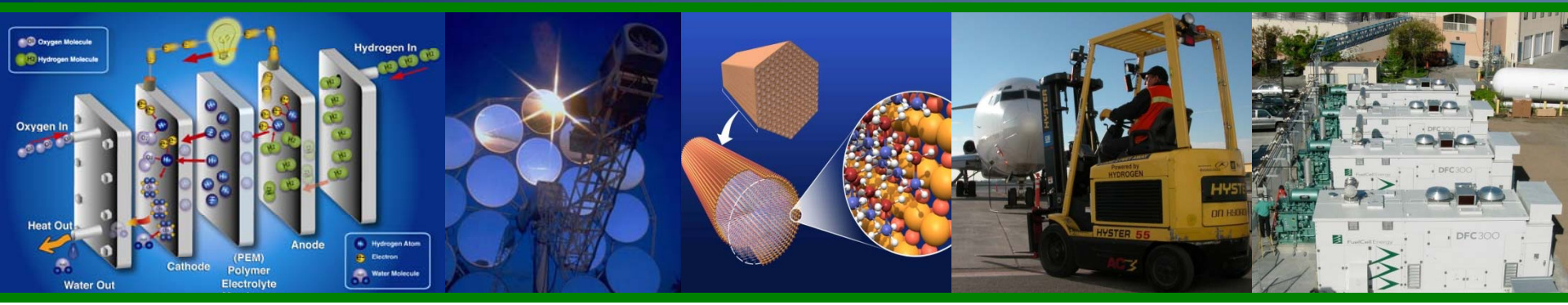
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Overview of DOE Hydrogen and Fuel Cell Activities

Dr. Sunita Satyapal

Program Manager

U.S. Department of Energy

Fuel Cell Technologies Program

DOE-DOD MOU Workshop

September 30, 2010

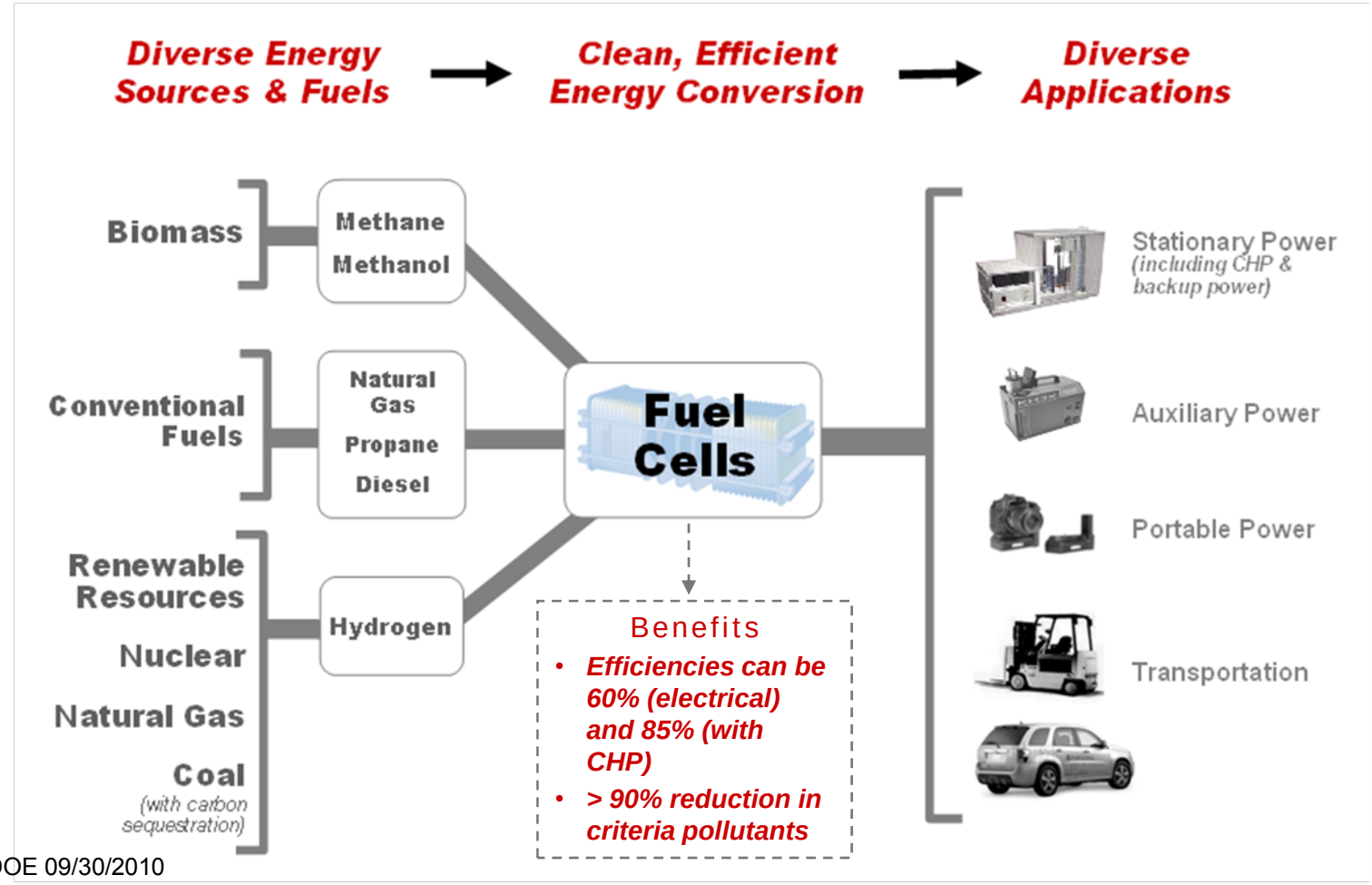
Fuel Cells: Addressing Energy Challenges

