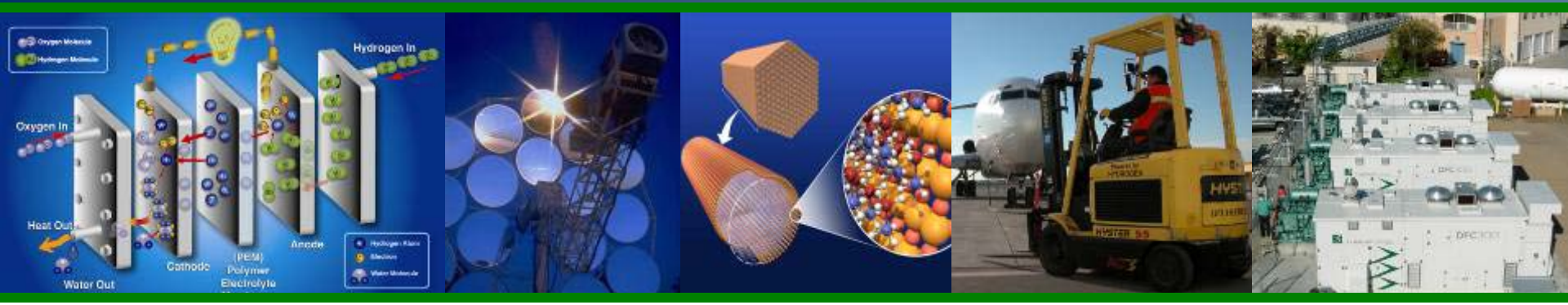
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



EERE Fuel Cell Technologies Program

Sunita Satyapal

Acting Program Manager

U.S. Department of Energy Fuel Cell Technologies Program

Fuel Cell Project Kickoff

September 30, 2009

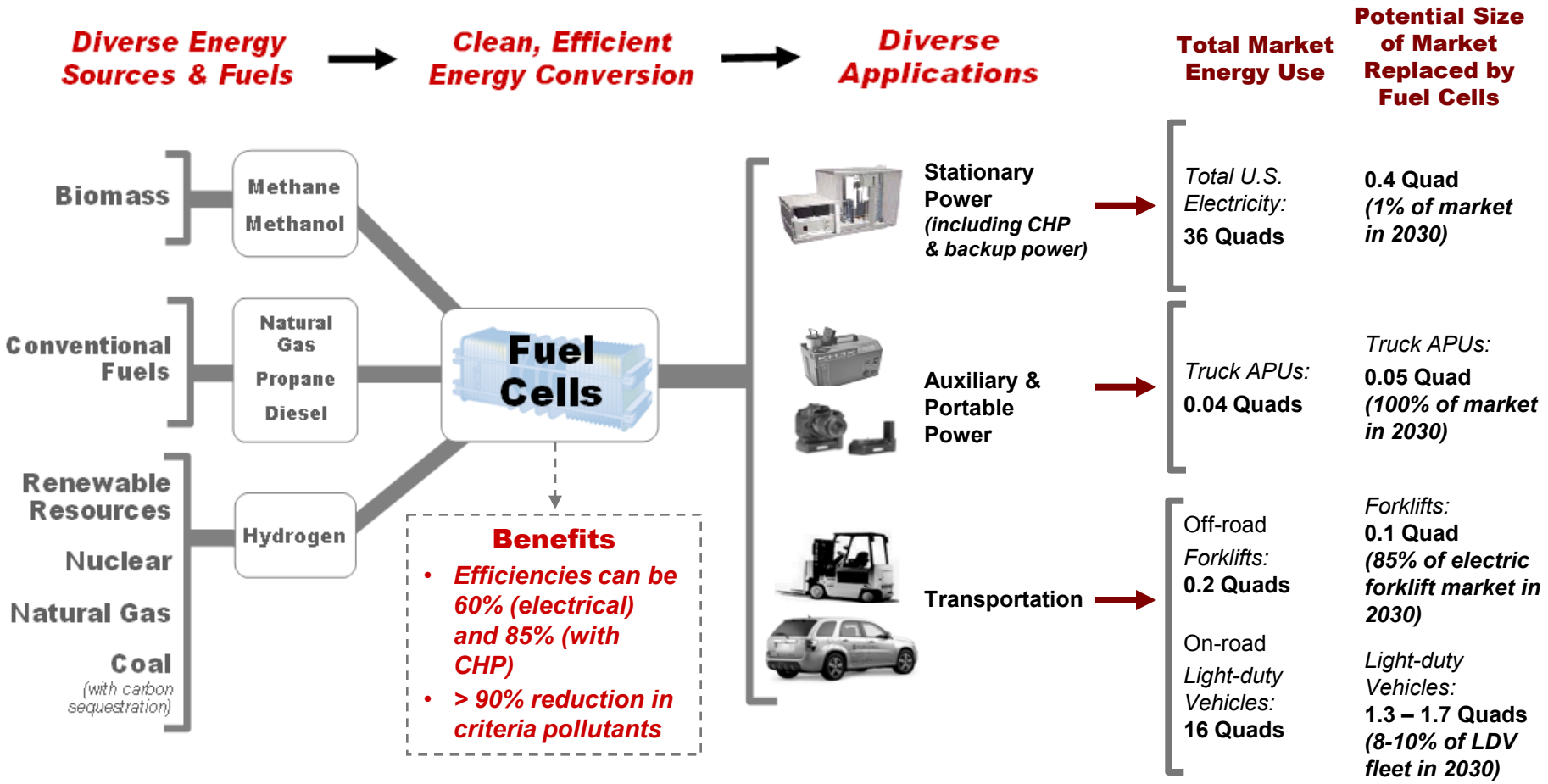
Fuel Cells: Addressing Energy Challenges

Energy Efficiency and Resource Diversity

→ *Fuel cells offer a highly efficient way to use diverse fuels and energy sources.*

Greenhouse Gas Emissions and Air Pollution:

→ *Fuel cells can be powered by emissions-free fuels that are produced from clean, domestic resources.*



Fuel Cells — *Where are we today?*

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Fuel Cells for Stationary Power, Auxiliary Power, and Specialty Vehicles

The largest markets for fuel cells today are in stationary power, portable power, auxiliary power units, and forklifts.

