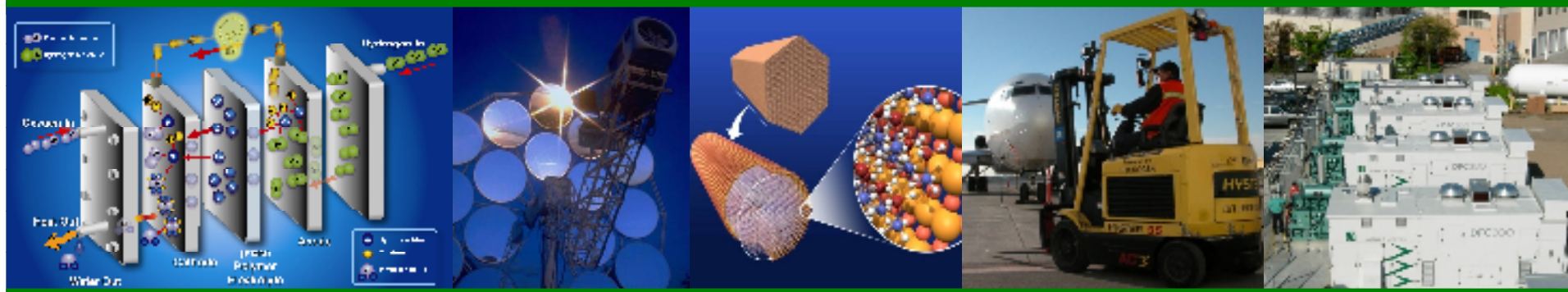




U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Hydrogen and Fuel Cell Technologies Update

Dr. Sunita Satyapal

Program Manager

U.S. Department of Energy

Fuel Cell Technologies Program

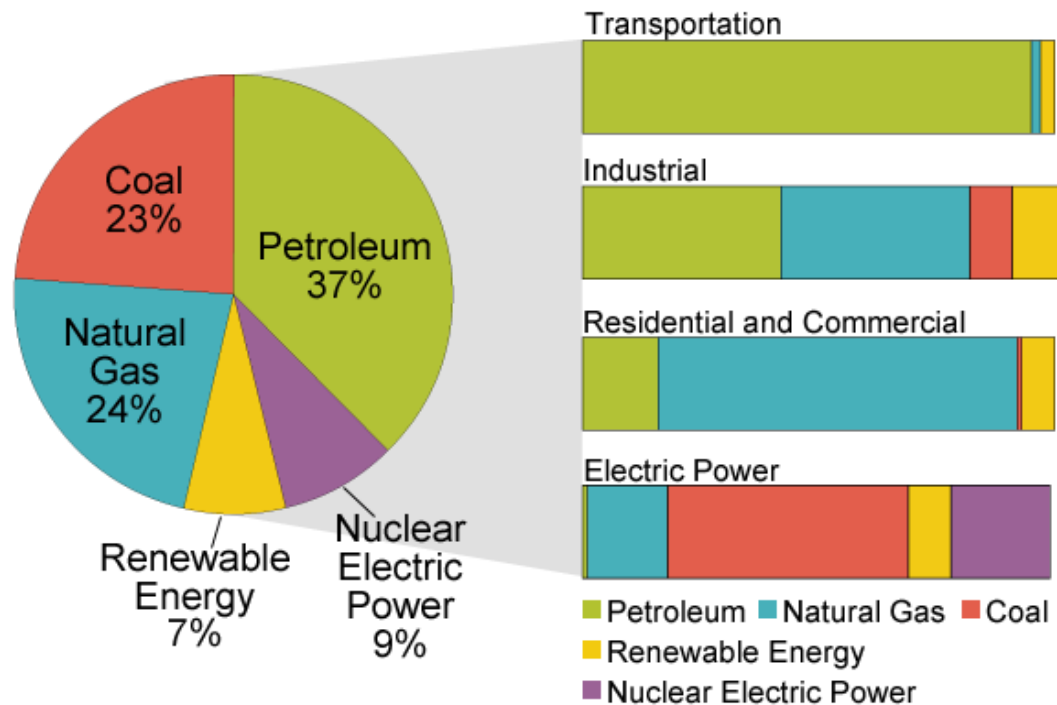
Fuel Cells & Hydrogen Joint Undertaking Stakeholders General Assembly

November 9, 2010

- **Overview**
 - RD&D Progress
 - Analysis & Key Publications
- **Budget & Policy Update**
- **Next Steps**
 - DOE Releases Program Plan for Stakeholder Input

U.S. Energy Consumption

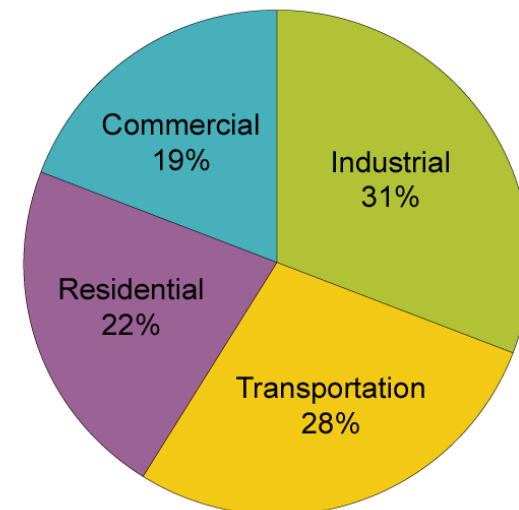
U.S. Primary Energy Consumption by Source and Sector



Total U.S. Energy = 99.3 Quadrillion Btu

Source: Energy Information Administration, *Annual Energy Review 2008*, Tables 1.3, 2.1b-2.1f.

Share of Energy Consumed by Major Sectors of the Economy, 2008



Source: Energy Information Administration, *Annual Energy Review 2008*.

Fuel Cells - Where are we today?

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.

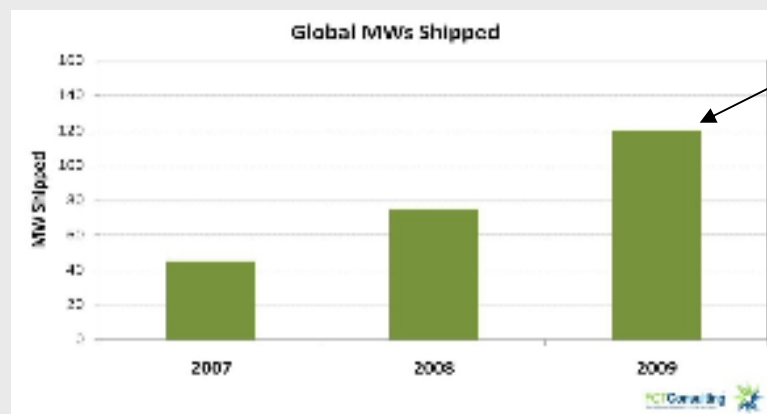
~75,000 fuel cells have been shipped worldwide.

*>24,000 fuel cells shipped in 2009
(> 40% increase over 2008).*

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



Increase in Fuel Cell Sales



Significant increase in MW shipped in 2009.

Fuel Cells for Transportation

In the U.S., there are currently:

> 200 fuel cell vehicles

~ 20 active fuel cell buses

~ 60 fueling stations

Sept. 2009: Auto manufacturers from around the world signed a letter of understanding supporting fuel cell vehicles in anticipation of widespread commercialization, beginning in 2015.



