

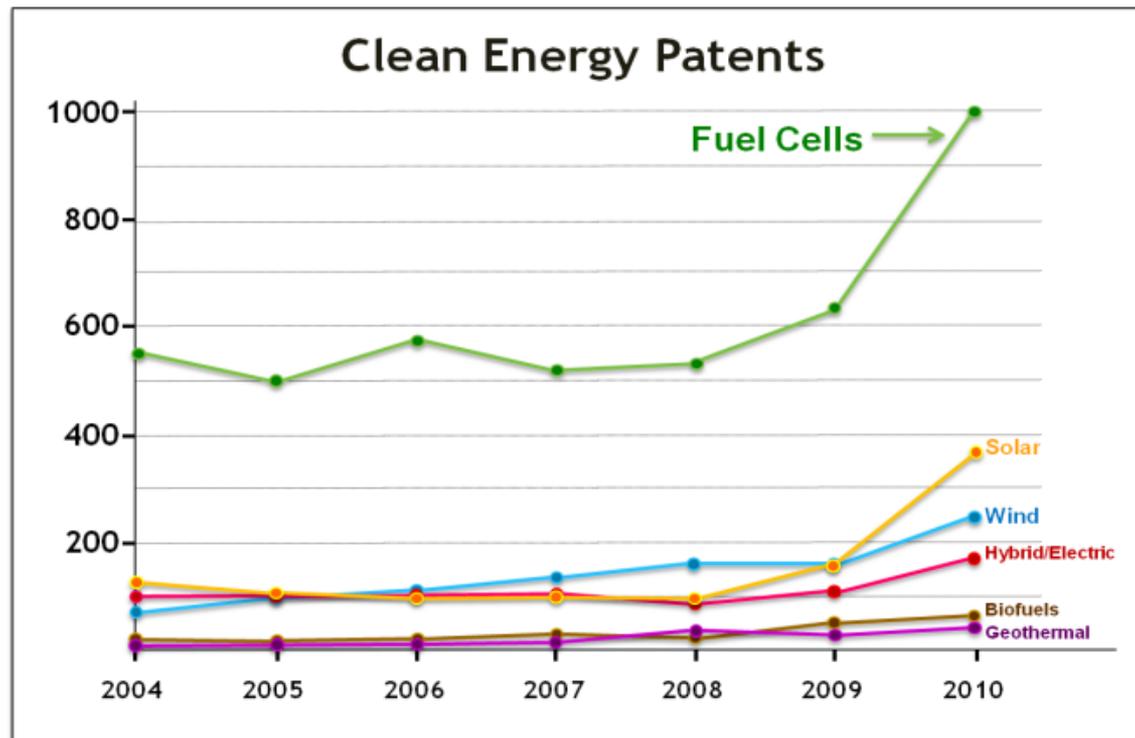


## Program Update

November 3, 2011

**Sunita Satyapal**

U.S. Department of Energy  
Fuel Cell Technologies Program  
Program Manager

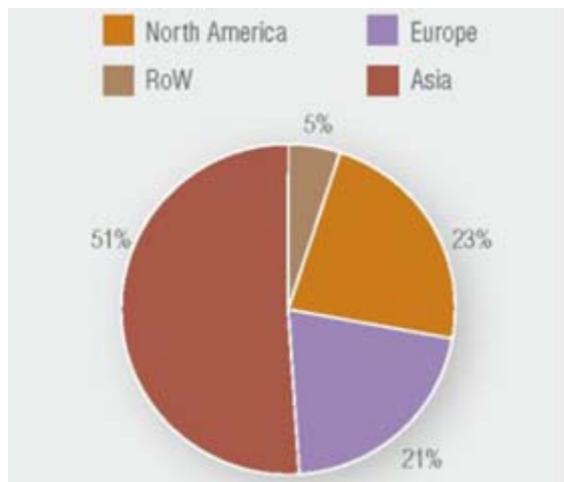


Clean Energy Patent Growth Index<sup>[1]</sup> shows that fuel cell patents lead in the clean energy field with nearly 1,000 fuel cell patents issued worldwide in 2010.

- 3x more than the second place holder, solar, which has just ~360 patents.
- Number of fuel cell patents grew > 57% in 2010.

[1] 2010 Year in Review from [http://cepqi.typepad.com/heslin\\_rothenberg\\_farley/](http://cepqi.typepad.com/heslin_rothenberg_farley/)

Job Creation by Region of Production 2009-2019



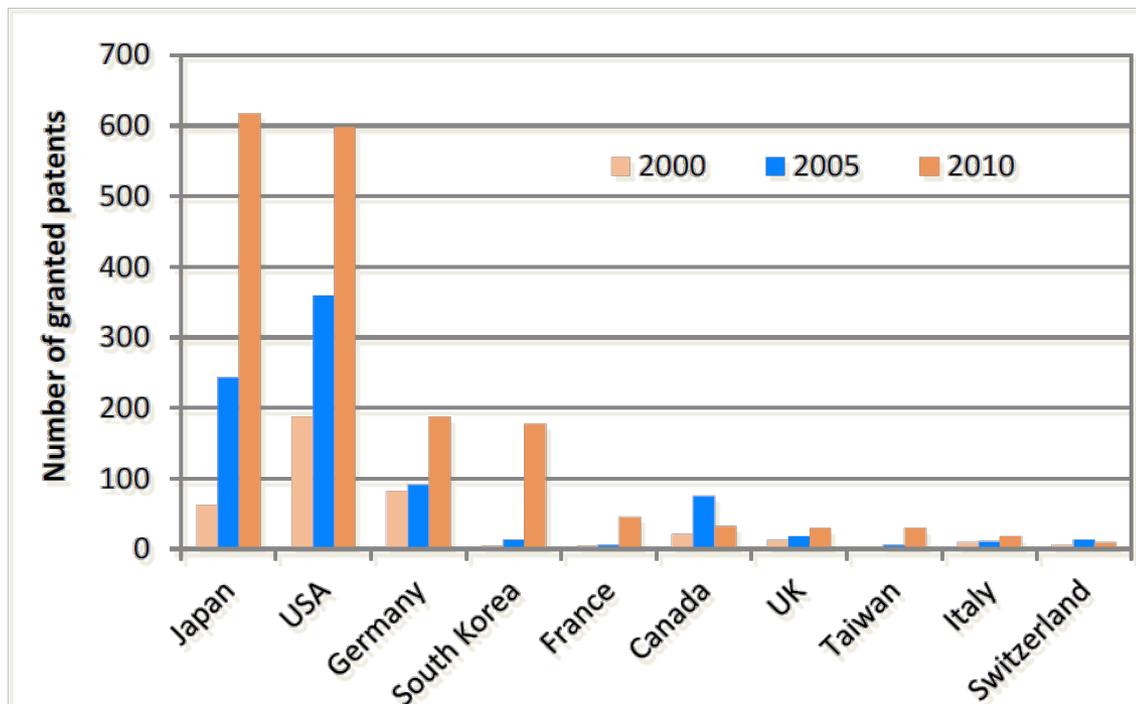
Source: FuelCellToday

Various analyses project revenues (>2020) of:

- \$14 – \$31 B/yr for stationary power
- \$11 B/yr for portable power
- \$18 – \$97 B/yr for transportation

Significant growth in number of patents filed by Japan, Korea, Germany, U.S.  
Job creation projections show significant growth in Asia and Europe.

