



U.S. DEPARTMENT OF
ENERGY

Federal Government Support for Fuel Cell Technologies

Sunita Satyapal
Acting Program Manager

Hydrogen and Fuel Cell State and Regional Initiatives

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- **Overview & Challenges**
- **Progress & Accomplishments**
- **A New Direction for the Program**

The Program has been working to address a number of key challenges facing the widespread commercialization of hydrogen and fuel cells.

Technology
Barriers

Fuel Cell Cost & Durability

Targets:

Stationary Systems: \$750/kW, 40,000-hr durability

Vehicles: \$30 per kW, 5000-hr durability

Hydrogen Cost

Target: \$2 – 3 /gge

Hydrogen Storage Capacity

Greater than 300-mile range, without reducing interior space or compromising performance

Technology Validation:

Technologies must be demonstrated under real-world conditions.

Market Transformation

Assisting the growth of early markets will help to overcome many barriers, including achieving significant cost reductions through economies of scale.

Economic &
Institutional
Barriers

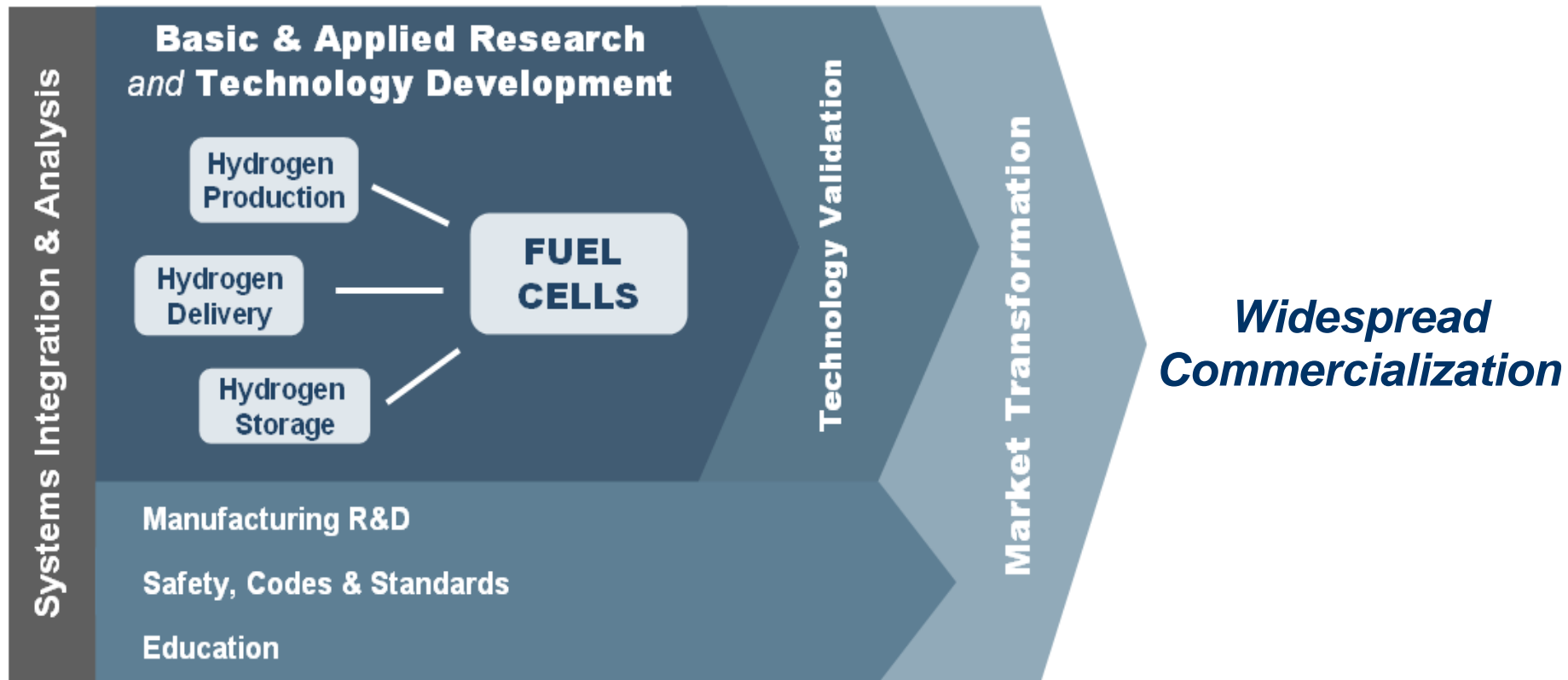
Safety, Codes & Standards Development

Hydrogen Supply & Delivery Infrastructure

Domestic Manufacturing & Supplier Base

Public Awareness & Acceptance

The Program is an integrated effort, structured to address all the key challenges and obstacles facing widespread commercialization.



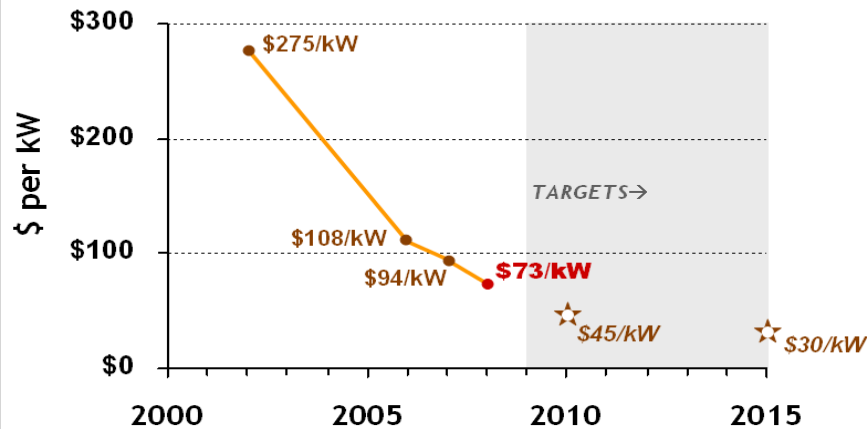
The DOE Hydrogen Program includes activities within the Offices of Energy Efficiency & Renewable Energy, Fossil Energy, Nuclear Energy, and Science.

We've reduced the cost of fuel cells to \$73/kW*

- *Nearly 75% reduction since 2002*
- *More than 20% reduction in one year*

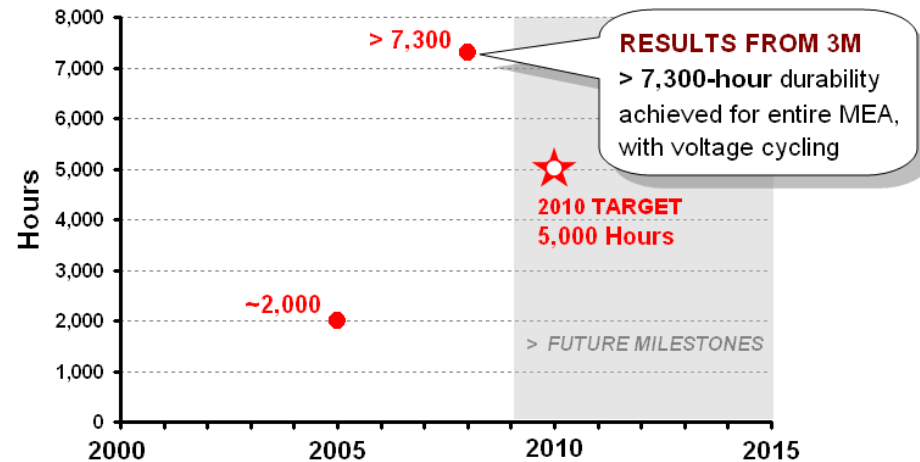
Transportation Fuel Cell System Cost

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



*Based on projection to high-volume manufacturing (500,000 units/year). Analysis by TIAx and DTI. Results validated by independent assessment.