Key Challenges

The Program has been addressing the key challenges facing the widespread commercialization of fuel cells.

Technology Barriers*

Fuel Cell Cost & Durability

Targets*:

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

Vehicles: \$30 per kW, 5,000-hr durability

Hydrogen Cost

Target*: \$2 – 4 /gge, (dispensed and untaxed)

Hydrogen Storage Capacity

Target: > 300-mile range for vehicles—without compromising interior space or 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

Domestic Manufacturing & Supplier Base

Public Awareness & Acceptance

Hydrogen Supply & Delivery Infrastructure

* Targets and Metrics are being updated in 2010 .

Projected high-volume cost of fuel cells has been reduced to \$51/kW (2010)*

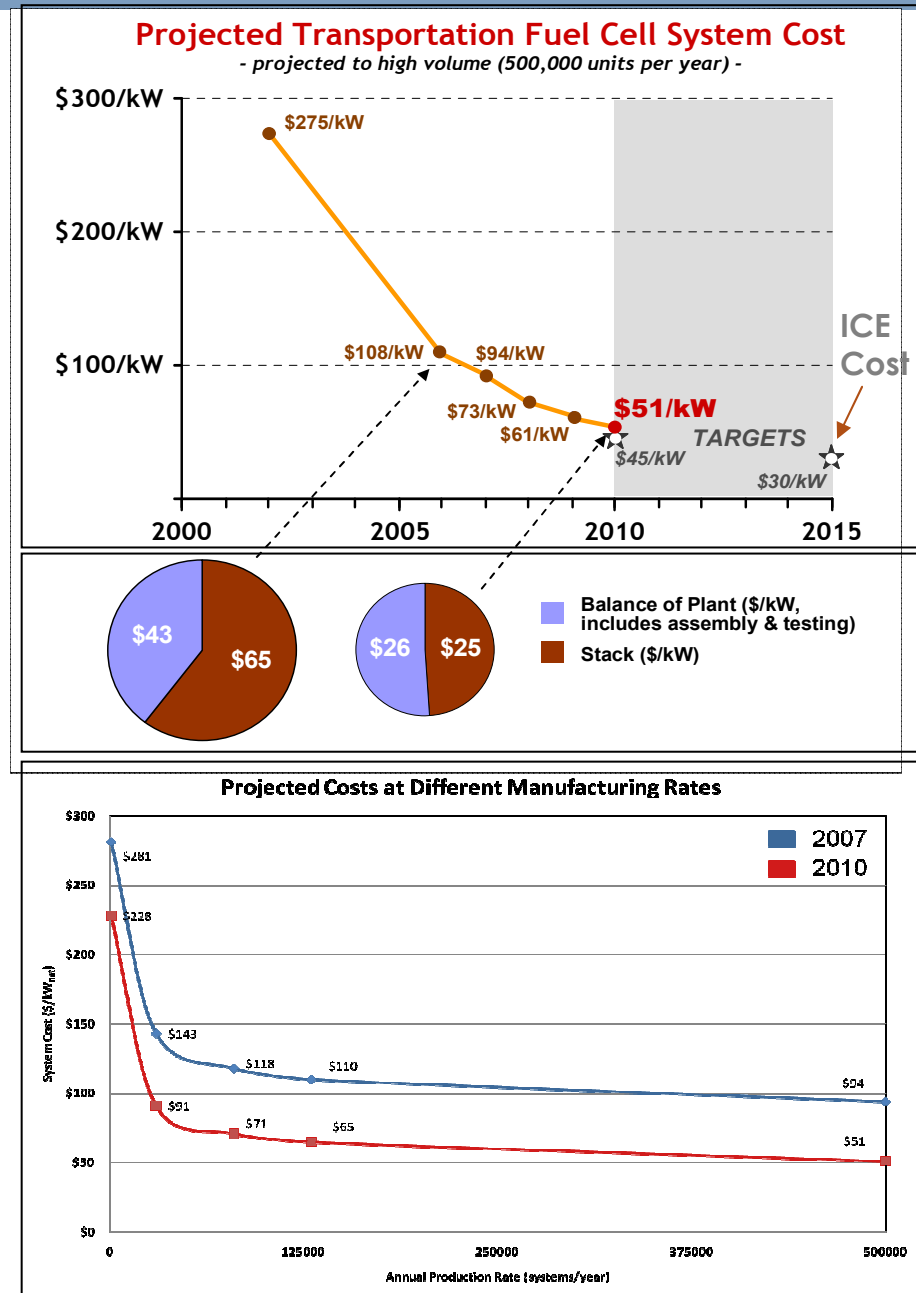
- *More than 15% reduction since 2009*
- *More than 80% reduction since 2002*
- *2008 cost projection was validated by independent panel***

As stack costs are reduced, balance-of-plant components are responsible for a larger % of costs.

*Based on projection to high-volume manufacturing (500,000 units/year).

**Panel found \$60 – \$80/kW to be a “valid estimate”:
http://hydrogendoedev.nrel.gov/peer_reviews.html

Source: US DOE 10/2010



Hydrogen Threshold Cost Analysis

Revising the hydrogen threshold cost will result in an assessment of Hydrogen Production and Delivery R&D priorities.
Projections of high-volume / nth plant production and delivery of hydrogen meet the targets for most technologies.

Projected High-Volume Cost of Hydrogen (Dispensed)—Status

Updated to
address
gasoline cost
volatility and
range of
vehicle
assumptions

NEAR TERM:

Distributed Production

- ▲ Natural Gas Reforming
- ▲ Ethanol Reforming
- ▲ Electrolysis

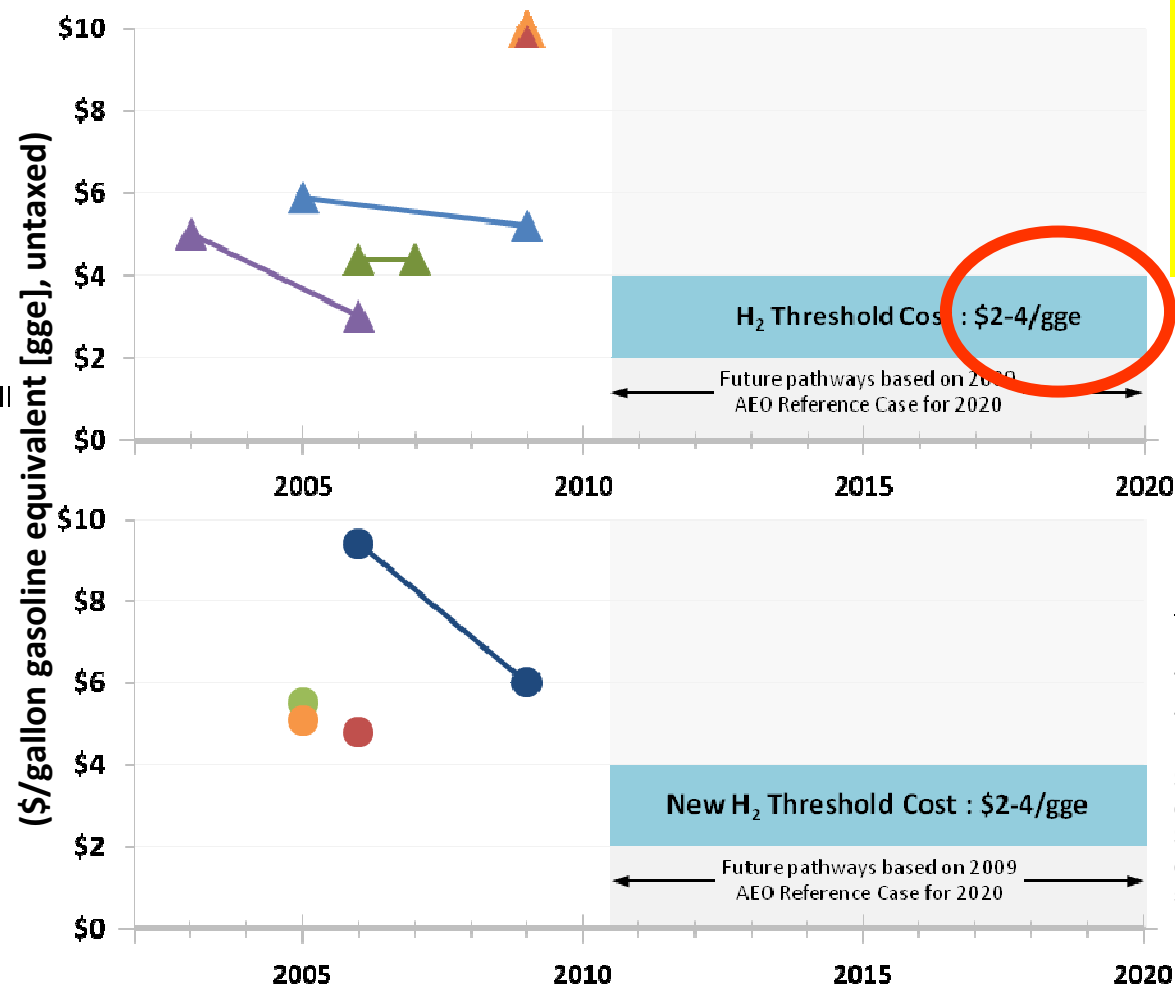
Low-volume (200 kg/day)

- ▲ Steam Methane Reforming
- ▲ H₂ from Combined Heat, Hydrogen, and Power Fuel Cell

LONGER TERM:

Centralized Production

- Biomass Gasification
- Central Wind Electrolysis
- Coal Gasification with Sequestration
- Nuclear



Notes:

Data points are being updated to the 2009 AEO reference case.

The 2010 Technology Validation results show a cost range of \$8-\$10/gge for a 1,500 kg/day distributed natural gas and \$10-\$13/gge for a 1,500 kg/day distributed electrolysis hydrogen station.

Technology Validation

Demonstrations are essential for validating the performance of technologies in integrated systems, under real-world conditions.

RECENT PROGRESS

Vehicles & Infrastructure

- 152 fuel cell vehicles and 24 hydrogen fueling stations
- Over 2.8 million miles traveled
- Over 114 thousand total vehicle hours driven
- 2,500 hours (nearly 75K miles) durability
- Fuel cell efficiency 53-59%
- Vehicle Range: ~196 – 254 miles

Buses

- DOE is evaluating real-world bus fleet data (DOT collaboration)
- H₂ fuel cell buses have a 39% to 141% better fuel economy when compared to diesel & CNG buses

Forklifts

- Over 18,000 refuelings at Defense Logistics Agency site

Recovery Act

- DOE (NREL) is collecting operating data from deployments for an industry-wide report



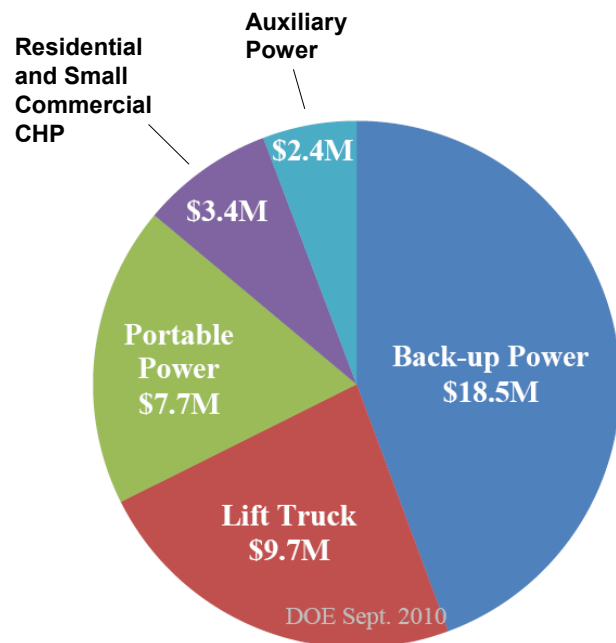
Source: US DOE 09/2010

Recovery Act Funding for Fuel Cells

More than \$40 million from the 2009 American Recovery and Reinvestment Act to fund 12 projects to deploy up to 1,000 fuel cells

FROM the LABORATORY to DEPLOYMENT:

DOE funding has supported R&D by all of the fuel cell suppliers involved in these projects.