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:

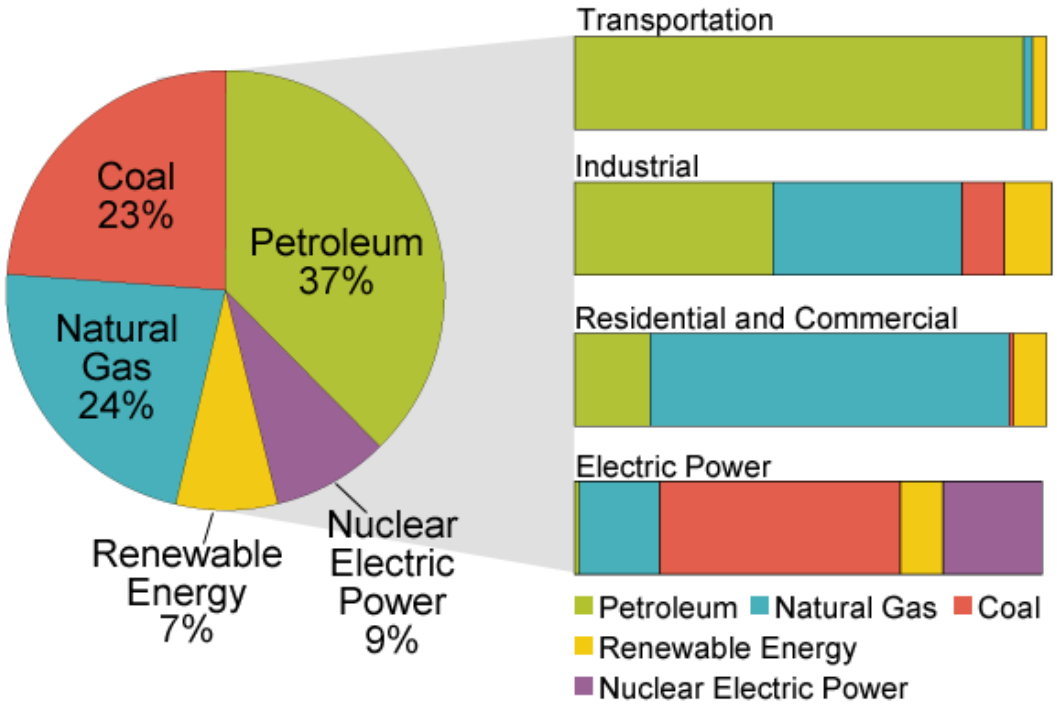
→ ***Fuel cells can be powered by emissions-free fuels that are produced from clean, domestic resources.***



Source: US DOE 09/30/2010

U.S. Energy Consumption

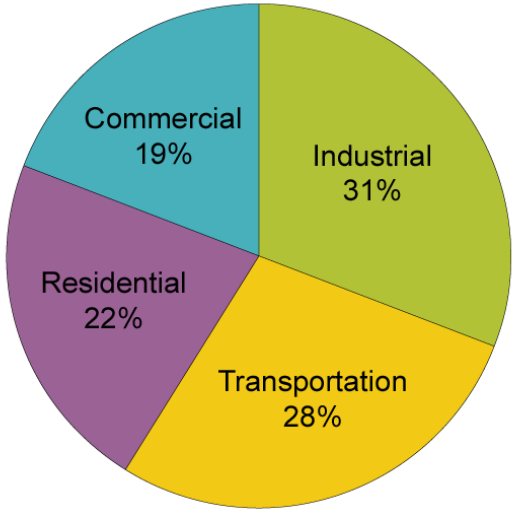
U.S. Primary Energy Consumption by Source and Sector



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*.

