Overview of the Hydrogen, Fuel Cells and Infrastructure Program and Heavy Duty Truck APUs

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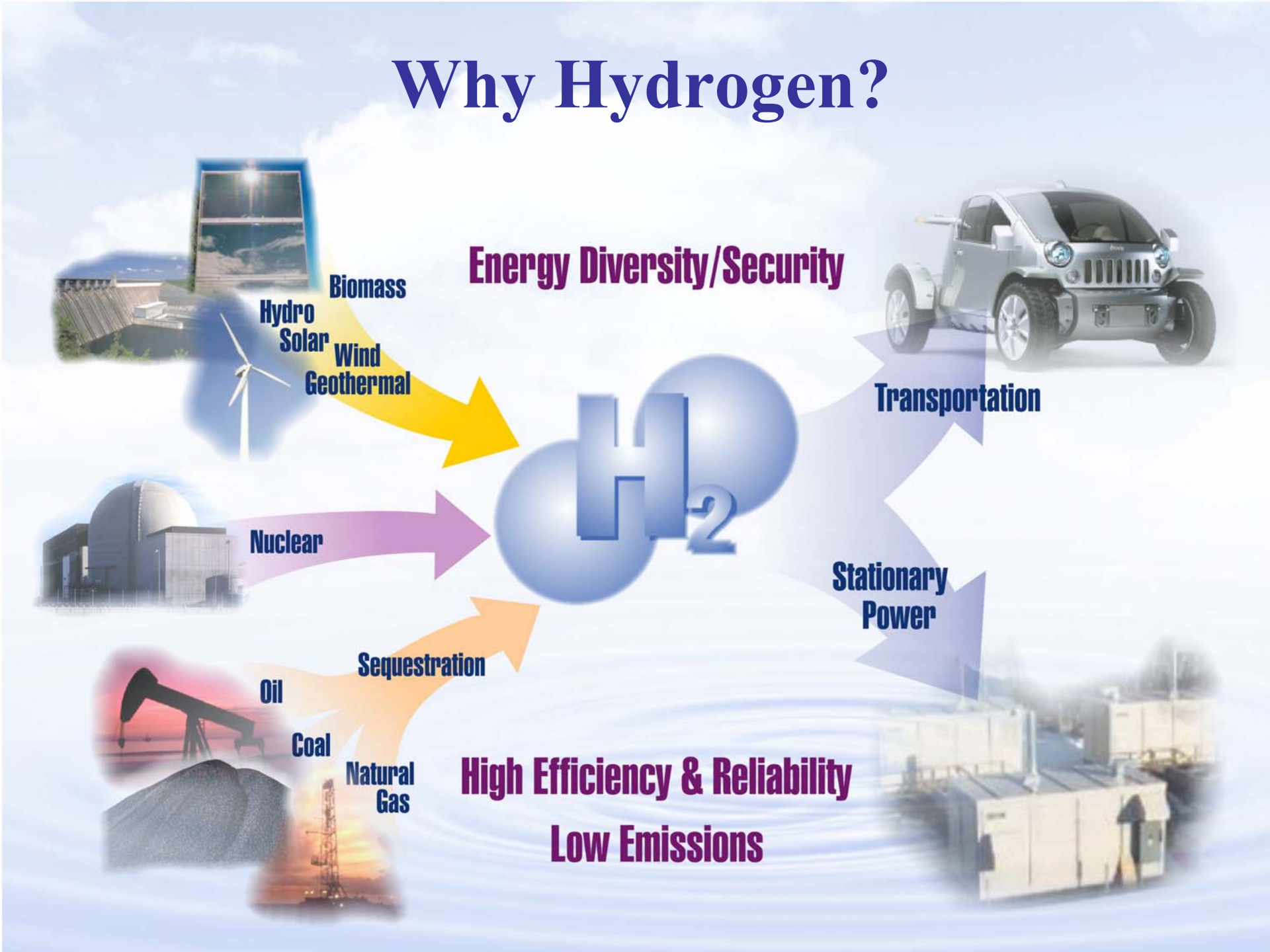
Why Hydrogen?