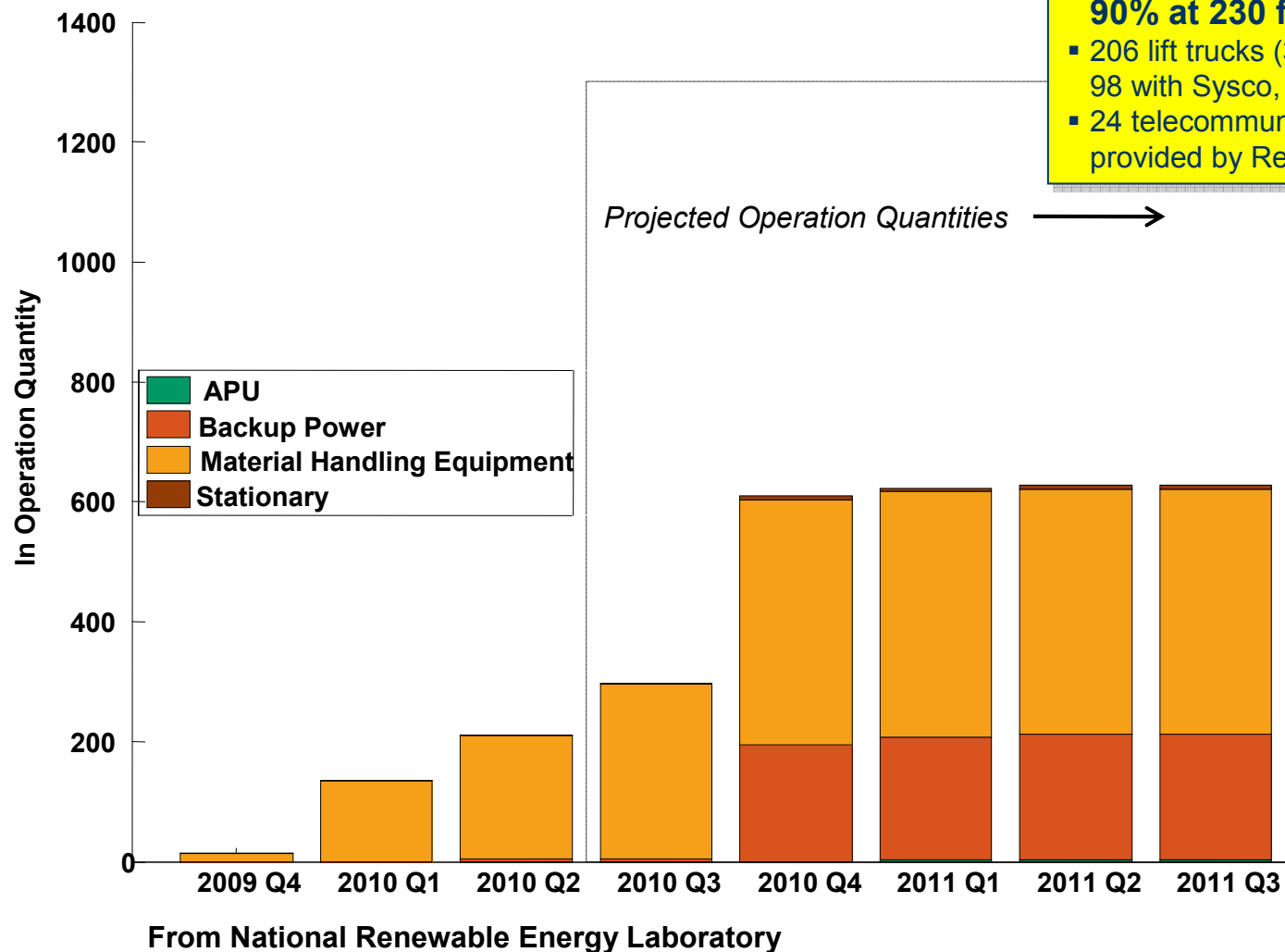


Approximately \$54 million in cost-share funding from industry participants—for a total of about \$96 million.

COMPANY	AWARD	APPLICATION
Delphi Automotive	\$2.4 M	Auxiliary Power
FedEx Freight East	\$1.3 M	Lift Truck
GENCO	\$6.1 M	Lift Truck
Jadoo Power	\$2.2 M	Portable
MTI MicroFuel Cells	\$3.0 M	Portable
Nuvera Fuel Cells	\$1.1 M	Lift Truck
Plug Power, Inc. (1)	\$3.4 M	CHP
Plug Power, Inc. (2)	\$2.7 M	Back-up Power
Univ. of N. Florida	\$2.5 M	Portable
ReliOn, Inc.	\$8.5 M	Back-up Power
Sprint Nextel	\$7.3 M	Back-up Power
Sysco of Houston	\$1.2 M	Lift Truck

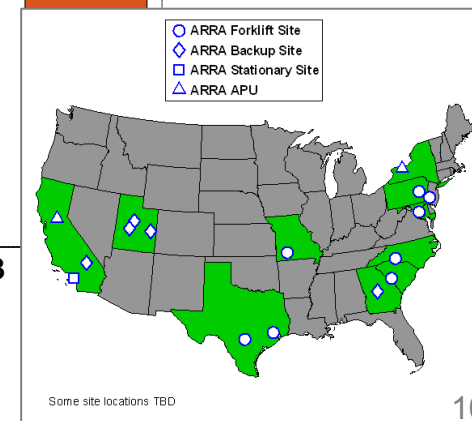
ARRA Fuel Cell Deployments

DOE ARRA-funded Early Market Fuel Cell Installations
(actual and projected)



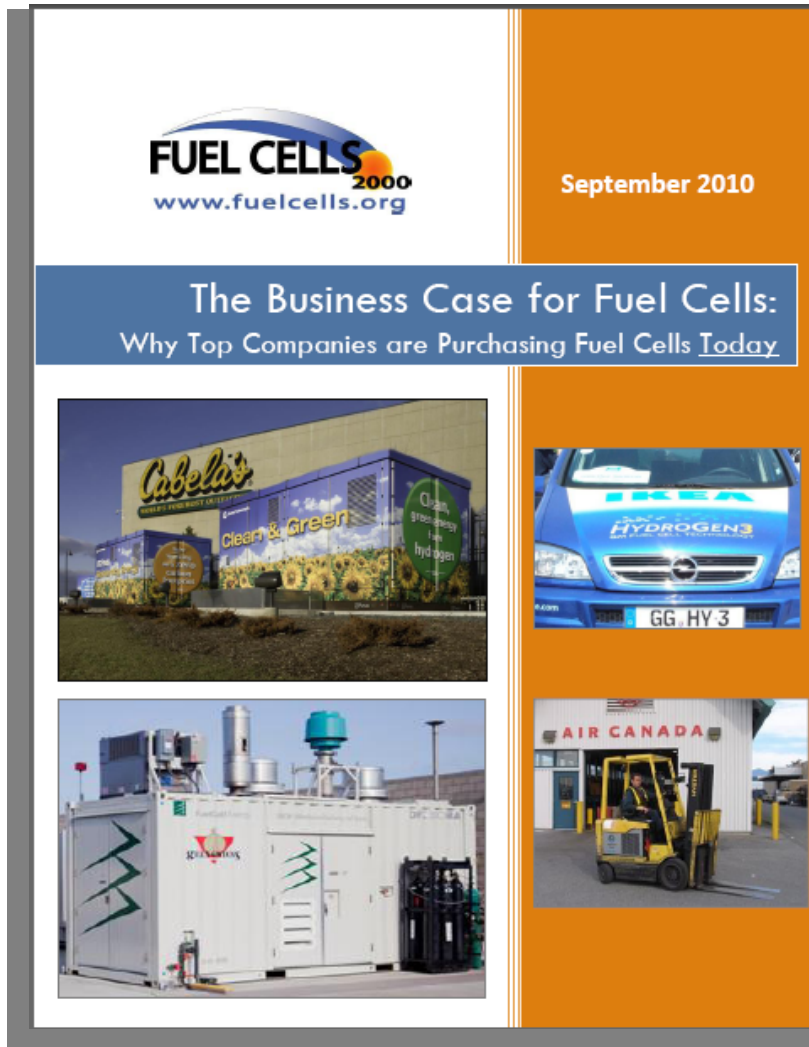
Exceeded 2010 target for Recovery Act fuel cell installations by more than 90% at 230 fuel cells installed:

- 206 lift trucks (35 with FedEx, 14 with Nuvera, 98 with Sysco, and 59 with GENCO)
- 24 telecommunication backup power units provided by ReliOn for AT&T.



