U.S. Department of Energy

Overview of the DOE Hydrogen Program

DOE Fuel Cell Pre-Solicitation Workshop

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Challenges & Barriers

Technology Barriers

- **Hydrogen Cost**
  (target: $2 – $3/gge)
- **Hydrogen Storage Capacity & Cost**
  (targets: 2.7kWh/L, 3kWh/kg, and $2/kWh)
- **Fuel Cell Cost and Durability**
  (targets: $30 per kW, 5000-hour durability)

Technologies must be validated under real-world conditions.

Economic & Institutional Barriers

- **Delivery Infrastructure**
- **Safety, Codes & Standards Development**
- **Public Awareness & Acceptance**
- **Domestic Manufacturing and Supplier Base**

Hydrogen Fuel Initiative Budget

FY 2004 – FY 2008

	Funding *($ in thousands)*					
	FY 2004 Approp.	**FY 2005** Approp.	**FY 2006** Approp.	**FY 2007** Approp.	**FY 2008** Approp.	**TOTAL** (FY 04 – FY 08)
HYDROGEN FUEL INITIATIVE						
EERE Hydrogen (HFCIT)	144,881	166,772	153,451	189,511	211,062	**865,677**
Fossil Energy (FE)	4,879	16,518	21,036	22,997	24,773	**90,203**
Nuclear Energy (NE)	6,201	8,682	24,057	18,855	9,909	**67,704**
Science (SC)	0	29,183	32,500	36,388	36,388	**134,459**
DOE Hydrogen TOTAL	**155,961**	**221,155**	**231,044**	**267,751**	**282,132**	**1,158,043**
Department of Transportation	555	549	1,411	1,420	1,425	**5,360**
Hydrogen Fuel Initiative TOTAL	**156,516**	**221,704**	**232,455**	**269,171**	**283,557**	**1,163,403**

EERE Hydrogen Program Budget

FY 2004 – FY 2008

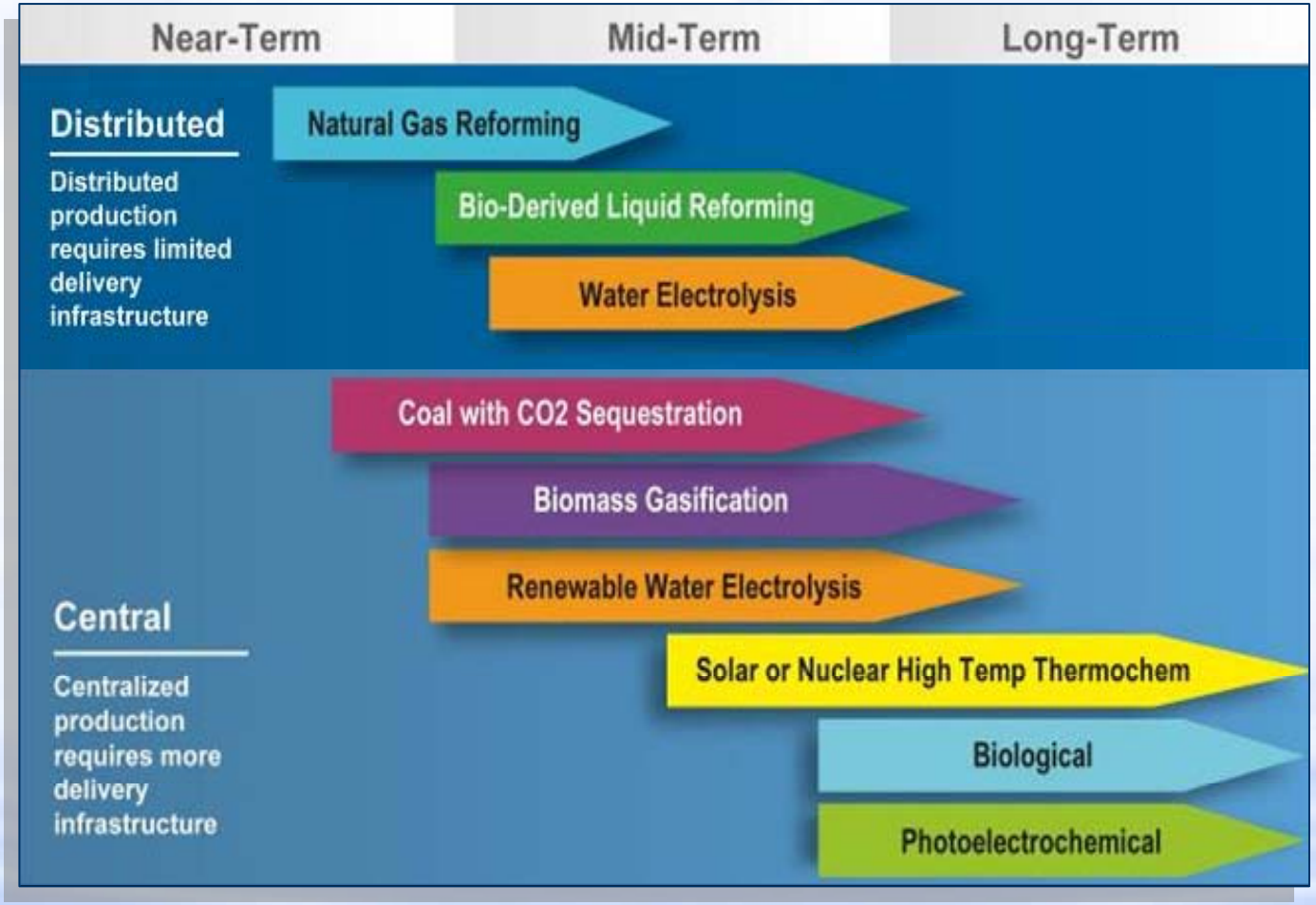
Activity	Funding *($ in thousands)*				
	FY 2004 Approp.	FY 2005 Approp.	FY 2006 Approp.	FY 2007 Approp.	FY 2008 Approp.
Hydrogen Production & Delivery	10,083	13,303	8,391	33,702	39,636
Hydrogen Storage R&D	13,628	22,418	26,040	33,728	43,501
Fuel Cell Stack Component R&D	24,551	31,702	30,710	37,100	43,600
Technology Validation	15,648	26,098	33,301	39,413	29,727
Transportation Fuel Cell Systems	7,317	7,300	1,050	7,324	7,927
Distributed Energy Fuel Cell Systems	7,249	6,753	939	7,257	7,630
Fuel Processor R&D	14,442	9,469	637	3,952	2,973
Safety, Codes & Standards	5,755	5,801	4,595	13,492	15,854
Education	2,417	0	481	1,978	3,865
Systems Analysis	1,429	3,157	4,787	9,637	11,395
Manufacturing R&D	0	0	0	1,928	4,954
Technical/Program Management Support	395	535	0	0	0
Congressionally Directed Activities	41,967	40,236	42,520	0	0
TOTAL	**144,881**	**166,772**	**153,451**	**189,511**	**211,062**