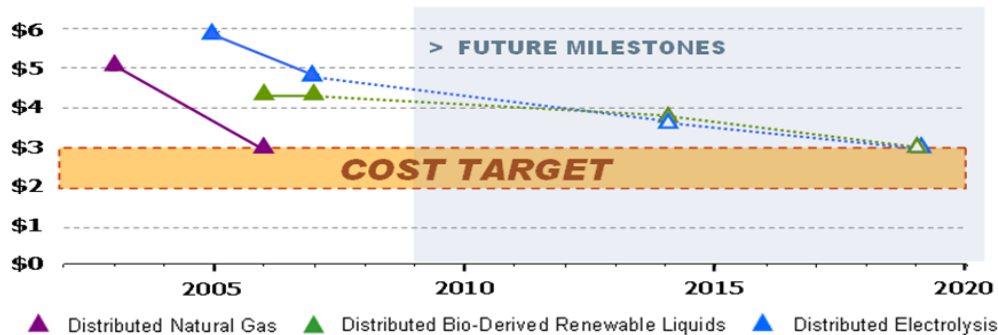
Durability of Automotive Membrane Electrode Assembly (MEA) (in the lab)



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

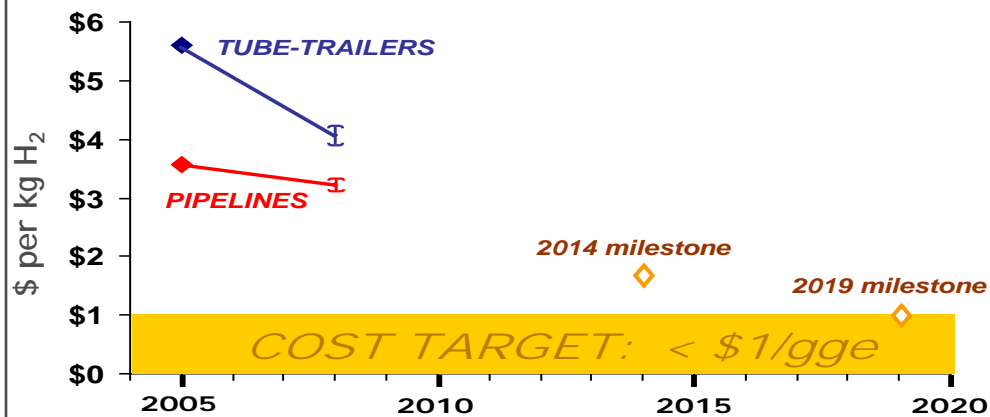
We've reduced the cost of hydrogen from multiple sources* — including meeting the cost-target for H₂ from natural gas.

Cost of Hydrogen: Status & Targets for Distributed Production
(\$/gallon gasoline equivalent, untaxed)



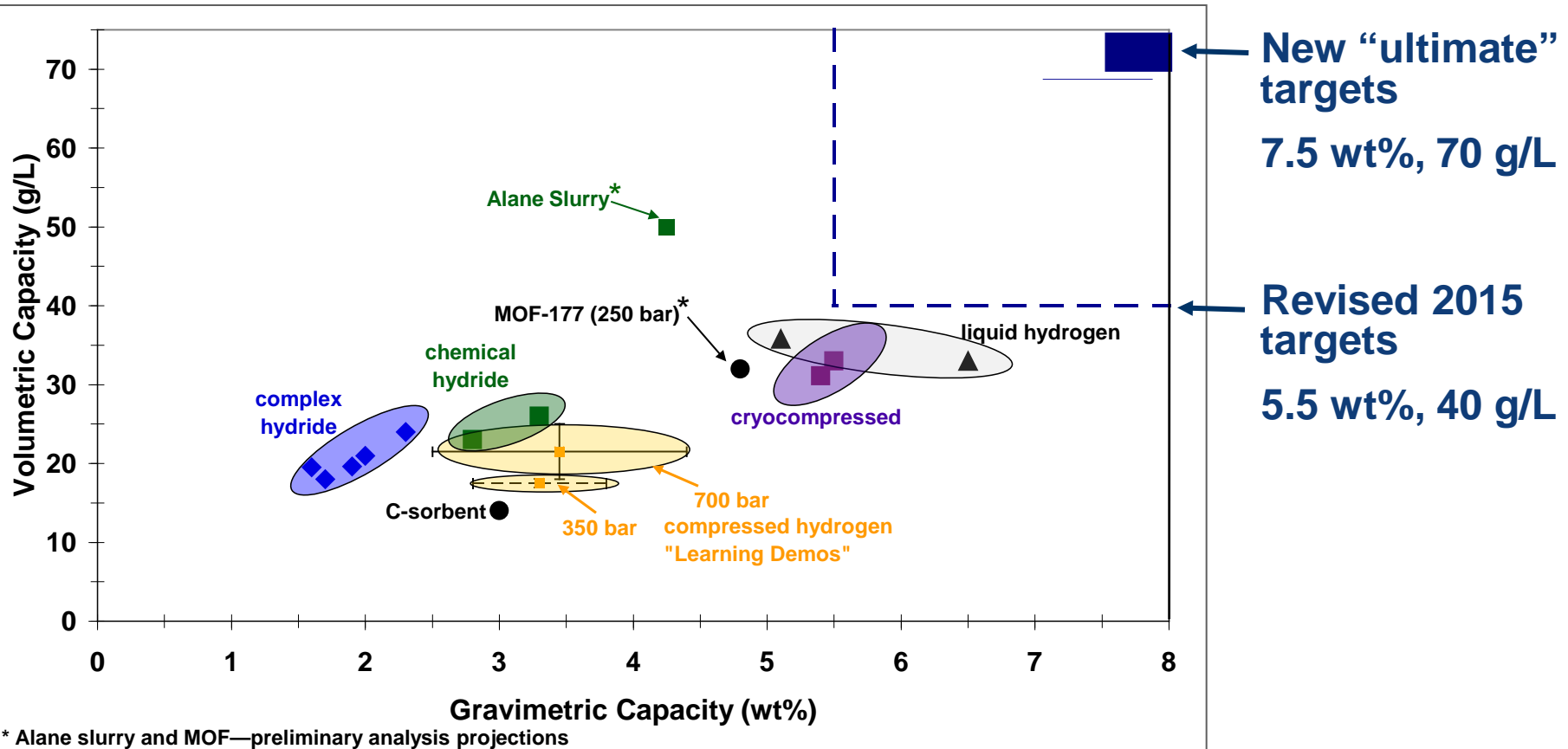
*projected cost, assuming 1500 kg/day, 500 units/year

Projected Cost of Delivering Hydrogen



*modeled cost, based on analysis of state-of-the-art technology

We've reduced the cost of hydrogen delivery* — ~30% reduction in tube-trailer costs, 10% reduction in pipeline costs



- **Assessed and updated targets as planned** (based on real-world experience with vehicles, weight & space in vehicle platform, and needs for market penetration)
- **Developed and evaluated more than 200 materials approaches**
- **Launched New Storage Engineering Center of Excellence** to address systems integration and prototype development—efforts coordinated with materials centers



We are demonstrating the technologies to validate their performance in integrated systems, under real-world conditions.



