, was achieved by industry (4Q, 2006).
- **Milestone 5**: Validate vehicle refueling time of 5 minutes or less for a 5 kg tank (1 kg/min). (4Q, 2006).
- **Milestone 7**: Validate vehicle refueling time of 5 minutes or less for a 5 kg tank (1 kg/min) at 5,000 psi through the use of advanced communications technology. (4Q, 2007).
- **Milestone 8**: Fuel cell vehicles demonstrate the ability to achieve 250-mile range without impacting passenger cargo compartment (4Q, 2008).
- **Milestone 10**: Validate FCVs 2,000-hour fuel cell durability, using fuel cell degradation data. (4Q, 2009)
- **Milestone 22**: Five fueling stations and two vehicle maintenance facilities constructed using advanced sensor systems and operating procedures (YE 2006).
- **Milestone 23**: Total of 10 stations constructed with advanced sensor systems and operating procedures. (1Q, 2008)
- **Milestone 24**: Validate a hydrogen cost of $3.00/gge (based on volume production) (4Q, 2009).

Accomplishments

- As reported in 2005, dynamometer testing confirms 50% higher fuel economy and indicates that the target set in this program Milestone 2 has been met.
- 1,000-hour durability has been demonstrated in on-road durability testing. The 18-car demonstration fleet has exceeded this Milestone target.
- Average data in 2009 for both communications and non-communications fueling fill-ups indicates an average fill rate of more than 1.1 kg/min which meets the Milestone 5 target.
- Fill times of 5 minutes or less have been demonstrated for 'full' fills using vehicle-to-station communication. Milestone 7 has been met.
- As detailed in earlier reports, Ford's Technology Demonstrator Vehicle (TDV) program of progressive design levels demonstrating improved range in functional configurations (Table 1) has demonstrated capability for the targeted 250-mile range, in a sport utility vehicle (SUV) configuration with slightly reduced passenger volume, and also in a plug-in hybrid fuel cell cross-over vehicle with little passenger compartment compromise.
- Ford is submitting ongoing field vehicle data in support of Milestone 10.
- In support of Milestone 22:
  - Service Facilities: As previously reported, Ford has completed two service facilities for project vehicles in Dearborn, MI, and Sacramento, CA. In Florida, repair work is being performed in a nearby, cooperating Ford dealership. A fourth service operation has been opened in Reykjavik, Iceland. All facilities utilize state-of-the-art hydrogen sensors, and have service and operating procedures established for hydrogen-fueled vehicles. Hundreds of operators and emergency responders have been trained in safe operation and approaches to hydrogen powered vehicles.
  - Fueling Stations: In Michigan BP began operation of the City of Taylor (CoT) hydrogen liquid delivery station in October 2006. In Florida, construction and installation of the electrolysis hydrogen station was completed in April 2007. In California, the renewable hydrogen generation station at Sacramento Municipal Utility District (SMUD) opened in March 2008. The 700 bar upgrade of the Ford Dearborn station is operational. BP completed three stations and an upgrade to the Dearborn station for 700 bar fueling.
- As previously reported, BP has assessed, through meetings with suppliers, several technologies to understand the current status and potential for meeting the $3.00/gasoline gallon equivalent (gge) target untaxed by 2009. Their study concluded that the H2Gen 2000 and the Air Products Harvester units could meet the $3.00/gge untaxed hydrogen production cost target using the H2A model assumptions. BP will not provide independent verification.

Since the last annual report, specific accomplishments in this technology demonstration are:

- Fleet vehicle operation continued past the original 36-month operation and will continue to supply data until September 30, 2009. Eleven vehicles will have operated for 48 months.
- Fueling fill times that meet the program milestone target of five minutes or less continue to be demonstrated.
- Technology demonstrator vehicles have been used to certify and demonstrate effective 700 bar fuel systems, both on vehicle and in the fueling station.