Hydrogen Production & Delivery

GOAL: *Diverse, domestic pathways to hydrogen production*

KEY OBJECTIVE:

Reduce the cost to $2.00 – $3.00/gge (gallon gasoline equivalent) at the pump



Hydrogen Production — Cost Status

The Program has reduced the cost of producing hydrogen from multiple pathways

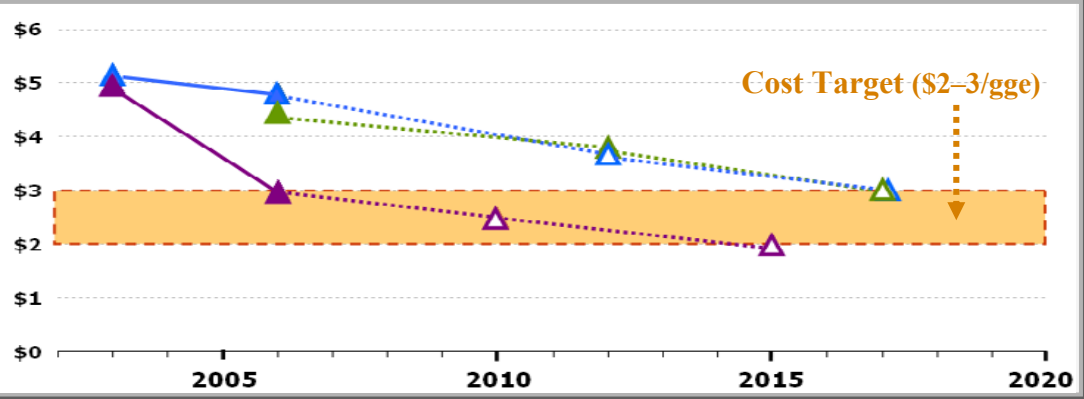
Cost of Hydrogen — Status & Targets

(in $/gallon gasoline equivalent (gge), delivered, untaxed)

NEAR TERM: Distributed Production

→ *Hydrogen is produced at station to enable low-cost delivery*

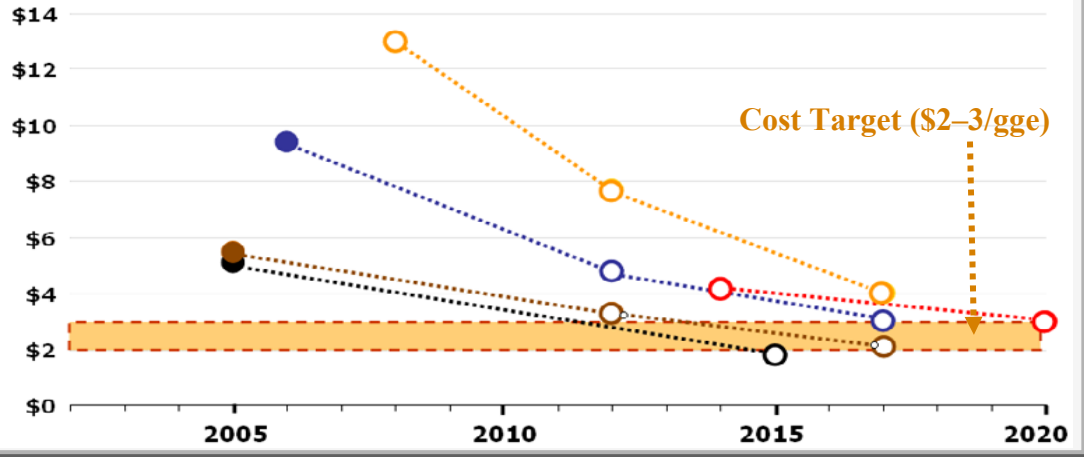
- Distributed Natural Gas
- Distributed Electrolysis
- Distributed Bio-Derived Renewable Liquids



LONGER TERM: Centralized Production

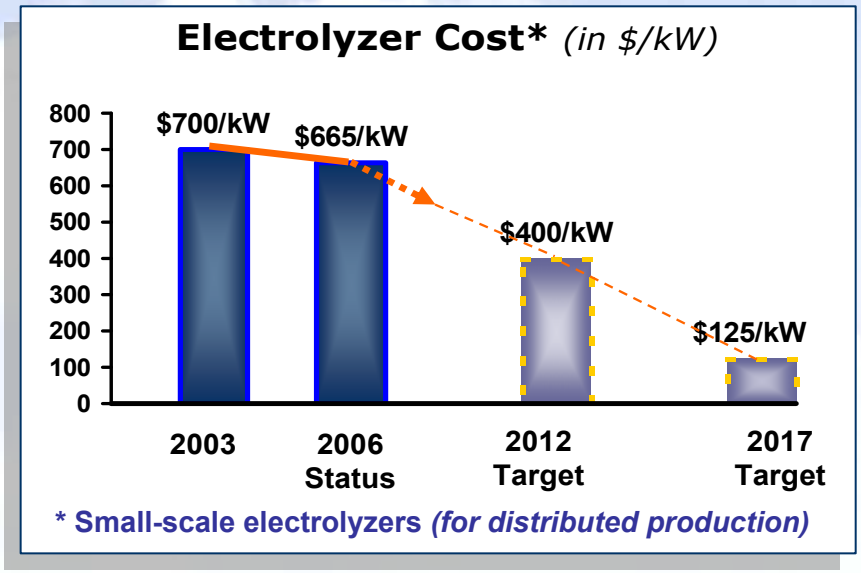
→ *Large investment in delivery infrastructure needed*