Source: US DOE 09/30/2010

DOD Energy Use

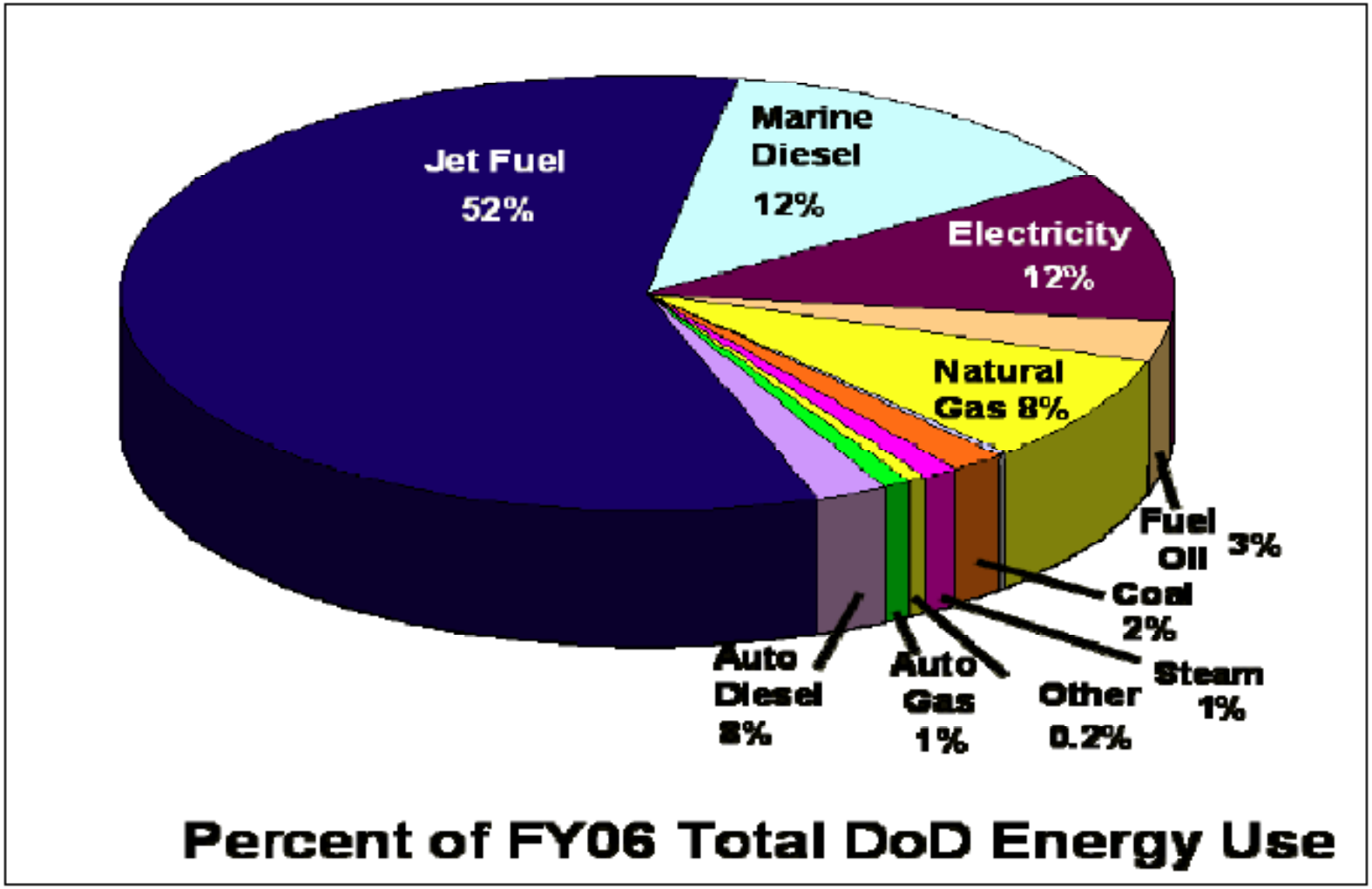


Figure 2.2: DoD Energy Consumption by Type of Fuel

Source: ***Report of the Defense Science Board Task Force*** **on DoD Energy Strategy, February 2008**

Source: US DOE 09/30/2010

Fuel Cells — *Where are we today?*

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

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 were shipped in 2009 (> 40% increase over 2008).

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

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, GM, and Proterra (buses) — have announced plans to commercialize vehicles by 2015.

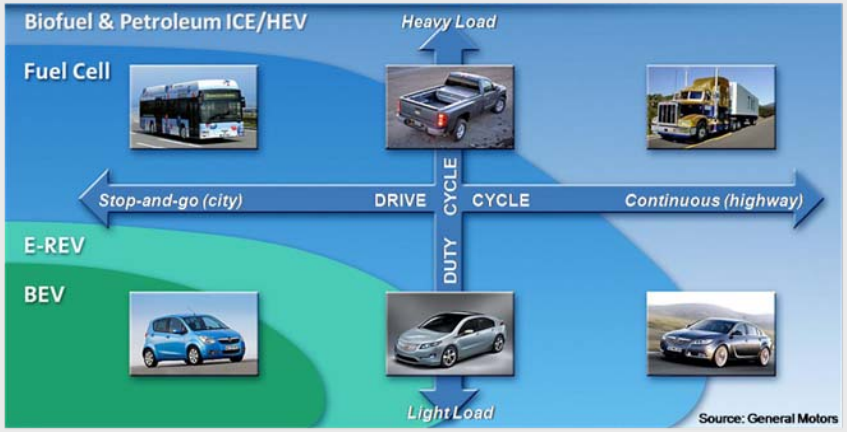
Production & Delivery of Hydrogen

In the U.S., there are currently:

~9 million metric tons of H_2 produced annually

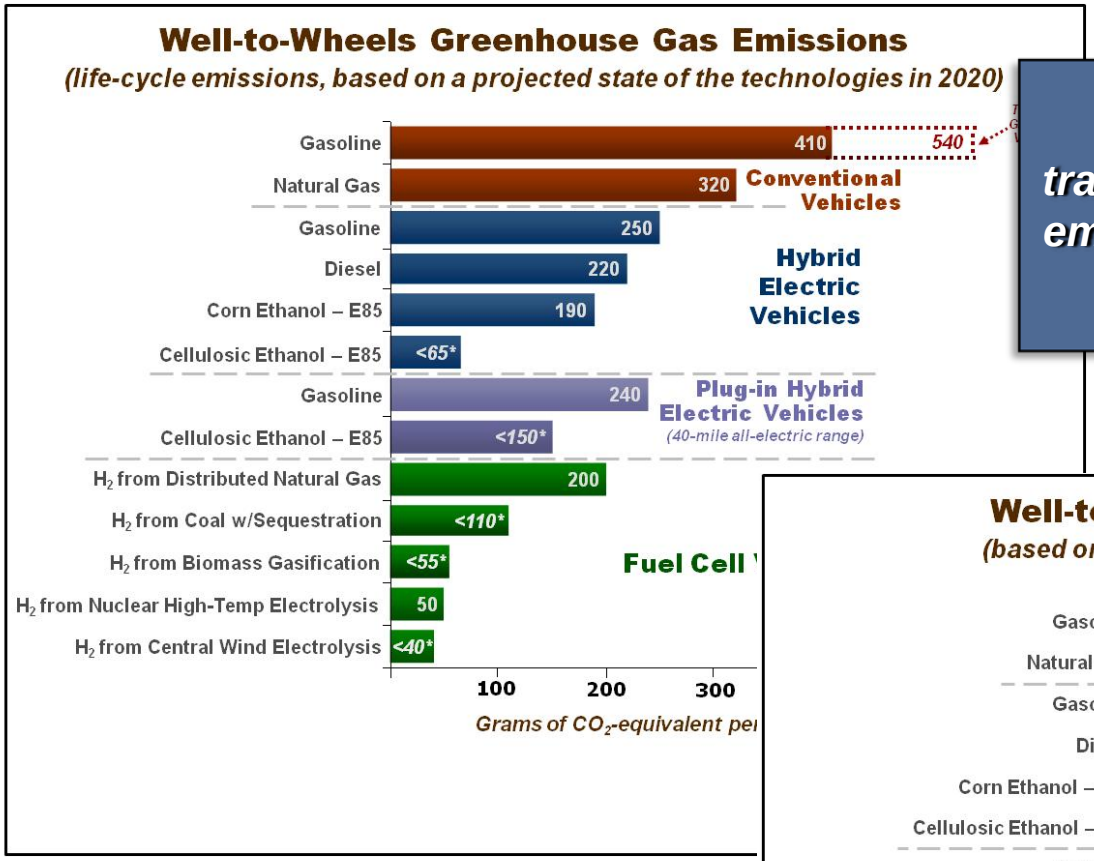
> 1,200 miles of H_2 pipelines

The Role of Fuel Cells in Transportation

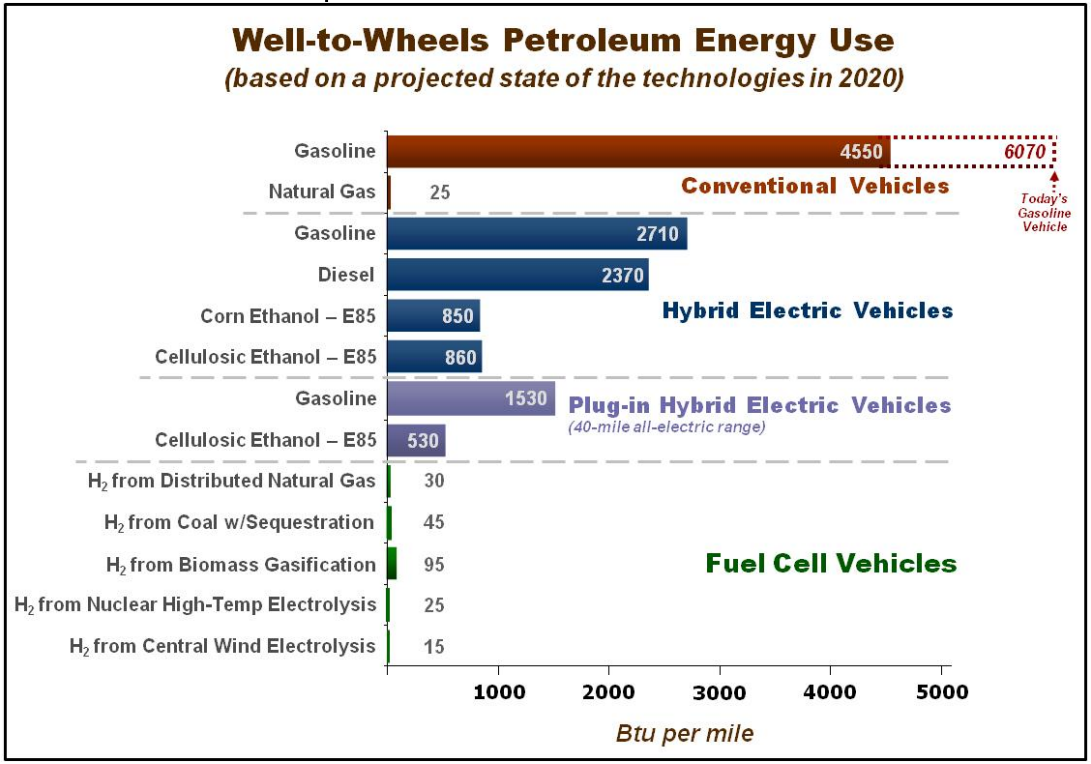


Source: US DOE 09/30/2010

Systems Analysis — *Examples of Benefits*



Analysis shows portfolio of transportation technologies will reduce emissions of greenhouse gases and oil consumption.



