

Hydrogen and Fuel Cell Technologies Update

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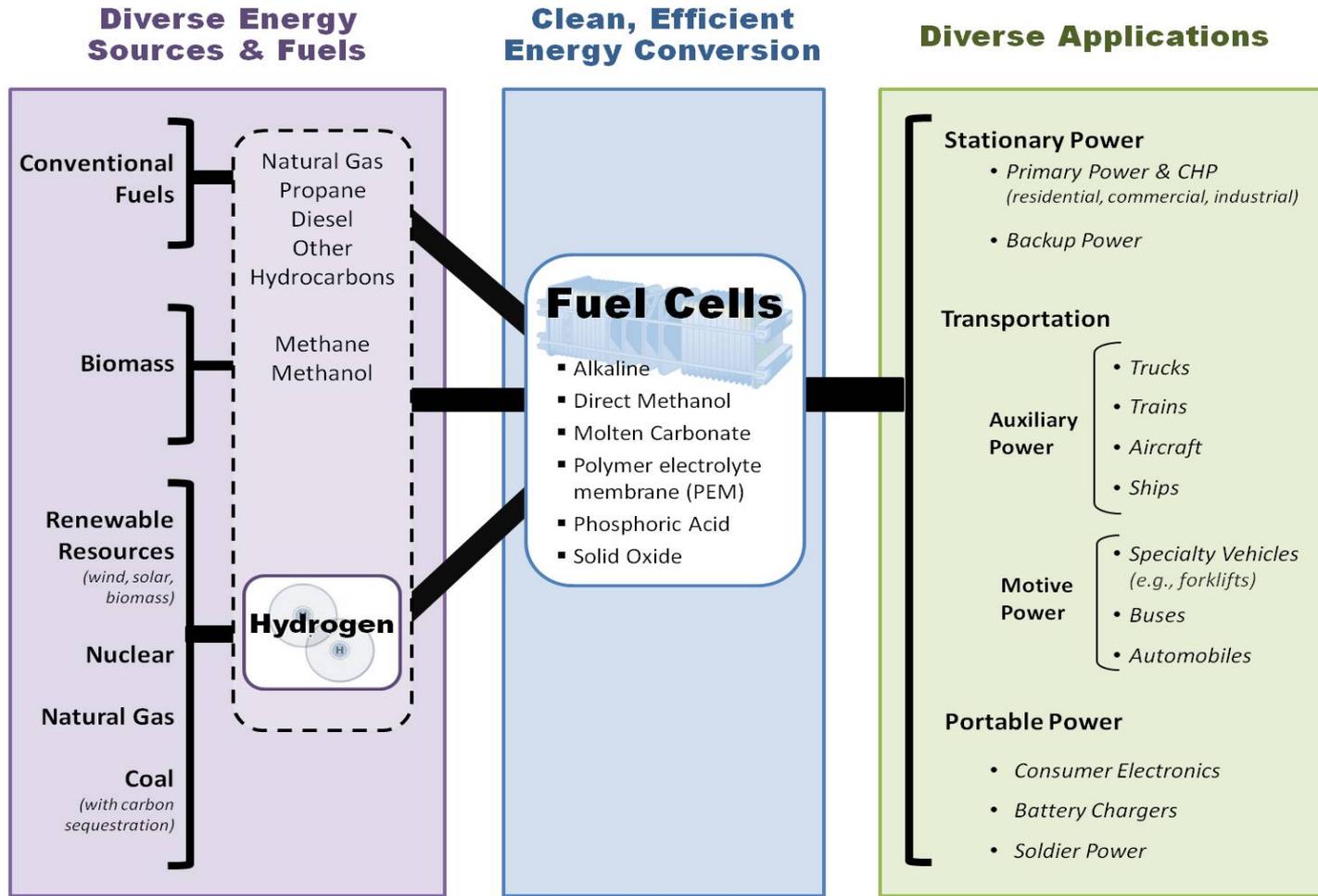
Fuel Cell Seminar & Exposition
San Antonio, TX
October 19, 2010

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

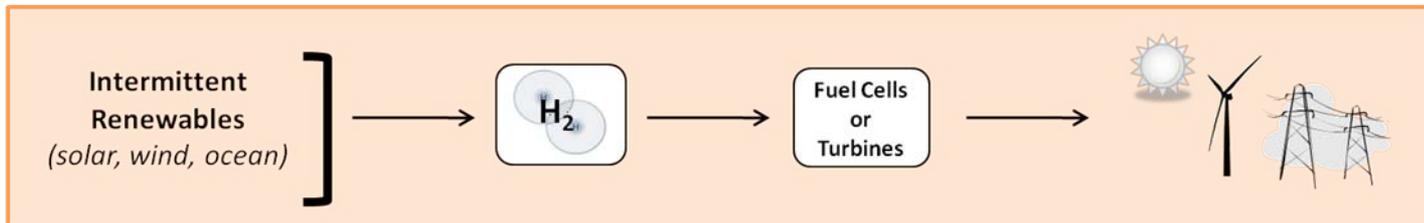
Key Examples

- ✓ **Double Renewable Energy Capacity by 2012**
- ✓ **Invest \$150 billion over ten years in energy R&D to transition to a clean energy economy**
- ✓ **Reduce GHG emissions 83% by 2050**