Annual granted fuel cell patents per country of origin (top ten)



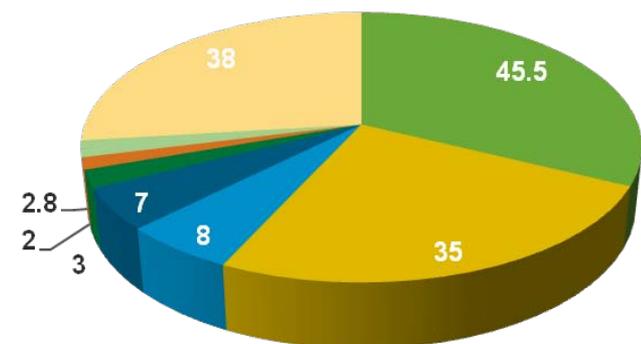
Source: FuelCellToday

## DOE Appropriations and Budget Request for Hydrogen and Fuel Cells

### EERE Funding (\$ in thousands)

Key Activity	FY 2010 Appropriation	FY 2011 Appropriation	FY 2012 Request	House Mark	Senate Mark
Fuel Cell Systems R&D	75,609	43,000	45,450	41,450	42,000
Hydrogen Fuel R&D	45,750	33,000	35,000	33,000	33,000
Technology Validation	13,005	9,000	8,000	5,000	8,000
Market Transformation	15,005	0	0	0	3,000
Safety, Codes & Standards	8,653	7,000	7,000	7,000	7,000
Education	2,000	0	0	0	0
Systems Analysis	5,408	3,000	3,000	3,000	3,000
Manufacturing R&D	4,867	3,000	2,000	2,000	2,000
<b>Total</b>	<b>\$170,297</b>	<b>\$98,000</b>	<b>\$100,450</b>	<b>\$91,450</b>	<b>98,000</b>

Total DOE Hydrogen and Fuel Cell Technologies FY12 Budget Request (in millions of US \$)



- Fuel Cell Systems R&D
- Hydrogen Fuel R&D
- Technology Validation
- Safety, Codes & Standards
- Systems Analysis
- Manufacturing R&D
- Nuclear Energy (NE)\*
- Basic Science (SC)\*\*

\*Based on FY11 appropriations.

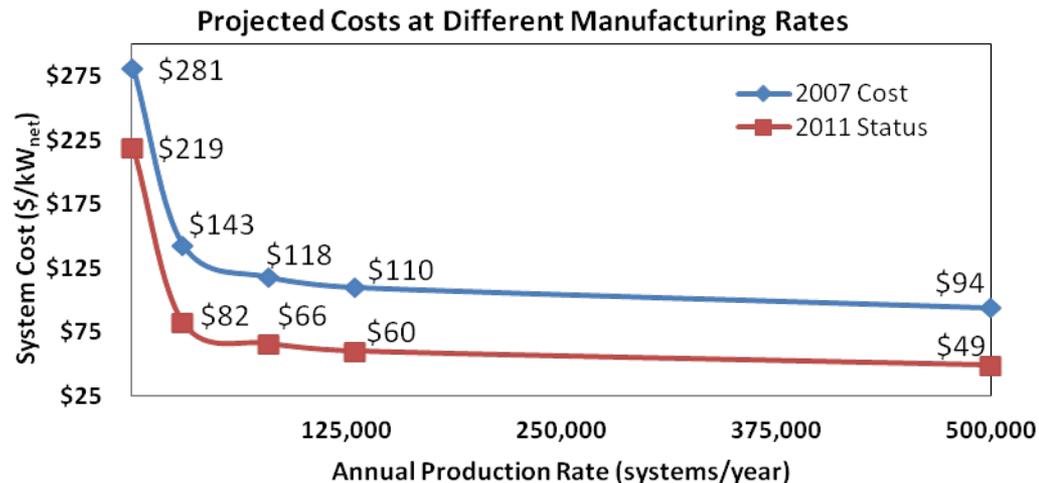
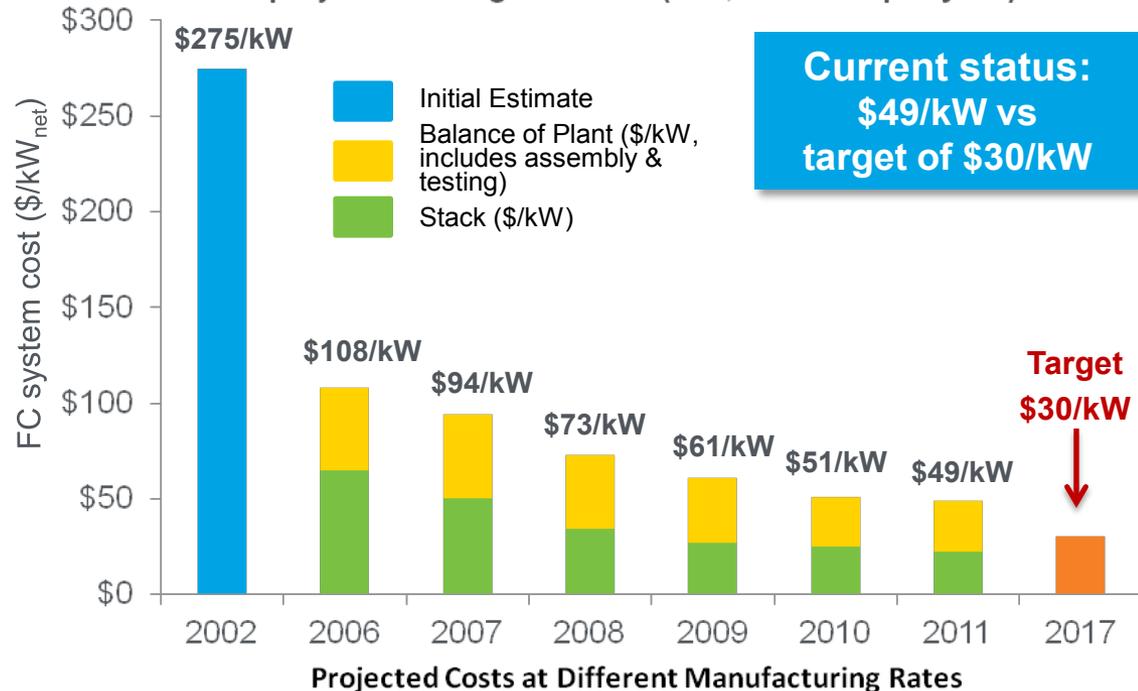
Notes: Hydrogen Fuel R&D includes Hydrogen Production, Delivery and Hydrogen Storage R&D. FY11, FY12 include SBIR/STTR funds to be transferred to the Science Appropriation; prior years exclude this funding