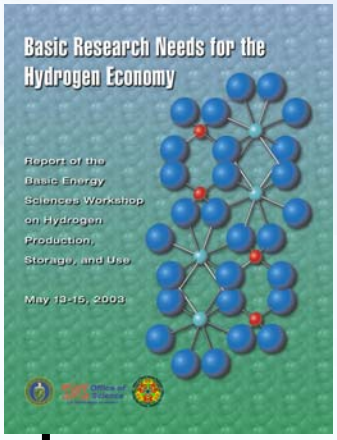


DOE Milestones

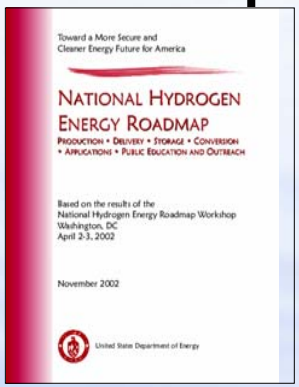
President's Hydrogen Fuel Initiative

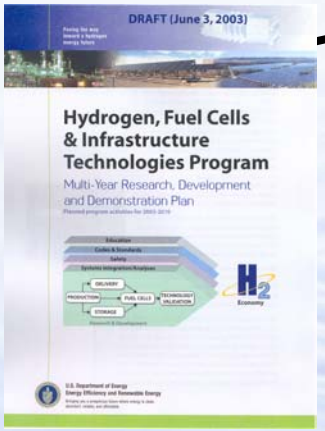
FreedomCAR

FutureGen

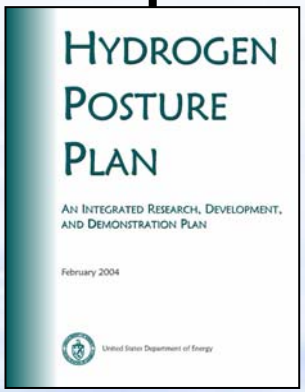


Jan'02 | Nov'02 | Jan'03 | Feb'03 | May'03 | Nov'03 | Feb'04





International Partnership for the Hydrogen Economy

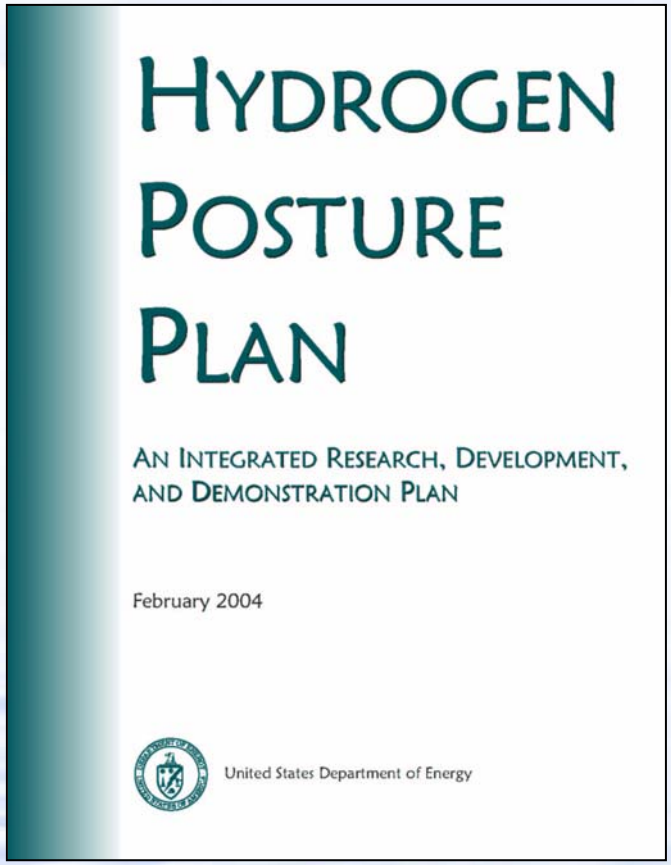


Hydrogen Posture Plan

- **Integrates the hydrogen activities supporting the President's Hydrogen Fuel Initiative across the renewable energy, fossil energy, science, and nuclear energy offices**

