HYDROGEN TO THE HIGHWAYS
Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

Ronald Grasman
May 20, 2009

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Program Objectives

- Record, collect and report data from fuel cell vehicles and hydrogen fuelling stations to validate 2009 DOE performance targets:
  - Fuel cell stack durability: 2,000 hours
  - Vehicle range: 250 miles
  - Hydrogen cost at station: $3.00/GGE
- Demonstrate the safe installation and operation of service facilities
- Raise public awareness of hydrogen technology
- Develop Codes and Standards and implement rigorous safety processes
# Program Overview

## US Dept. of Energy Fuel Cell Vehicle and Infrastructure Cooperative Program

<table>
<thead>
<tr>
<th><strong>Timeline</strong></th>
<th><strong>Partners</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Project Start Date: 01/07/04</td>
<td>- Chrysler</td>
</tr>
<tr>
<td>- Project End Date: 09/30/09</td>
<td>- BP America</td>
</tr>
<tr>
<td>- Percent Complete: 90%</td>
<td>- Daimler</td>
</tr>
<tr>
<td></td>
<td>- DTE Energy</td>
</tr>
<tr>
<td></td>
<td>- MBUSA</td>
</tr>
<tr>
<td></td>
<td>- NextEnergy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Budget</strong></th>
<th><strong>Barriers</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- $88.8M Total Project Funding</td>
<td>A. Vehicles</td>
</tr>
<tr>
<td>- $44.4M Federal Share</td>
<td>B. Storage</td>
</tr>
<tr>
<td>- $44.4M Industry Share</td>
<td>C. Hydrogen Refueling Infrastructure</td>
</tr>
<tr>
<td>- $5.1M FY05 Funding</td>
<td>D. Maintenance and Training Facilities</td>
</tr>
<tr>
<td>- $6.3M FY06 Funding</td>
<td>E. Codes and Standards</td>
</tr>
<tr>
<td>- $7.6M FY07 Funding</td>
<td></td>
</tr>
<tr>
<td>- $5.2M FY08 Funding</td>
<td></td>
</tr>
</tbody>
</table>
Approach

• Operate Gen-I and Gen II vehicles under real world condition to monitor 2009 performance targets
• Install and maintain data acquisition system that automatically collects vehicle data
• Establish initial fueling network to support FCV fleet
• Align the Chrysler Team’s outreach activities with the education goals of the DOE
• Support codes and standards activities
2008/09 Objectives

• Fuel Cell Vehicles
  – Maintain smooth operation of Gen I vehicles
  – Finalize development and begin operations of 70MPa fuel tank upgrade
  – Complete lifetime test of Gen II fuel cell stack system
  – Begin internal operations of Gen II vehicles

• Hydrogen Infrastructure
  – Complete site development of City of Burbank station
  – Continue operations of PG&E and LAX stations as agreed by partners
  – Maintain operations of DTE and NextEnergy hydrogen fueling stations

• Safety and Data Reporting
  – Maintain project safety
  – Complete safety and risk assessment activities with the construction of new 70MPa Burbank station
  – Maintain the high quality of data reporting structure

• Outreach/Media Events
  – Raise public knowledge of hydrogen technology and demonstration projects
Milestones

<table>
<thead>
<tr>
<th>Milestones</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Percent Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gen I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Gen I Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%*</td>
</tr>
<tr>
<td>• 70MPa Vehicles Upgrade and Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75%</td>
</tr>
<tr>
<td><strong>Gen II</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Fuel Cell Stack System Durability Test &amp; Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td>• Gen II FDA Infrastructure Upgrade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>• Internally Operate Vehicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75%</td>
</tr>
<tr>
<td>• Externally Operate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0%</td>
</tr>
</tbody>
</table>