***~52,000** fuel cells have been shipped worldwide.*

***~18,000** fuel cells were shipped in 2008 (> 50% increase over 2007).*

Fuel cells can be a cost-competitive option for critical-load facilities, backup power, and forklifts.

Production & Delivery of Hydrogen

In the U.S., there are currently:

- ***~9 million metric tons** of H_2 produced annually*
- ***> 1200 miles** of H_2 pipelines*

Fuel Cells for Transportation

In the U.S., there are currently:

- *> 200 fuel cell vehicles*
- *> 20 fuel cell buses*
- *~ 60 fueling stations*

Several manufacturers—including Toyota, Honda, Hyundai, Daimler, Proterra (buses), and GM—have announced plans to commercialize vehicles in the next few years.

Program Goals and Barriers

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The Program's overarching goal is to enable the widespread commercialization of hydrogen and fuel cell technologies.

Technology Barriers

Fuel Cell Cost & Durability

	Status:	Targets:
Stationary Systems:	~$3,500/kW	$750/kW
	20,000 hr	40,000-hr durability
Vehicles:	$61/kW	$30/kW
	2,000 hr	5,000-hr durability

Cost of H_2 Production & Delivery

(cost is untaxed and delivered)

	Status:	Targets:
Production:	$3 - $12/gge	$2 – 3/gge
Delivery:	$2.30 – 3.30/gge	<$1/gge

gge = gallon gasoline equivalent

Capacity & Cost of H_2 Storage

(>300 mile range)	Status:	Targets:
Volumetric	15 – 50 g/L	70 g/L
Gravimetric	3.0 – 6.5 wt%	7.5 wt%
Cost	$15 – 23/kWh	$2/kWh

Technology Validation:

Technologies must be demonstrated under real-world conditions.

E.g., 140 vehicles & 20 stations demonstrated with GM, Ford, Daimler/ Chrysler, Hyundai

- *2.2 million miles, 90,000 kg dispensed; 53-58% efficiency; up to 254 mile range demonstrated.*

Economic & Institutional Barriers

Safety, Codes & Standards Development

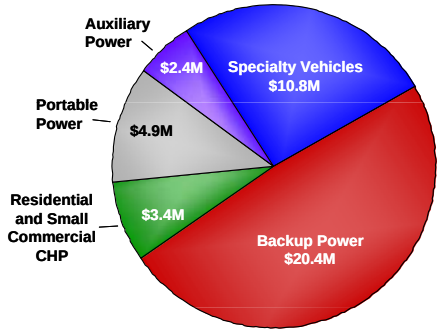
Domestic Manufacturing & Supplier Base

Public Awareness & Acceptance

Investment in Delivery Infrastructure

COMPANY	AWARD
Delphi Automotive	$2.4 M
FedEx	$1.3 M
GENCO	$6.1 M
Jadoo Power	$1.8 M
MTI MicroFuel Cells	$2.4 M
Nuvera Fuel Cells	$1.1 M
Plug Power	$3.4 M
Plug Power	$2.7 M
PolyFuel	$2.5 M
ReliOn (inc. AT&T)	$8.6 M
Sprint Comm.	$7.3 M
Sysco of Houston	$1.2 M

Market Transformation



Recovery Act enables up to 1,000 fuel cell systems for early markets (>$40 M)

NOTE: All costs are projected to high-volume manufacturing and production.

Fuel Cells — *Worldwide Interest & Investment*

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Interest in fuel cells and hydrogen is global, with more than $1 billion in public investment in RD&D annually, and 17 members of the International Partnership for the Hydrogen Economy (IPHE).

U.S.A.

RD&D Funding:

~$500 M (FY09, total)

~$270 M (FY09, DOE)

Deployments/Demonstrations:

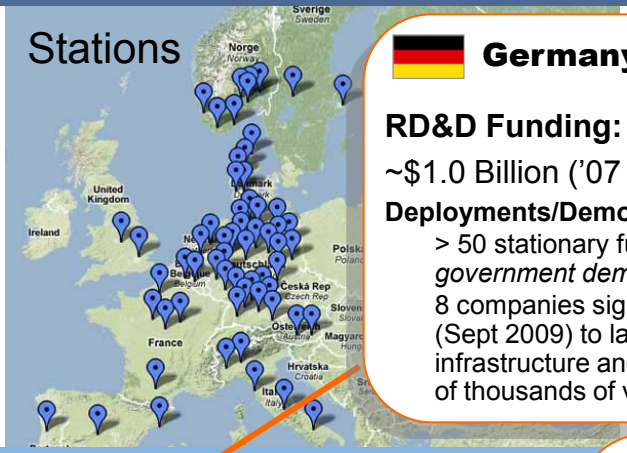
- ~ 2,000 stationary fuel cells
- ~ 60 fueling stations
- > 200 fuel cell vehicles
- > 20 fuel cell buses

European Union

RD&D Funding:

>$600 M (’08 – ’13)

Fuel Cell and Hydrogen Joint Technology Initiative: 50/50 cost-shared with industry.