DOE Vehicle/Infrastructure Demonstration

Four teams in 50/50 cost-shared projects with DOE Vehicle Technologies Program

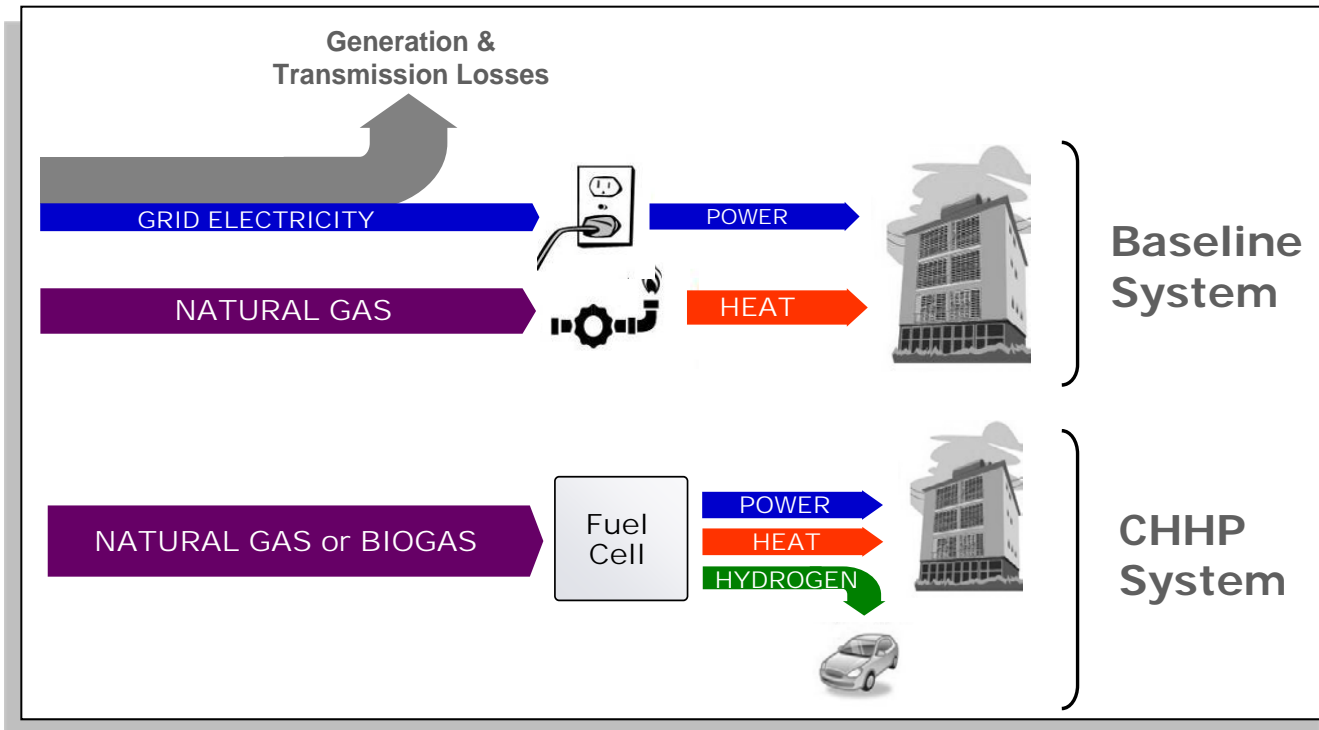
- **140 fuel cell vehicles and 20 fueling stations demonstrated**
- **More than 1.9 million miles traveled**
- **More than 90,000 kg hydrogen produced/dispensed**
- **Analysis by NREL shows:**
 - **Efficiency:** 53 – 58% (>2x higher than gasoline internal combustion engines)
 - **Range:** ~196 – 254 miles
 - **Fuel Cell System Durability:**
Nearly 2,000 hrs (~60,000 miles)

We are also demonstrating stationary fuel cells and evaluating real-world forklift and bus fleet data (DOD and DOT collaboration).



Combined heat, hydrogen, and power systems (CHHP) can:

- *Produce clean power and fuel for multiple applications*
- *Provide a potential approach to establishing an initial fueling infrastructure*



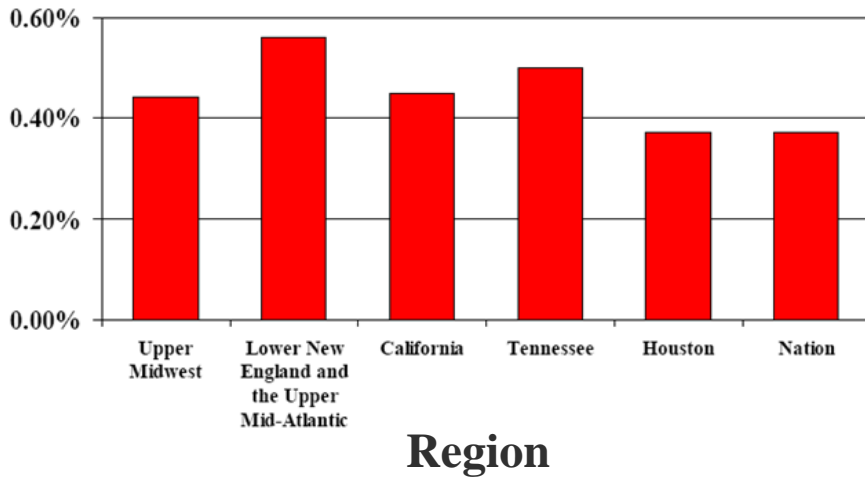
CHHP Project is Underway:

Orange County Sanitation District in Fountain Valley, CA—Air Products & FuelCell Energy

- **System has been designed, fabricated and shop-tested.**
- **Improvements in design have led to higher H₂-recovery (from 75% to >85%).**
- **On-site operation and data-collection planned for FY09 – FY10.**

Systems Analysis continues to provide data on costs & benefits of fuel cell technologies.