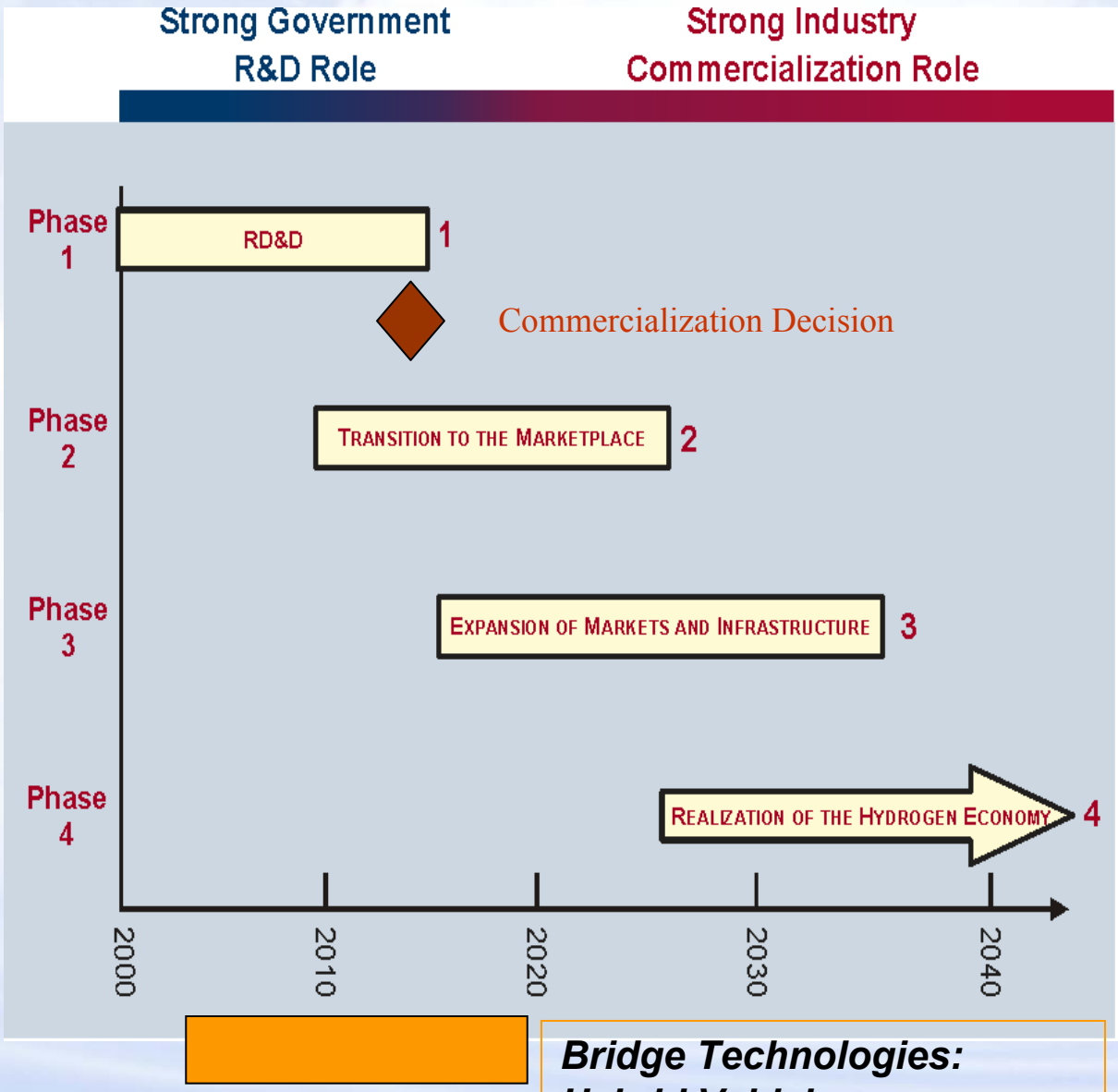
- **Lays the foundation for a coordinated response to the President's commitment for accelerated research on critical path hydrogen and fuel cell technologies.**