Germany

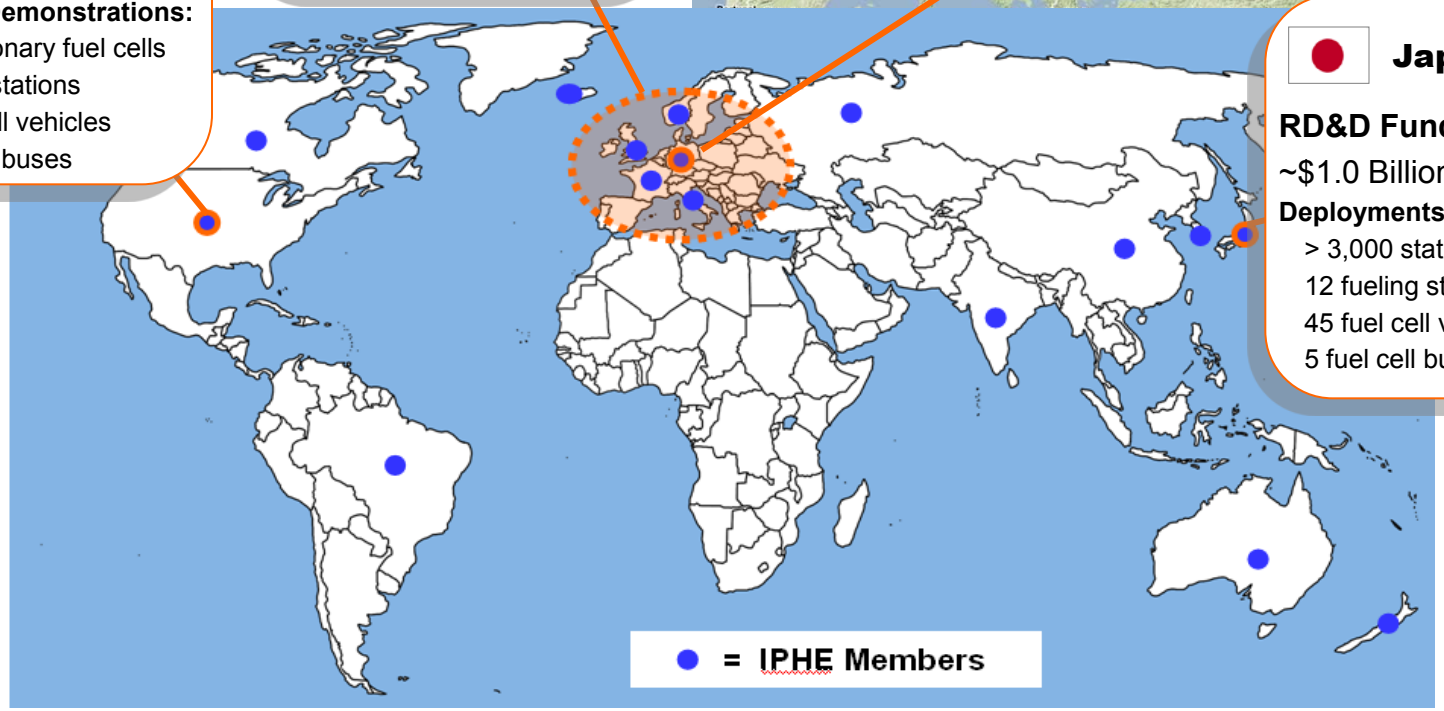
RD&D Funding:

~$1.0 Billion (’07 – ’16)

Deployments/Demonstrations:

> 50 stationary fuel cells *in government demonstrations*

8 companies signed MOU (Sept 2009) to launch infrastructure and hundreds of thousands of vehicles



Japan

RD&D Funding:

~$1.0 Billion (’08 – ’12)

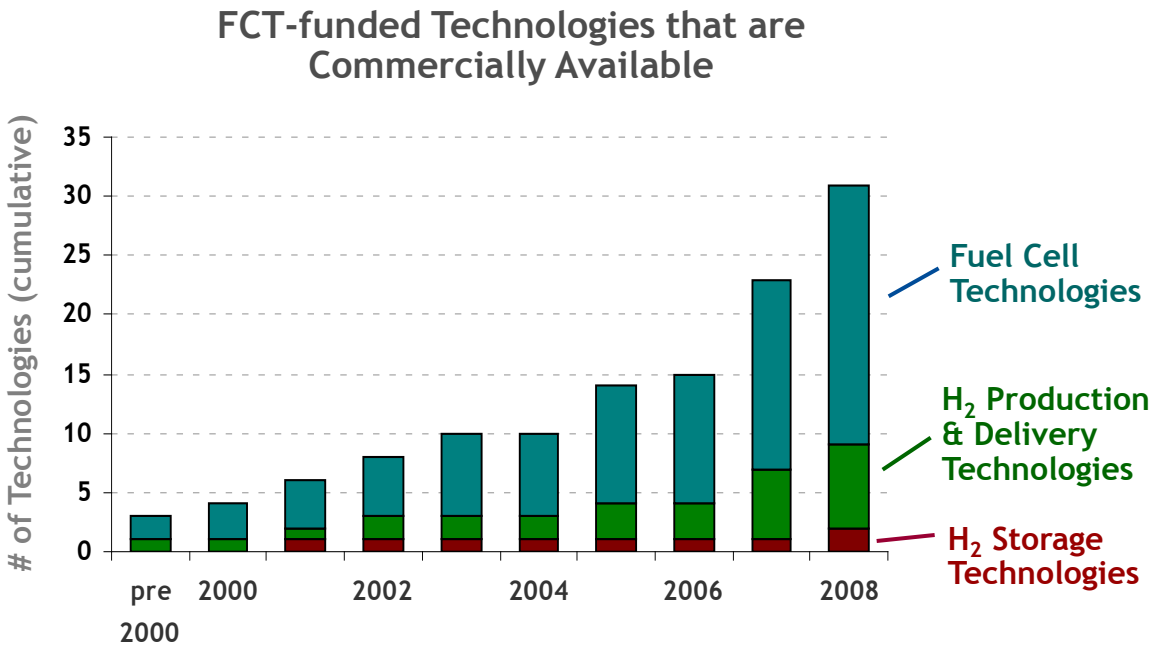
Deployments/Demonstrations:

- > 3,000 stationary fuel cells
- 12 fueling stations
- 45 fuel cell vehicles
- 5 fuel cell buses

We are tracking the commercial success of technologies developed by the Program.

Accelerating Commercialization:

An increasing number of FCT-funded technologies have been entering the market.