Energy Storage for Renewable Electricity



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, delivered

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

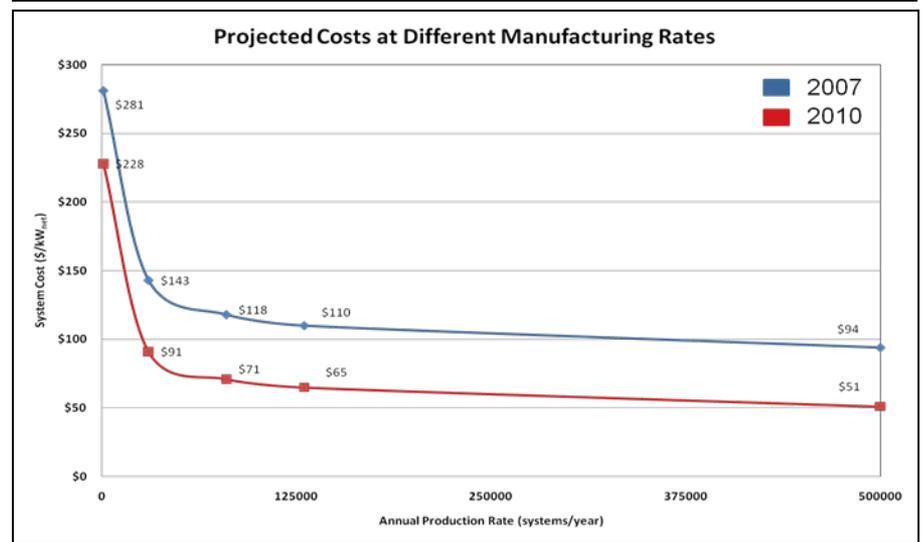
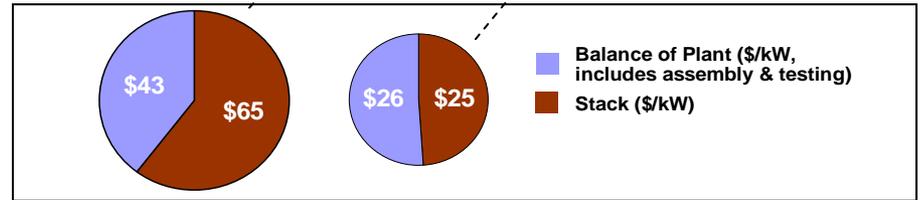
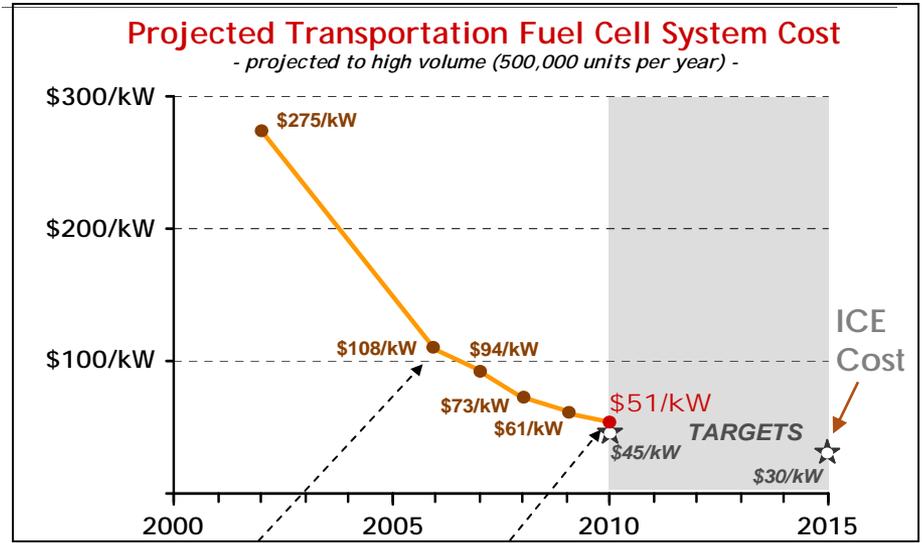
*Metrics available/under development for various applications

RD&D Progress

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://hydrogenodev.nrel.gov/peer_reviews.html

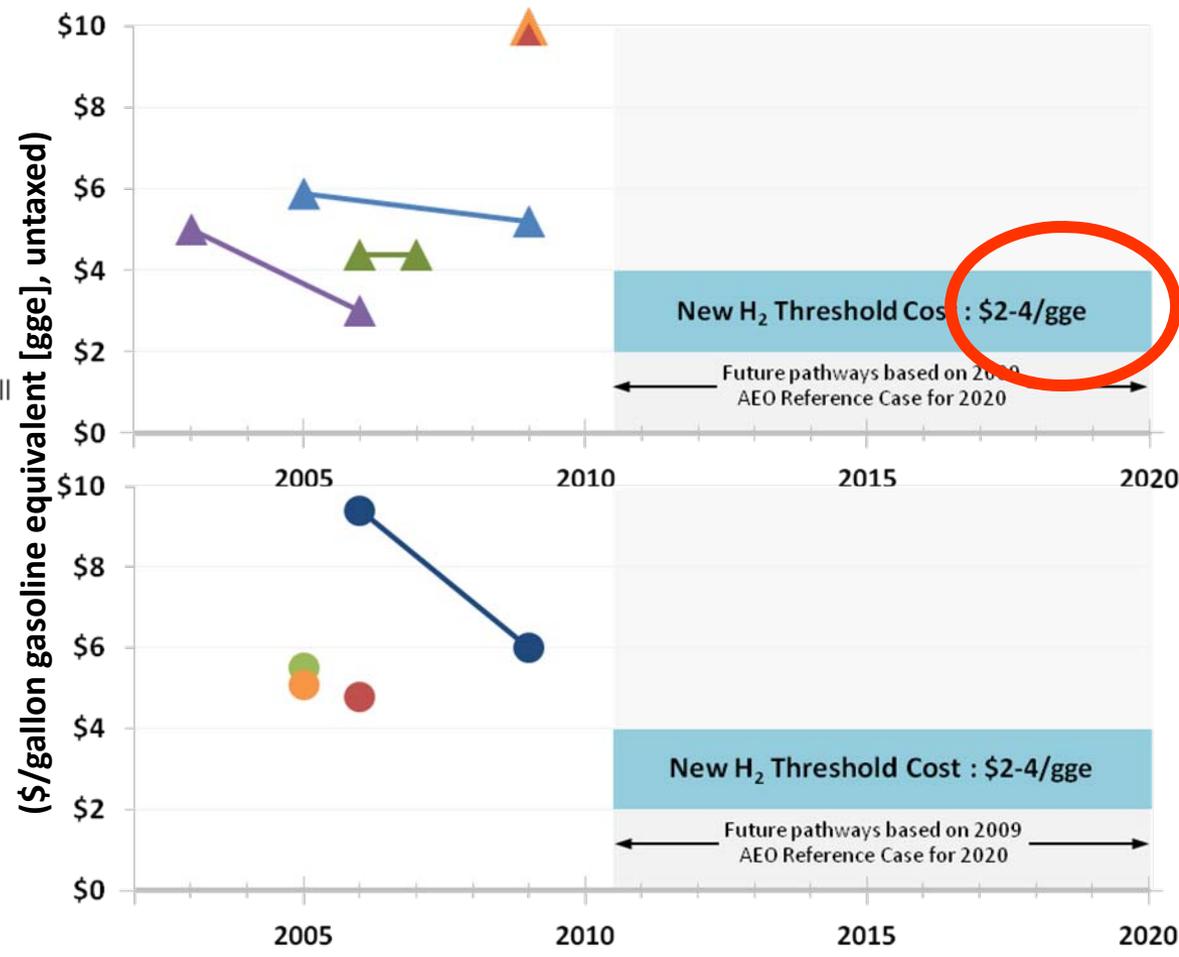
The projected high-volume cost of distributed hydrogen production technologies is beginning to approach targets. Low-volume/early market costs must be reduced. The competitive hydrogen threshold cost for 2020 is \$2-4/gge.