U.S. Fuel Cell Deployments Using Market Transformation and Recovery Act Funding





The Business Case for Fuel Cells: Why Top Companies are Purchasing Fuel Cells Today

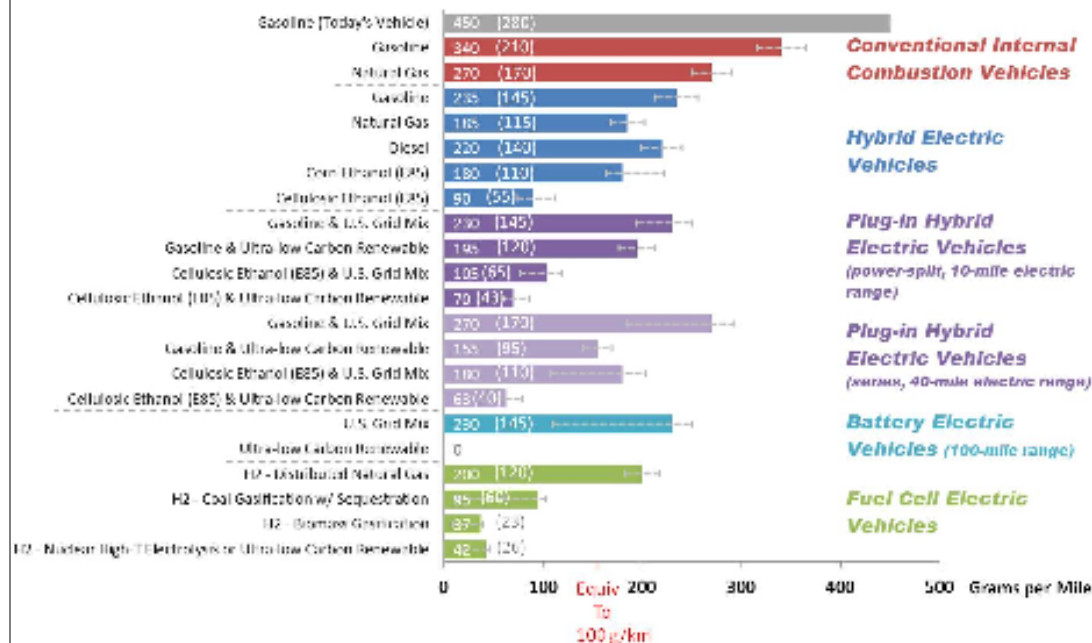
By FuelCells2000
<http://www.fuelcells.org>

38 companies profiled in the report,
cumulatively, have ordered, installed or
deployed:

- more than 1,000 fuel cell forklifts;
- 58 stationary fuel cell systems
totaling almost 15MW of power;
- more than 600 fuel cell units at
telecom sites.

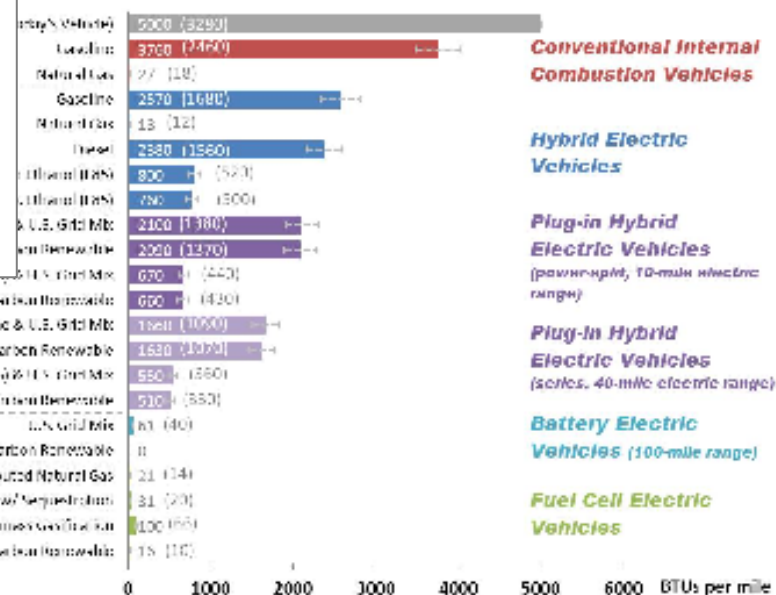
See report:
<http://www.fuelcells.org/BusinessCaseforFuelCells.pdf>

Well-to-Wheels Greenhouse Gases Emissions Future Mid-Size Car
Grams of CO₂-equivalent per mile (Grams of CO₂-equivalent per km)



Analysis includes portfolio of transportation technologies and latest models and updates to well-to-wheels assumptions

Wheels Petroleum Energy Use for Future Mid-Size Car
BTUs per mile (kl per km)



Fuel Cell for CHP:
75-90% less Nox
75-80% less particulates
> 50% less CO₂ emissions

Analysis & Assumptions at:
http://hydrogen.energy.gov/pdfs/10001_well_to_wheels_gge_petroleum_use.pdf

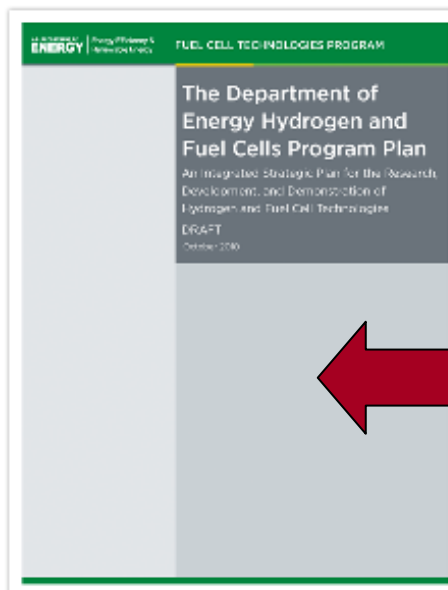
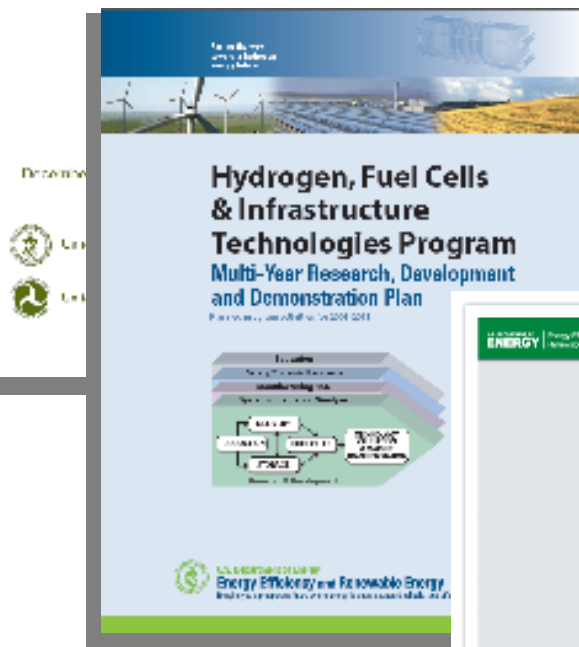
Program Plan

Describes the planned RD&D activities for hydrogen and fuel cell technologies

- **Update to the Hydrogen Posture Plan (2006)**
- **Addresses previous reviews (e.g. GAO, HTAC, NAS, etc.)**