Employment (% increase from base case)



www.hydrogen.energy.gov/pdfs/epact1820_employment_study.pdf



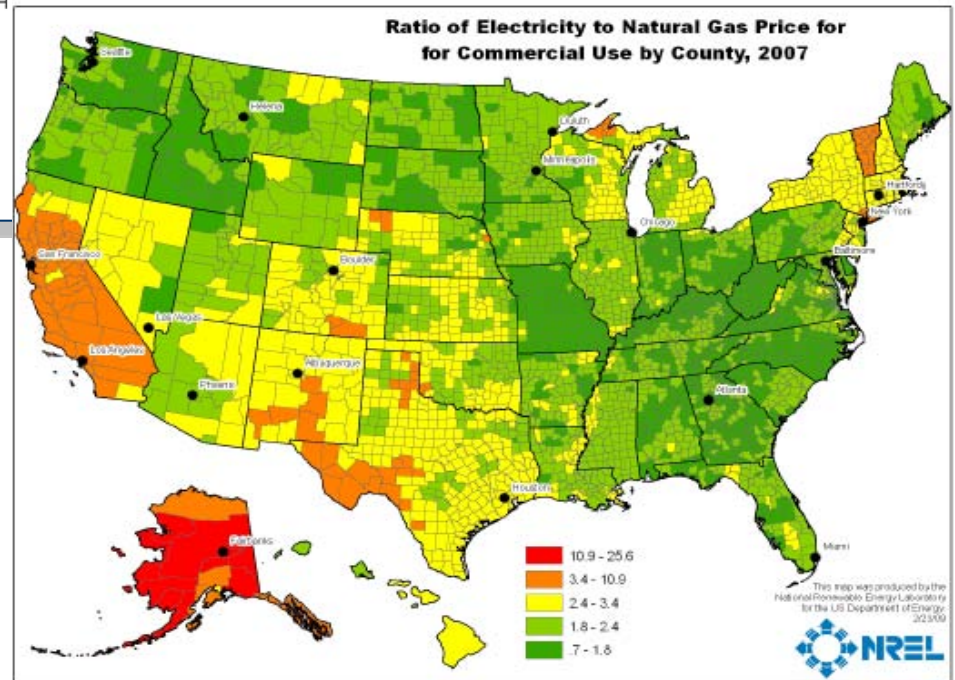
Analysis shows potential for 360,000 – 675,000 new jobs from growth of hydrogen and fuel cell industries, across 41 industries.

Preliminary analysis shows areas where fuel cells for CHP can be cost-competitive.



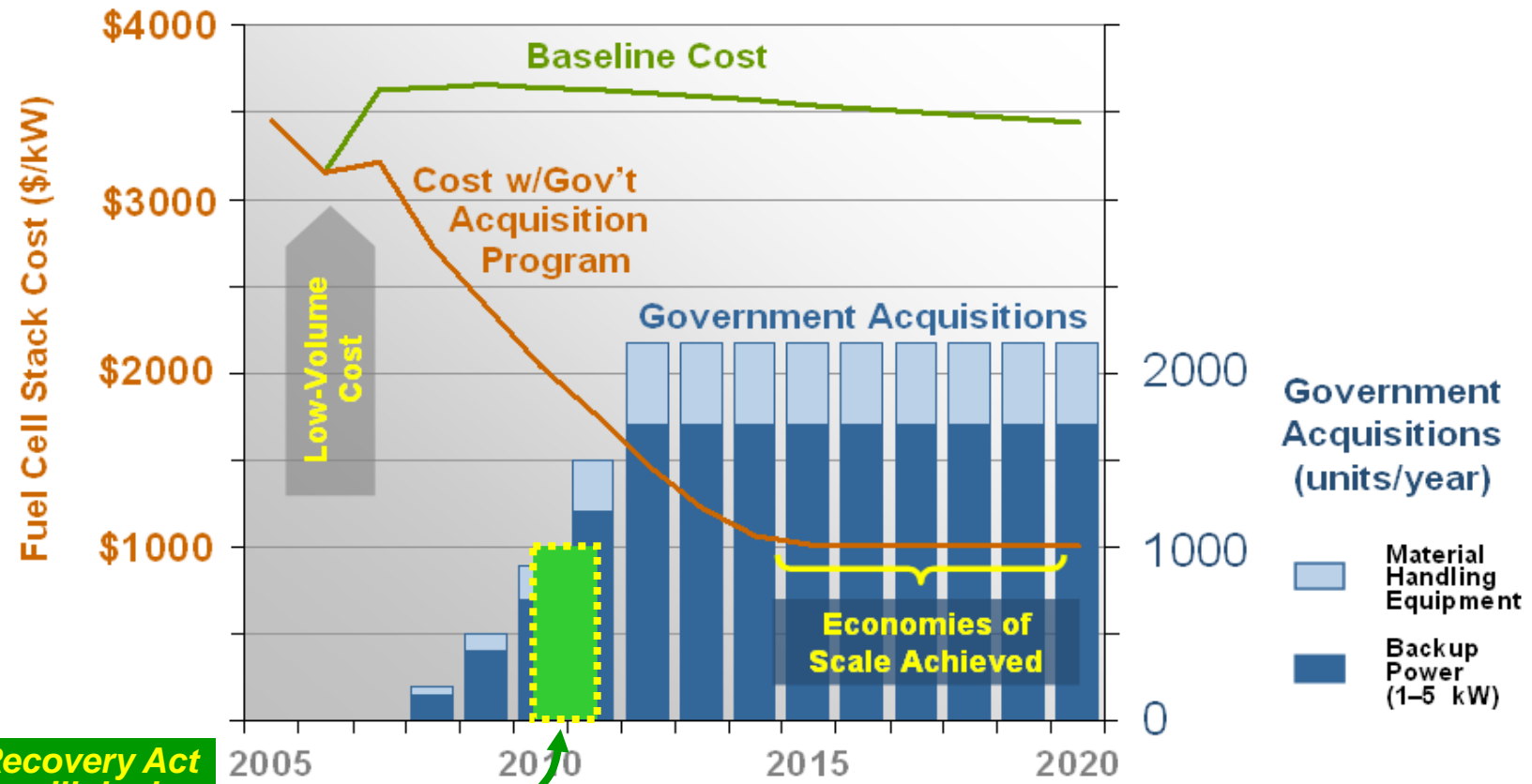
New resources include:

- **Updated well-to-wheels emissions & petroleum use results**
- **Employment Study**
- **Analysis of costs of tri-generation of hydrogen, heat, and power**



Government acquisitions could significantly reduce the cost of fuel cells through economies of scale, and help to support a growing supplier base.

Impact of Government Acquisitions on Fuel Cell Stack Costs (for non-automotive fuel cells)



Recovery Act funding will deploy up to 1000 fuel cells, in the private sector, by 2012.

Source: David Greene, ORNL; K.G. Duleep, Energy and Environmental Analysis, Inc., *Bootstrapping a Sustainable North American PEM Fuel Cell Industry: Could a Federal Acquisition Program Make a Difference?*, 2008.

The Program is facilitating the adoption of fuel cells across government and industry.

RECENT ACCOMPLISHMENTS Leveraging federal collaborations

Interagency agreements under development

- Deployment of up to 100 fuel cells underway
- Army Construction Engineering Research Lab, Federal Aviation Administration, Department of Homeland Security, Office of Naval Research

Developed Investment Tax Credit fact sheet and case studies

Identifying locations for fuel cells across federal facilities



40 fuel cell forklifts are in operation at the Defense Logistics Agency, Defense Depot Susquehanna, PA.

The Program and DOE are working with the Treasury Department on the “grant in lieu of a tax credit” option for installing and using energy efficient and renewable energy systems—including FUEL CELLS. Final guidance expected ~ July 2009.

