

VII.2 Ford and BP Hydrogen Fuel Cell Vehicle and Infrastructure Demonstration Program Review 2008

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BP America Inc., Naperville, IL

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Projected End Date: June 2010

Technologies Program Multi-Year Research, Development and Demonstration Plan (October 10, 2007):

- (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 fuel cell vehicles (FCVs) that achieve 50% higher fuel economy than gasoline vehicles (3Q 2005).
- **Milestone 4:** Operate FCV 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:** FCVs 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).

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:

- Develop retail compatible hydrogen refuelling systems.
- Evaluate emerging hydrogen technologies that have the ability to meet DOE cost and performance targets.
- Explore cost and commercial feasibility of renewable-based hydrogen generation.

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

Accomplishments

- As reported in 2005, dynamometer testing of field tested units confirms 50% higher fuel economy and indicates that the target set in Milestone 2 has been met.
- 1,000-hour durability has been demonstrated on the first engineering test vehicles in accelerated on-road durability testing. A demonstration fleet has accumulated an average of 1,000 hours of driving, indicating Milestone 4 has been met.
- Average data in the first quarter of 2008 for both communications and non-communications fueling fill-ups achieves the 1 kg/min average fill rate, which meets the Milestone 5 target.
- Fill times of 5 minutes or less have been demonstrated for ‘full’ fills using vehicle-to-station communication. With this data, Milestone 7 has been met.
- Ford has a Technology Demonstrator Vehicle (TDV) plan that is providing progressive design levels demonstrating improved range in functional configurations (Table 1). This plan has demonstrated the 250-mile range in a sport utility vehicle (SUV) configuration with slightly reduced passenger volume, and a plug-in hybrid FCV cross-over vehicle with little passenger compartment compromise.
- Ford is submitting ongoing field vehicle data in support of Milestone 10. Ten of the 18 demonstration vehicles have exceeded 1,000 hours.
- In support of Milestone 22:
 - Ford has completed two service facilities (including use of unique FCV diagnosis and tracking software/hardware) for program vehicles in Dearborn, MI and Sacramento, CA. In Florida, repair work is being performed in a nearby, cooperating Ford Dealership. With a recent reassignment of a vehicle to Iceland, another service center has been opened and is operating. The existing facilities utilize state-of-the-art hydrogen sensors, and have service procedures established for hydrogen fueled vehicles, and operating procedures for personnel working in a hydrogen vehicle service facility. 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 Sacramento Airport station permits were withdrawn due to protracted negotiations. Instead, BP proceeded with the renewable hydrogen generation

TABLE 1. Technology Demonstration Vehicle Plan

Vehicle Attributes	H ₂ Storage Upgrade	Robustness Demonstrator	Designed Around Hydrogen Demonstrator	Flexible Series H ₂ Hybrid
Fuel Cell Generation	Gen 1	Gen 2 (Stage 1)	Gen 2/3 (Stage 2)	APU
Number of Vehicles	1	1	5	1
Timing	1 Q '08	1Q '06	4Q '06	4Q '06
Range (miles)	240	200	>300	300
Hydrogen Storage (bar)	700	350	350	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

station at Sacramento Municipal Utility District (SMUD) which opened in March 2008. Current plans include the 700 bar upgrade of the Ford Dearborn station which is scheduled to operate by the end of July 2008.

- BP informed both Ford and DOE that the number of stations has been reduced to three permanent stations and the Dearborn 700 bar upgrade.
- BP has assessed through meetings with suppliers several technologies to understand their current status and potential of meeting the \$3.00 gasoline gallon equivalent (gge) target untaxed by 2009. The following is a list of a few of the technologies reviewed to date; H2Gen 2000, Air Products Harvester, Proton Energy high pressure proton exchange membrane system with electrochemical compression and GE autothermal reformer. Of these systems, the H2Gen 2000 and the Air Products Harvester unit can 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:

- Deployed one of the vehicles to Iceland New Energy in Reykjavik, Iceland for new geographic data input.
- The demonstration period for the fleet has been revised for continued fleet vehicle operation through December, 2010.

- Fueling fill times that meet the program milestone target of five minutes or less continued to be demonstrated.
- All fueling station deployment has been complete including the COT, the Florida Progress Energy station and the SMUD station.
- New concept vehicle architecture has demonstrated the ability to improve vehicle operating characteristics and consumer-focused attributes in designs developed for hydrogen-powered drivetrains.



Introduction

In order to meet the objectives and deliverables of this technology demonstration project, Ford and BP have developed an approach that permits demonstration of the current state of technology while continuing to develop and prepare demonstrations for newly emerging technologies and techniques. In this approach, Ford has deployed 18 vehicles with state-of-the-art fuel cell system designs in customer fleet applications. Detail data of the operating parameters are 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 against 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 have agreed to continue field operations through the end December, 2010.

At the beginning of the vehicle demonstration, BP first deployed delivered hydrogen to permit fleet operations. With initial fleet deployment complete, BP has worked with local authorities where the cars are operating, to locate, plan and certify permanent 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 four different geographic and climatic areas (California, Florida, Michigan, and Iceland) and 2) development of TDVs that incorporate advanced technology and design concepts directed at meeting future DOE targets for improved hydrogen storage & interface, durability, fuel economy, and reduced weight and cost.

BP's Infrastructure Approach follows in two phases: 1) test infrastructure deployment by installing hydrogen delivery stations, including electronic data collection for select sites, and 2) assessing the ability to meet cost targets by installing onsite renewable H₂ electrolysis production and/or 700 bar fueling at select sites. Completed station installations include COT, Michigan and Florida Progress Energy, Orlando and SMUD, Sacramento, California. Future stations include 700 bar at Ford Dearborn.

Results

The vehicles are operating efficiently and effectively and have exceeded an average 1,000 hours of use. The fleet and involved personnel have also continued to demonstrate a 100% safety performance with no incidents or near misses. Four Second Phase demonstrators are built and have demonstrated new concepts for packaging of the various system components for improved performance, range and noise reductions.

Three hydrogen fueling stations are operating (Table 2). The Jamestown station was commissioned in June 2007; two months after start-up problems occurred which resulted in extended use of the Jamestown mobile refueler. Re-start of the Jamestown permanent station occurred January 2008. As the SMUD renewable hydrogen station opened in March 2008 summary data from that station will be shared in the next annual report.

TABLE 2. Infrastructure Demonstration Summary

	Open	Planned	Decommission
California			
Sacramento Mobile Refueler	Oct 2005		Jun 2008
SMUD	Mar 2008		Dec 2009
Florida			
Jamestown Mobile Refueler	Sep 2005		Jan 2008
Jamestown Stationary Site w/electrolyser	Apr 2007		Dec 2009
Michigan			
City of Taylor Temporary Station	Oct 2005		Jan 2007
City of Taylor Stationary Site (Liquid delivery)	Oct 2006		Dec 2009
Dearborn (700 bar) (liquid delivery)	July 2008		Dec 2009

Conclusions and Future Directions

The project is providing important data on both vehicle performance and infrastructure development. Three configurations of FCVs, a passenger car, an SUV and a cross-over continue to demonstrate useable customer designs with some compromise for passengers. Fuel storage of 700 bar has been successfully developed and evaluated. Advanced vehicle designs will continue to be prepared in accordance with the TDV program approved by the DOE. Data collection will continue for the 18 customer vehicles, providing the required data to support the program milestones.

The Jamestown, COT and SMUD permanent stations present an opportunity to better understand the differences in support service for a variety of gas and equipment suppliers, as well as offer comparisons between renewable and non-renewable hydrogen generation or delivered vs. distributed production.