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.

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

- Forklifts at Defense Logistics Agency site have completed more than 18,000 refuelings

Recovery Act

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

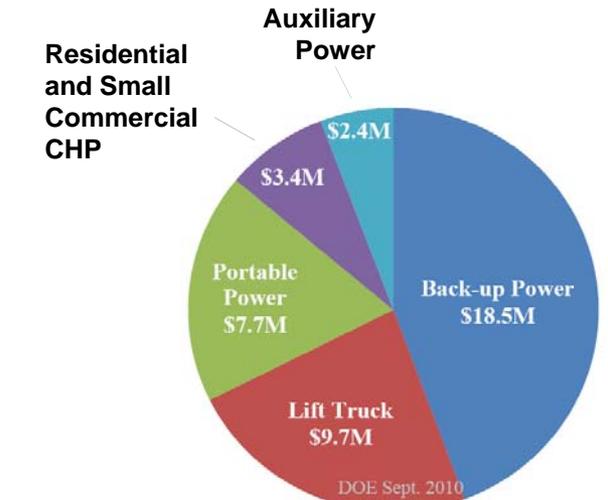


Recovery Act Fuel Cell Funding & Projects

DOE announced \$42 million from the American Recovery and Reinvestment Act to fund 12 projects, which will deploy up to 1,000 fuel cells

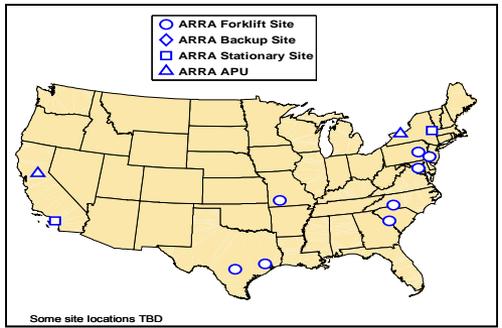
FROM the LABORATORY to DEPLOYMENT:

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



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
University of North 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

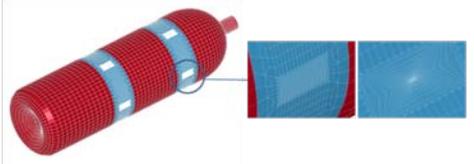
Approximately \$54 million in cost-share funding from industry participants for a total of about \$96 million.



Reporting deployment and performance metrics to inform goals and targets for FC RD&D.



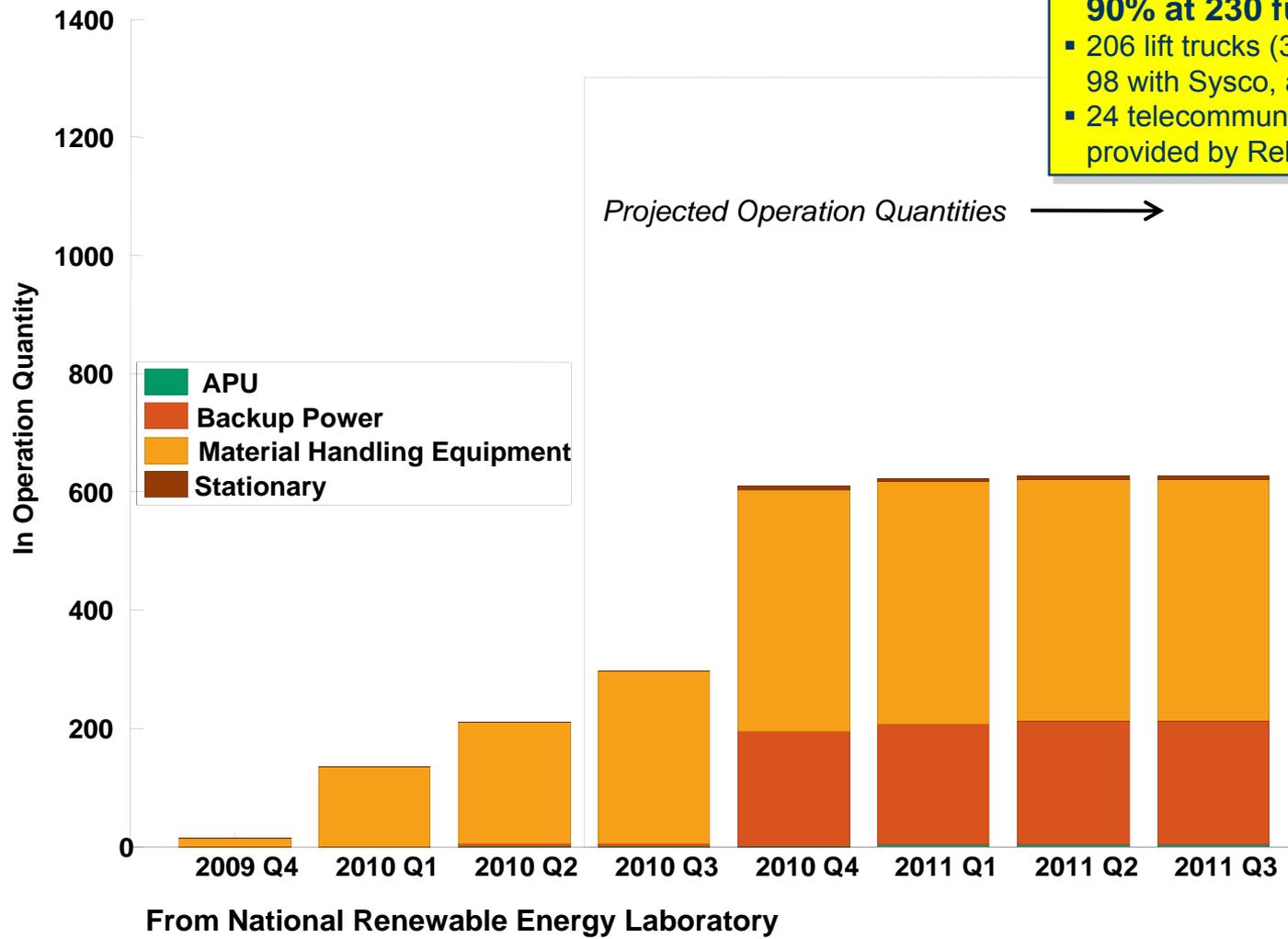
Real-life field testing of portable power units by end users to improve future fuel cell designs



Partnering in studies of cyclic fatigue of steel tanks to provide technical basis for codes & standards development to enable commercial acceptance of fuel cell systems. Emphasizes importance of safety, codes & standards subprogram

ARRA Fuel Cell Deployments

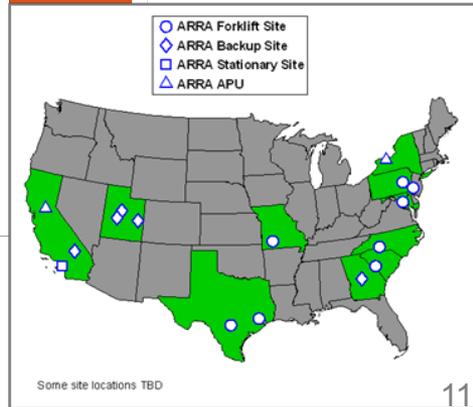
DOE ARRA-funded Early Market Fuel Cell Installations
(actual and projected)



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.