**DOE-funded efforts have reduced the projected high-volume cost of fuel cells to \$49/kW (2011)\***

**• More than 30% reduction since 2008**

**• More than 80% reduction since 2002**

**Projected Transportation Fuel Cell System Cost**  
-projected to high-volume (500,000 units per year)-



*\*Based on projection to high-volume manufacturing (500,000 units/year). The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the DOE Program at the laboratory scale. Additional efforts would be needed for integration of components into a complete automotive system that meets durability requirements in real-world conditions.*

## Reduced cost of H<sub>2</sub> production (multiple pathways)

### Vehicles & infrastructure

- 170 fuel cell vehicles, 24 hydrogen stations
- > 3.3 million miles traveled
- > 146 thousand total vehicle hours driven
- ~ 2,500 hours (nearly 75K miles) durability
- ~ 5 minute refueling time (4 kg of hydrogen)

H<sub>2</sub> fuel cell buses (w/ DOT) have a 42% to 139% better fuel economy when compared to diesel & CNG buses

- Tanks can achieve >250 mile range
- Validated vehicle that can achieve 430 mi
- Developed and evaluated more than 400 material approaches experimentally and millions computationally

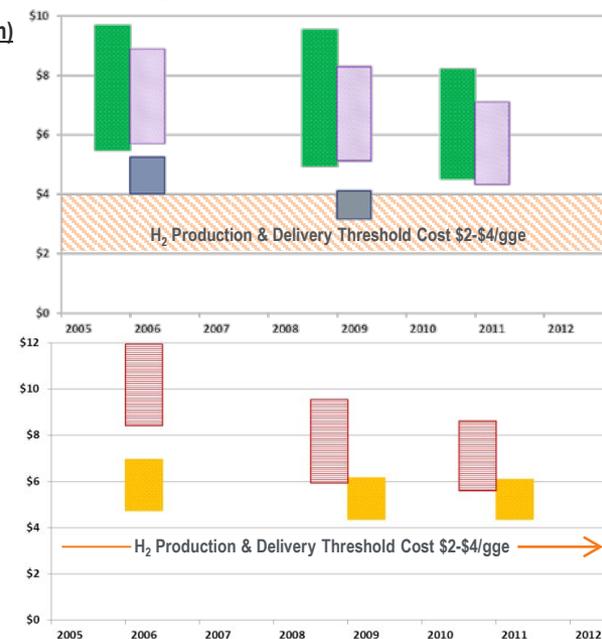
### Projected High-Volume Cost of Hydrogen Production<sup>1</sup> (Delivered<sup>2</sup>)—Status

#### Distributed Production (near term)

-  Electrolysis  
Feedstock variability: \$0.03 - \$0.08 per kWh
-  Bio-Derived Liquids  
Feedstock variability: \$1.00 - \$3.00 per gallon ethanol
-  Natural Gas Reforming  
Feedstock variability: \$4.00 - \$10.00 per MMBtu

#### Central Production (longer term)

-  Electrolysis  
Feedstock variability: \$0.03 - \$0.08 per kWh
-  Biomass Gasification  
Feedstock variability: \$40- \$120 per dry short ton

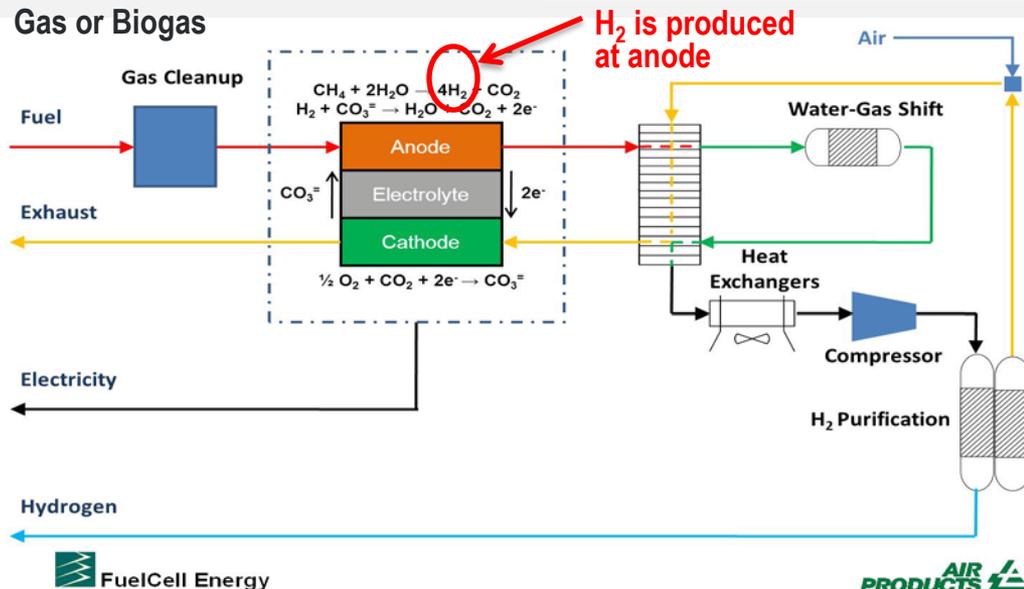
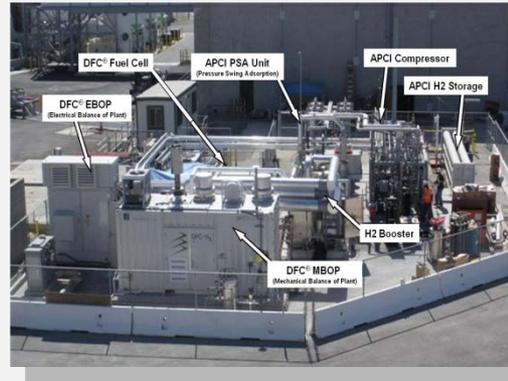