Hydrogen Posture Plan

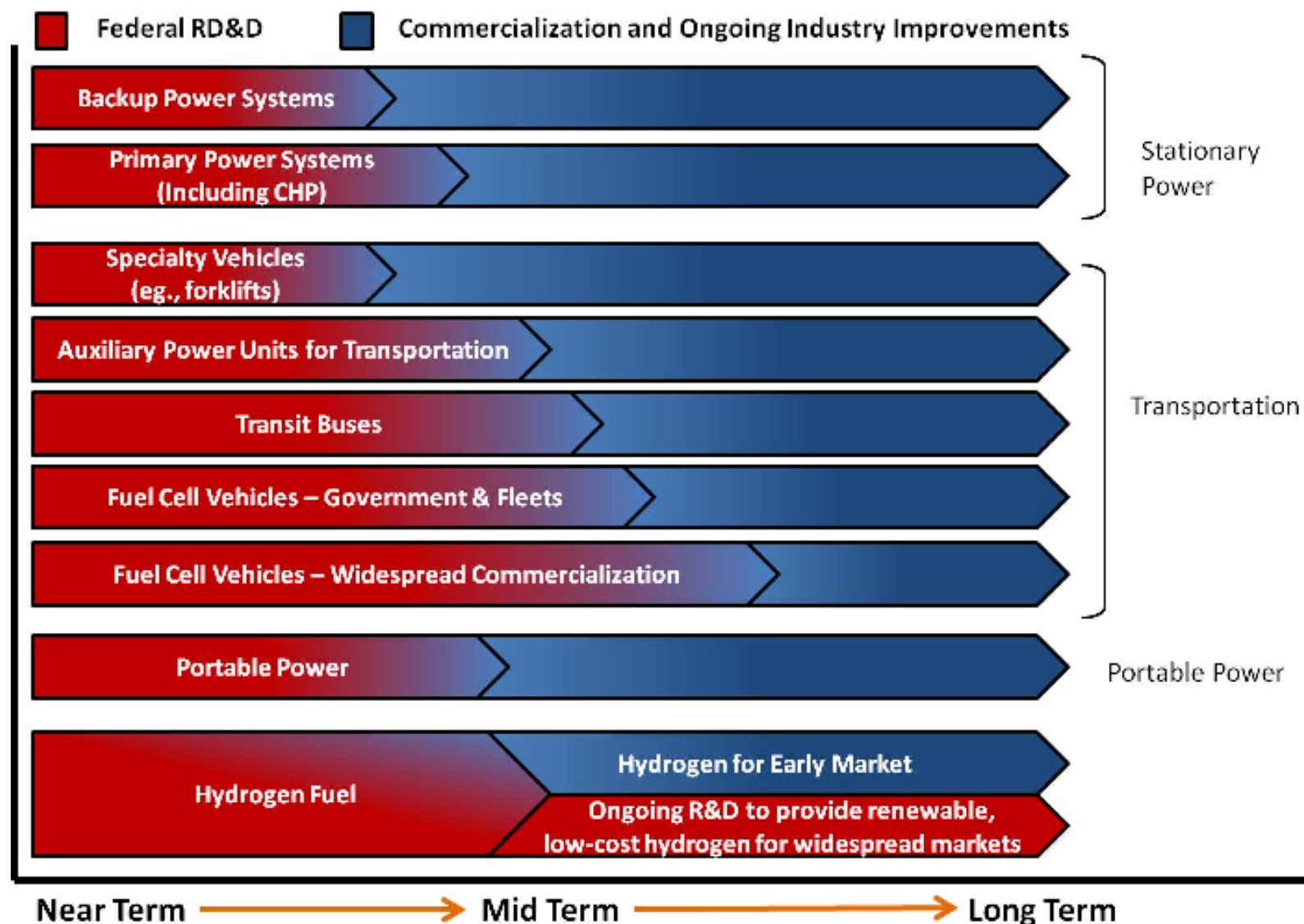
An Integrated Research, Development and Demonstration Plan



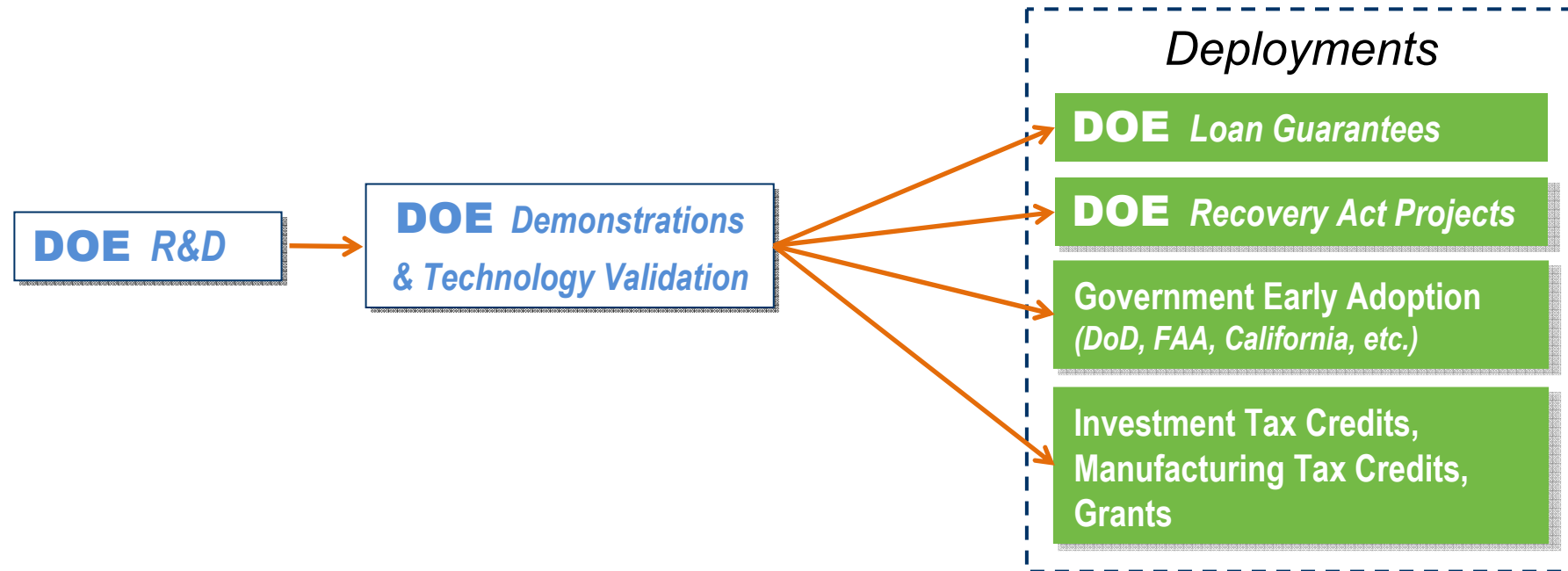
Draft available 10/22/10
for stakeholder public
comment until 11/30/10.
DOEH2ProgramPlan@ee.doe.gov

<http://www1.eere.energy.gov/hydrogenandfuelcells/>

The Role of Federal Research, Development, and Demonstration



Example of RD&D to Deployments



Project Example:

- Stationary fuel cells (hundreds of kW to tens of MW) for commercial applications including combined heat and power (and/or cooling).
- Multimillion \$ loan guarantee available.

What more can Government do to accelerate commercialization?