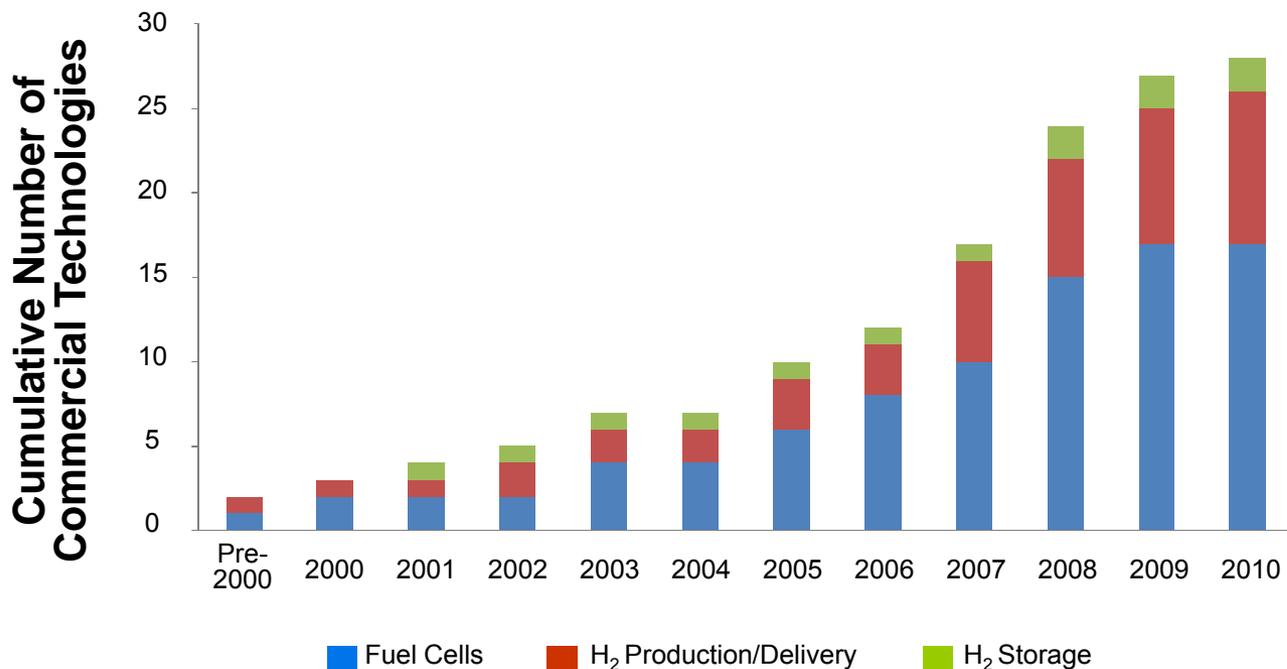
Projected Operation Quantities →



Close to 30 hydrogen and fuel cell technologies developed by the Program entered the market.

Accelerating Commercialization

EERE-funded Fuel Cell Technologies that are Commercially Available



198 PATENTS
resulting from
EERE-funded R&D:

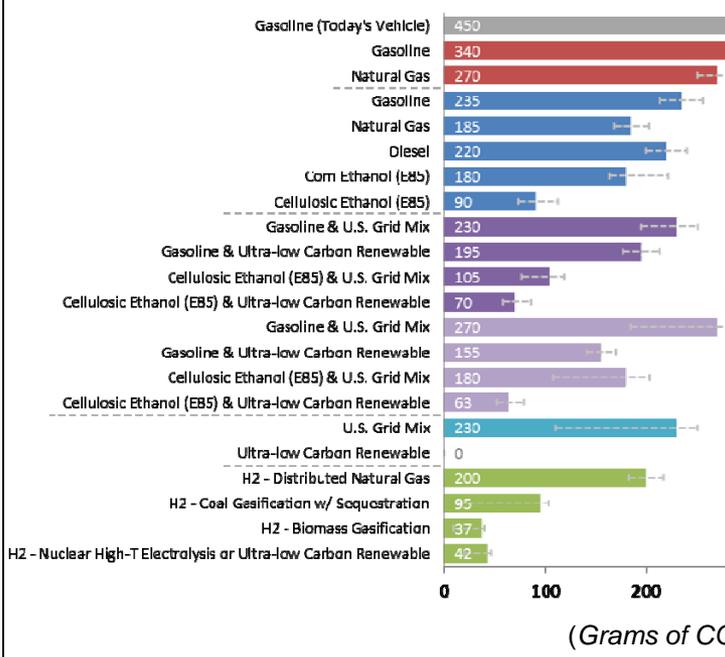
- 99 fuel cell
- 74 H₂ production and delivery
- 25 H₂ storage

60% are actively used in:

- 1) Commercial products
- 2) Emerging technologies
- 3) Research

Completed Fuel Cell Market Report provides an overview of market trends and profiles for select fuel cell companies