- **Establishes high-level performance based milestones to track progress**



http://www.eere.energy.gov/hydrogenandfuelcells/

Timeline for Hydrogen Economy



Transitional Phases

1. **Technology Development Phase**
   H_2 power and transport systems available in select locations; limited infrastructure
2. **Initial Market Penetration Phase**
   H_2 power and transport systems begin commercialization; infrastructure investment begins with governmental policies
3. **Infrastructure Investment Phase**
   H_2 power and transport systems commercially available; infrastructure business case realized
4. **Fully Developed Market and Infrastrucure Phase**
   H_2 power and transport systems commercially available in all regions; national infrastructure

Near-term strategy: Bridge Technologies

Hybrids

Hybrid electric vehicles combine greatly reduced emissions and fuel consumption, with extended range and convenient refueling

Engines & Emission Control

Commercially viable engine and emission-control technologies for light-duty passenger vehicles and heavy-duty commercial vehicles lead to a reduction in transportation energy use and in petroleum use

Lightweight materials

Weight reduction is one of the most practical ways to increase the fuel economy of vehicles while reducing exhaust emissions

An Integrated Vision

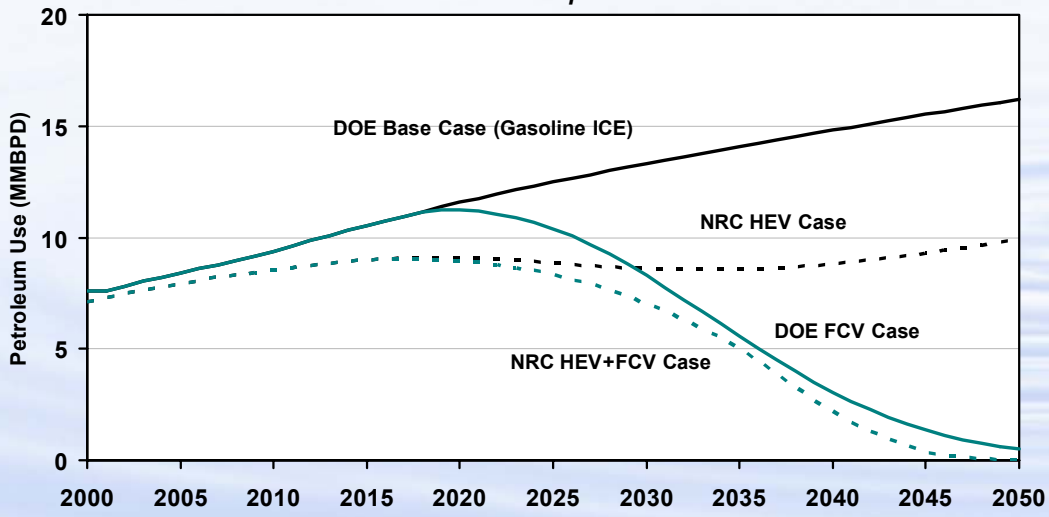
- FreedomCAR Partnership $.5 B
- Hydrogen Fuel Initiative $1.2 B

Aiming for an Industry Commercialization Decision by 2015

Hybrid vehicles are a bridge technology that can reduce pollution and our dependence on fossil fuel until long-term technologies like hydrogen fuel cells are market-ready.