- Demonstrated cycle-life of >50,000 refuelings of metal tanks for forklift applications
- Developed safety courses, educated >17,000 first responders and code officials through introductory web-based courses and advanced hands-on training

## “Energy Department Applauds World’s First Fuel Cell and Hydrogen Energy Station in Orange County”

### Demonstrated world’s first Tri-generation station (CHHP with 54% efficiency)

-Anaerobic digestion of municipal wastewater-



### Fountain Valley demonstration

- ~250 kW of electricity
- ~100 kg/day hydrogen capacity (350 and 700 bar), enough to fuel 25 to 50 vehicles.



## Released Program Plan

- An integrated strategic plan for RD&D activities of DOE's Hydrogen and Fuel Cells Program (included input from HTAC and stakeholders)

## Held Interagency Task Force meeting across 10 Agencies and Developed Interagency Action Plan

## ARRA Projects

- Deployed ~830 fuel cells (primarily for lift trucks and back up power for cell phone towers)

## Developed Procurement Guide for Federal Agencies (ORNL)

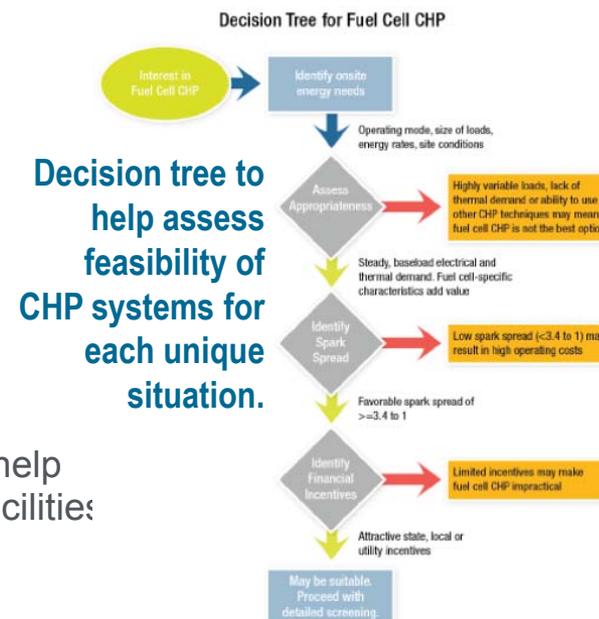
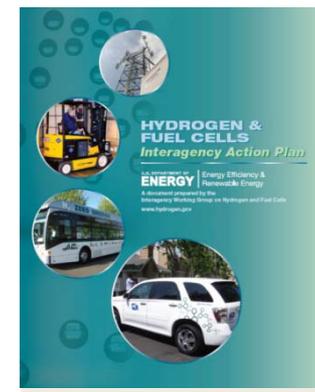
- To help identify opportunities for facility managers

## Examples of Recent Workshops-

- Manufacturing
- Natural Gas/Hydrogen Infrastructure
- US DRIVE All Tech Team Meeting
- International H2 Safety, Codes and Standards

## Interagency Deployments

- Funded 18 fuel cell backup power systems at 10 installation sites to help accelerate deployment of clean technology at Federal government facilities and provide valuable data and feedback for fuel cells.

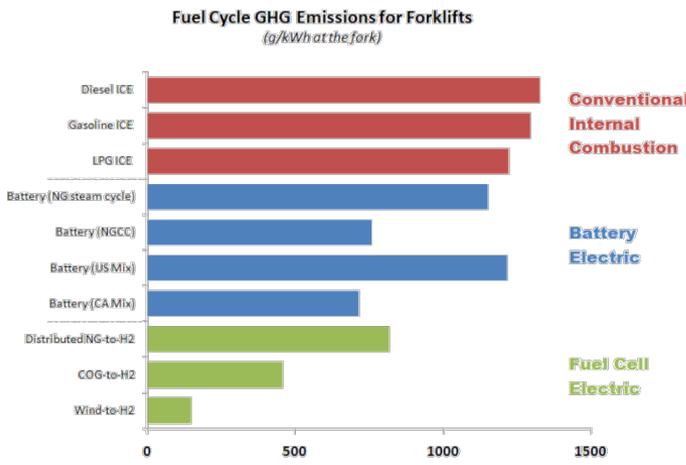


<http://www1.eere.energy.gov/hydrogenandfuelcells/>

**ARRA deployments of fuel cells for lift trucks (~400) led to industry purchases\* of an estimated 3,000 additional fuel cell lift trucks with NO DOE funding**