DOE Program Record #9002,
www.hydrogen.energy.gov/program_records.html.

Source: US DOE 09/30/2010

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 – 3 /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.

Economic & Institutional Barriers

Safety, Codes & Standards Development

Domestic Manufacturing & Supplier Base

Public Awareness & Acceptance

Hydrogen Supply & Delivery Infrastructure

Market Transformation

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

*** Targets and Metrics are being updated in 2010 .**

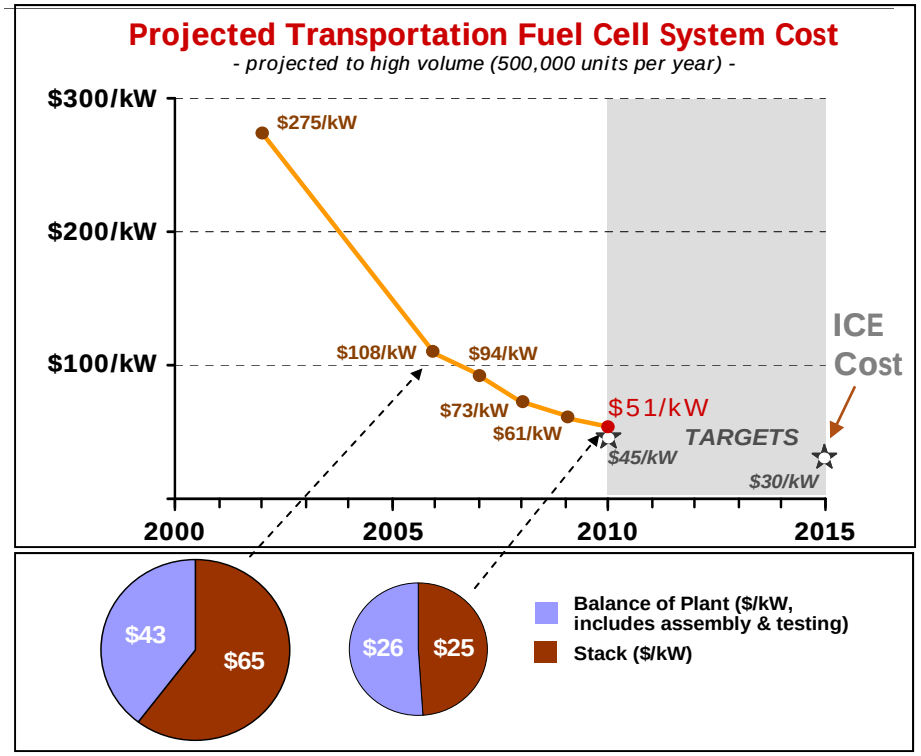
Source: US DOE 09/30/2010

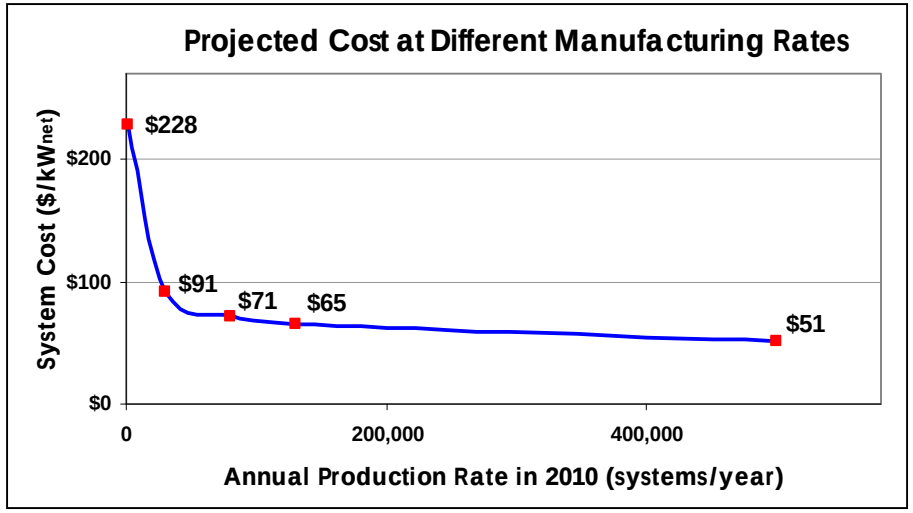
Fuel Cell R&D — *Progress: Cost*

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 09/30/2010

Technology Validation
2010 Vehicles Progress & Accomplishments

U.S. DEPARTMENT OF ENERGY

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

RECENT ACCOMPLISHMENTS

Vehicles & Infrastructure

- Fuel cell durability
  - 2,500 hours projected (nearly 75K miles)
- Over 2.8 million miles traveled
- Over 114 thousand total vehicle hours driven
- Fuel cell efficiency 53-59%
- Vehicle Range: ~196 – 254 miles
- Over 134,000 kg- H_2 produced or dispensed*
- 152 fuel cell vehicles and 24 hydrogen fueling stations have reported data to the project