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



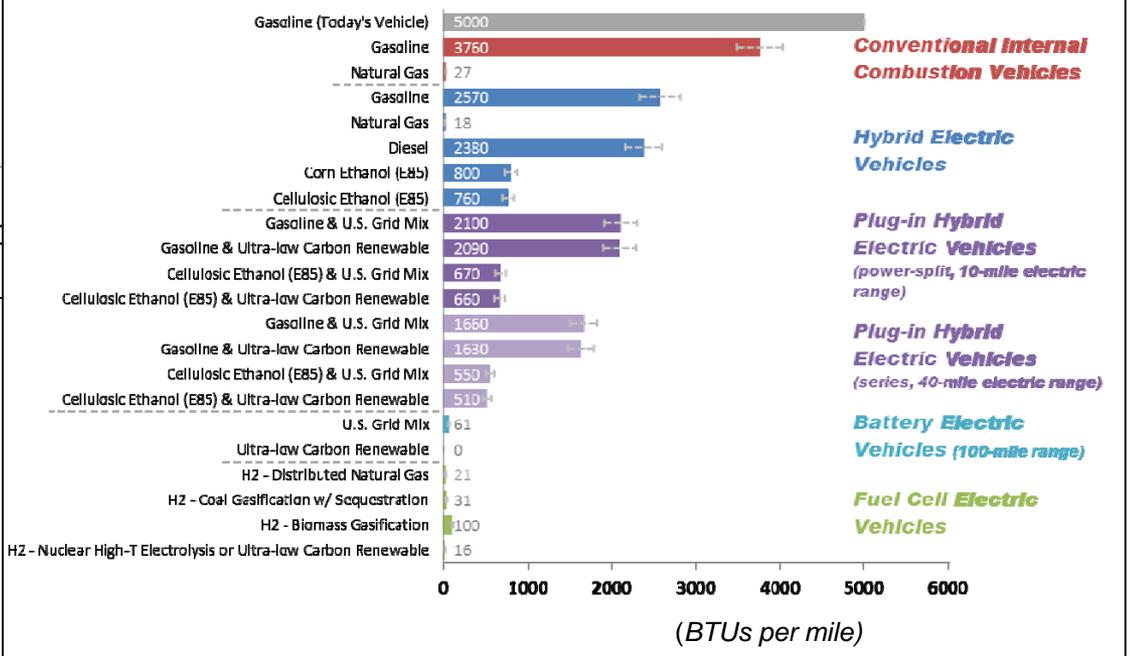
Conventional Internal Combustion Vehicles

Hybrid Electric Vehicles

Plug-in Hybrid Electric Vehicles (power-split, 10-mile electric)

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

Well-to-Wheels Petroleum Energy Use for Future Mid-Size Car (BTUs per mile)



Conventional Internal Combustion Vehicles

Hybrid Electric Vehicles

Plug-in Hybrid Electric Vehicles (power-split, 10-mile electric range)

Plug-in Hybrid Electric Vehicles (series, 40-mile electric range)

Battery Electric Vehicles (100-mile range)

Fuel Cell Electric Vehicles

Analysis details to be published October, 2010

Assumptions at: http://hydrogen.energy.gov/program_records.html

Notes:
 For a projected state of technologies in 2035-2045.
 Ultra-low carbon renewable electricity includes wind, solar, etc.
 Does not include the life-cycle effects of vehicle manufacturing and infrastructure construction/decommissioning.
 Global warming potential of primary fuels excluded.

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

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

Profile of 38 companies who have ordered, installed, or deployed fuel cell forklifts, stationary fuel cells or fuel cell units.

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

2009 Fuel Cell Technologies Market Report

By Breakthrough Technologies Institute, <http://www.btionline.org/>

This report describes data compiled in 2010 on trends in the fuel cell industry for 2009 with some comparison to previous years. (July 2010).

See report: <http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/48219.pdf>

Molten Carbonate and Phosphoric Acid Stationary Fuel Cells: Overview and Gap Analysis

By NREL and DJW Technology, LLC

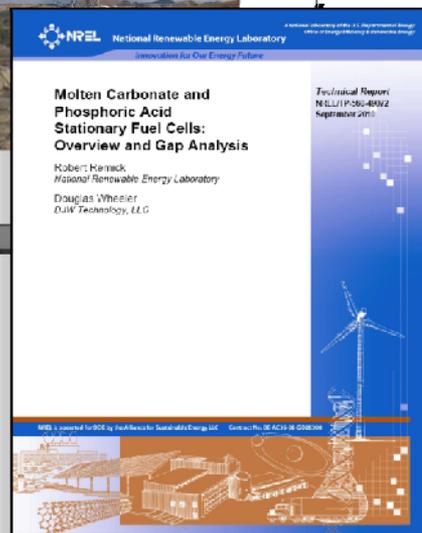
This report describes the technical and cost gap analysis performed to identify pathways for reducing the costs of molten carbonate fuel cell (MCFC) and phosphoric acid fuel cell (PAFC) stationary fuel cell power plants.

See report: <http://www.nrel.gov/docs/fy10osti/49072.pdf>

Fuel Cell Today 2009 Market Analysis

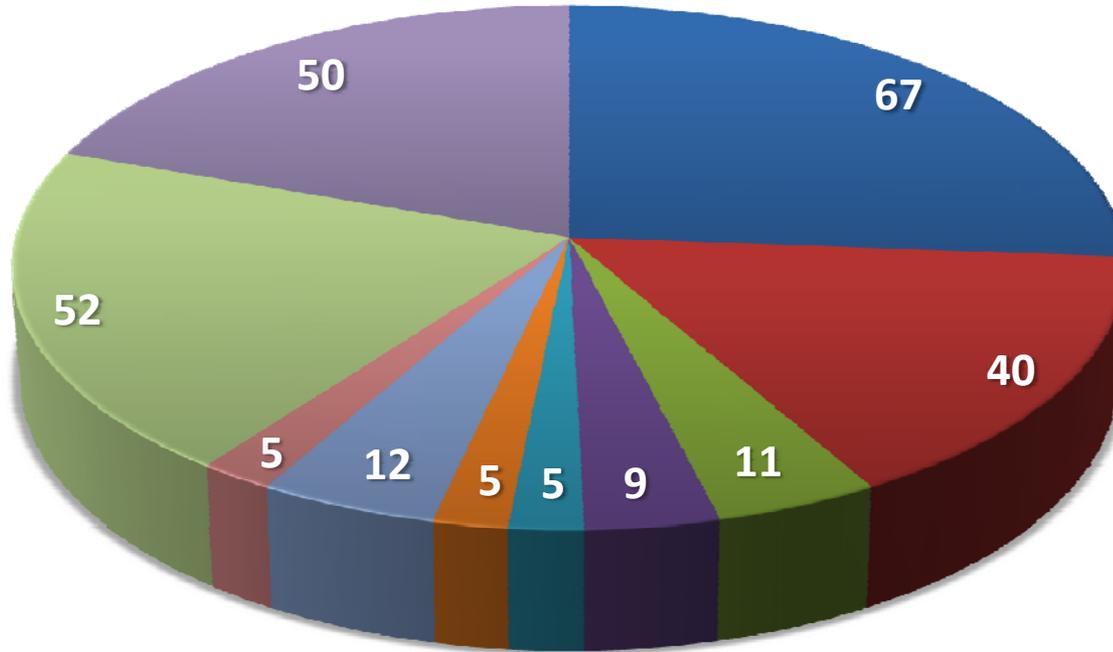
The report describes sales of fuel cells in US and worldwide.