Safety, Codes & Standards

- *Facilitating the development & adoption of codes and standards fuel cells*
- *Identifying and promoting safe practices industry-wide*

ACTIVITIES



Develop data needed for key codes & standards (C&S)

Harmonize domestic and international C&S

Simplify permitting process



Promote adoption of current C&S and increase access to safety information



PROGRESS (key examples)

Published Web-based resources, including: *Hydrogen Safety Best Practices Manual*; *Permitting Hydrogen Facilities*


Conducted R&D to enable harmonized domestic and international Fuel Quality Specifications

Developed safety course for researchers and hands-on training for emergency responders

Growing number of C&S published

Education: *We are working to increase public awareness and understanding of hydrogen and fuel cells.*

ACTIVITIES



Educate key audiences to facilitate demonstration, commercialization, and market acceptance



PROGRESS (key examples)

Launched courses for code officials and first responders (>9000 users)

Conducted seminars and developed fact-sheets and case studies for end-users

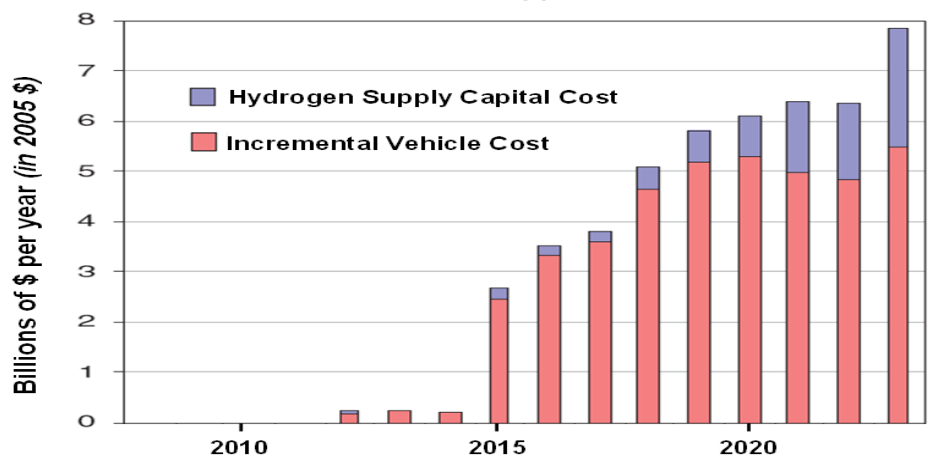
Conducted workshops to help state officials identify deployment opportunities

Recent independent analyses assess technology status, expected costs and benefits, and effectiveness of the Program.

National Academies Study¹

- By 2050, a portfolio of technologies—including FCVs—could eliminate petroleum use by light-duty vehicles (LDVs) and reduce CO₂ emissions from LDVs to 20% of current levels.
- FCVs could reach 2 million by 2020, 60 million by 2035, and 200 million by 2050.
- Transition cost to Govt: \$55B (\$40B vehicles, \$10B infrastructure, \$5B R&D from 2008 – 2023).
- Study is being updated to include impacts of PHEVs

Estimated Government Cost to Support a Transition to FCVs



¹Transitions to Alternative Transportation Technologies: A Focus on Hydrogen

Independent Assessment of Fuel Cell System Cost

NREL convened independent experts to provide rigorous, unbiased analysis.

- **\$60 – \$80 per kW is a “valid estimation”** of the potential manufactured cost for an 80-kW fuel cell system based on 2008 technology, extrapolated for high volumes (500,000 units/yr).
- **Validates DOE estimate of \$73/kW.**

www.hydrogen.energy.gov/peer_reviews.html

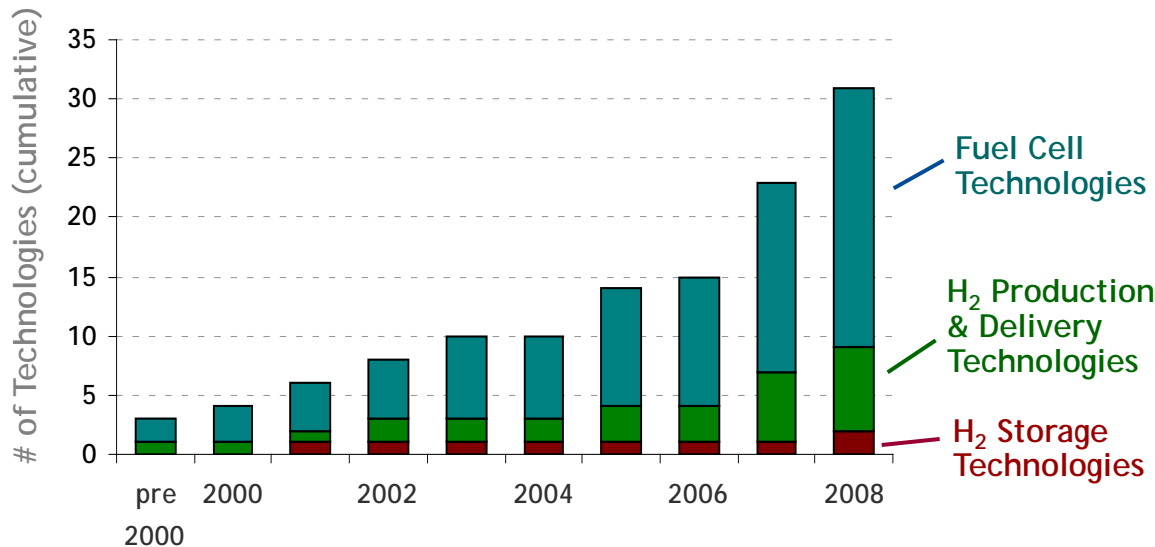
Independent Assessment of Electrolysis Cost

- Preliminary analysis indicates ~\$5 – \$5.50/gge for H₂ from distributed electrolysis.

Pacific Northwest National Lab is tracking commercial successes of technologies developed by the Hydrogen, Fuel Cells and Infrastructure Technologies Program.

**Accelerating Commercialization:
An increasing number of HFCIT-funded technologies have been entering the market.**

HFCIT-funded Technologies that are Commercially Available



PATENTS resulting from HFCIT-funded R&D:

118 patents reviewed:

- 74 fuel cell patents
- 49 hydrogen production/delivery patents
- 21 storage patents

Results will be documented in a report:

“Pathways to Commercial Success: Technologies and Products Supported by the Hydrogen, Fuel Cell Infrastructure Technology Program”



The new Program is aligned with the Department's portfolio of technologies for nearer-term impact and improved energy efficiency using multiple fuels.

Diverse Fuels *Clean, Efficient Energy Conversion* **Diverse Applications**

Biogas & Natural Gas

Propane

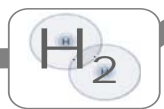
Methanol

Biogas & Natural Gas

Renewable Resources
(biomass, wind, solar, etc.)