- Biomass Gasification
- Coal Gasification with Sequestration
- Solar High-Temperature Thermochemical Cycle
- Central Wind Electrolysis
- Nuclear



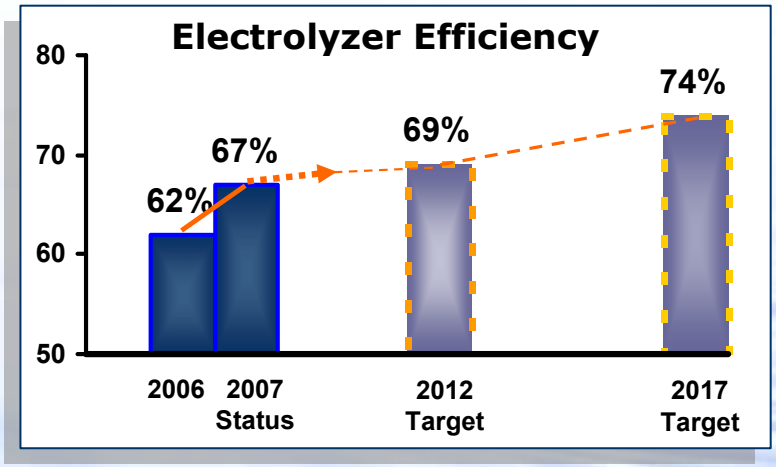
Hydrogen Production — *Technology Progress*

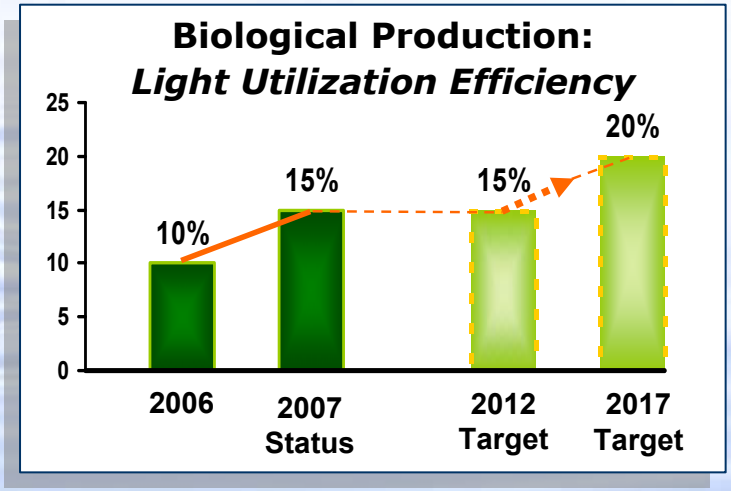
The capital cost of electrolyzers is being reduced



Progress is being made in biological production

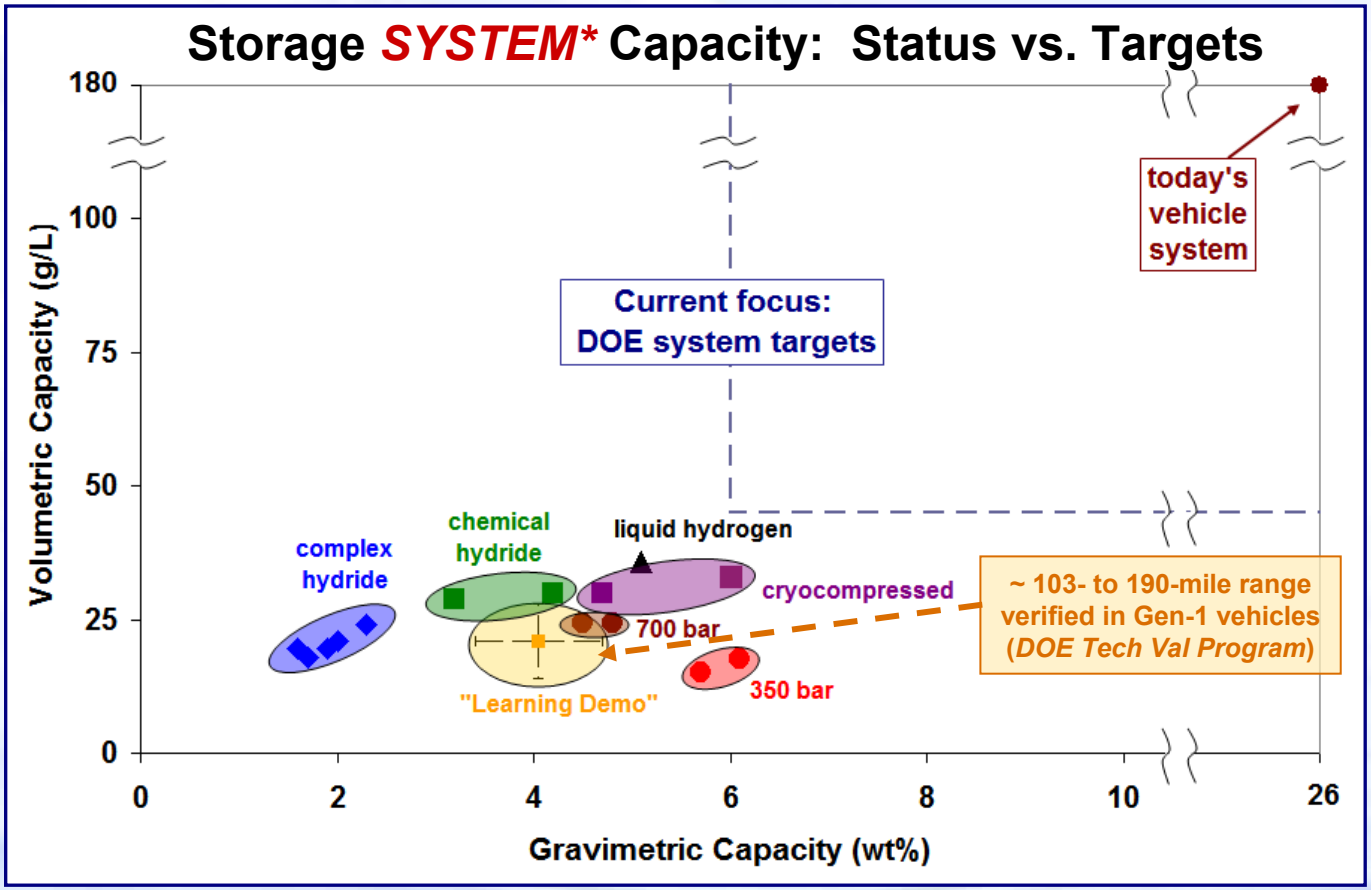
The energy efficiency of electrolyzers is being improved