October 2010

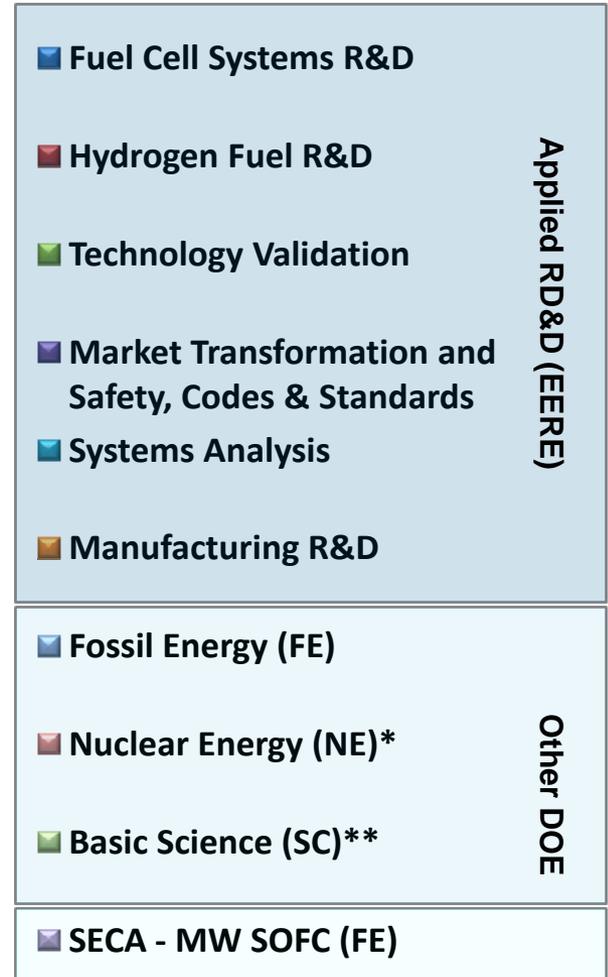


FY 2011 Budget Update

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

DOE 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	Included above (in \$67M)		
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	Included above (in \$40M)		
Hydrogen Storage R&D	42,371	57,823	32,000			
Technology Validation	29,612	14,789⁴	13,097	11,000	11,000	20,000
Market Transformation	0	4,747	15,026	0	0	20,000
Safety, Codes & Standards	15,442	12,238⁴	8,839	9,000	9,000	9,000
Education	3,865	4,200⁴	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

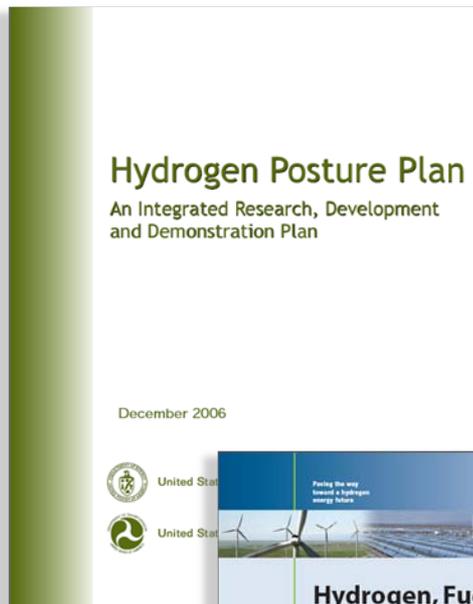
⁴ Under Vehicle Technologies Budget in FY 2009

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

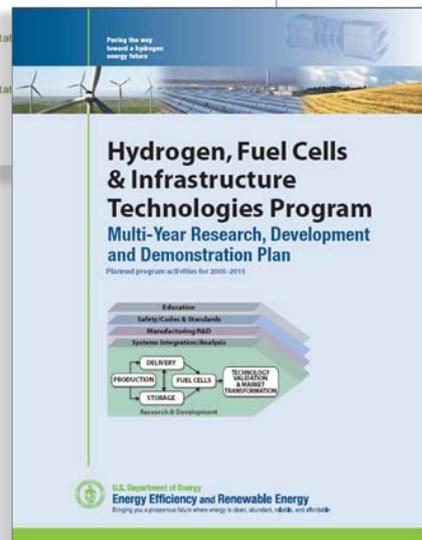
Next Steps

Upcoming Workshops and Solicitations

An integrated strategic plan for the research, development, and demonstration activities of DOE's Hydrogen and Fuel Cells Program



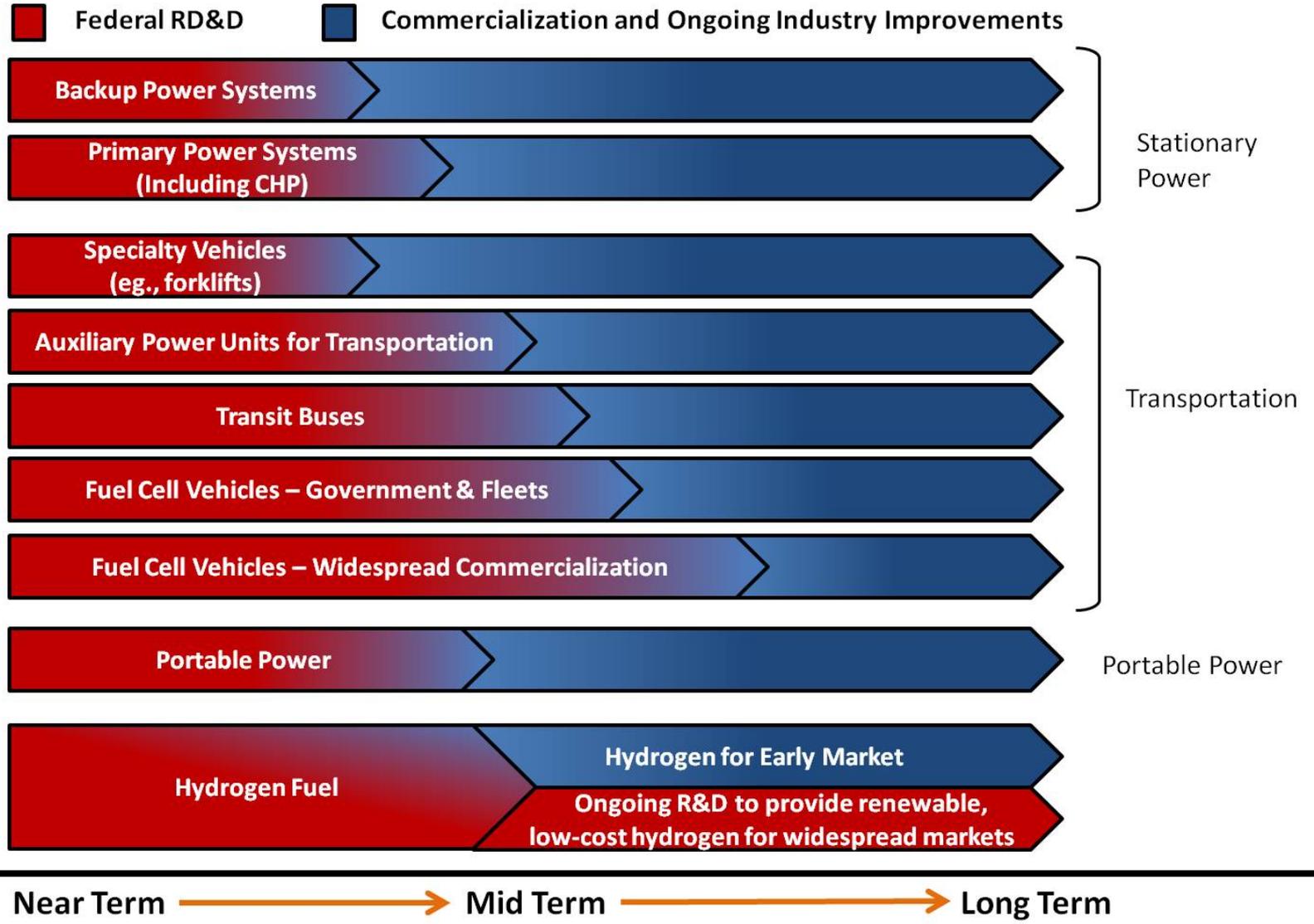
- **Update to the Hydrogen Posture Plan (2006)**
- **Addresses previous reviews (e.g. GAO, HTAC, NAS, etc.)**