Nuclear

Coal
(with carbon sequestration)



Fuel Cells

- Alkaline
- Direct Methanol
- Molten Carbonate
- PEM
- Phosphoric Acid
- Solid Oxide



EERE Hydrogen and Fuel Cells Budget *(in thousands)*

<i>Key Activity</i>	<i>FY 2007 appropriation</i>	<i>FY 2008 appropriation</i>	<i>FY 2009 appropriation</i>	<i>FY 2010 request</i>
Fuel Cell Systems R&D	0	0	0	63,213
Hydrogen Production & Delivery	33,702	38,607	10,000	0
Hydrogen Storage	33,728	42,371	59,200	0
Fuel Cell Stack Component	37,100	42,344	62,700	0
Technology Validation	39,413	29,612	15,000*	0
Transportation Fuel Cell Systems	7,324	7,718	6,600	0
Distributed Energy Fuel Cells	7,257	7,461	10,000	0
Fuel Processor R&D	3,952	2,896	3,000	0
Safety, Codes & Standards	13,492	15,442	12,500*	0
Education	1,978	3,865	4,200*	0
Systems Analysis	9,637	11,099	7,713	5,000
Manufacturing R&D	0	2,413	5,000	0
Market Transformation	0	0	4,687	0
Total	\$187,583	\$206,241	\$200,600	68,213

* Under Vehicle Technologies Budget in FY 2009

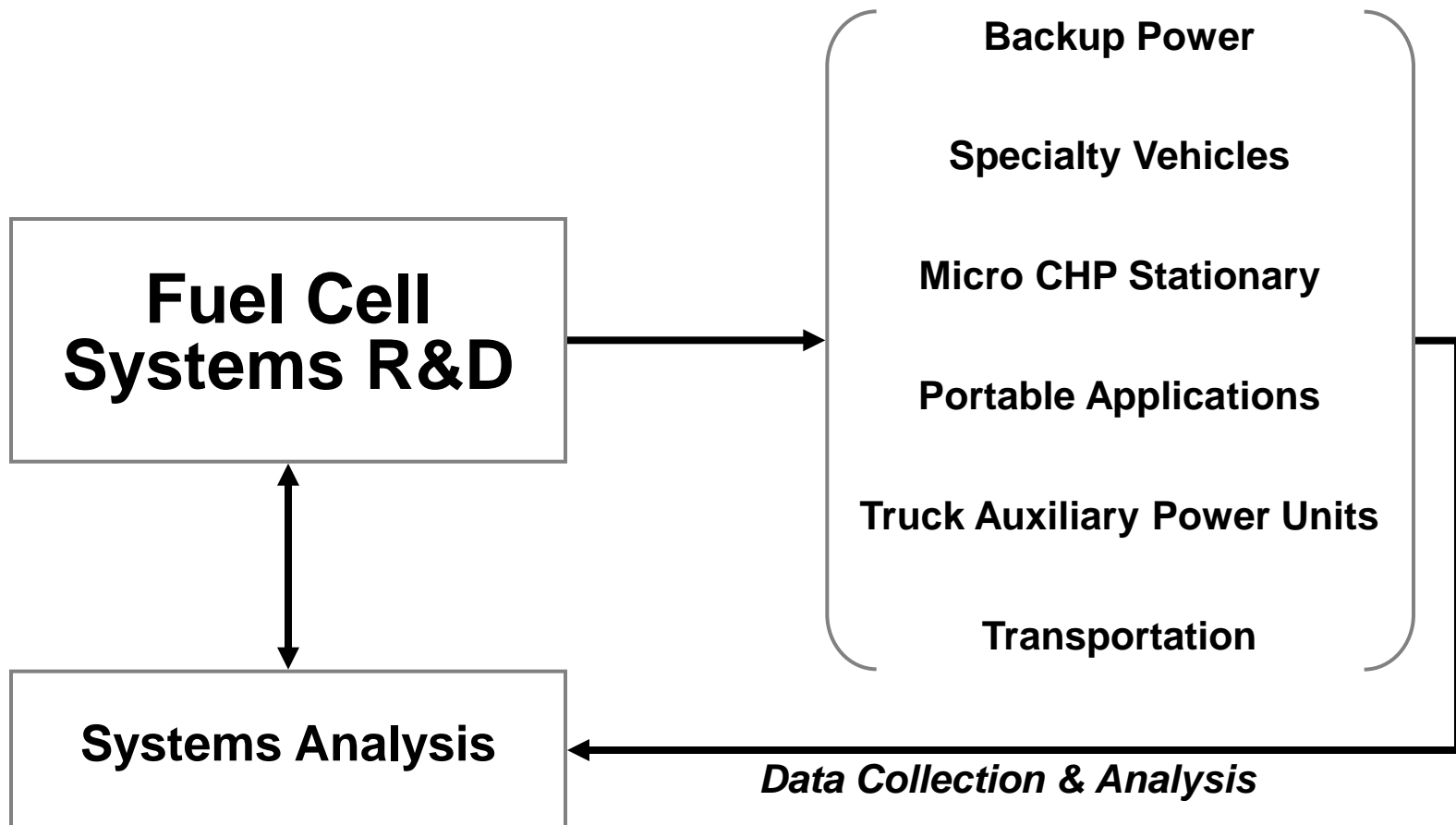


	Funding (\$ in thousands)						
	FY 2004 Approp.	FY 2005 Approp.	FY 2006 Approp.	FY 2007 Approp.	FY 2008 Approp.	FY 2009 Approp.	FY 2010 Request
EERE Hydrogen	144,881	166,772	153,451	189,511	206,241	200,600	68,213
Fossil Energy (FE)	4,879	16,518	21,036	21,513	24,088	21,400*	16,400*
Nuclear Energy (NE)	6,201	8,682	24,057	18,855	9,668	7,500	0
Science (SC)	0	29,183	32,500	36,424	36,509	36,509	36,509**
DOE TOTAL	155,961	221,155	231,044	266,303	276,506	266,009	121,122
Department of Transportation (DOT)	555	549	1,411	1,420	1,425	1,800	1,800
TOTAL	156,516	221,704	232,455	270,423	277,931	267,809	122,922

* Includes funding for R&D plus program direction. Fossil Energy also plans \$58M for SECA in FY10.

** The Office of Science also plans ~\$14M for Biological and Environmental Research in FY10

The Program will refocus on technology-neutral Fuel Cell Systems R&D and Systems Analysis to prioritize research & quantify impacts/benefits.





Request for Information (RFI) on Targets for Combined Heat and Power (CHP) and Auxiliary Power Units (APUs)

- **Opportunity for stakeholder and developer input**
- **Examples of information requested:**
 - *Relevance of the proposed targets*
 - *Recommendations for testing conditions and protocols*
 - *Adequacy of target table explanations and/or need for additional supporting information*
 - *Need for thermal cycling or on/off cycling durability targets*
 - *Recommendations for additional targets*
 - *Current status compared to targets & potential areas of R&D*