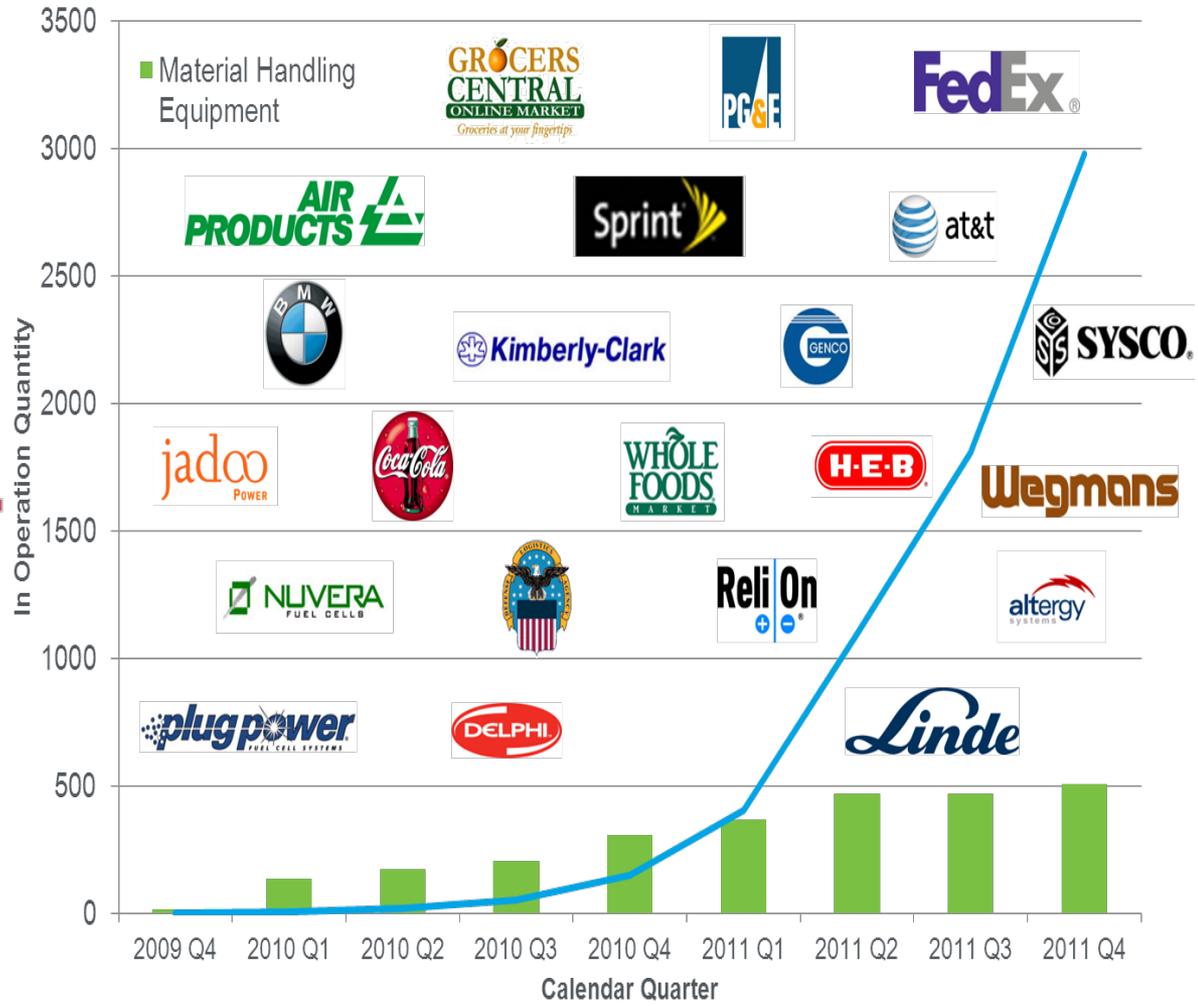
**The Case for Forklifts\***  
Compared to conventional forklifts, fuel cell forklifts have:

- 1.5 X lower maintenance cost
- 8 X lower refueling labor cost
- 2 X lower net present value of total system cost



*\*Preliminary Analysis*

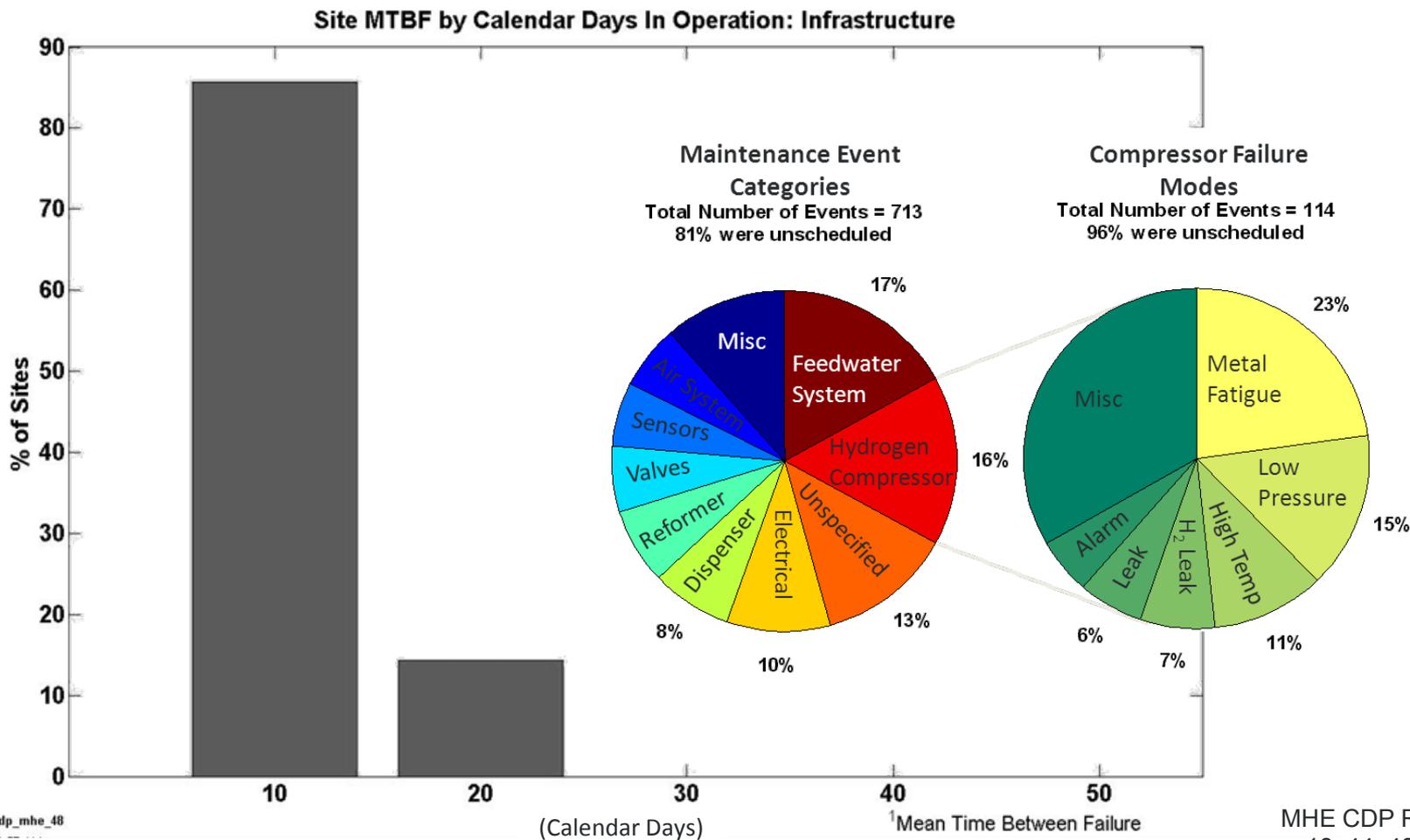
## Fuel Cell Lift Truck Purchases



\* Including deployed and on order

## Infrastructure Reliability (Example)

High use (130,742 hydrogen fills) has shown infrastructure maintenance to be an area needing continued development due to a low site MTBF (~10 days for most NHE sites) A primary category for maintenance is compressors. The top four reasons for compressor failure are metal fatigue, low pressure, high temperature, and hydrogen leaks. The site average labor hour per maintenance event ranges from 4 to 11 hours.