Buses

- DOE is evaluating real-world bus fleet data (DOT collaboration)
  - H_2 fuel cell buses have a range of 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

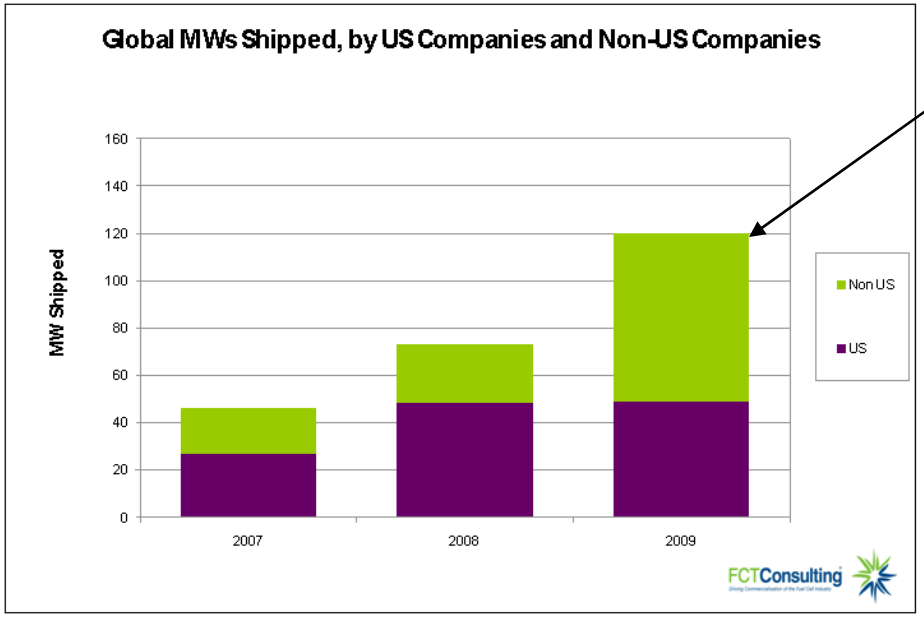
Recovery Act

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

* Not all hydrogen produced is used in vehicles

Source: US DOE 09/30/2010

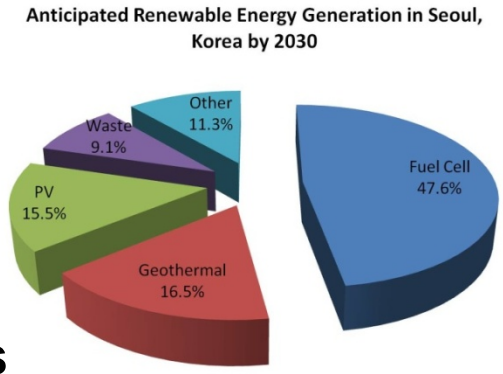
Global competition is increasing



Preliminary market analysis

Significant increase in MW shipped by non-US companies

Example: Seoul's Renewable energy generation is 48% fuel cells



Source: Municipal Government of Seoul

International landscape favors H_2 & Fuel Cells

- Germany (~$1.2B; 1,000 stations)
- European Commission (Joint Technology Initiative)
- Japan (2M vehicles, 1,000 stations by 2025)
- Korea (plan 20% of world shipments, 560,000 jobs)
- China (many thousands of units; FCVs at Expo & Olympics)
- Subsidies for jobs & manufacturing (e.g. South Africa)