Hydrogen Storage — *Status*

GOAL: *On board storage with > 300-mile driving range* ***(while meeting all requirements for safety, cost, and performance)***



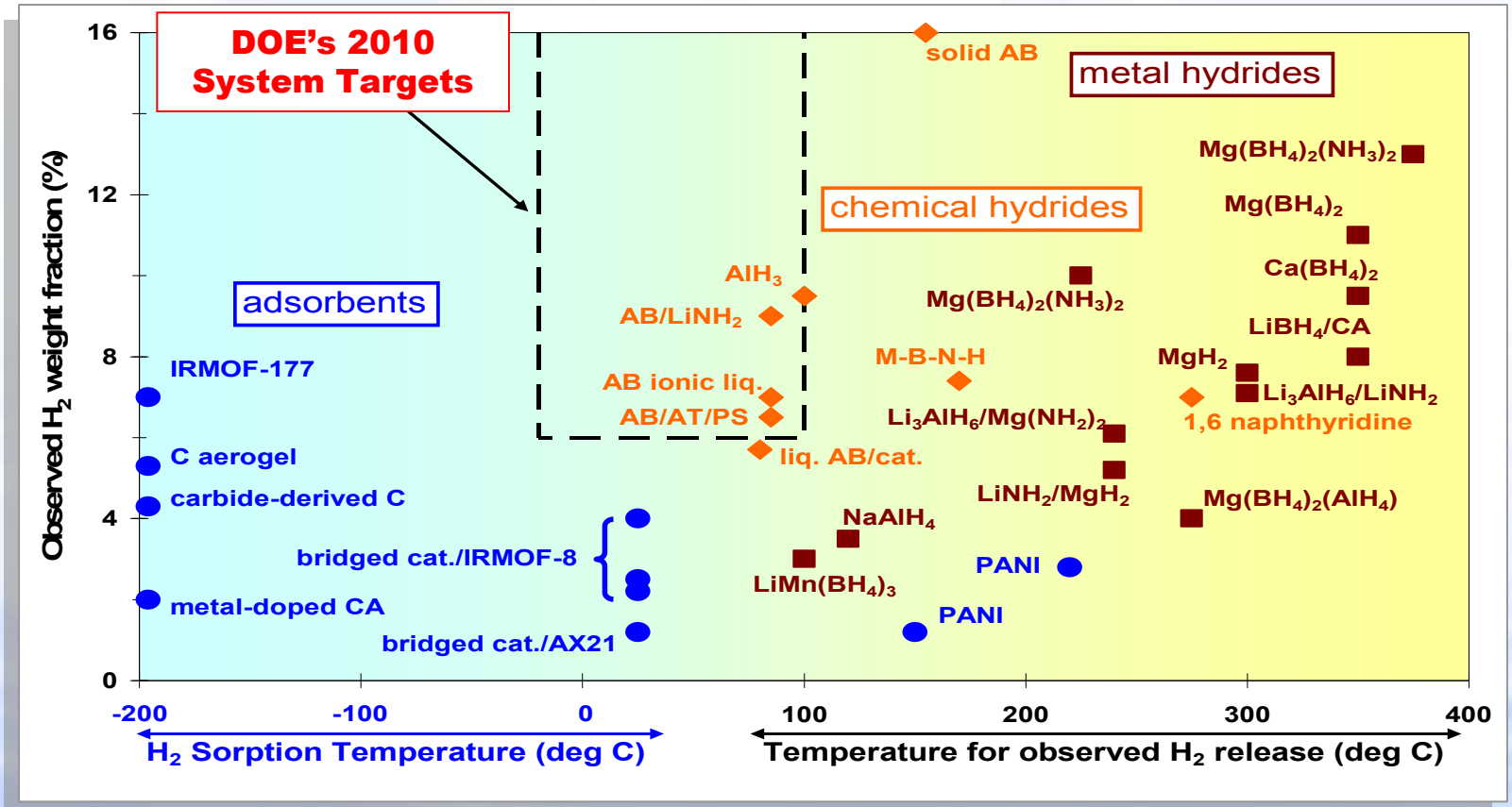
The Program has identified materials with > 50% improvement in capacity since 2004

** System capacity estimates include materials, tanks, and balance of plant*

Hydrogen Storage — *Progress*

Storage materials must meet capacity and temperature requirements to effectively integrate with an automotive fuel cell system.

R&D will continue to focus on new materials and their operating characteristics.