PATENTS resulting from FCT-funded R&D:

118 patents reviewed:

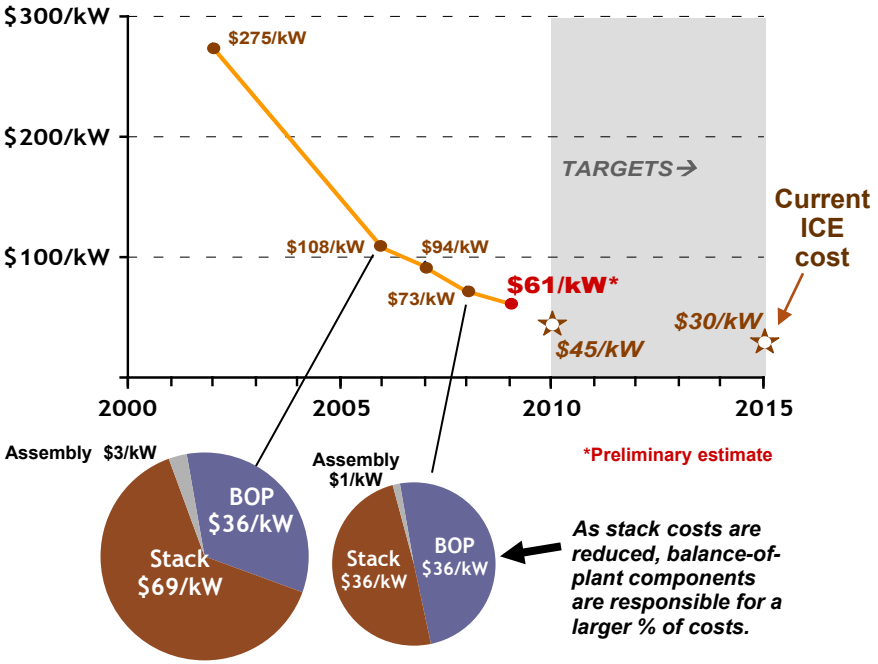
- 60 fuel cell patents
- 37 hydrogen production/delivery patents
- 21 storage patents

Results will be documented in a report by Pacific Northwest National Lab:

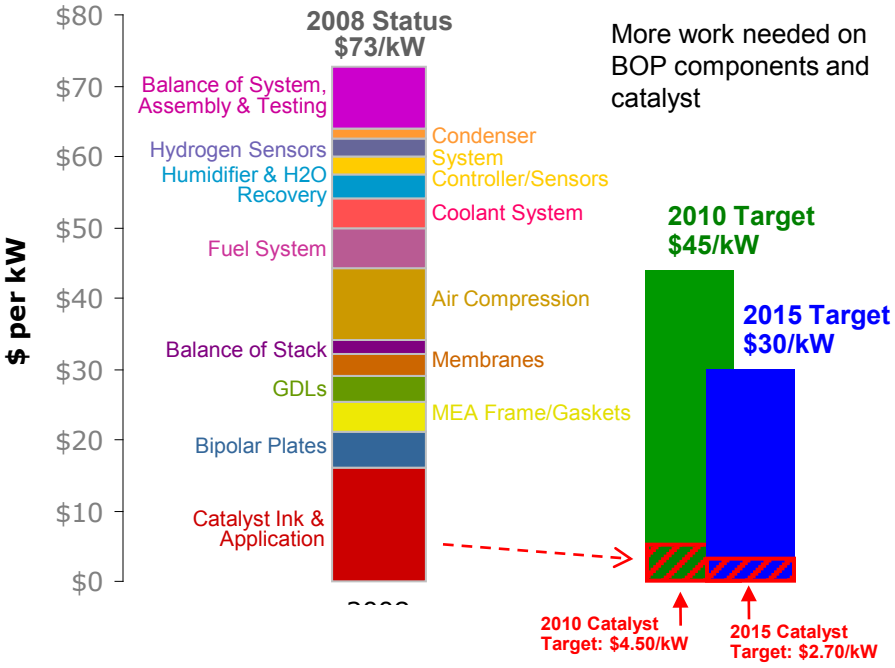
"Pathways to Commercial Success: Technologies and Products Supported by the Hydrogen, Fuel Cells and Infrastructure Technologies Program"

Major Technology Pathways: Status of Fuel Cells

We've reduced the cost of fuel cells by more than 75% since 2002.



Breakdown of 2008 Cost Estimate



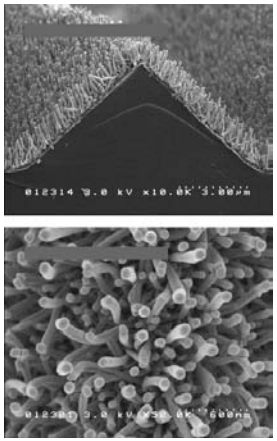
From 2007 to 2008, key cost reductions were made by:

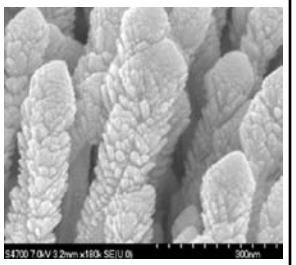
- ***Reducing platinum group metal content from 0.6 to 0.35 g/kW***
- ***Increasing power density from 583 to 715 mW/cm²***

→ **These advances resulted in a $12.40/kW cost reduction.**

- *2008 cost projection validated by an independent panel, which found $60 – 80/kW to be a "valid estimate"*
- *Cost estimates are based on projection to high-volume manufacturing (500,000 units/year); 80 kW PEM fuel cell. Breakdown by DTI, Inc.*

Key Improvements enabled by using novel organic crystalline whisker catalyst supports and Pt-alloy whiskerettes ~ 5 billion whiskers/cm² Whiskers are ~ 25 X 50 X 1000 nm