TABLE 1. Technology Demonstration Vehicle Plan

Vehicle Attributes	H2 Storage Upgrade	Robustness Demonstrator	Designed Around Hydrogen Demonstrator	Flexible Series H2 Hybrid
Fuel Cell Generation	Gen 1	Gen 2 (Stage 1)	Gen 2/3 (Stage 2)	APU
Number of Vehicles	1	1	3	1
Range (miles)	240	200	>300	300
Hydrogen Storage (bar)	700	350	350 & 700	350
Unassisted Cold Start	2°C	2°C	< 0°C	-15°C
Assisted Cold Start	2°C	2°C	-15°C	-25°C
Fuel Efficiency (mpg) (*normalized to Focus)	50	50	50	40-70

Introduction

In order to meet the objectives and deliverables of this technology demonstration project, Ford and BP developed an approach that permits demonstration of the current state of technology while continuing to develop and prepare demonstrations of newly emerging technologies and techniques. In this approach, Ford has deployed 18 vehicles, powered by a Ballard Mark 902 fuel cell system, in customer fleet applications. DOE requested data describing operating parameters is being collected using computerized, automated data collection and analysis techniques. At the same time, new concepts of vehicle and component design are being developed using emerging technologies to demonstrate progress toward the DOE's longer-term milestones and targets.

The original plan defined the fleet operational period to be 36 months per car. Based on the value of data that is being collected and the learning from high hour fuel cell stack data, Ford, BP and the DOE had agreed to continue field operations through the end December, 2009. However, late changes by BP have caused the demonstration end date to be moved forward to September 30, 2009.

At the beginning of the vehicle demonstration, BP first deployed delivered hydrogen to permit fleet operations. With initial fleet deployment complete, BP worked with local authorities where the cars are operating, to locate, plan and certify hydrogen fueling stations in each of the fleet operating areas.

Approach

The Ford vehicle demonstration approach utilizes two phases: 1) deployment of 18 customer-operated vehicles in three different geographic and climatic areas (California, Florida and Michigan) and 2) development of TDVs that incorporate advanced technology and design concepts directed at meeting future DOE targets for improved hydrogen storage and interface, durability, low temperature operation, fuel economy, range and reduced weight and cost.

BP's infrastructure approach followed in two phases: 1) test infrastructure deployment by installing hydrogen delivered stations, including electronic data collection for select sites, and 2) assessing the ability to meet cost targets by installing onsite renewable hydrogen electrolysis production and/or 700 bar fueling at select sites. Completed station installations include CoT, Michigan, Florida Progress Energy, Orlando, and SMUD, Sacramento, California. 700 bar capability was made available at the Ford Dearborn site.

Results

The vehicles are operating efficiently (meeting fuel consumption targets) and effectively (vehicle "up-time" in excess of 95%). The fleet and involved personnel have also continued to demonstrate a 100% safety performance with no incidents or near misses. Six second-phase demonstrators are built and have demonstrated new concepts for packaging of the various system components for improved performance, range and noise reductions. Two vehicles are operating with 700 bar fuel systems

Three hydrogen fueling stations are operating. The CoT station has presented challenges with dispenser and compressor reliability. Problems continue and have increased as the station ages. Although the Jamestown station was commissioned in June 2007, problems with the nine electrolyser power supplies caused the station to use delivered hydrogen until January 2008. It has performed well since the reopening. The SMUD renewable hydrogen station opened in March 2008 and has operated efficiently.

Conclusions and Future Direction

The project is providing important data on both vehicle performance and infrastructure development. Three configurations of fuel cell vehicles, a passenger car, an SUV and a cross-over continue to demonstrate useable customer designs with some compromise for passengers. 700 bar fuel storage has been successfully implemented in vehicles and a station. Data collection will continue through September 30, 2009 for the 18 customer vehicles, providing the required data to support the program milestones.

The Jamestown, CoT and SMUD stations have presented an opportunity to better understand the differences in support service from a variety of gas and equipment suppliers, as well as offer comparisons between renewable and non-renewable hydrogen generation, or delivered vs. distributed production. Although the Dearborn 700 bar station is complete, the short time remaining in the demonstration minimizes the opportunity to gather and share relevant operational data.

With the decommissioning of the three fleet fueling stations, the fleet demonstration project will come to an end and final technical reporting will be prepared. The final technical report will be submitted early in 2010. Ongoing TDV evaluation data will continue to be shared with the DOE until such time as the DOE and Ford determine that the effort should terminate.