Fuel Cell R&D

MAJOR RESEARCH AREAS:

- Membranes
- Catalysts & Supports
- Water Transport
- Characterization & Analysis

PRIMARY FOCUS

- *Primary focus is on fuel cells for transportation applications*
- *R&D is focused on components rather than systems*

KEY TARGETS:

- **$45/kW by 2010; $30/kW by 2015**
- **5,000-hour durability by 2015**
- **60% efficiency**

SECONDARY FOCUS

Stationary and other early-market fuel cells to establish the manufacturing base

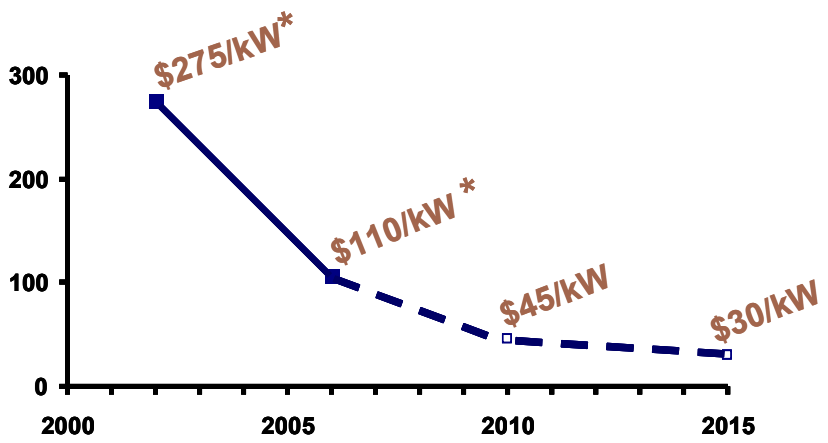
KEY TARGETS:

- **Distributed Power:** $750/kW and 40,000-hour durability (with 40% efficiency) by 2011
- **APUs:** Specific power of 100 W/kg and power density of 100 W/L by 2010
- **Portable Power:** Energy density of 1,000 W-h/L by 2010

Fuel Cells — *Status & Progress*

Fuel Cell System Cost

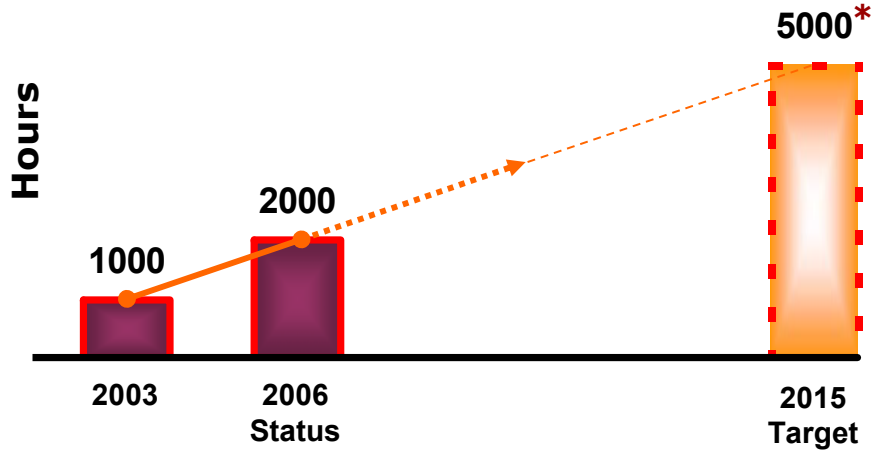
(80kW Direct H_2 automotive fuel cell)



** Projected to high-volume manufacturing of 500,000 units/year*

Laboratory Stack Durability

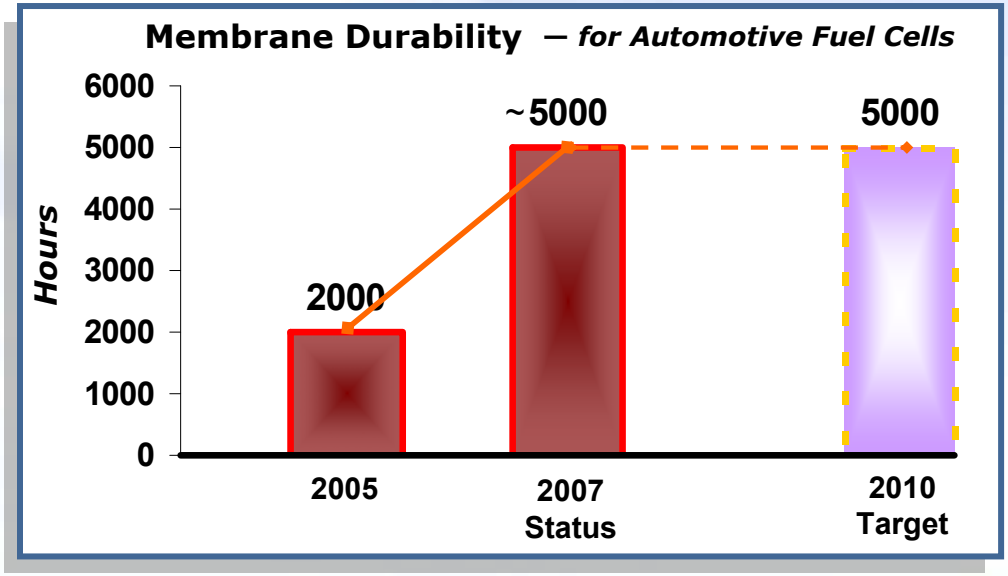
(automotive fuel cell)