Whiskerettes: 6 nm x 20 nm

Fuel Cell R&D — *Progress*

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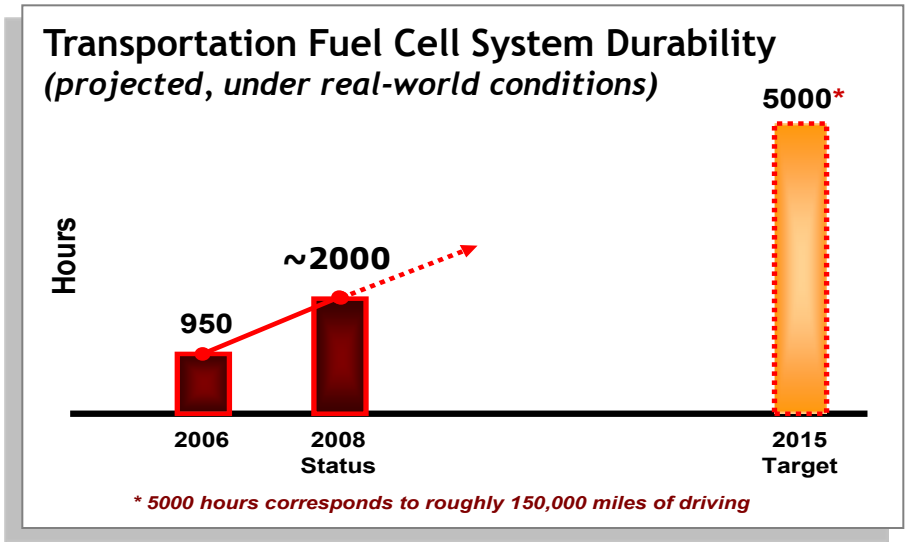
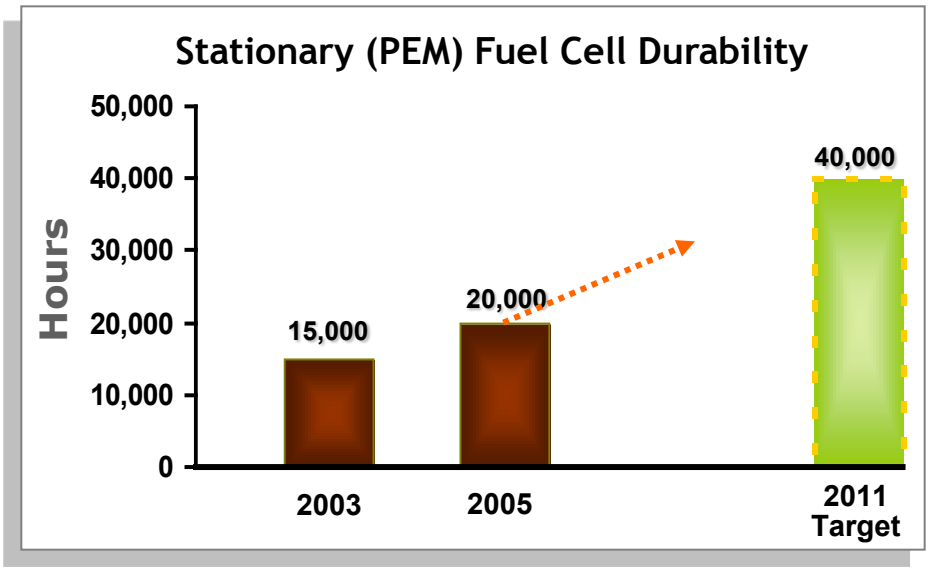
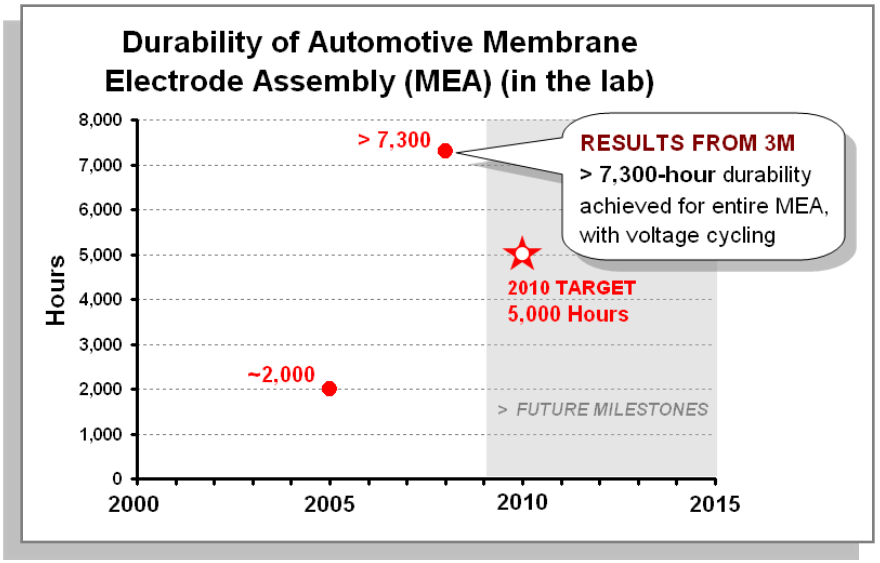
We've greatly increased durability—including more than doubling the demonstrated durability of transportation fuel cells.





Demonstrated >7,300-hour durability →

This exceeds our target for MEA durability, in single-cell testing—and has the potential to meet the 2010 target for MEAs in a fuel cell system.



Collaborations

Federal Agencies

- DOC
- DOD
- DOEd
- DOT
- EPA
- GSA
- DOI
- DHS
- NASA
- NSF
- USDA
- USPS

- *Interagency coordination through staff-level Interagency Working Group (meets monthly)*
- *Assistant Secretary-level Interagency Task Force mandated by EPACT 2005.*

Universities

~ 50 projects with 40 universities

International

- **IEA Implementing agreements 25 countries**
- **International Partnership for the Hydrogen Economy –**
  - **16 countries**
  - **30 projects**

EERE Fuel Cell Technologies Program

- ***Applied RD&D***
- ***Efforts to Overcome Non-Technical Barriers***
- ***Internal Collaboration with FE, NE, BES***

Industry Partnerships & Stakeholder Assn's.