MHE CDP Ref #s:  
18, 44, 48, & 52

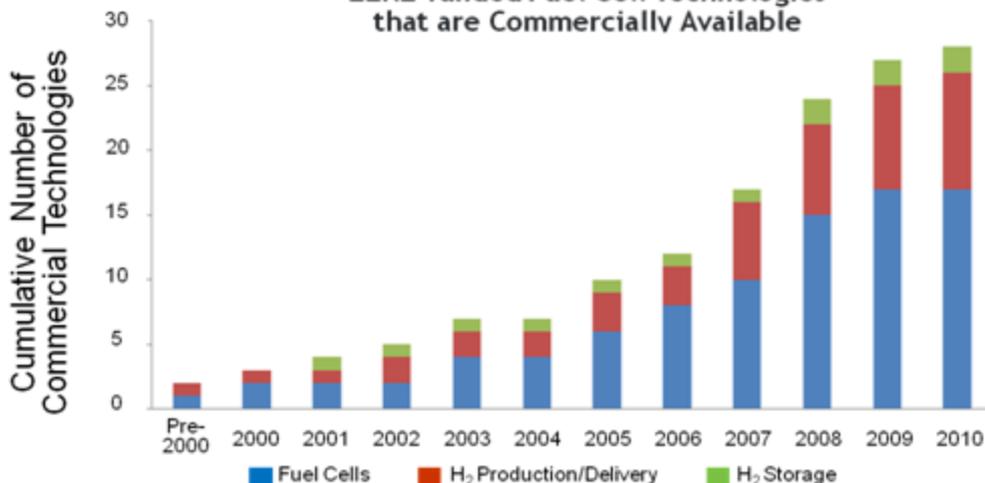
# Assessing the Impact of DOE Funding - Commercializing Technologies

DOE funding led to ~30 commercial technologies and >60 emerging technologies

The Program is tracking impact: for example, ~\$70M in DOE-funding has led to nearly \$200M in industry investment and revenues.

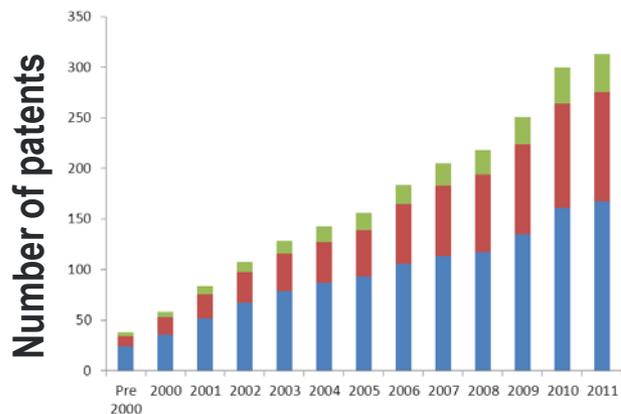
## Accelerating Commercialization

EERE-funded Fuel Cell Technologies that are Commercially Available



Source: Pacific Northwest National Laboratory

[http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways\\_success\\_hfcit.pdf](http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_success_hfcit.pdf)



**>300 PATENTS** resulting from EERE-funded R&D:

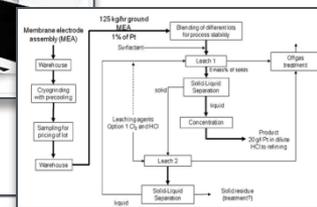
- Includes technologies for hydrogen production and delivery, hydrogen storage, and fuel cells

## Examples

DuPont



BASF Catalysts LLC



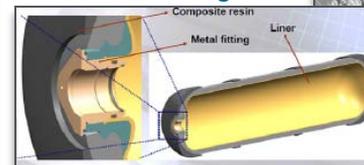
Proton Energy Systems



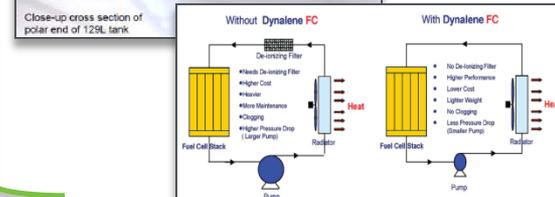
3M



Quantum Technologies



Dynalene, Inc.