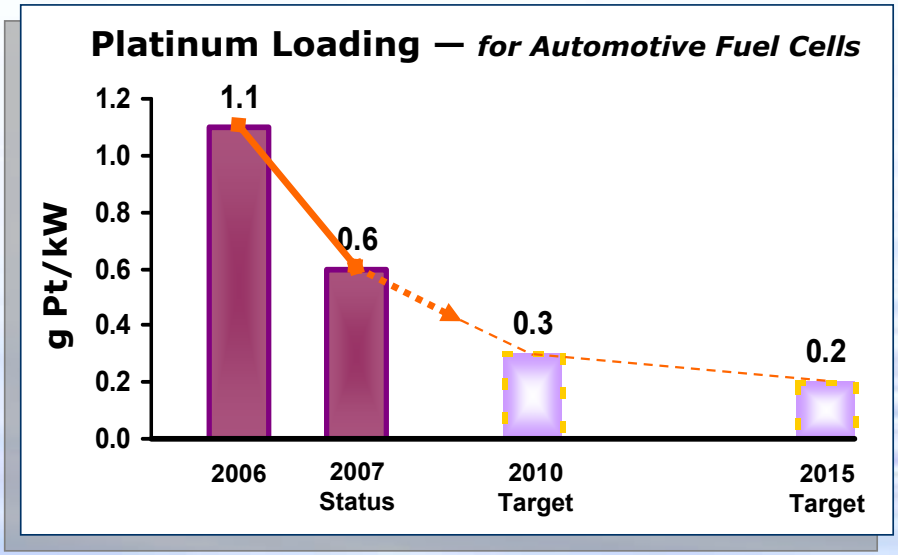


** 5000 hours corresponds to roughly 150,000 miles of driving*

Fuel Cells for Transportation —
Status & Progress

Improvements in membrane durability



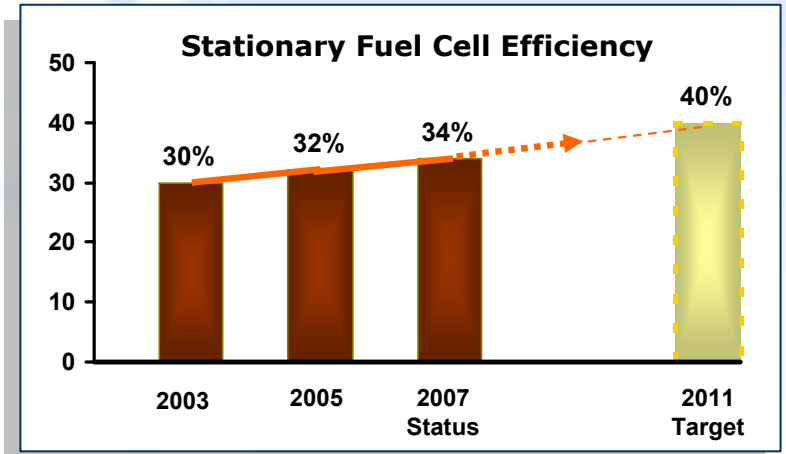


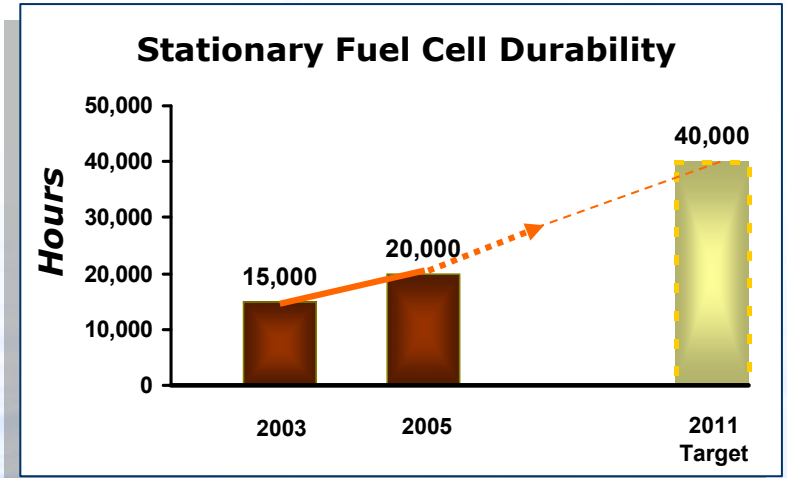
Reductions in Platinum Loading

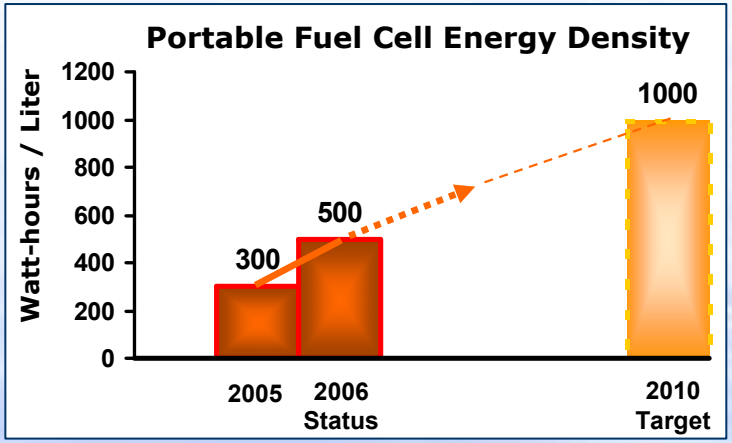
Fuel Cells for Stationary & Portable Power — *Status & Progress*

FUEL CELLS for DISTRIBUTED STATIONARY POWER:

Improvements in efficiency and durability







FUEL CELLS for PORTABLE APPLICATIONS:

Improvements in energy density

Technology Validation:
Vehicles & Infrastructure

Technologies are validated & progress evaluated through learning demonstrations.
(Four teams in 50/50 cost-shared projects, operating 77 fuel cell vehicles and 14 stations.)

DOE Vehicle/Infrastructure Demonstration

Verified fuel cell vehicle performance:

- ***EFFICIENCY:*** ***53 – 58%*** *(>2x higher than internal combustion gasoline engines)*
- ***RANGE:*** ***103 – 190 miles***
- ***FUEL CELL SYSTEM DURABILITY:*** ***1600 hours*** *(~48,000 miles)*

Demonstrated Fuel Cost: ***$3/gge, from natural gas***

DOT is demonstrating fuel cell buses and providing data to DOE for analysis

Eight buses in California, Massachusetts, New York, South Carolina, and Washington, DC