Recent Federal Grants and Tax Credits



Energy Efficiency &
Renewable Energy

Section 1603: Payments in Lieu of Tax Credits

Business	Property Location	Fuel Cell MWe	Amount
Gills Onions, LLC	California	0.6	\$1,141, 560
M&L Commodities, Inc.	California	0.6	\$997,913
Preservation Properties, Inc.	California	0.1	\$300,000
Logan Energy Corporation	Hawaii	0.3	\$900,000
Plug Power, Inc.	Illinois	0.28	\$723,334
Logan Energy Corporation	South Carolina	0.05	\$148,988
Totals		1.9	\$4,211,795

Section 48C: Manufacturing Tax Credit

Business	Location	Product	Amount
UTC Power Corporation	Connecticut	Fuel Cells	\$5,300,100
W.L. Gore & Associates	Maryland	Fuel Cell Membranes	\$604,350
Total			\$5,904,450



***On October 5, 2009
President Obama signed
Executive Order 13514 –
Federal Leadership in
Environmental, Energy, and
Economic Performance***

▪ **Requires Agencies to:**

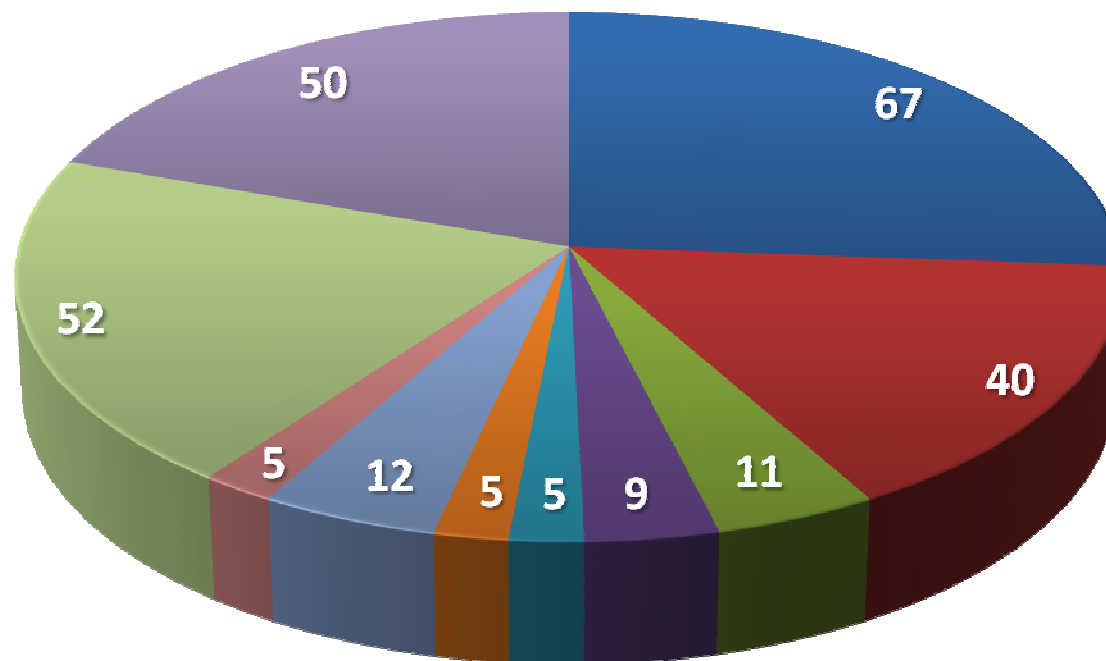
- **Set GHG reduction Targets**
- **Develop Strategic Sustainability Plans and provide in concert with budget submissions**
- **Conduct bottom up Scope 1, 2 and 3 baselines**
- **Track performance**

Examples:

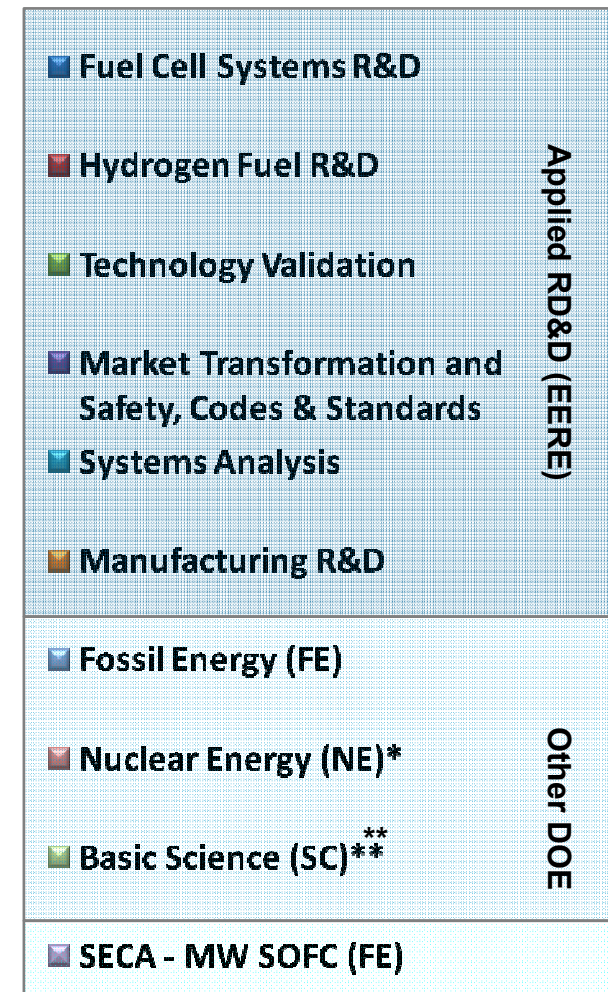
- **Achieve** 30% reduction in vehicle fleet petroleum use by 2020
- **Requires** 15% of buildings meet the *Guiding Principles for High Performance and Sustainable Buildings* by 2015
- **Design** all new Federal buildings which begin the planning process by 2020 to achieve zero-net energy by 2030

Potential opportunities for fuel cells and other clean energy technologies....

Total DOE Hydrogen and Fuel Cell Technologies FY11 Budget Request (in millions of US\$)