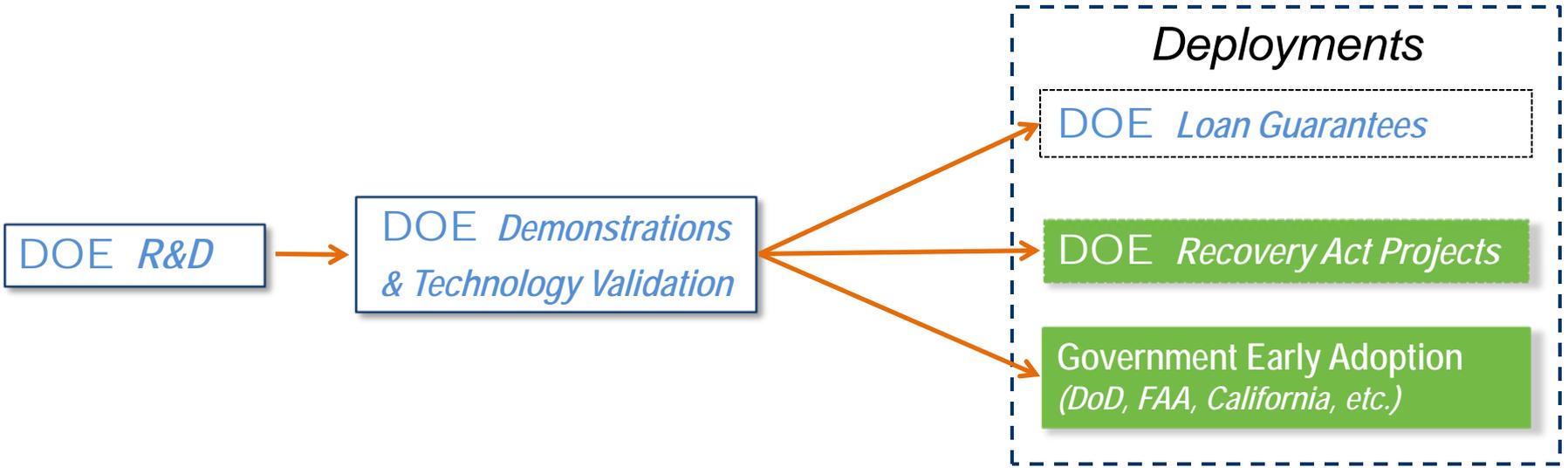
Draft available for stakeholder and public comment:
DOEH2ProgramPlan@ee.doe.gov
Until 11/30/2010

<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?

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
LoganEnergy Corporation	Hawaii	0.3	\$900,000
Plug Power, Inc.	Illinois	0.28	\$723,334
LoganEnergy 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

Source: US DOE & US Treasury 10/2010



***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....](#)

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

Upcoming Workshops

Hydrogen Production, Delivery, and Storage

Production

- PEC workshop on EERE/BES Partnerships (TBD)
- Biological workshop on EERE/BES Partnerships (TBD)
- STCH discussion of down-select report and future directions (TBD)

Delivery

- Joint storage and delivery interface discussion with industry partners currently interested in refilling station design compatible with advanced storage concepts (TBD)

Storage

- Workshop to develop roadmap for lower cost compressed H₂ storage activities (Q2, FY 2011)
- Workshop to identify key R&D issues for cryo-compressed H₂ storage (Q2, FY 2011)
- Follow-up workshops on hydrogen sorbents (TBD)
- Workshops on interface issues between the infrastructure and on-board storage (TBD)
- Workshops to develop roadmap/strategies for future storage materials R&D

Education

- Stakeholder updated roadmap workshop planned in October

Manufacturing

- Stationary Manufacturing R&D FY11 (TBD)

Fuel Cells

- Reversible fuel cells (TBD)
- AFC workshop: Status, prospects and R&D needs (TBD)

Safety, Codes and Standards

- Insurability of Hydrogen and FC Technologies (Spring-Summer 2011)
- Collaborative Safety R&D (March 2011, Japan)
- Assessment of Sensor Technology and Targets (Summer-Fall 2011)
- FC Systems and Components Certification and Qualification (Nov 5, 2010, SNL, CA)

Systems Analysis

- Infrastructure workshop on station cost identification and identification of R&D gaps (TBD)
- Workshop tentatively planned for NHA (Feb 2011)

Source: US DOE 10/2010

First-ever customer-focused panel conducted by the Fuel Cell Seminar

- **Wednesday, October 20, 2010 at 8:00am**

Panelists to include:

- Mr. Harry S. Pettit, Pepperidge Farm, Inc.
- Mr. J. D. Van Wyhe, PG&E
- Ms. Elizabeth A. Moore, Defense Distribution Depot Warner Robins
- Mr. Scott Kliever, Sysco Houston, Inc.
- Mr. Gary Lunz, Crown Equipment Corporation



Providing Primary, Back Up, and Motive Power

Contact: Pete Devlin, DOE



Topic 3: Hydrogen and Fuel Cells

- **Subtopic 3a – Reducing the Cost of High Pressure Hydrogen Storage Tanks**
- **Subtopic 3b – Fuel Cell Balance-of-Plant**
- **Subtopic 3c – Hydrogen Odorant Technology**
- **Subtopic 3d – Demonstration of Alternative-Fuel Cells as Range Extenders for Battery-Powered Airport Ground Support Equipment (GSE)**
- Subtopic 3e – Other: Should address one of the four subtopics (a-d). However, the proposal can take an approach that is not specified in the subtopic description but that will still meet the technical targets, goals or objectives, which are referenced in the description.