*Gen I vehicle operation achieved and exceeded

Official End Date
Accomplishments and Progress
Gen-I Operations

- Continuing mileage accumulation through customer operations in 2009 with vehicles in service for over 5 years
- Submitted over 85 DVD’s of raw data to NREL
- Embraced DOE’s “lighthouse” vision by relocating primary workshop from West Sacramento to Long Beach
  - (Service center in Palo Alto remains for Northern California customers)
Accomplishments and Progress
Gen-I Operations

Operated Gen I vehicles with optimized 70MPa tank systems and CPU software upgrade

Deployed F-Cell to NREL (Golden, Colorado) for Advanced Technology Fleet Effort
Accomplishments and Progress
Transition to Gen II Technology

Next generation of the fuel cell-power train:
- Higher stack lifetime (>2000h)
- Increased power
- Higher reliability
- Freeze start ability
- Li-Ion Battery

A-Class F-Cell

<table>
<thead>
<tr>
<th>Technical Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Type</td>
<td>Mercedes-Benz A-Class</td>
</tr>
<tr>
<td>Fuel Cell System</td>
<td>PEM, 72 kW (97 hp)</td>
</tr>
<tr>
<td>Engine</td>
<td>Engine Output (Continuous / Peak): 45 kW / 65 kW (87hp) Max. Torque: 210 Nm</td>
</tr>
<tr>
<td>Fuel</td>
<td>Hydrogen (35 MPa / 5,000 psi)</td>
</tr>
<tr>
<td>Range</td>
<td>105 miles (170 km / NEDC)</td>
</tr>
<tr>
<td>Top Speed</td>
<td>88 mph (140 km/h)</td>
</tr>
<tr>
<td>Battery</td>
<td>NiMh</td>
</tr>
</tbody>
</table>

B-Class F-Cell

<table>
<thead>
<tr>
<th>Technical Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Type</td>
<td>Mercedes-Benz B-Class</td>
</tr>
<tr>
<td>Fuel Cell System</td>
<td>PEM, 80 kW (108 hp)</td>
</tr>
<tr>
<td>Engine</td>
<td>IPT Engine Output (Continuous / Peak) 70kW / 100kW (136hp) Max. Torque: 320 Nm</td>
</tr>
<tr>
<td>Fuel</td>
<td>Hydrogen (70 MPa / 10,000 psi)</td>
</tr>
<tr>
<td>Range</td>
<td>250 miles (400 km)</td>
</tr>
<tr>
<td>Top Speed</td>
<td>106 mph (170 km/h)</td>
</tr>
<tr>
<td>Battery</td>
<td>Li-Ion</td>
</tr>
</tbody>
</table>
Accomplishments and Progress
Gen-II Technical Accomplishments

• Completed durability testing on Gen-II fuel cell stack system to support 2009 DOE target

• Developed, optimized and tested Gen II start/stop algorithm to further improve fuel economy and start-up time of fuel cell system

• Completed vehicle dynamometer testing to verify fuel economy and range
Accomplishments and Progress
Gen-II Technical Accomplishments

• Internally operated Gen II pre-production vehicles
  • Hot weather conditions
  • Cold start capability
• Submitted Gen II raw data for NREL analysis to validate 2008 milestone
Accomplishments and Progress
Codes and Standards

Daimler participated in various working groups to ensure continuous progress with regards to Codes and Standards

- J2578 - Recommended Practice for General Fuel Cell Vehicle Safety
  - Revised version published January 2009
  - Revised version published January 2009
- J2601 - Fueling Protocols for Gaseous Hydrogen Surface Vehicles
  - Final draft sent out for review, ballot targeted for May 2009
  - Proposal to change reporting units of particle sampling and particulate size requirements
  - Letter (draft) to be sent to NIST
- FMVSS 305
  - Expected to be finalized in 2009
  - J1766 will be revised to reflect the content of the final rule
- Database (NextEnergy)
  - Hydrogen Permitting Officials database posted to live NextEnergy Center website
  - Intended to be used as future DOE tool to identify H2 AHJs in Michigan
- Annual Conference (NextEnergy)
  - Slated for Fall 2009
  - Focus on current industry efforts toward C&S development
Accomplishments and Progress