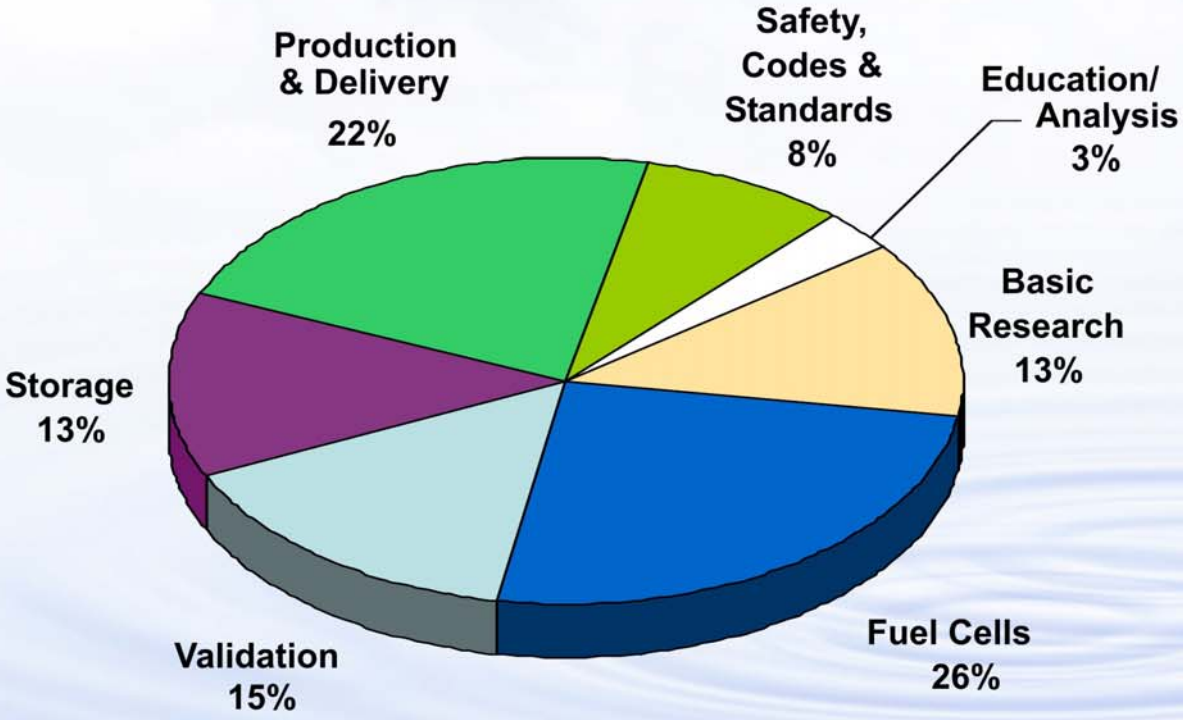
Hybrid/Hydrogen FCV Strategy

Potential scenarios – not predictions



- In 2040, the use of FCV's would generate a savings of 11 mbpd in oil consumption in the light-duty transportation sector.
- In 2040, U.S. carbon reduction is 19%, equivalent to 500 million metric tons per year

DOE FY05 Hydrogen Technology Budget Request



$227 Million

Hydrogen, Fuel Cells, and Infrastructure Technologies

Program Focus: Research, develop, and validate fuel cell and hydrogen production, delivery, and storage technologies for transportation and stationary applications.

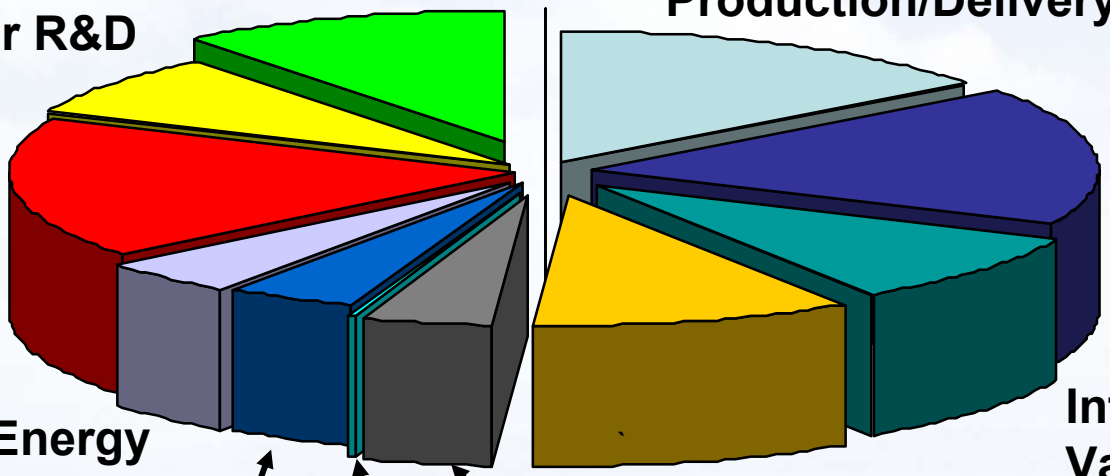
Budget

	Funding (dollars in thousands)		
Activity	**FY03 Approp.**	**FY04 Approp.**	**FY05 Request**
Hydrogen Technology			
Production and Delivery R&D	11,215	22,564	25,325
Storage	10,790	29,432	30,000
Infrastructure Validation	9,680	18,379	15,000
Safety, Codes & Standards, and Utilization	4,531	5,904	18,000
Education and Cross-Cutting Analysis	1,897	5,712	7,000
Fuel Cell Technology			
Transportation Systems	6,160	7,506	7,600
Distributed Energy Systems	7,268	7,408	7,500
Stack Component R&D	14,803	25,186	30,000
Fuel Processor R&D	23,489	14,815	13,858
Technology Validation	1,788	9,877	18,000
Technical/Program Management Support	398	395	542
Total	**92,019**	**147,178**	**172,825**