Source: US DOE 09/30/2010

Example - *Executive Order 13514*

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

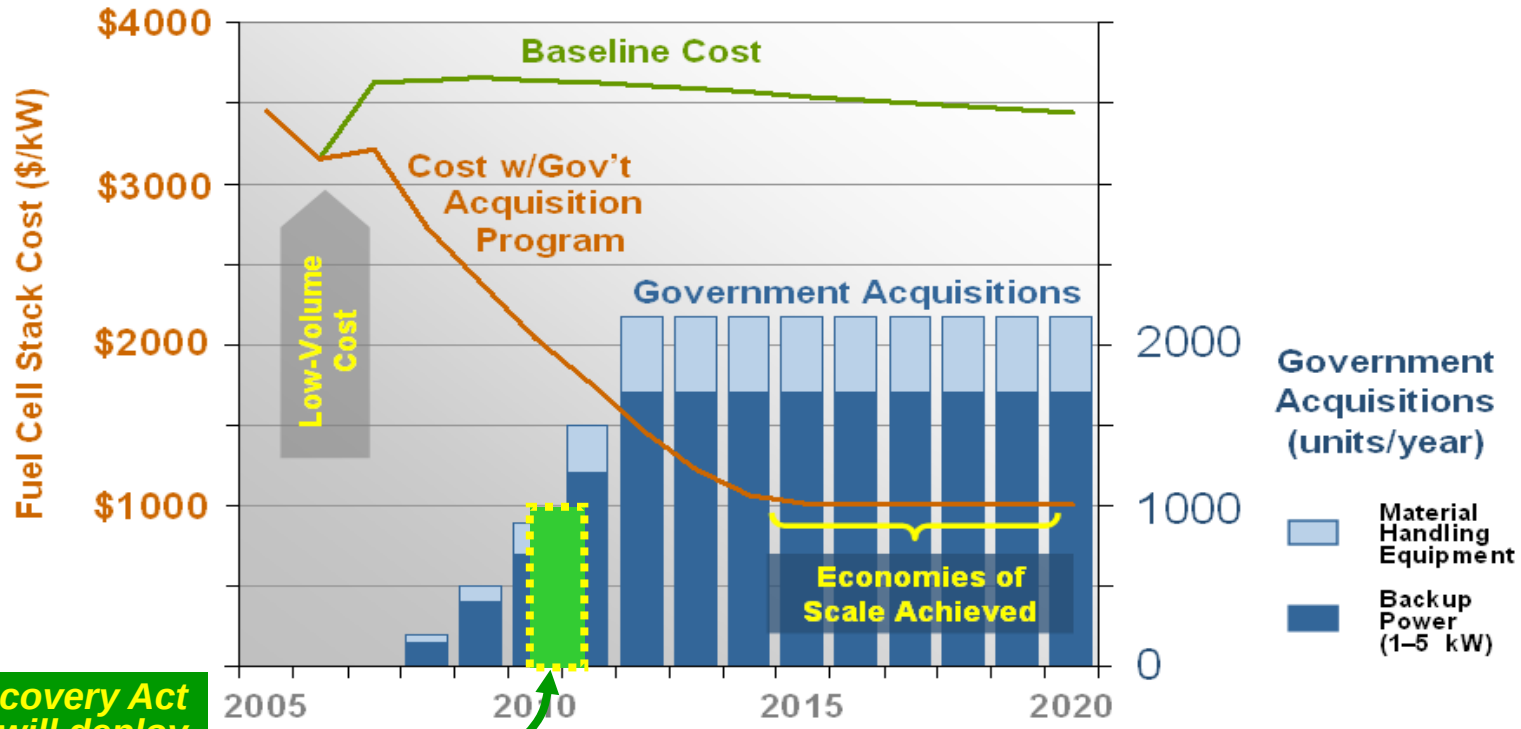
Potential opportunities for fuel cells and other clean energy technologies....

Source: US DOE 09/30/2010

http://www1.eere.energy.gov/femp/regulations/eo13514.html

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: ORNL

We are facilitating the adoption of fuel cells across government and industry:

- **100 fuel cells are being deployed, through interagency agreements.**
- **More interagency agreements under development.**

Source: US DOE 09/30/2010

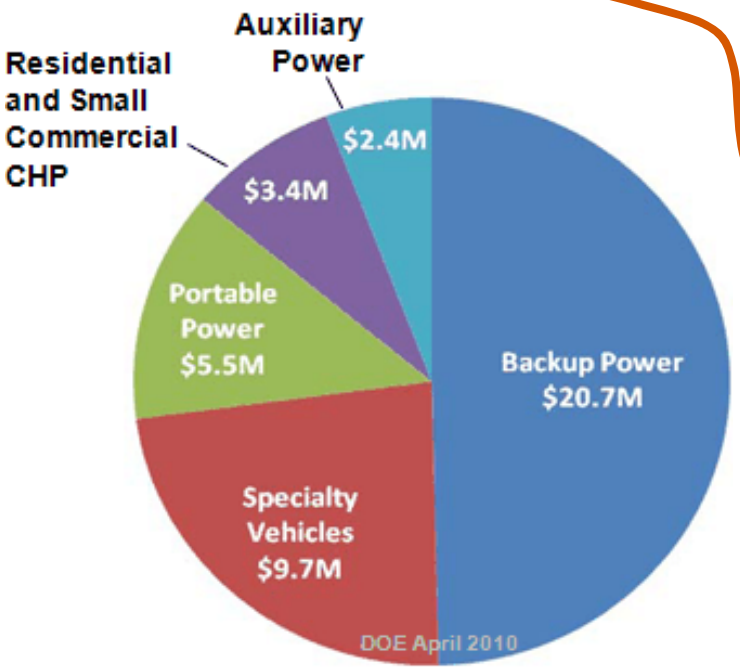
Recovery Act Funding for Fuel Cells

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

DOE announced more than $40 million from the American Recovery and Reinvestment Act to fund 12 projects, which will deploy up to 1,000 fuel cells — to help achieve near term impact and create jobs in fuel cell manufacturing, installation, maintenance & support service sectors.