- **FreedomCAR and Fuel Partnership**
- **National Hydrogen Association**
- **U. S. Fuel Cell Council**
- **Hydrogen Utility Group**
- **~ 65 projects with 50 companies**

State & Regional Partnerships

- **California Fuel Cell Partnership**
- **California Stationary Fuel Cell Collaborative**
- **SC H_2 & Fuel Cell Alliance**
- **Upper Midwest Hydrogen Initiative**
- **Ohio Fuel Coalition**
- **Connecticut Center for Advanced Technology**

NREL ($23M)
P&D, S, FC, A, SC&S, TV

ANL ($15M)
A, FC, P&D

LANL ($15M)
S, FC, SC&S

SNL ($8M)
P&D, S, SC&S

PNNL ($7M)
P&D, S, FC, A

BNL ($3M)
S, FC

LLNL ($4M)
P&D, S

ORNL ($6M)
P&D, S, FC, A

SRNL ($4M)
S, P&D

LBNL ($4M)
FC, A

Other Labs

- **JPL**
- **NIST**
- **NETL**
- **INL**

P&D = Production & Delivery; S = Storage; FC = Fuel Cells; A = Analysis; SC&S = Safety, Codes & Standards; TV = Technology Validation

Key Partnerships

U.S. PARTNERSHIPS

- **FreedomCAR & Fuel Partnership:** *Ford, GM, Chrysler, BP, Chevron, ConocoPhillips, ExxonMobil, Shell, Southern California Edison, DTE Energy*
- **Hydrogen Utility Group:** *Xcel Energy, Sempra, DTE, Entergy, New York Power Authority, Sacramento Municipal Utility District, Nebraska Public Power Authority, Southern Cal Edison, Arizona Public Service Company, Southern Company, Connexus Energy, etc.*
- **State/Local Governments:** *California Fuel Cell Partnership, California Stationary Fuel Cell Collaborative*
- **Industry Associations:** *US Fuel Cell Council, National Hydrogen Association*

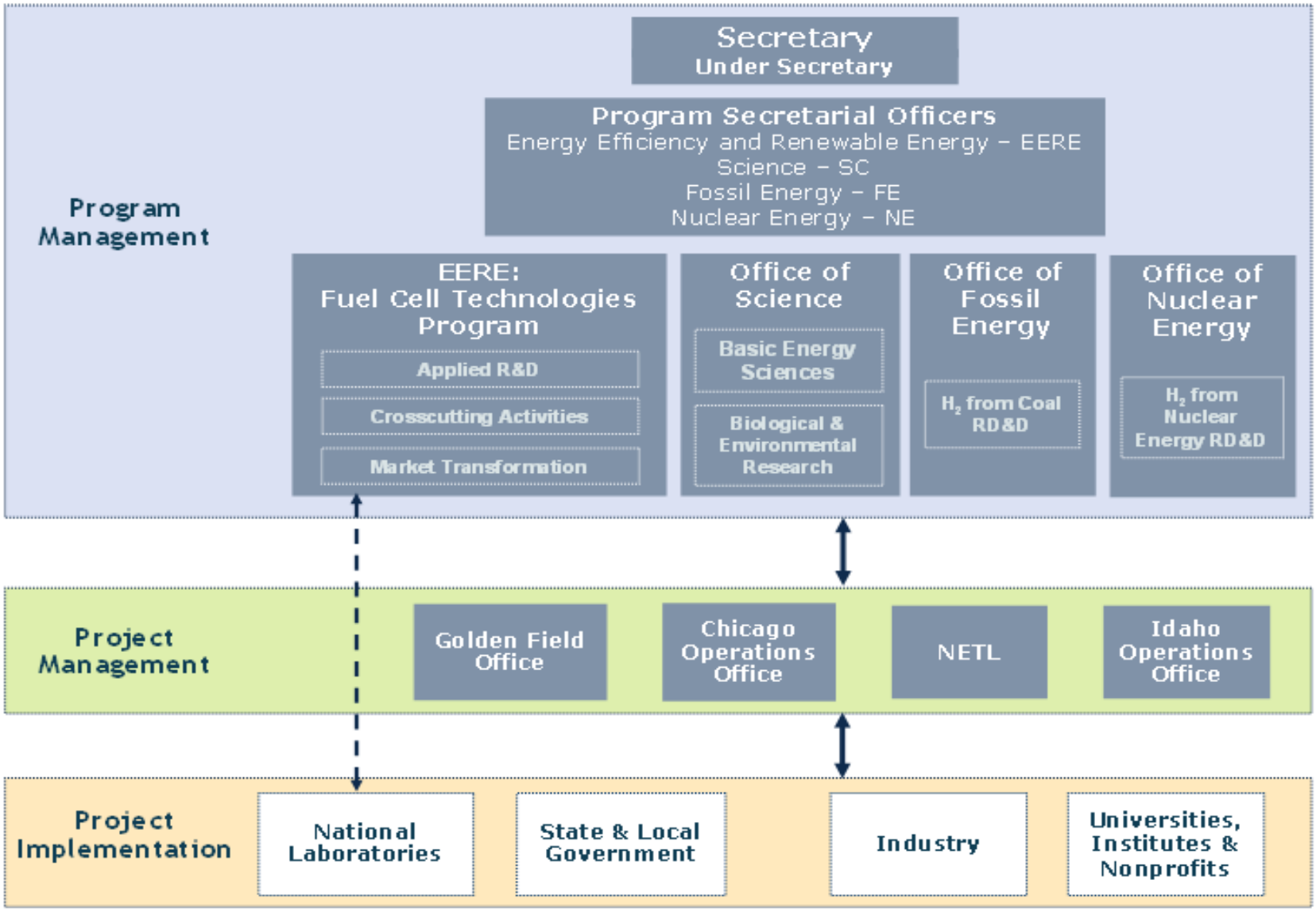
INTERNATIONAL PARTNERSHIPS

International Partnership for the Hydrogen Economy—
partnership among 16 countries and the European Commission