Safety

- Emergency responder training at NextEnergy
- Joint table top exercise
- No safety incident

- Project Fleet Vehicle Incident Management Plan
- Palo Alto Service Facility

- Risk assessment and HAZOP activities for 70MPa station in Burbank, CA
Accomplishments and Progress
Public, Political & Industry Outreach

Public Outreach

Conference Exhibitions

H2 Road Tour
Accomplishments and Progress
Infrastructure

- Southern California: Burbank
  - **Status:** Construction complete
  - **Technical Data:**
    - On-site SMR hydrogen production; 108 kg/day capacity
    - 352 kg storage capacity
    - 60 Hp 70MPa compressor
    - Dual pressure dispenser
    - H2 truck off-loading
    - Operational video monitoring
  - **Hydrogen Delivery:** 35 and 70 MPa
  - **Site Utilization:**
    - Planned as an open site for all OEMs with a supply agreement
    - Burbank will use 10-15kg/day of hydrogen for fuel cell bus
    - Burbank and Daimler/Chrysler will have priority of supply
    - 70 MPa cars must have communication capabilities for complete fill
Accomplishments and Progress
Infrastructure

- **Southern California: Burbank (Continued)**
  - **Start-Up Issues:**
    - Reformer had start up issues that delayed commissioning
    - New infrared 70MPa interface needed developing; Now operational
  - **Going Forward:**
    - Open site and start 70MPa filling
    - Open site to other OEM’s
    - Learn what reformer and 700 bar operations require
    - Transfer BP ownership to City of Burbank September 2009 after funding found
Accomplishments and Progress
Infrastructure

- Michigan: DTE Energy
  - Technical Data:
    - Hydrogen produced by electrolysis
    - Storage capacity of 140 kg
    - Capable of dispensing 15 kg/day
  - Accomplishments:
    - Operational since 2004
    - Cold weather areas
    - Community outreach
    - New electrolyzer & dispenser installed winter of 2008-2009
Accomplishments and Progress
Infrastructure

**Southern California: LAX (non-DOE)**
- **Technical Data:** Hydrogen produced by on-site electrolysis; Capacity of about 25 kg/day
- **Accomplishments:** In operations since early 2006; Serving a number of Daimler/Chrysler vehicles on a regular basis, and other OEM’s (Ford, Toyota, Honda, etc.) vehicles; Site remained available beyond 2008 although BP transferred responsibilities

**Michigan: Next Energy**
- **Technical Data:** Hydrogen produced by remote SMR; Usable capacity of 50 kg; 10-15 kg/day
- **Accomplishments:** Only one of a small number of stations in cold weather areas; Additional station training given to Michigan inspectors; Fueling agreement signed with GM to fuel vehicles
### Critical Infrastructure Next Steps

Further station deployment must be made to support future vehicle fleets

- Funding essential for infrastructure build-up
- 40 stations needed in Los Angeles area by 2010

- Coordination with DOE and State agencies

- Needs of all fleets
- NextEnergy Release A document

- Fuel cost reduction
Future Work

• Prepare for next generation demonstrations
• Work with DOE to ensure existing hydrogen stations remain open and available
• Finalize decision and plan for project extension
• Maintain smooth operation of Gen I fuel cell vehicles with on-going service, maintenance and customer support
• Continue internal operations of Gen II vehicles
• Maintain the high quality of technical vehicle and infrastructure data reporting to NREL/DOE
• Pursue novel approaches toward outreach and media events to raise public knowledge of hydrogen technology and demonstration projects
Conclusion

- Completed construction of City of Burbank 70MPa station.
- Installed new electrolyzer & dispenser at DTE Station
- Internally operated Gen II pre-production vehicles
- Upgraded and operated vehicles with 70MPa tank system and new CPU software
- Continued mileage accumulation of Gen I vehicles
- Relocated service facility to support of DOE’s “lighthouse” vision
- Continued data collection, analysis and reporting