Key Activities

- Initiate three “Centers of Excellence” for hydrogen storage meeting 2010 targets of 2.0 kWh/kg and 1.5 kWh/L.
- Complete testing of 10,000 psi tanks achieving 2005 targets of 1.5 kWh/kg and 1.2 kWh/L.
- Initiate comprehensive safety research for codes and standards development.
- Complete research on distributed NG production technologies leading to $3.00/gge at the station.
- Initiate new industry projects that will use wind and biomass to produce hydrogen for $4.60/gge by 2009.
- Reduce cost of a 50kW fuel cell power system to $125/kW (assume high volume production.)
- Validate current technology through vehicle/ infrastructure “learning” demonstrations.

Hydrogen and Fuel Cell FY2005 Budget Request

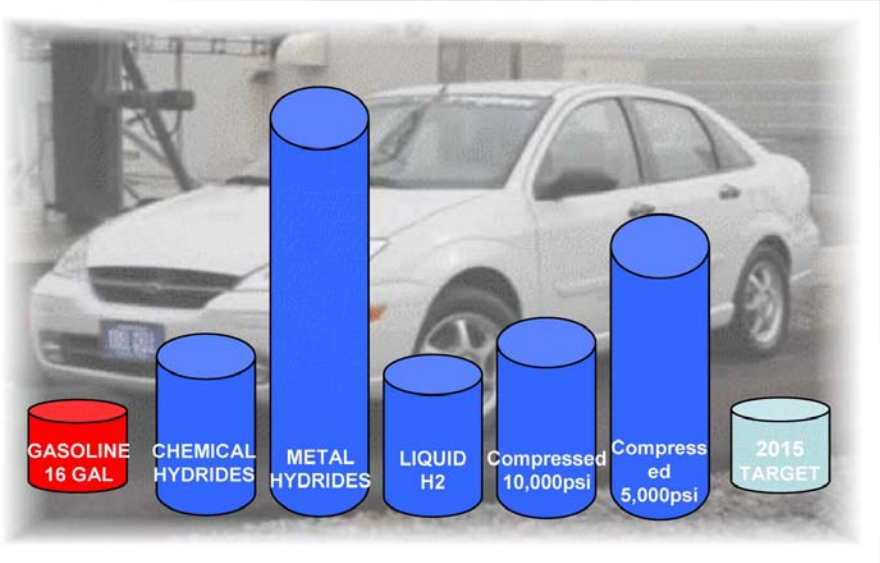


Total FY-05 Request: $172.8M

Barriers to a Hydrogen Economy

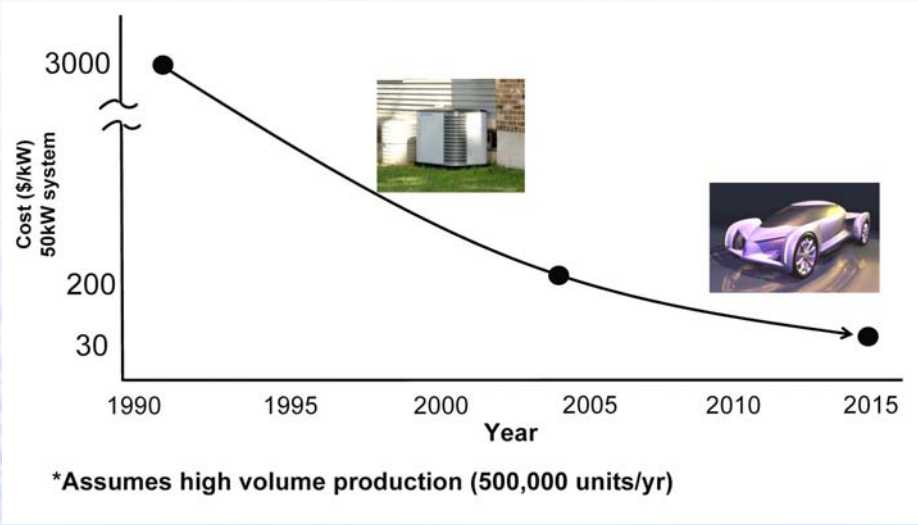
Critical Path Technology Barriers:

