

2005

# DOE Hydrogen Program Review

“Hydrogen Vehicle and Infrastructure  
Demonstration and Validation”

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Project TV12



# Overview

## Timeline

- Project Start = 10/1/04
- Project End = 9/30/09

## Budget

- \$88.0 M Total Project
  - \$44.0 M DOE share
  - \$44.0 M GM share
- \$0.244 M FY04 funding
- \$6.565 M FY05 funding

## Barriers

- Vehicles
- Storage
- Hydrogen Refueling Infrastructure
- Maintenance and Training Facilities
- Codes and Standards

## Partners

- Shell Hydrogen, LLC – hydrogen refueling
- U.S. Army – maintenance facilities
- Quantum – maintenance facilities
- Viewpoint Systems – remote collection of performance data
- NextEnergy – Codes and Standards
- State of Maryland – vehicle operator



# Objectives

- DOE Learning Demo Objectives for FY2009
  - 250 mile vehicle range
  - 2,000 hour fuel cell durability
  - \$3.00/gge hydrogen production cost
- General Motors and energy partner Shell Hydrogen, LLC, to deploy a system of hydrogen fuel cell vehicles integrated with a hydrogen refueling infrastructure to operate under real world conditions
  - Demonstrate progressive generations of fuel cell technology
  - Demonstrate multiple approaches to hydrogen generation and delivery for vehicle refueling
  - Collect and report operating data
  - Collaborate with key partners to execute project



# Approach (1)

- Demonstrate a total of 40 fuel cell vehicles spanning 2 generations of fuel cell system technology
  - Next generation to deliver more power, enhanced durability, and a simpler design
- Set up operations in 3 regions of the U.S.
  - Test fuel cell vehicles in various terrains, under a variety of driving conditions, and different climates including cold weather
  - Establish service facilities and maintenance operations
  - Train personnel in maintenance, service, refueling, technical support, and safety procedures

# Approach (2)

- Establish hydrogen refueling for vehicle operations
  - Set-up 5 retail refueling sites including 3 nodes of unique East Coast corridor
  - Provide additional refueling capability as needed, e.g., at maintenance sites
  - Ensure refueling availability for both liquid and compressed hydrogen vehicles
  - Explore hydrogen generation and delivery options such as electrolysis and implement where feasible
- Generate and report data required by DOE Learning Demo
  - Run vehicle on-road and dynamometer test protocols and collect data
  - Capture hydrogen infrastructure production and refueling operation data
  - Complete NREL Data Reporting Templates
- Document Codes and Standards learnings
  - NextEnergy to develop Codes and Standards permitting templates and experience database
  - GM and Shell to collect Codes and Standards learnings and input to database

# Technical Accomplishments

## GM Project Milestones

- All Phase 1 hydrogen fuel cell vehicles have been deployed
  - All Phase 1 maintenance sites are operational
  - All Phase 1 support personnel received technical & safety training
- Nation's 1st retail hydrogen refueling station opened
- All compressed hydrogen fuel cell vehicles of current fleet are equipped with 700 bar compressed hydrogen storage system and are the first fuel cell vehicles to receive certification for using a 700 bar system
- Safety procedures for emergency responders distributed
- Vehicle data collection systems are defined and initiated
- Infrastructure data collection systems are defined and initiated
- Baseline testing for dynamometer facility is complete
- Agreements with key GM partners are concluded
- Resources are assigned and project team is operational



# Technical Accomplishments

## Eastern Region (1)

### ● Vehicles

- 6 Opel Zafira hydrogen fuel cell minivans deployed in Washington, D.C., area using current generation of fuel cell technology
  - 2 vehicles use compressed hydrogen, 4 vehicles use liquid hydrogen
- Vehicles are operated for demonstration to fulfill data collection requirements under DOE program
- State of Maryland to operate fuel cell vehicle beginning in 2005
- Humid and moderate climate with four distinct seasons
- Driving conditions are primarily urban

### ● Hydrogen Refueling Infrastructure

- 2 locations providing both liquid and compressed hydrogen
  - Shell opened Benning Road site in Washington, D.C., Nov 2004
  - Fueling also available at on-base facility at Ft. Belvoir
- Central production of hydrogen trucked to locations

### ● Maintenance and Training Facilities

- On-base facility at Ft Belvoir, VA through an agreement with U.S. Army
- GM maintains, services, and fuels fleet at base facility
- Personnel have been trained in maintenance and safety procedures



# Technical Accomplishments

## Eastern Region (2)

- Shell Benning Road - World Firsts
  - Integration of retail hydrogen and retail gasoline sales
  - Designed for future 700 bar refuelings
  - Below grade storage of liquid hydrogen
  - Safety devices such as below-mount dispenser shear valves and liquid hydrogen hose break-away