# RFI Released: Total Cost of Ownership for Future Light-Duty Vehicles

RFI Closes: December 16, 2011

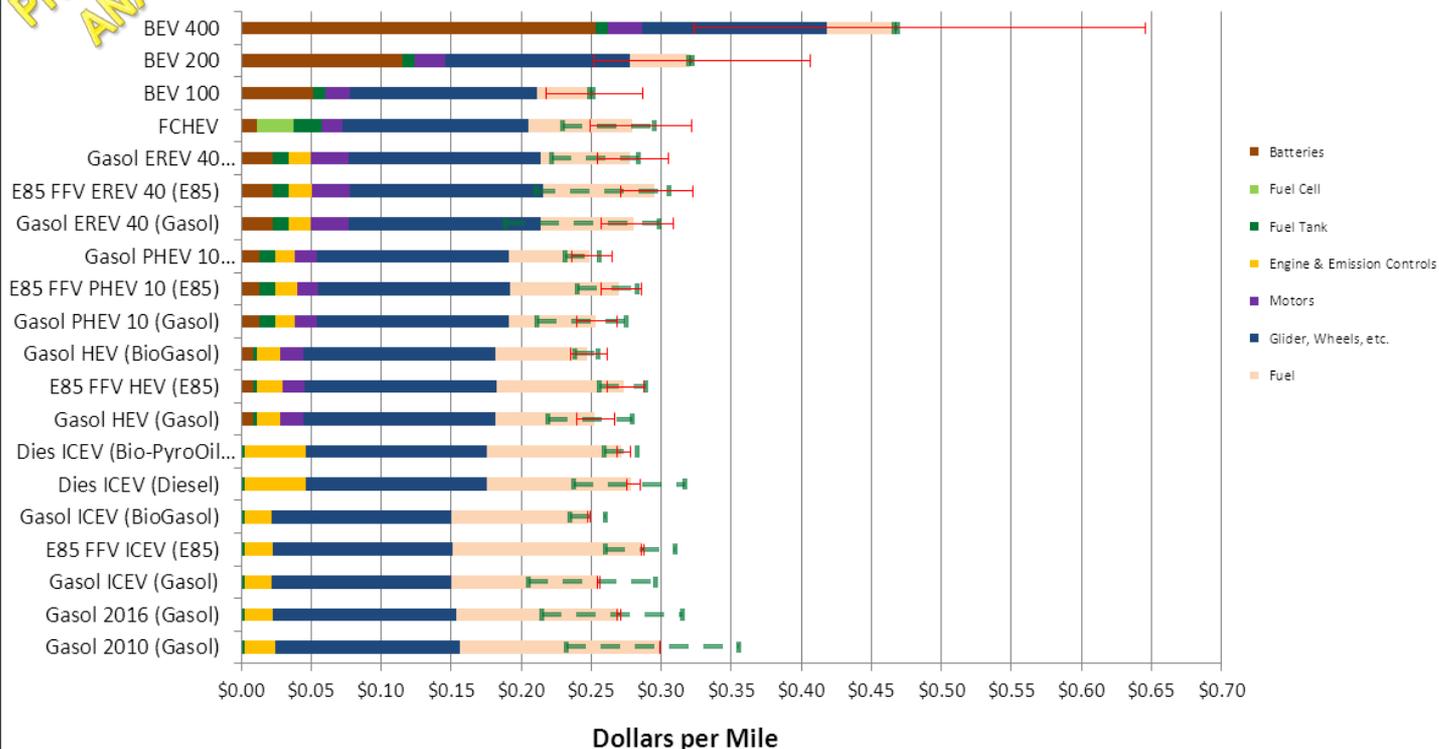
For Questions, Email: [TCORFI@go.doe.gov](mailto:TCORFI@go.doe.gov)

## Lifecycle Costs of Advanced Vehicles

### Component Cost per Mile in Year 2030

(except where indicated)

**PRELIMINARY  
ANALYSIS**



Feedback is requested on:

- The assumptions (aggressive, moderate or conservative levels of success for various technologies).
- The projection of cost reduction rates for technologies that are not yet fully commercial.
- The general financial analysis approach used.

Error bars include fuel price volatility (green) and different assumptions for technology success (red) (2030 timeframe)

*Workshop convened industry and stakeholders with expertise in natural gas and hydrogen technologies, vehicle OEMs, CHP, policy, and regulations. The focus of the workshop is to facilitate the growth of natural gas and hydrogen use in the U.S. for transportation and other applications.*

## Workshop Activities Included:

- Discussion led by plenary speakers and expert panels
- Break-out sessions to identify key questions and resolutions on:
  - R&D Needs
  - Regulatory / Environmental Barriers
  - Innovative Approaches



## Outcomes:

- Summarize the status of natural gas and hydrogen infrastructure
- Identify opportunities and barriers for expanding the infrastructure
- Identify synergies between natural gas and H<sub>2</sub> use
- Identify and prioritize specific actions to address barriers
- Identify the roles of government and industry in promoting growth of natural gas and H<sub>2</sub> infrastructure

**Tuesday, October 18<sup>th</sup> and Wednesday, October 19<sup>th</sup> 2011**

Argonne Facilities, Chicago, Illinois

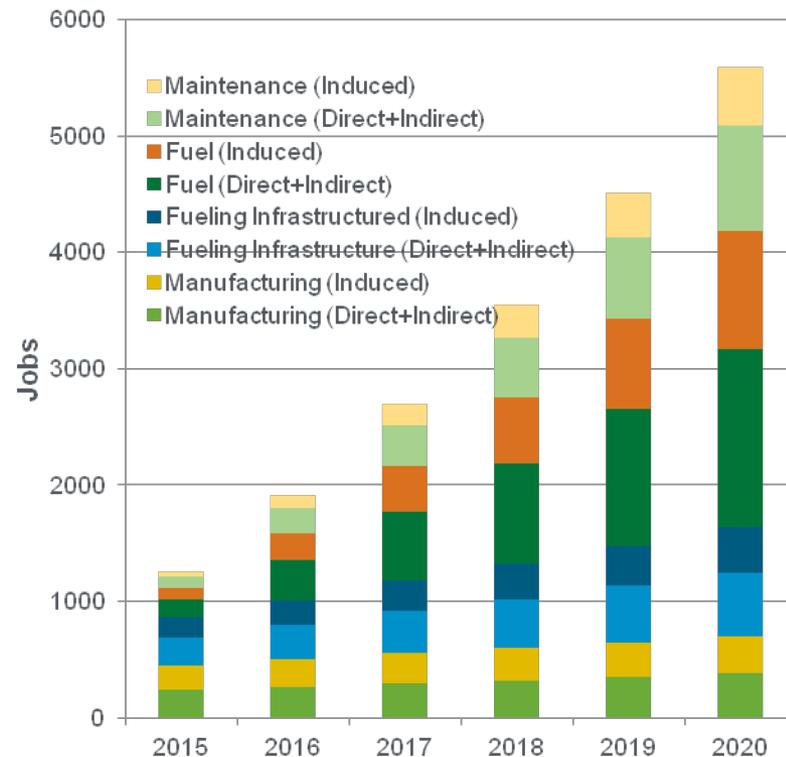
*Organized by the Argonne National Laboratory for the U.S. Department of Energy*

## Required User Input Fields

Includes selections for state/region, system size, new or existing project, needed and current capacity, etc.