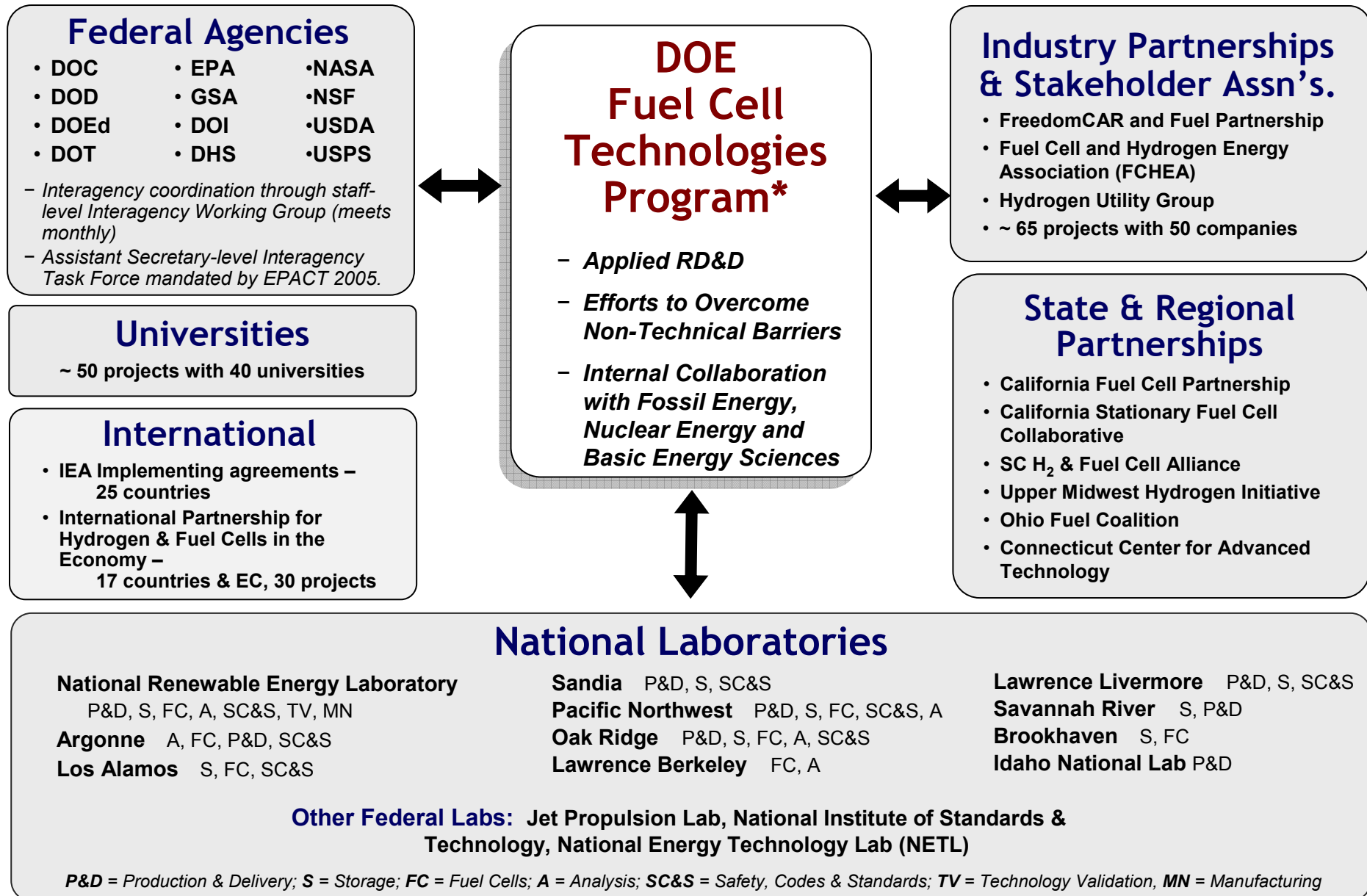
Total FY11 Budget Request \$256 Million



*NE: \$5M represents FY10 funding

**SC Includes BES and BER

- **Continue R&D portfolio**
- **Infrastructure Analysis**
 - Identify options, business cases
 - Regional coordination (e.g. CA)
- **Market Analysis**
 - Assessment of manufacturing capacity
 - Impact of tax credits, grants, ARRA
- **Interagency Coordination**



Key Program Documents



Hydrogen Posture Plan

An Integrated Research, Development and Demonstration Plan

Fuel Cell Program Plan

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

- Replacement for current Hydrogen Posture Plan
- To be released in 2010

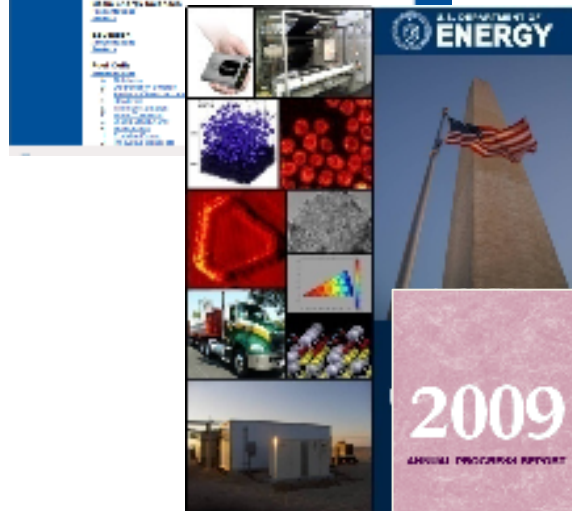


Annual Merit Review & Peer Evaluation Proceedings

Includes downloadable versions of all presentations at the Annual Merit Review

- Latest edition released June 2010

www.hydrogen.energy.gov/annual_review10_proceedings.html



Annual Merit Review & Peer Evaluation Report

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

- To be released 2010

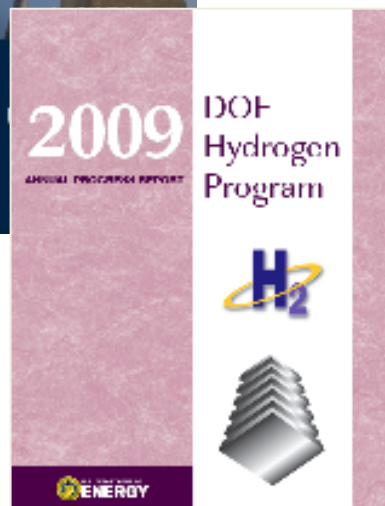
www.hydrogen.energy.gov/annual_review09_report.html

Annual Progress Report

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

- To be released 2010

www.hydrogen.energy.gov/annual_progress.html



**Next Annual Review: May 9 – 13, 2011
Washington, D.C.**

<http://annualmeritreview.energy.gov/>

Thank you

Sunita.Satyapal@ee.doe.gov

hydrogenandfuelcells.energy.gov

Additional Information

EERE H₂ & Fuel Cells Budgets

Funding (\$ in thousands)						
Key Activity	FY 2008	FY 2009 ³	FY 2010	FY 2011 Request	FY 2011 House	2011 Senate
Fuel Cell Systems R&D¹	-	-	-	67,000	67,000	67,000
Fuel Cell Stack Component R&D	42,344	61,133	62,700	-	-	
Transportation Systems R&D	7,718	6,435	3,201	-	-	
Distributed Energy Systems R&D	7,461	9,750	11,410	-	-	
Fuel Processor R&D	2,896	2,750	171	-	-	
Hydrogen Fuel R&D²	-	-	-	40,000	40,000	47,000
Hydrogen Production & Delivery R&D	38,607	10,000	15,000	-	-	
Hydrogen Storage R&D	42,371	57,823	32,000	-	-	
Technology Validation	29,612	14,789 ⁴	13,097	11,000	11,000	20,000
Market Transformation	0	4,747	15,026	0	0	20,000
Safety, Codes & Standards	15,442	12,238 ⁴	8,839	9,000	9,000	9,000
Education	3,865	4,200 ⁴	2,000	0	0	1,000
Systems Analysis	11,099	7,520	5,556	5,000	5,000	5,000
Manufacturing R&D	4,826	4,480	5,000	5,000	5,000	5,000
Total	\$206,241	\$195,865	\$174,000⁵	\$137,000	\$137,000	\$174,000

¹ Fuel Cell Systems R&D includes Fuel Cell Stack Component R&D, Transportation Systems R&D, Distributed Energy Systems R&D, and Fuel Processor R&D

² Hydrogen Fuel R&D includes Hydrogen Production & Delivery R&D and Hydrogen Storage R&D

³ FY 2009 Recovery Act funding of \$42.967M not shown in table

⁴ Under Vehicle Technologies Budget in FY 2009

⁵ Includes SBIR/STTR funds to be transferred to the Science Appropriation; all prior years shown exclude this funding

Market Transformation

RFI: Fuel Cell Commercialization Topics

Need ideas for “turn key” approaches to finance, procure, install and operate fuel cells for stationary power on Federal facilities and utility scale hydrogen energy storage from renewables.

Need information and recommendations for installing and operating fuel cell powered airport Ground Support Equipment.

Need stakeholder responses by mid December 2010