Technology Validation

Integrating Renewable Power & Hydrogen Production

Three Demonstration Projects

DTE Energy *(ongoing)*

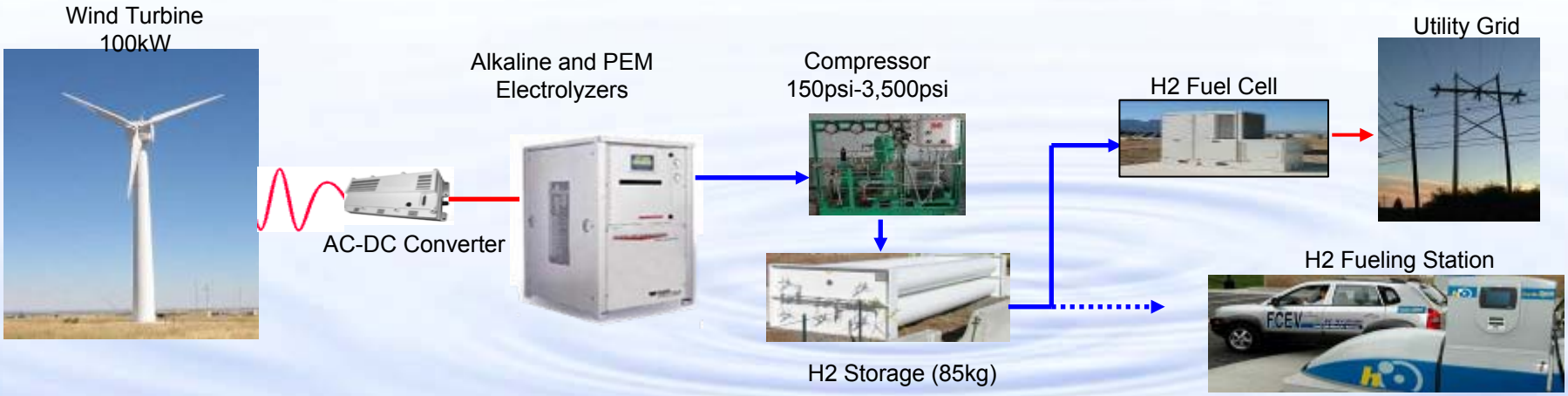
Hydrogen production using water electrolysis with on-site solar energy (Southfield, Michigan).

Xcel/NREL Wind/Hydrogen Project *(ongoing)*

Integrates electrolyzers and wind turbines to understand the benefits and impacts of adding hydrogen production facilities to the electric power grid (NREL wind site at Golden, Colorado).

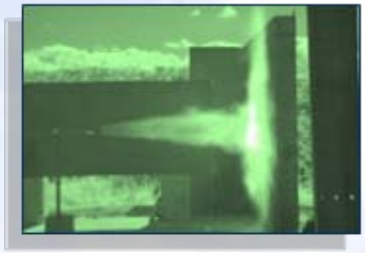
Hawaii *(planned)*

Hydrogen production using curtailed wind and geothermal energy to generate electricity and to fuel hydrogen buses at national parks.



Xcel-NREL Wind2H2 Project

Safety, Codes & Standards



CHALLENGES

- Lack of technical data to support codes & standards development; need for domestic and international consistency; delayed adoption of approved codes & standards
- Need to streamline and standardize the permitting process for hydrogen facilities
- Need to compile and disseminate hydrogen safety information

STRATEGY

SAFETY

- Facilitate the development of safe hydrogen systems by increasing understanding of hydrogen behavior and material compatibility
- Promote the safe use of hydrogen industry-wide, through safety education activities and the development of safety information tools

CODES & STANDARDS

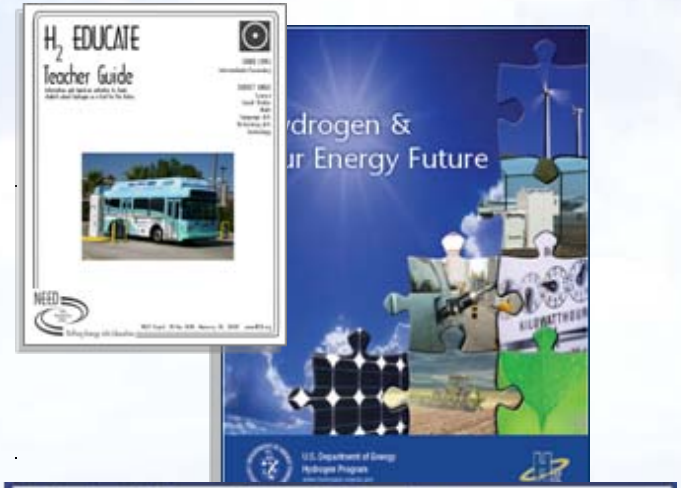
- Conduct research to enable codes and standards to be developed for hydrogen in all applications
- Facilitate the development and harmonization of domestic and international codes and standards

PROGRESS

- Developed *Technical Reference for Hydrogen Compatibility of Materials*
- Developed Web-based *Hydrogen Safety Best Practices Manual* (released for limited review)
- Developed the *Hydrogen Fueling Station Permitting Compendium* (due for release in 2Q of FY08)

Education

CHALLENGE: ***Lack of public awareness and understanding of H_2 and fuel cell technologies***



STRATEGY

Educate target audiences about hydrogen and fuel cell technologies to facilitate near-term demonstration, commercialization, and long-term market acceptance.

FOCUS on near-term high-priority target audiences:

- Safety and code officials
- Local communities
- State and local government officials
- End-users/early adopters