# Technical Accomplishments

## Eastern Region (3)

- Shell Benning Road
  - Over 150 vehicle refuelings
    - Hydrogen fuel cell and hydrogen internal combustion engine (ICE) vehicles
    - Multiple automotive manufacturers - GM, DaimlerChrysler (DCX), Ford, Honda, SunLine Bus
  - Hydrogen dispenser accessible to public
  - Multiple liquid hydrogen deliveries
  - Zero incidents since opening
  - Visitors center, kiosk, and hydrogen economy display
  - Training for 180 local First Responders
  - 75 station tours and over 300 guests YTD 2005
    - Includes Codes and Standards tours for International Code Council (ICC), National Association of State Fire Marshals (NASFM), and other code developers



# Technical Accomplishments

## Western Region

- Vehicles
  - 2 Opel Zafira hydrogen fuel cell minivans deployed in Southern California area using current generation of fuel cell technology
    - Compressed hydrogen usage only
  - Vehicles are operated for demonstration to fulfill data collection requirements under DOE program
  - Driving conditions include large, urban complex traffic patterns enhanced by mountain and desert terrain
- Hydrogen Refueling Infrastructure
  - Compressed hydrogen fueling at maintenance facility
- Maintenance and Training Facilities
  - Facility site in Lake Forest, CA through agreement with Quantum Technologies, Inc.
  - GM maintains, services, and fuels fleet at site
  - Personnel have been trained in maintenance and safety procedures



# Technical Accomplishments

## Midwest Region

- Testing and Data Collection
  - GM Milford Proving Ground (MPG) dynamometer facility modified for hydrogen use
  - Hydrogen refueling installed at MPG
  - Dynamometer facility completed baseline testing
  - Dynamometer test scheduling and vehicle logistics defined
  - Personnel trained to conduct dyno testing
  - Preliminary test plan completed



# Technical Accomplishments

## Chassis Dynamometer

Milford Proving Ground, MI



# Technical Accomplishments

## Codes and Standards

- GM, DCX, and Ford to work with NextEnergy to develop a Michigan focused Codes and Standards initiative
- NextEnergy Statement of Work
  - Permitting experience database
  - Templates for implementation of Codes and Standards
  - Annual Codes and Standards workshops
  - Training and education products for local officials and emergency responders

This Project has not been  
reviewed before

# Future Work

- Determine candidate locations for refueling site in NYC metro area and in Southern California
- Begin State of Maryland demonstration and identify additional fleet operators
- Submit 90-day Project Deliverables
- Conduct 1<sup>st</sup> of semi-annual dynamometer tests to generate required data
- Submit 1<sup>st</sup> of quarterly NREL Data Reporting Templates
- Continue regular submission of Project Deliverables

# Supplemental Slides





# Supplemental

## Publications and Presentations

### ● Press Events

- New York DOE Fuel Cell Fleet Announcement, New York City, January 27, 2005 – L. Burns
- Signing of DOE contract at National Hydrogen Association (NHA), March 30, 2005 – E. Lowery
- GM, DOE Sign \$88-Million Agreement to Advance Fuel Cell Development press release, March 30, 2005
- DOE Learning Demo referenced in various radio and print interviews around unveiling of Department of Defense GM fuel cell pickup, April 1, 2005

### ● Presentations

- Duke University Fuel Cells Class Field Trip, Washington, D. C., October 15, 2004 – K. Cole
- US-China Hydrogen Roadmap, Beijing, China, January 18, 2005 – K. Cole
- School of Advanced International Studies (SAIS), Johns Hopkins University, Washington, D.C., December 9, 2004 – K. Cole
- Northern Virginia Technology Council, Vienna, VA, March 8, 2005 – K. Cole
- The Energy Council, Washington, D.C., March 11, 2005 – R. Choudhury
- Plenary II, NHA Annual Hydrogen Conference, Washington, D.C., March 31, 2005 – C. Sloane
- “Reinventing the Automobile,” Wm. A. Patterson Lecture, Northwestern University Transportation Center, Evanston, IL, April 6, 2005 – L. Burns
- “Fuel Cell Vehicles and the Hydrogen Economy,” Nuclear Energy Institute Conference, Washington, D.C., May 17, 2005 – L. Burns



## Hydrogen Safety

*The most significant hydrogen hazard associated with this project is:*

- Loss of containment of hydrogen at a refueling facility with subsequent ignition

# Supplemental

## Hydrogen Safety

*Our approach to deal with this hazard is:*

- Engineering & Design related measures include
  - Site risk assessment, system HazOp, Health, Safety, and Environment (HSE) Safety Case, and meeting or exceeding applicable codes, standards, and industry practices
  - These efforts provide for controls and will test recovery measures
- Operational measures include
  - Site Operations Manual, Site Emergency Response Plan, First Responder Training, Site Operator Training, Daily Systems Inspection Procedures, Preventive Maintenance Inspection Procedures, Annual HSE Audit, Remote monitoring of certain system conditions in most cases
  - These efforts provide assurance that Safety Case elements are executed