- Hydrogen storage (>300 mile range)
- Hydrogen production cost ($1.50 - 2.00 per gge)
- Fuel cell cost ($30 per kW)



Economic/Institutional Barriers:

- Codes and standards (Safety and global competitiveness)
- Hydrogen delivery (Investment for new distribution infrastructure)
- Education



FY04 Fuel Cell Highlights and R&D Emphasis

- Membrane durability and high temperature operation
- Non-precious metal catalysis
- Technology validation through vehicle “learning” demonstrations
- On-board Fuel Processing go/no go decision in June (see Federal Register Notice)
- Development of fuel cells for consumer electronics and **APUs for Heavy Duty Trucks**
- Newly established stationary fuel cell systems contracts

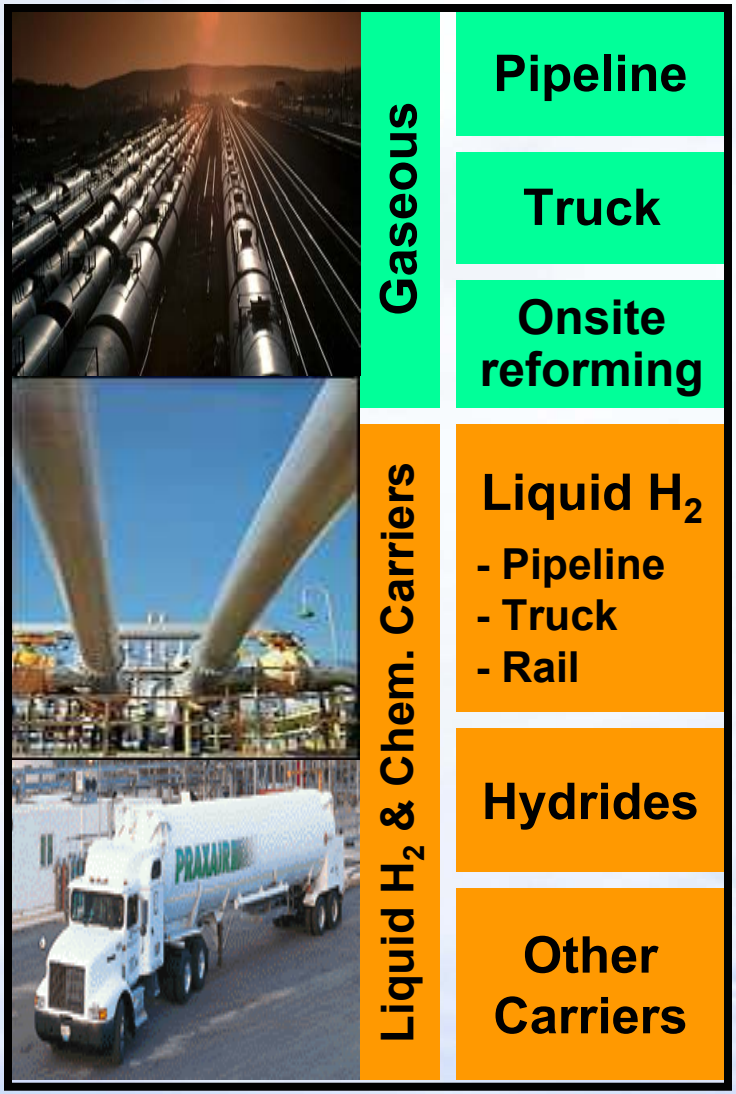
H_2 Production Strategies

For the transition, focus on <u>distributed natural gas</u>

The fuel needed for the hydrogen FCV fleet during the transition years is estimated to be only 2-3% of natural gas used in the United States, and will make little impact on natural gas availability for power plants (where it might displace coal) or on prices.