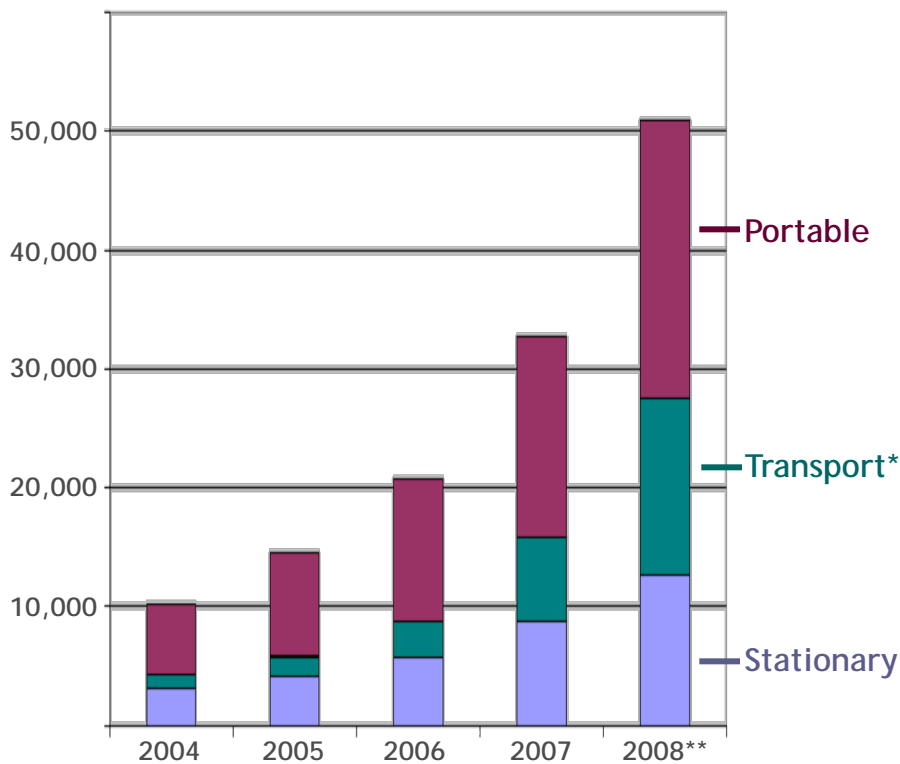
RFI to be posted online (www1.eere.energy.gov/hydrogenandfuelcells/)

Responses due June 30, 2009

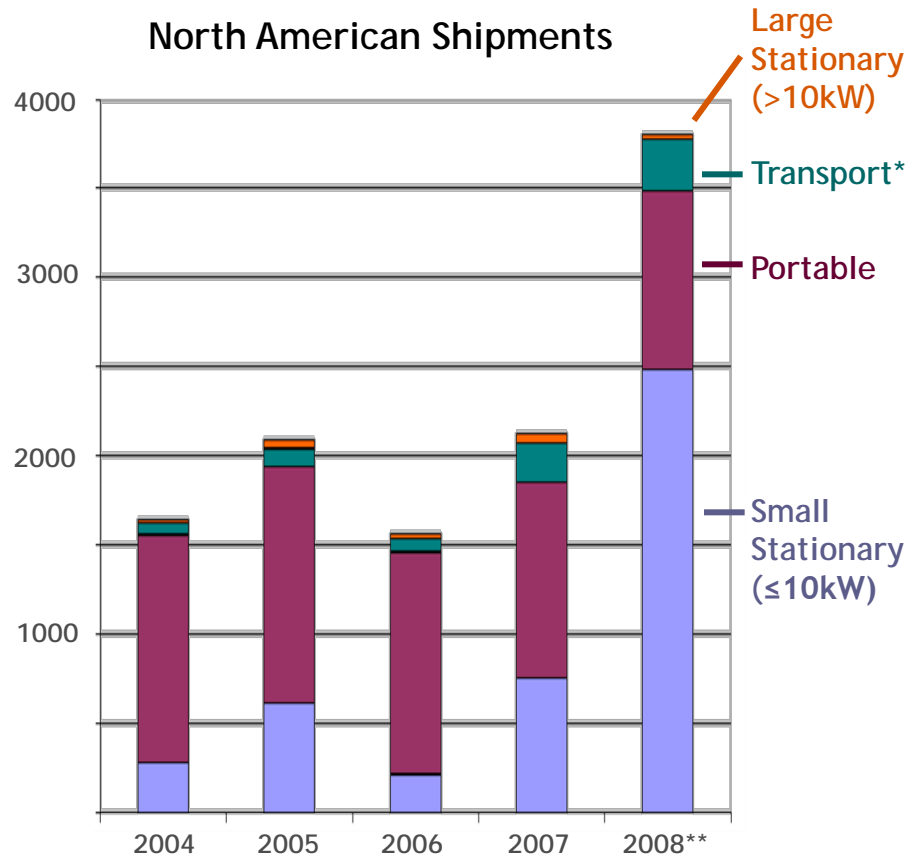


The fuel cell industry has seen growth of more than 50% annually over the past four years. Estimates show about 18,000 new units were shipped worldwide in 2008.

Cumulative Shipments Worldwide



North American Shipments

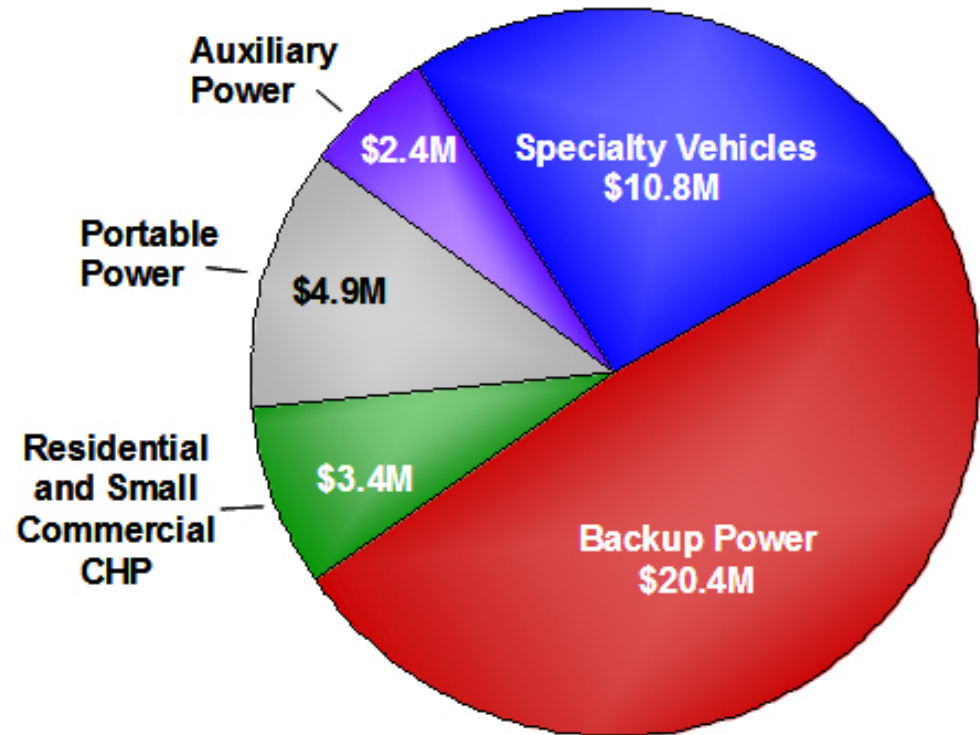


* "Transport" includes specialty vehicles (e.g., forklifts) and auxiliary power units, which currently account for most of the sales in that sector.

** 2008 numbers are preliminary estimates.

DOE announced \$41.9 million from the American Recovery and Reinvestment Act to fund 13 projects to deploy more than 1,000 fuel cells — to help achieve near term impact and create jobs in fuel cell manufacturing, installation, maintenance & support service sectors.

COMPANY	AWARD
Anheuser-Busch	\$1.1 M
Delphi Automotive	\$2.4 M
FedEx Freight East	\$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, Inc. (1)	\$3.4 M
Plug Power, Inc. (2)	\$2.7 M
PolyFuel, Inc.	\$2.5 M
ReliOn Inc.	\$8.6 M
Sprint Comm.	\$7.3 M
Sysco of Houston	\$1.2 M



Approximately \$72.4 million in cost-share funding from industry participants—for a total of nearly \$114.3 million.