International Energy Agency — Implementing Agreements

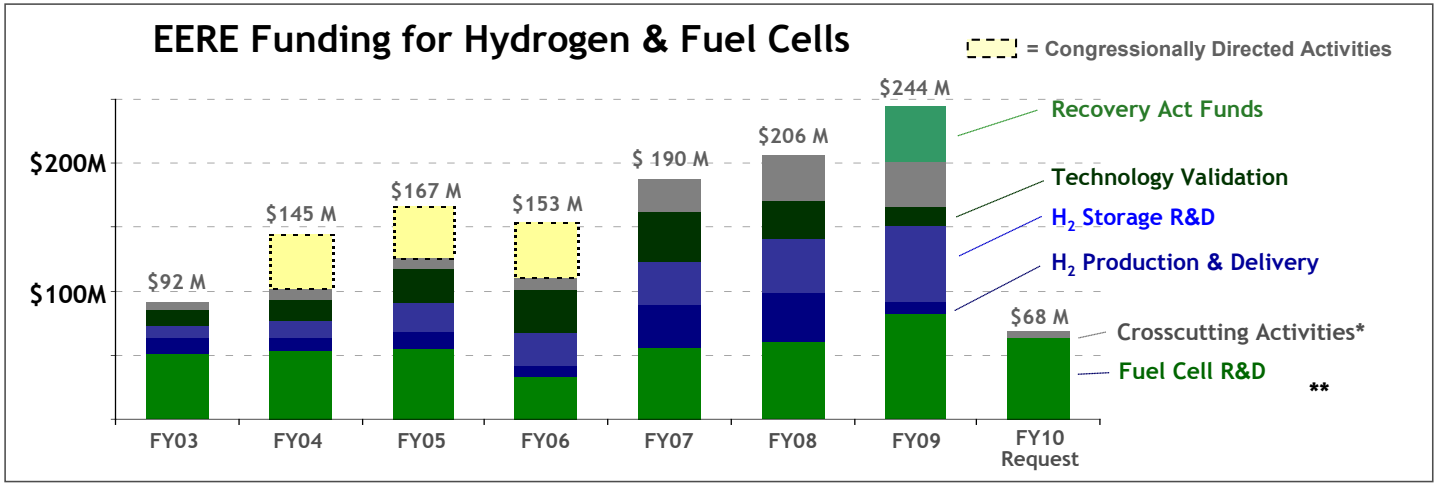
- ***Hydrogen Implementing Agreement — 21 countries and the European Commission***
- ***Advanced Fuel Cells Implementing Agreement — 19 countries***

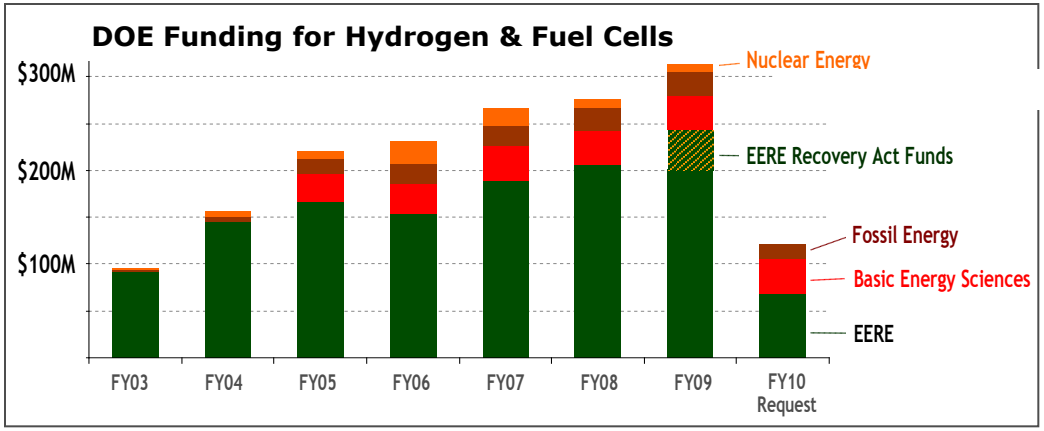
Organization



Budget

Program activities are an integrated, comprehensive effort addressing the full range of technical, institutional, and economic barriers.





*Crosscutting activities include Safety, Codes & Standards, Education, Systems Analysis, Manufacturing R&D, and Market Transformation.

** FY10 Senate mark is $190M for Hydrogen Technologies; FY10 House mark is $153M.

New Fuel Cell Projects

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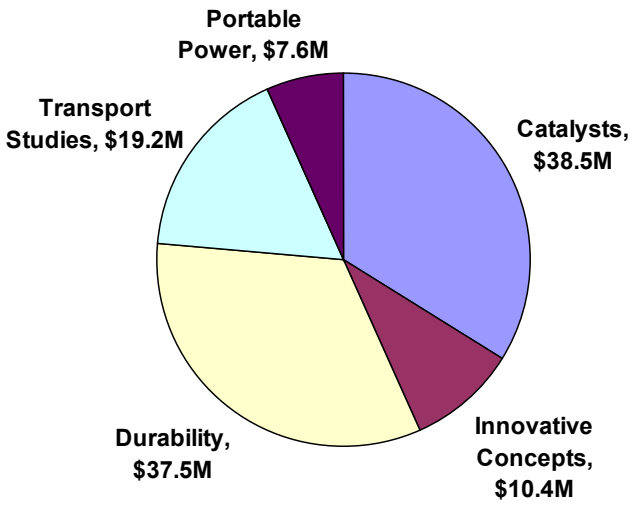
28 innovative R&D projects kicked off today, $113M in DOE funding



