U.S. Hydrogen Demonstration Program Update

IPHE Steering Committee

March 28, 2006

Vancouver, Canada

United States of America

Outline

- National Hydrogen Light Duty Demonstration Project
- National Fuel Cell Bus Program
- Hydrogen Powered Transportation Navigation / Communication Systems

Refueling Stations from All Four Teams to Test Under Various Climates

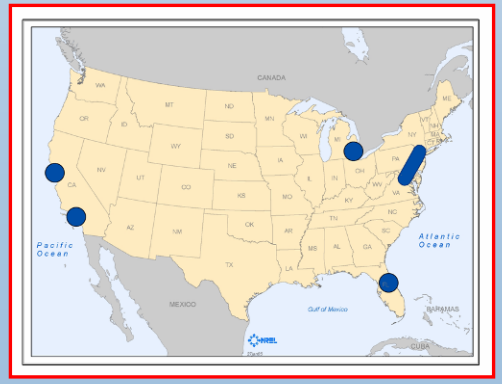
Additional Planned Stations
Ford & BP (3)
DaimlerChrysler & BP (TBD)
General Motors & Shell (1)

Additional Planned Stations
DaimlerChrysler & BP (2)
Ford (1)
Chevron & Hyundai/Kia (1)

Additional Planned Stations
General Motors & Shell (2)

Legend
- Chevron & Hyundai/Kia
- DaimlerChrysler & BP
- Ford & BP
- General Motors & Shell
- Other Companies

Additional Planned Stations
DaimlerChrysler & BP (2)
General Motors & Shell (2)
Chevron & Hyundai/Kia (2)



National Hydrogen Learning Demonstration Project

- Objectives
  - Validate H_2 FC Vehicles and Infrastructure in Parallel
  - Identify Current Status of Technology and its Evolution
  - Re-Focus H2 Research and Development
  - Support Industry Commercialization Decision by 2015

Hydrogen and gasoline station, WA DC

Key Targets

Performance Measure	2009*	2015**
Fuel Cell Stack Durability	2000 hours	5000 hours
Vehicle Range	250+ miles	300+ miles
Hydrogen Cost at Station	$3/gge	$2-3/gge

* To verify progress toward 2015 targets
** Subsequent projects to validate 2015 targets

Teams are Fielding Four Main* Types of Vehicles

*DaimlerChrysler will also have FCV Sprinter vans

*Kia Sportage FCVs will also be used

Sample Hydrogen Refueling Infrastructure

DTE/BP Power Park, Southfield, MI

LAX refueling station

Hydrogen and gasoline station, WA DC

Photo:Shell Hydrogen

Chino, CA

Photo: H2CarsBiz

Composite Data Products (CDPs) are Main Output to Public and Hydrogen Community

A. Critical Program Metrics:

1. Fuel Cell Durability, Actual vs. DOE Targets, All OEM's
2. Vehicle Ranges, Actual vs. DOE Targets, All OEM's
3. H2 Production Cost. Actuals/Projections vs. DOE Targets

B. Composite Performance Tracking:

Vehicles

4. Reliability (FC System & Powertrain, MTBF)
5. Start Times vs. DOE Target
6. Fuel Economy: Dyno, On-Road
7. Normalized Vehicle Fuel Economy
8. Fuel Cell System Efficiency
9. Safety Incidents - Vehicle Operation
10. Weight % Hydrogen
11. Energy Density of Hydrogen Storage
12. Vehicle Hydrogen Tank Cycle Life

Hydrogen Infrastructure

13. H2 Production Efficiency vs. Process
14. Combined Heat and Power (CHP) Efficiencies
15. H2 Production Cost vs. Process
16. H2 Purity vs. Production Process
17. Hydrogen Impurities - Range for Production Process A
18. Histogram: Refueling Rate
19. Average Maintenance Hours - Scheduled and Unscheduled
20. Safety Incidents - Infrastructure

Highlighted CDPs Have Been Completed

C. High Level Program Progress:

Vehicles

21. Range of Actual Ambient Temperatures During Vehicle Operation – All Vehicle Teams
22. Histogram: # Vehicles vs. Operating Hours to Date
23. Histogram: # Vehicles vs. Miles Traveled to Date
24. Cumulative Vehicle Miles Traveled - All Teams
25. Progression of Low to High Pressure On-board H2 Storage

