Hydrogen Fuel Cell Vehicle & Infrastructure Demonstration Program Review

Ford Motor Company
Research & Advanced Engineering
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Overview

Timeline
• Project start: Nov. 17, 2004
• Project end: Jun. 2009
• 5% complete

Budget
• $88 mil project
  – DOE $44 mil
  – Ford $44 mil
• FY04: $0.4 mil
• FY05: $34.2 mil

Barriers Addressed
• Vehicles
• Storage
• Hydrogen Refueling Infrastructure
• Maintenance and Training Facilities
• Codes & Standards

Partners
• BP America
• Ballard
• States of California & Florida
• Cities Ann Arbor & Taylor
• SMUD, Progress Energy & NextEnergy
Project Objectives

To gain FCV operational data in differing climate conditions to direct and augment future design efforts

- Complete Program Management Documentation
  - Plans for Safety, Risk Mitigation, Communication, Training, Facility Preparation, Test & Data, Vehicle Delivery and Program Plan
- Begin Vehicle Build Process
- Design Data Collection Architecture
- Prepare Service Facilities
- Train Emergency Responders
- Train Service Technicians
- Prepare & Deliver Training Material for Drivers & Fleet Managers
Provide safe, reliable user friendly hydrogen infrastructure for vehicles, install technology to meet cost targets and establish an initial infrastructure network to fuel small fleets across a metropolitan area

- Stations in Florida, Sacramento, California and SE Michigan
- Implement data collection system
- Commence community engagement
- Complete Program Management Documentation
  - Plans for Safety, Risk Mitigation, Communication, Training, Facility Preparation, Test & Data, and Program Plan
Vehicle Approach

- Two demonstration components
  - Component 1: developed technology installed in contemporary vehicles for real world use
  - Component 2: controlled in-house demonstration of extended range, durability and operating temperature
- Fleet vehicles in three differing geographic/climatic regions
- Automated data collection methodologies for effective data analysis
## Vehicle Approach

<table>
<thead>
<tr>
<th>Program Elements</th>
<th>Component 1</th>
<th>Component 2</th>
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</thead>
<tbody>
<tr>
<td>Real World Data</td>
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<tr>
<td>Maintenance &amp; Training</td>
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<tr>
<td>Hydrogen Storage &amp; Interface</td>
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<tr>
<td>Durability</td>
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<td>✔</td>
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<td>Economy</td>
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<td>Weight</td>
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<td>Cost</td>
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Component 1: Focus Model Implementations

Designed for a customer life of 3yr/ 45,000 miles (73,000 km)

- Ford Focus 4 Door
- Weight: 1600 kg (3520 lbs)
- Fuel Cell: Ballard Mark 902 fuel cell stack
- Power: 67kW (87hp)
- Power train: Integrated--combines inverter module with AC electric motor transaxle
- Hybridized – 216 volt Battery Pack
- Regenerative Braking System
- Range: 260 - 320 km (160 - 200 miles)
- Max speed: 128+ kph (80+ mph)
- Fuel: 5000 psi Compressed Gaseous Hydrogen
- Emissions: Zero
• Developed systems control improvements to enhance reliability

• Established Fuel Economy

• Implemented Data collection architecture using Vehicle Network Gateway at one second intervals

• Developed Training Material

• Conducted Emergency Responder Training
Technical Accomplishments/ Progress/Results

Development

- Tested to 4.5 yr/ 65,000 miles (109,000 km) target
- Over 165,000 miles (275,000 km) accumulated on our FCV fleet to date
- Production validation testing completed
Robustness Improvement

Significant Reliability Improvements

- Systems Control Software enhanced
- Improved robustness of interfacing vehicle systems

![Vehicle Generation - Test Cycles per Day](chart.png)

Test Cycles per Day

1. Vehicle Generation
2. Production Release
Completed Proving Grounds tests of three vehicles to equivalent of 150% of program duration (4.5 years)
Vehicles Robustness and Durability Testing

14,000 Ft Altitude Testing

Mud Bath / Salt Water Fording

Brake Testing -18 C

Hot Weather Thermal / Durability Tests
Impact Safety Tests Complete

90º 30 MPH Front Fixed Barrier Impact

90º 30 MPH Rear Moving Barrier Impact
Vehicle Development – Fuel Economy

6700 miles of Development

Result:
Achieved 50 mpg M-H Target
Vehicle Data Collection

Data acquisition, transfer, and analysis capability is piloted and ready to deploy.
Vehicle Placements Activities

Training Material Developed

• Service Manuals
• Operator Training
• ER Training

ER Training Conducted

• 110 in Dearborn, MI

8 Vehicles already in service provide model for DOE launch
• **Employ Two Phase Approach**
  • Phase I: Test Infrastructure Deployment
    • Install H2 Delivered Stations
    • Include electronic data collection for select sites
  • Phase II: Meet Cost Targets
    • Install onsite H2 Production and/or 700 bar Fueling at Select Sites

• **Station Locations**
  • Orlando Florida (1)
  • Sacramento (up to 4)
  • Taylor, Michigan (up to 2)
## Approach

<table>
<thead>
<tr>
<th>Location</th>
<th>Phase 1 Delivered H2</th>
<th>Phase 2 Electrolysis</th>
<th>Phase 2 SMR</th>
<th>Phase 2 700 Bar</th>
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<td>Station M2</td>
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Technical Accomplishments

- Initiated Permanent Station Permitting Process
  - Florida
  - Sacramento
  - Michigan

- Leasing Mobile Refueler to meet immediate vehicle fueling needs

- Selected Turn Key Infrastructure Suppliers for 2005 Projects

- Evaluated reformer and electrolysis options

- Completed Hydrogen Fire Marshal Workshops
  - Florida
  - Sacramento
2005 Work Plan

• Upcoming Events:
  - Install fueling capability in California
  - Complete operator, fleet manager & technician training in Sacramento
  - Deliver vehicles to Sacramento
  - Install fueling capability in Orlando
  - Complete operator, fleet manager & technician training in Orlando
  - Deliver vehicles to Orlando
  - Install fueling capability in SE Michigan
  - Complete operator, fleet manager training in Michigan
  - Deliver vehicles in SE Michigan
2005 Vehicle Deployment

- Sacramento: 2nd Qtr
- Florida: 2nd Qtr
- SE Michigan: 3rd Qtr