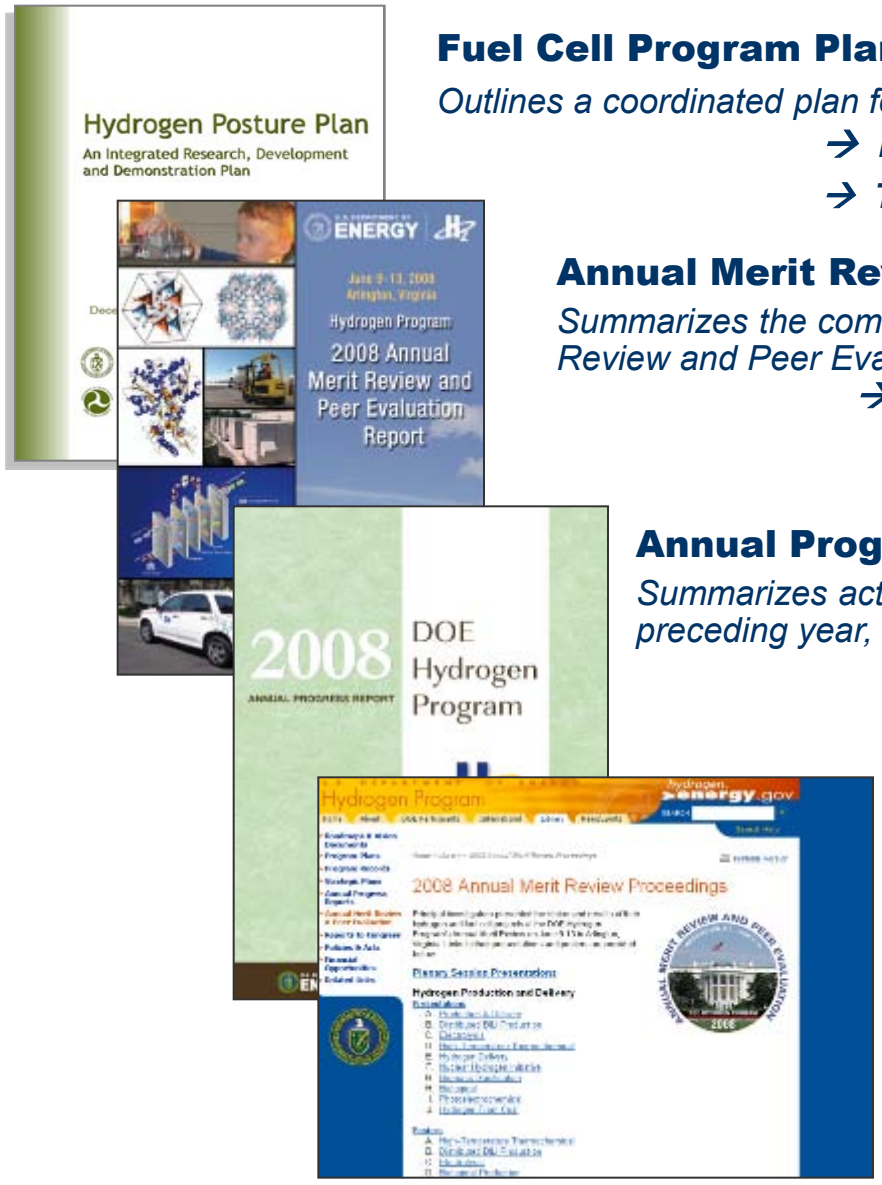
New projects will:

- **Develop improved fuel cell catalysts**
- **Enhance fuel cell durability**
- **Characterize transport phenomena**
- **Optimize fuel cells for early market applications**
- **Develop innovative concepts leading to a new generation of fuel cell technology**

55 participating organizations:

- 3M
- Argonne National Lab
- Arkema
- Ballard Power Systems
- Brookhaven National Lab
- Brown University
- Case Western Reserve University
- Colorado School of Mines
- Dalhousie University
- dpoint Technologies
- Engineered Fibers Technology
- Gas Technology Institute
- General Motors Corporation
- Georgia Institute of Technology
- Giner Electrochemical Systems
- Hawaii Natural Energy Institute
- IBIS Associates
- Illinois Institute of Technology
- Indiana University – Purdue University Indianapolis
- Ion Power
- Jet Propulsion Lab
- Johnson Matthey Fuel Cells
- Lawrence Berkeley National Lab
- Los Alamos National Lab
- Massachusetts Institute of Technology
- Michigan Technological University
- National Renewable Energy Laboratory
- Northeastern University
- Nuvera Fuel Cells
- Oak Ridge National Lab
- Orion Industries
- Penn State University
- Plug Power
- PolyFuel
- QuantumSphere
- Queen's University
- Sandia National Lab
- Southern Illinois University
- Stanford University
- SUNY Albany
- SUNY Stony Brook
- Tech-Etch Inc
- TreadStone Technologies
- United Technologies Research Center
- University of CA Riverside
- University of Connecticut
- University of Hawaii
- University of New Mexico
- University of South Carolina
- University of Texas Austin
- University of Wisconsin Madison
- UTC Power
- Versa Power Systems
- Virginia Tech
- W. L. Gore & Associates

Key Program Documents



Fuel Cell Program Plan

Outlines a coordinated plan for fuel cell activities in the Department of Energy

→ ***Replacement for current* Posture Plan**

→ ***To be released in late 2009***

Annual Merit Review & Peer Evaluation Report

Summarizes the comments of the Peer Review Panel at the Annual Merit Review and Peer Evaluation Meeting

→ ***Next edition to be published in Fall 2009***

www.hydrogen.energy.gov/annual_review08_report.html

Annual Progress Report

Summarizes activities and accomplishments within the Program over the preceding year, with reports on individual projects

→ ***Next edition to be published in Fall 2009***

www.hydrogen.energy.gov/annual_progress.html

Annual Merit Review Proceedings

Includes downloadable versions of all presentations at the Annual Merit Review

→ ***Latest edition released June 2009***

www.hydrogen.energy.gov/annual_review09_proceedings.html

Next Annual Review: June 7-11, 2010

Washington, D.C.

www.hydrogen.energy.gov **www.hydrogenandfuelcells.energy.gov**

Thank you

We look forward to your progress!