Hydrogen Infrastructure

26. Cumulative Hydrogen Production – All Teams

Light-Duty Learning Demonstration Program Summary

- First year of the 5-year project completed
  - 59 vehicles now in fleet operation
  - Several new refueling stations opened
  - No major safety problems encountered
- Project has identified current technical status relative to program targets
  - Will track improvements from 2nd generation stacks/vehicles introduced mid-way through project
- Future public results will include:
  - FC durability, reliability, efficiency, and start-up times
  - H2 production cost, efficiency, and maintenance

Fuel Cell Bus Demonstrations

- Three fuel cell bus demonstration locations
  - Santa Clara Valley Transportation Authority
  - AC Transit in Oakland, CA
  - SunLine Transit in Palm Springs, CA
- Currently 7 fuel cell buses in revenue service
- Set the current Benchmark for the National Fuel Cell Bus Program

National Fuel Cell Bus Program (NFCBP)

- Facilitate Development of Commercially Viable Fuel Cell Buses
- Competitive Selection of Up to 3 Regionally Diverse Non-Profit Organizations
- One or More Transit Agency as Partner
- 50% Cost Share Required
- $49 Million Available from FY06 – FY09
  - **$11,250,000 – FY 06**
  - **$11,500,000 – FY 07**
  - **$12,750,000 – FY 08**
  - **$13,500,000 – FY 09**

NFCBP Goals

- Facilitate Development of Commercially Viable Fuel Cell Bus Technologies
  - Fuel Cell Technologies
  - Energy Storage
  - Transit Bus System Integration
  - Power Electronic Technologies
- Significantly Improve Transit Bus Fuel Efficiency & Reduce Petroleum Use
- Reduce Transit Bus Emissions
- Establish Globally Competitive U.S. Industry
- Increase Public Acceptance of Fuel Cells

NFCBP Performance Objectives & Technical Targets

- Pathway to Commercialization
- Fuel Efficiency – 2x Comparable Transit Bus
- Emissions – Exceed 2010 EPA Standards
- Reliability – >90% Availability
- Durability – 4 to 6 Years/20,000 to 30,000 hours
- Bus Cost – <5x Comparable Transit Bus
- Vehicle Performance – Equal or Better to Comparable Transit Bus

Draft National Fuel Cell Bus Program Parameters & Technical Targets

Fuel cell system	Durability	Market Readiness	Emissions Target	Fuel Efficiency Target	Cost
Gen I 2003-2007	2 year useful life for fuel cell system 4000 – 5000 hrs	Limited revenue service capable, (mostly demo/data collection)	Exceed 2004 EPA and CARB emissions standards for transit bus (ZEV or PZEV)	Exceed fuel efficiency of comparable standard transit bus by 25-percent	Cost about 10 times the cost of comparable transit bus
Gen II 2007-2010	4-6 year useful life for fuel cell system 25,000 – 30,000 hrs.	Revenue service capable	Exceed EPA 2010 transit bus emissions standards	Fuel efficiency equivalency of 7-mpg	Cost less than 5 times comparable transit bus
Gen III 2010-2015 +	6 year useful life for fuel cell system 40,000 – 50,000 hrs.	Revenue service operational	Exceed all transit bus emissions standards, ZEV or PZEV	Fuel efficiency equivalency of 10-mpg	Cost less than 2 times comparable transit bus

Navigation/Communication Systems Hydrogen Fuel Cell Standby Power

- **Standby Fuel Cell**:
  - A Proton Exchange Membrane (PEM) fuel cell it can provide up to 72 hours of continuous 24/48 DC backup power from stored hydrogen for critical communications or facility.
  - The PEM fuel cell operates at low temperature.
  - Saves weight and space by using a much smaller string of storage batteries to provide bridge capacity.
  - The fuel cell converts stored hydrogen into clean and reliable electrical power.
  - PEM fuel cells exhaust water vapor and low levels of CO2

U.S. Hydrogen Transportation Demonstration Program Summary

- **Objectives**
  - Validate H_2 Fuel Cell Vehicles and Infrastructure in Parallel
  - Identify Current Status of Technology and its Evolution
  - Re-Focus H_2 Research and Development
  - Support Light-Industry Commercialization Decision by 2015 and Bus commercialization before then

- **Vehicle Targets for Commercialization**
  - Facilitate Development of Commercially Viable Fuel Cell Vehicle Technologies
  - Achieve range equivalent of conventional vehicles
  - Improved Fuel Cell engine lifetime
  - Significantly Improve Fuel Efficiency
  - Reduce Petroleum Use & Emissions
  - Increase Public Acceptance of Fuel Cells

- **Infrastructure Targets**
  - Improve Reliability
  - Improve Codes & Standards
  - Improve Permitting
  - Deliver Cost effective hydrogen