Deploying Fuel Cells for Specialty Vehicles



Anheuser-Busch
(St. Louis, MO)

\$1.1 million

23 fuel cells in class-1 lift trucks

FedEx Freight East (Harrison, AR)

\$1.3 million

35 fuel cells in class-1 lift trucks

GENCO
(Pittsburgh, PA)

\$6.1 million

156 fuel cells in 6 fleets of class-1 and -3 lift trucks

Nuvera Fuel Cells
(Billerica, MA)

\$1.1 million

Supplement a fuel cell forklift fleet with 10 fuel cell power packs and a hydrogen fueling system

Sysco of Houston
(West Houston, TX)

\$1.2 million

90 fuel cells in class-3 pallet trucks

TOTAL: \$10.8 million

Advantages of Fuel Cells for Specialty Vehicles:

- Allow for rapid refueling — much faster than changing-out or recharging batteries (*refueling with hydrogen takes about one minute, while battery changes can take 20 – 45 minutes, and recharging can take anywhere from 2 to 16 hours*)
- Provide constant power without voltage drop
- Eliminate space requirements of batteries & chargers
- *Can provide substantial cost-savings over battery-powered forklifts (more than 50% reduction in lifecycle costs for a 3-kW pallet truck)*

Deploying Fuel Cells for Back-up Power

Plug Power
(Latham, NY)

\$2.7 million

- *Up to 275 kW at government sites*

ReliOn Inc.
(Spokane, WA)

\$8.6 million

- *25 sites in utility communications network*
- *180 installations for telecommunications network*

Sprint
(Reston, VA)

\$7.3 million

- *1- to 10-kW fuel cells for state/local first responders*

Jadoo Power
(Folsom, CA)

\$1.8 million

- *Evaluation of environmental and cost benefits of using 1-kW fuel cell, as opposed to gas/diesel generators and batteries*

TOTAL: \$20.4 million



Advantages of Fuel Cells for Backup Power:

- **Provide longer continuous run-time, greater durability than batteries** (*Battery systems usually run 4 – 8 hrs, and have to be replaced every 3 – 5 years, while fuel cell runtime is limited only by storage capacity, and they could last 15 years or more, depending on amount of actual use.*)
- **Require less maintenance than batteries or generators** (*estimated routine maintenance of 2 hours per year for fuel cells and 8 hours/year for batteries and generators*)
- **Can be remotely monitored**
- **Can provide substantial cost-savings over battery-generator systems** (*nearly 25% reduction in lifecycle costs for a 5-kW, 52-hour backup power system*)

Demonstrating PEM Fuel Cells for Residential and Small Commercial CHP

ADVANTAGES of FUEL CELLS for CHP...

- **Up to 85% overall efficiency**
- **25 – 35% reduction in emissions from household energy use**
- **Zero emissions**
- **Low noise and vibration**
- **Low O&M requirements, less down-time**
 - *100x more reliable than the average power supply for data centers—three seconds of down time per year versus an average of five minutes.*
- **Less variation in efficiency across variable loads**

Plug Power, Inc.
(Latham, NY)

\$3.4
million

*5-kW
stationary
CHP systems*



*Plug Power's
GenSys Blue, for
residential and small
commercial
applications*



Deploying Fuel Cells for Portable Power

MTI MicroFuel
Cells
(Albany, NY)

\$2.4 million

- *1 W consumer electronics power pack*

PolyFuel, Inc.
(Mountain View, CA)

\$2.5 million

- *Portable power system for mobile computing*

TOTAL: \$4.9 million

Deploying Fuel Cells for Auxiliary Power

Delphi Automotive
(Troy, MI)

\$2.4 million

- *3 – 5 kW SOFC APU for heavy-duty class 8 trucks*

Hydrogen and Fuel Cell-Related Financial Opportunity Announcements

<p>Weatherization and Intergovernmental Program</p>	<ul style="list-style-type: none"> • Energy Efficiency and Conservation Block Grants – Formula Grants for States (closes June 25) http://www.eecbg.energy.gov/downloads/WIP_EECBG_Fact_Sheet_FINAL_Web.pdf
<p>Industrial Technologies Program</p>	<ul style="list-style-type: none"> • Combined Heat and Power, District Energy Systems, Waste Energy Recovery Systems, and Efficient Industrial Equipment (closes July 14) • Improved Energy Efficiency for Information and Communication Technology (closes July 21) • Advanced Materials in Support of Advanced Clean Energy Technologies and Energy-Intensive Processes (coming soon)

<http://www.eere.energy.gov/hydrogenandfuelcells/recovery.html>

Some tax credits affecting fuel cells were expanded. Through new financing mechanisms, these credits can help facilitate deployments.

TAX CREDITS IN THE RECOVERY ACT

<p>Hydrogen Fueling Facility Credit</p>	<p>Increases the hydrogen fueling credit from 30% or \$30,000 to 30% or \$200,000.</p>
<p>Grants for Energy Property in Lieu of Tax Credits</p>	<p>Allows facilities with insufficient tax liability to apply for a grant instead of claiming the Investment Tax credit (ITC) or Production Tax credit (PTC). Only entities that pay taxes are eligible.</p>
<p>Manufacturing Credit</p>	<p>Creates 30% credit for investment in property used for manufacturing fuel cells and other technologies</p>
<p>Residential Energy Efficiency Credit</p>	<p>Raises ITC dollar cap for residential fuel cells in joint occupancy dwellings to \$3,334/kW.</p>



Energy Investment Tax Credit for Fuel Cell Systems

*(As amended by Section 103 of the
Emergency Economic Stabilization Act of 2008)*

- Credit of 30% of the cost, up to \$3,000 per kW
- Minimum 0.5 kW capacity
- Valid until December 31, 2016
- Electricity-only efficiency of more than 30%
- Eligibility extended to utilities and telecommunications firms
- Allowance of credit is permissible against Alternative Minimum Tax

New fact sheet

Fuel Cell Financing for Tax-Exempt Entities

***Facilitating deployments by structuring energy service contract
to include the Energy Investment Tax Credit***

<http://www.eere.energy.gov/hydrogenandfuelcells/incentives.html>



Loan Guarantee Program

- Loan guarantees for renewable energy, energy efficiency, & electricity transmission projects.

SBIR/STTR

- DOE SBIRs:
 - Annual solicitations on a wide variety of topics
 - 2010 Solicitation subtopics to be released in the Fall
- DoD SBIR topic: “Extraction of Atmospheric CO₂ and Conversion to Liquid Hydrocarbon Fuel” *(The Army is seeking ways to produce fuel from CO₂ and water in the atmosphere. Water will be used to provide the hydrogen needed for the conversion process)*; closes June 17.

Department of Defense

- Defense Logistics Agency—two Broad Agency Announcements expected in the next two months for deployment of material handling equipment (funding TBD by 2010 budget)
- Office of Naval Research and DOE to conduct a joint project on hydrogen for renewable energy storage (funding TBD)

H-Prize

- First round (\$1 million pilot award, for onboard storage materials) will open in spring 2009—award expected in September 2010.



Thank you