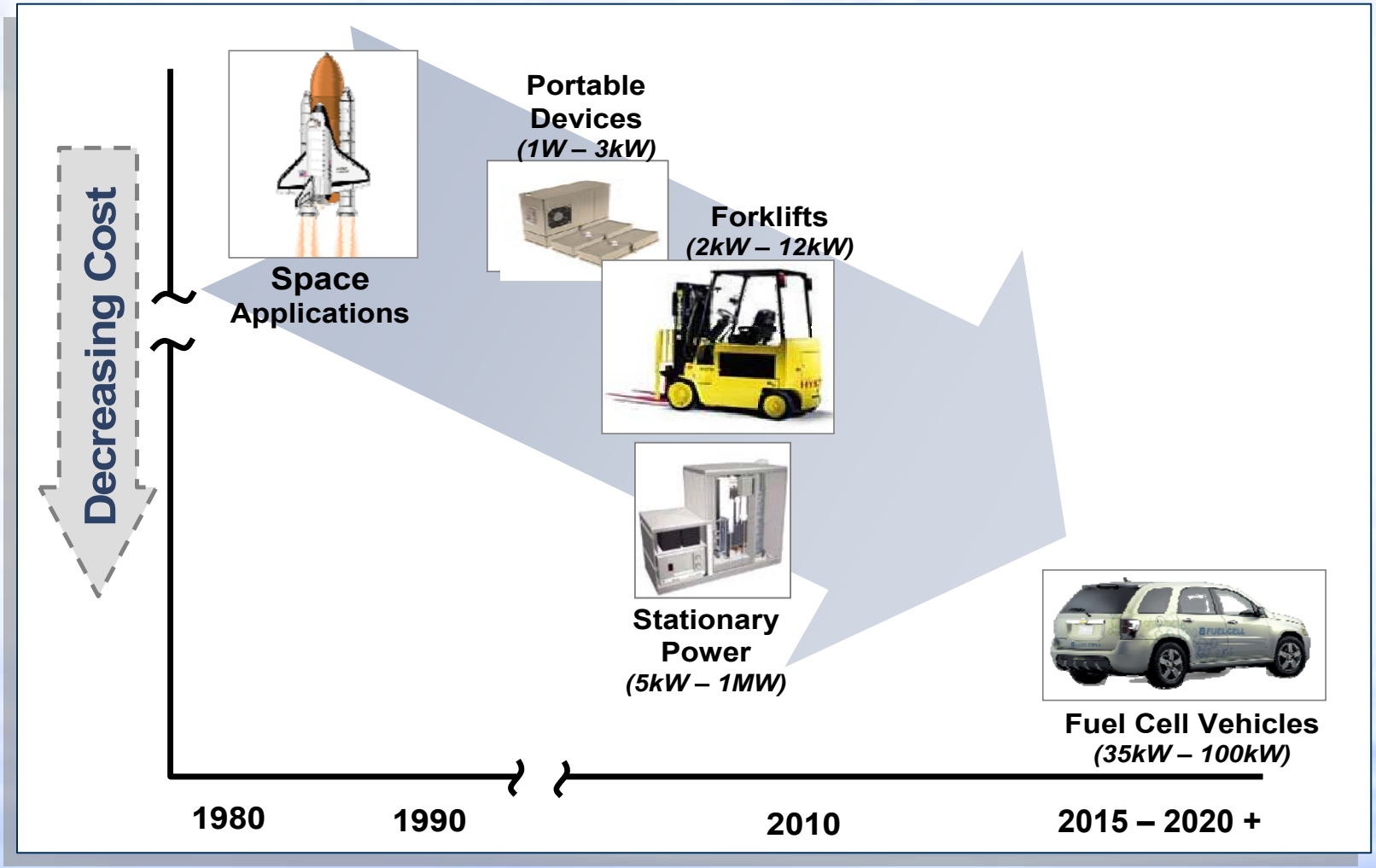
(other audiences include schools and universities)

PROGRESS

- Developed “Introduction to Hydrogen Safety for First Responders” educational tool
- Launched “Increase Your H2IQ Public Information Program” (includes radio spots, podcasts, and book about hydrogen)
- Held pilot “Hydrogen 101” workshops for state and local governments in six states
- Launched middle school and high school curricula and teacher professional development programs

Market Transformation — *From Early Markets to Fuel Cell Vehicles*

Early markets in stationary, portable, and niche applications will lower cost and establish a supplier base—paving the way for fuel cell vehicles



Market Transformation

***DOE is actively promoting commercialization** of PEM fuel cell technologies by supporting early adoption, and by building partnerships with the public and private sectors*

CHALLENGES

- ***Resistance to new technologies***
- ***Lack of information on life-cycle costs***
- ***Lack of user confidence related to reliability***
- ***High capital cost***

EARLY MARKET OPPORTUNITIES

*Fuel Cells for **Backup Power:***

- Longer continuous run-time, greater durability than batteries
- Require less maintenance than batteries or generators
- Potential cost savings over batteries and generators

A 1-kW fuel cell system has been providing power for this FAA radio tower near Chicago for more than three years.

Photo courtesy of ReliOn

*Fuel Cells for **Material Handling Equipment:***

Photo courtesy of Hydrogenics

- Allow for rapid refueling — much faster than changing-out or recharging batteries
- Provide constant power — without voltage drop
- Eliminate need for space for battery storage and chargers

Funding Opportunities — *recent & upcoming*

H_2 Storage	▪ **H_2 Storage Engineering Center of Excellence (CoE):** To address onboard systems engineering. Planned $35 – 40M over 5 – 6 years for one team. Planned issuance: Jan. '08 ▪ **H_2 Storage New Ideas:** Annual small solicitation to introduce new materials and concepts into portfolio. Planned $3 – 6M over 2 – 5 years for 3 – 6 projects. Planned issuance: Jan. '08

Fuel Cells	▪ **2008 Solicitation/Lab Call:**
	  ▪ Request for Information released in November 2007 (www.gpoaccess.gov/fr/index.html)
	  ▪ Fuel Cell Pre-Solicitation Workshop to be held in January 2008.
	  ▪ Ideas from the RFI and workshop will be taken into consideration for the solicitation/lab call to be released in April 2008

Manufacturing R&D	▪ **Manufacturing R&D For Hydrogen & Fuel Cell Systems. Closed October 15, 2007.** Focuses primarily on technologies that are near commercialization. Topics include: Alternative Electrode Deposition Processes; Gas Diffusion Layer Fabrication; Novel MEA Manufacturing; Process Modeling for Fuel Cell Stacks; Process and Device for Cost Effective Testing of Cell Stacks; and Manufacturing Technologies for High Pressure Composite Tanks
H_2 Education Development	▪ **Three topics, closed January 3, 2008:** State and Local Government Outreach; Early Deployment and Education; and University Programs
SBIR/ STTR	▪ **2008 Solicitation included four hydrogen-related subtopics. Closed Nov. 2007** ▪ H_2 from Waste; Development of a Sulfur Dioxide Electrolyzer for the Hybrid Sulfur H_2 Production Process; Bio-Fueled Solid Oxide Fuel Cell; Manufacturing of Bipolar Plates

Questions?

For more information visit: www.hydrogen.energy.gov

Hydrogen Posture Plan

For more information on the Hydrogen Program

www.hydrogen.energy.gov/roadmaps_vision.html

Learning Demonstration Interim Progress Report

For more information on the vehicle/infrastructure demonstration

www.hydrogen.energy.gov/news_learning_demo.html

Hydrogen Overview Book

For more information on hydrogen and fuel cell technologies

www1.eere.energy.gov/hydrogenandfuelcells/education/h2iq.html