FROM the LABORATORY to DEPLOYMENT:

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



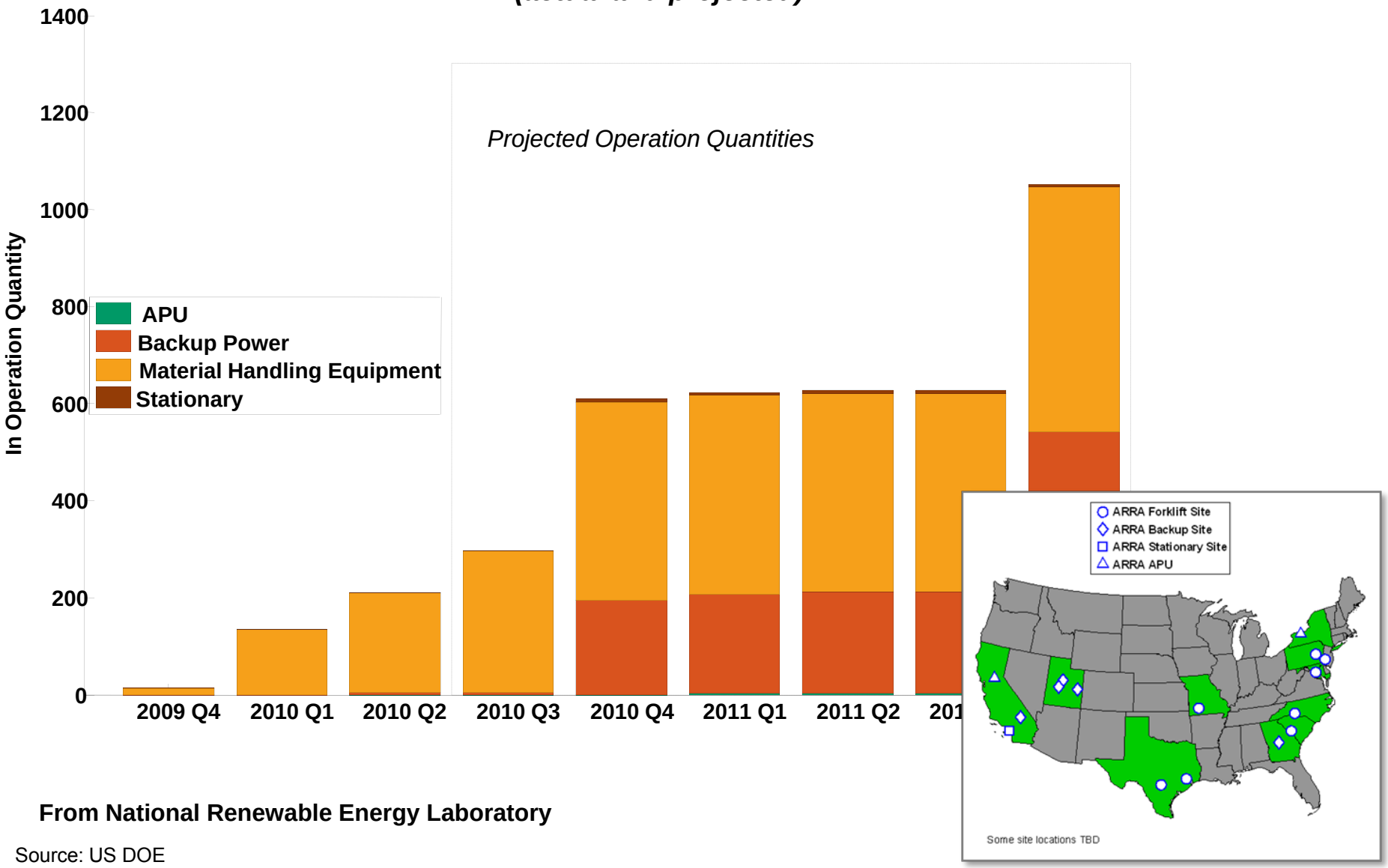
Approximately $54 million in cost-share funding from industry participants for a total of about $96 million.

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

Source: US DOE 09/2010

ARRA Fuel Cell Deployments

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



From National Renewable Energy Laboratory

Source: US DOE
09/30/2010

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

Source: US DOE 09/2010

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**

DOE Fuel Cell Technologies Program*

- ***Applied RD&D***
- ***Efforts to Overcome Non-Technical Barriers***
- ***Internal Collaboration with Fossil Energy, Nuclear Energy and Basic Energy Sciences***

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**

National Laboratories

National Renewable Energy Laboratory SC&S, P&D, S, FC, A, TV
Argonne A, FC, P&D
Los Alamos S, FC, SC&S
Sandia P&D, S, SC&S
Pacific Northwest P&D, SC&S, S, FC, A
Oak Ridge P&D, S, FC, A, SC&S
Lawrence Berkeley FC, A
Lawrence Livermore P&D, S, SC&S
Savannah River S, P&D
Brookhaven S, FC

Other Federal Labs: **Jet Propulsion Lab, National Institute of Standards & Technology, National Energy Technology Lab, Idaho National Lab**

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

Source: US DOE 09/30/2010

New Report Just Released

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

Source: US DOE 09/30/2010

Key Program Documents

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 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

- → ***Latest edition released October 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

- → ***Latest edition published November 2009***

www.hydrogen.energy.gov/annual_progress.html

Next Annual Review: May 9 – 13, 2011

Washington, D.C.

http://annualmeritreview.energy.gov/

Source: US DOE 09/30/2010

We look forward to continue to strengthen DOD-DOE collaboration

Thank you

www.hydrogenandfuelcells.energy.gov

Sunita.Satyapal@ee.doe.gov