Closes on **11/15/2010**

http://science.doe.gov/sbir/Solicitations/FOA_2011_Phase_I.pdf

- **Fuel Cell R&D**
 - **To be released before end of 2010**
 - **Additional Solicitations Planned**
 - **Cost analysis (stationary fuel cells, storage)**
 - **Hydrogen fuel R&D (e.g. production, storage)**
 - **Market transformation**
- (subject to appropriations)**

Challenging university-level, multidisciplinary, student teams to plan and design a Residential Hydrogen Fueling System



Registration and abstract submissions extended, due:

November 1, 2010

For more information and to register, please visit:

<http://www.hydrogencontest.org/>



Prizes:

Expenses-paid trip to present at 2011 National Hydrogen Association (NHA) Hydrogen Conference and Expo, February 13-16 in Washington, DC
Priority consideration for summer internships at participating sponsor organizations; and more...

Current Registration:

36 teams registered from 16 countries including the U.S. Australia, Canada, China, Czech Republic, Iceland, India, Indonesia, Japan, Latvia, Malaysia, Morocco, Spain, Turkey, UK, Ukraine

Supported by:



- Hydrogen and fuel cells are part of a diverse portfolio of RD&D activities within DOE and address stationary, portable and transportation applications.
- RD&D has resulted in significant progress - future work is still needed and will continue.
- DOE continues to solicit input from stakeholders on approaches to accelerate progress and enable widespread commercialization.

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

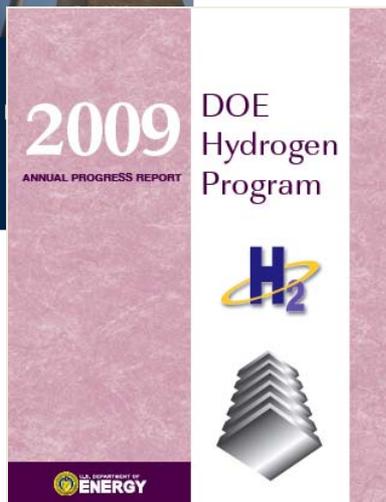
Annual Progress Report

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

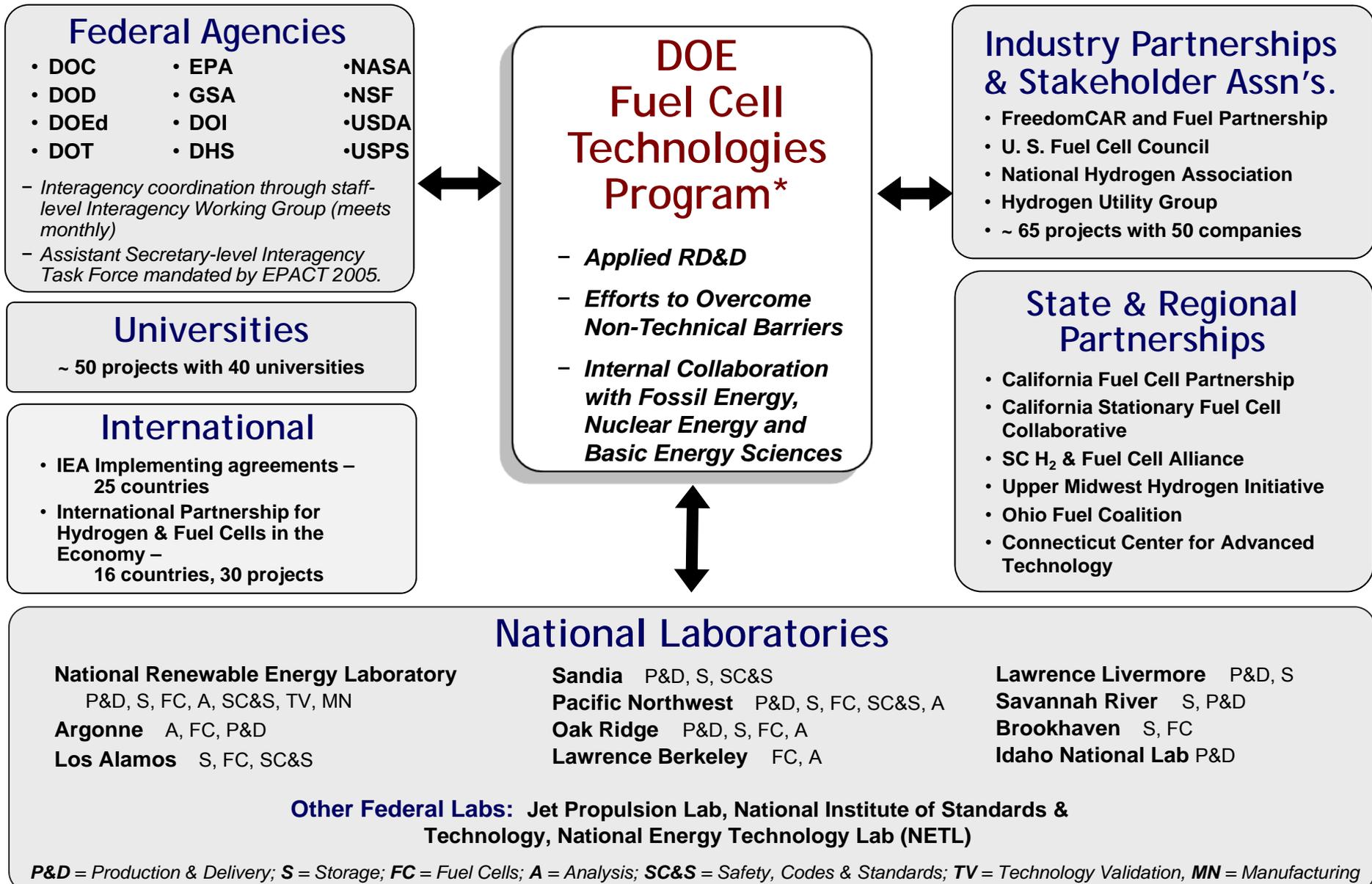
DOE job posting
planned
(check website/
USAjobs)



Next Annual Review: May 9 – 13, 2011

Washington, D.C.

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



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

Thank you

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hydrogenandfuelcells.energy.gov