In the longterm, diversify to renewable energy (esp. wind electrolysis), coal with carbon sequestration, nuclear energy, and other renewable production methods.

Hydrogen Delivery



Key Challenges

- Pipelines
  - Retro-fitting existing NG pipeline for hydrogen
  - Utilizing existing NG pipeline for Hythane
  - New hydrogen pipeline: lower capital cost
- Lower cost, more reliable and durable, and more energy efficient compression technology
- Lower cost and more energy efficient liquefaction technology
- Novel solid or liquid carriers

Cross-Cutting Program Elements

Technology Validation: Validate integrated hydrogen and fuel cell technologies in a systems context under real operating conditions

Safety, Codes & Standards: Facilitate the development and adoption of building codes and equipment standards, international standards, and safe practices that promote insurability.

Education: Educate key audiences about fuel cell and hydrogen systems to facilitate commercialization and market acceptance of these technologies

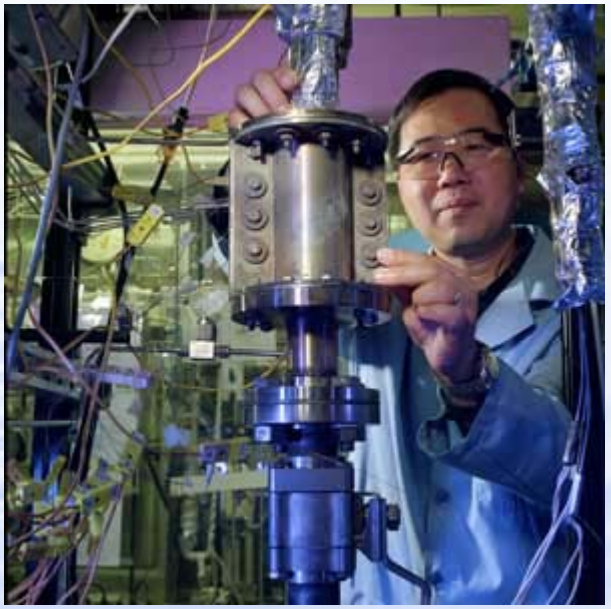
Secretary Abraham announced $350 M in Hydrogen Research Projects on April 27, 2004

- Hydrogen Storage
  - Three Centers of Excellence for exploratory research in hydrogen storage
  - Individual projects to explore new materials for hydrogen storage
- Vehicle and Infrastructure “Learning” Demonstration
  - Teams of automobile and energy companies will work together to demonstrate integrated and complete system solutions operating in real world environments.
- Fuel Cell Research
  - Consumer electronics, ***Fuel Cells for Auxiliary Power Generation***, and off-road fuel cell R&D.
- Hydrogen Education
  - Projects include middle school and high school curricula and teacher professional development.

Auxiliary Power Units

Excellent Heavy-Duty Transportation Market Potential:

- Eliminates heavy vehicle idling
- Supports electrification of truck systems, improving efficiency
- Good power source for refrigeration
- Fueling issue – diesel difficult to reform



Fuel Cells For Auxiliary Power Generation

- Cummins Power Generation
  - International Truck and Engine Corporation and SOFCo-EFS Holdings LLC
  - A solid oxide fuel cell auxiliary power unit will be designed and installed in a truck.
  - Will use fuel processor capable of operating on the 2006 ultra-low-diesel fuel.
  - International will develop and integrate new vehicle system, including heating, air conditioning and other electrical power loads and develop the vehicle interface to the APU.
  - The result will be a demonstration in a real-world application and a significant advance in the integration of energy-efficient technologies in auxiliary power.

Fuel Cells For Auxiliary Power Generation

- Delphi Automotive Systems, LLC
  - PACCAR, Volvo North America and Electricore
  - Objective is to develop, construct and validate an SOFC power system for APU applications
  - Auxiliary power systems in the range of 3-5 kW for APUs for truck idling reduction will be the primary focus.
  - Fuels utilized will be derived form either propane or low-sulfur diesel fuel.
  - A full APU system will be built and tested in a laboratory demonstration with simulated load cycles.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Information Resources

http://www.eere.energy.gov/hydrogenandfuelcells