*** FORKLIFT (PEM) MODULE ***					
REQUIRED USER INPUT FIELDS					
*** MANUFACTURING FACILITY (PEM) MODULE ***					
REQUIRED USER INPUT FIELDS					
Step 1	Select State or Region:	<input type="text" value="Please select"/>			
Step 2	Choose system size(s)	User-specified value	Default value	Notes	Value used in model
Class I/II forklift fuel cell size (average kW/unit)			10		10
Class III forklift fuel cell size (average kW/unit)			2.5		2.5
Backup power fuel cell size (kW/unit)			5		5
Step 3	Will this be a New production facility or will an existing production facility be Expanded?				
Expand existing PEM production facility(s) in region					
Step 4	Needed Capacity	What is the maximum number of PEM units that the new facility will be able to produce annually?			
Type	User-specified value	Default value	Notes	Values used in model calculations	
Class I/II forklift fuel cells (units/year)				5 kW unit equivalent ratio	5 kW unit equivalents
Class III forklift fuel cells (units/year)					-
Backup power fuel cells (units/year)					-
				Total Needed Capacity	-
Step 5	Current Capacity	What is the maximum number of PEM units that can currently be produced annually by the production facility in the region?			
Type	User-specified value	Default value	Notes	Values used in model calculations	
Class I/II forklift fuel cells (units/year)				5 kW unit equivalent ratio	5 kW unit equivalents
Class III forklift fuel cells (units/year)					-
Backup power fuel cells (units/year)					-
				Total Current Capacity	-

## Illustrative Example of JOBS FC Output



**Jobs tools to be available  
for BETA testing  
December 2011.**

**[www.hydrogen.energy.gov](http://www.hydrogen.energy.gov)**

**Published more than 70 news articles in FY11 (including blogs, progress alerts and DOE FCT news alerts)**

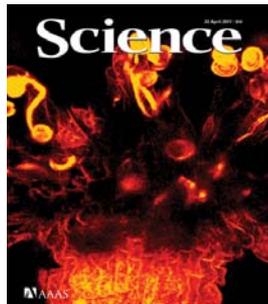
## Communication and Outreach Activities include:

- Webinar Series:
  - Series of informational webinars led by FCT and partners on various topics including: Hydrogen Fuel Cells in your Area, Local Green Policies, Mobile Lighting
- MotorWeek: PBS to air fuel cell episode in Fall 2011
- H<sub>2</sub> Student Design Contest: Registration closes November 15, 2011
- Portland Community College: Installed 1<sup>st</sup> of 38, 5KW units.
- New Awards: Nearly \$7 Million - Fuel Cell and Hydrogen Storage Cost Analysis
- Jobs tool developed, ANL (Beta testing, this year)

## Blogs Published to Energy.gov website include:

- Fuel Station of the Future
- Shuttle Launch

Progress in low and zero Pt catalysts highlighted in Science



"These technologies are part of a broad portfolio that will create new American jobs, reduce carbon pollution, and increase our competitiveness in today's global clean energy economy."



Hydrogen fuel cells providing critical backup power

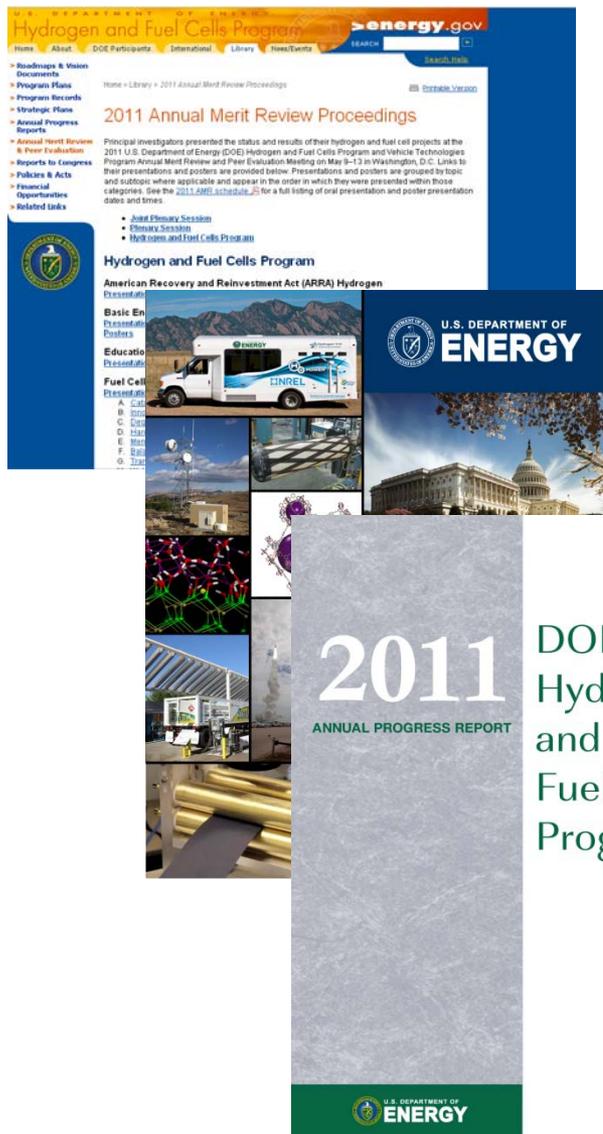


Hydrogen power lights at the space shuttle launch

# Additional Information

Funding (\$ in thousands)			
Activity	FY 2010	FY 2011	FY 2012 Request
Biomass and Biorefinery Systems	216,225	182,695	340,500
Building Technologies	219,046	210,500	470,700
Federal Energy Management Program	32,000	30,402	33,072
Geothermal Technology	43,120	38,003	101,535
Hydrogen and Fuel Cell Technologies	170,297	98,000	100,450
Water Power	48,669	30,000	38,500
Industrial Technologies	94,270	108,241	319,784
Solar Energy	243,396	263,500	457,000
Vehicle Technologies	304,223	300,000	588,003
Weatherization & Intergovernmental Activities	270,000	231,300	393,798
Wind Energy	79,011	80,000	126,589
Facilities & Infrastructure	19,000	51,000	26,407
Program Support	45,000	32,000	53,204
Program Direction	140,000	170,000	176,605
Congressionally Directed Activities	292,135	0	0
RE-ENERGYSE	0	0	0
Adjustments	0	-30,000	-26,364
<b>Total</b>	<b>\$2,216,392</b>	<b>\$1,795,641</b>	<b>\$3,200,053</b>

\*\* Includes \$250.0 million in emergency funding for the Weatherization Assistance Grants program provided by P.L. 111-6, "The Continuing Appropriations Resolution, 2009."



## Annual Merit Review & Peer Evaluation Proceedings

*Includes downloadable versions of all presentations at the Annual Merit Review*

- Latest edition released July 2011

[http://www.hydrogen.energy.gov/annual\\_review11\\_proceedings.html](http://www.hydrogen.energy.gov/annual_review11_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*

- Released September 2011

[http://hydrogen.energy.gov/annual\\_review11\\_report.html](http://hydrogen.energy.gov/annual_review11_report.html)

## Annual Progress Report

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

- To be released November 2011

[www.hydrogen.energy.gov/annual\\_progress.html](http://www.hydrogen.energy.gov/annual_progress.html)

**Next Annual Review: May 14 – 18, 2012**

**Arlington, VA**

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