FUEL CELL TECHNOLOGIES PROGRAM

HTAC Meeting

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

Program Update

November 3, 2011

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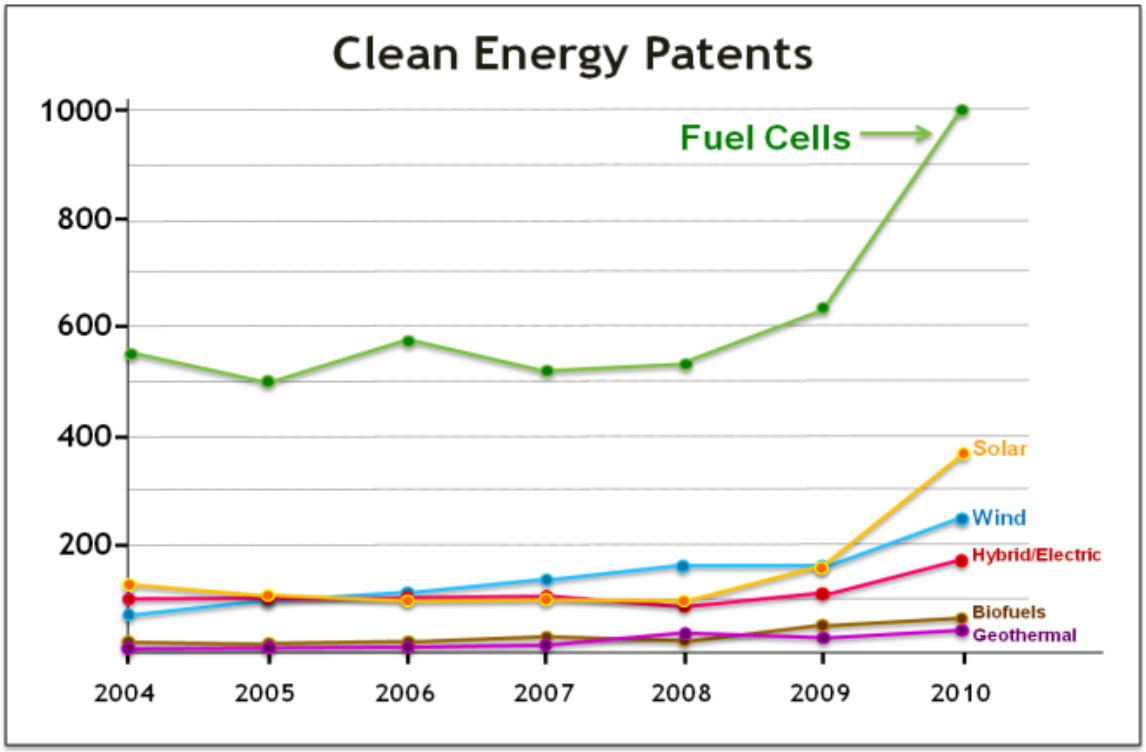
U.S. Department of Energy
Fuel Cell Technologies Program
Program Manager

Fuel Cell Patents Reflect Emerging Growth



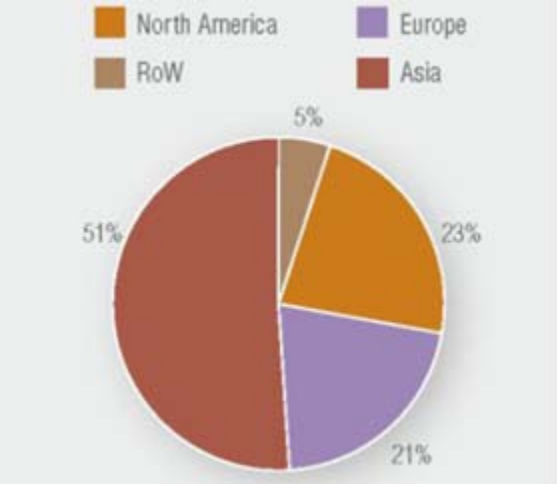
Clean Energy Patent Growth Index[1] shows that fuel cell patents lead in the clean energy field with nearly 1,000 fuel cell patents issued worldwide in 2010.

- **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://cepgi.typepad.com/heslin_rothenberg_farley_/

Patents and Job Creation

Job Creation by Region of Production 2009-2019



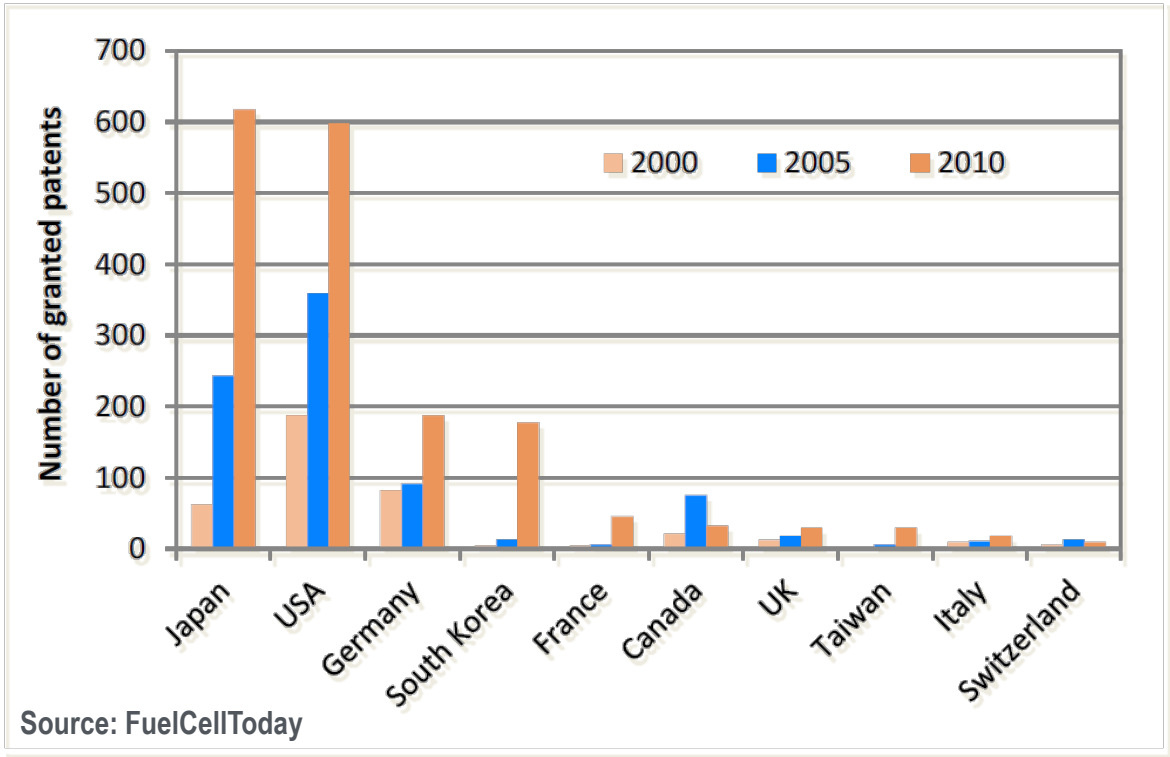
Source: FuelCellToday

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

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**

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



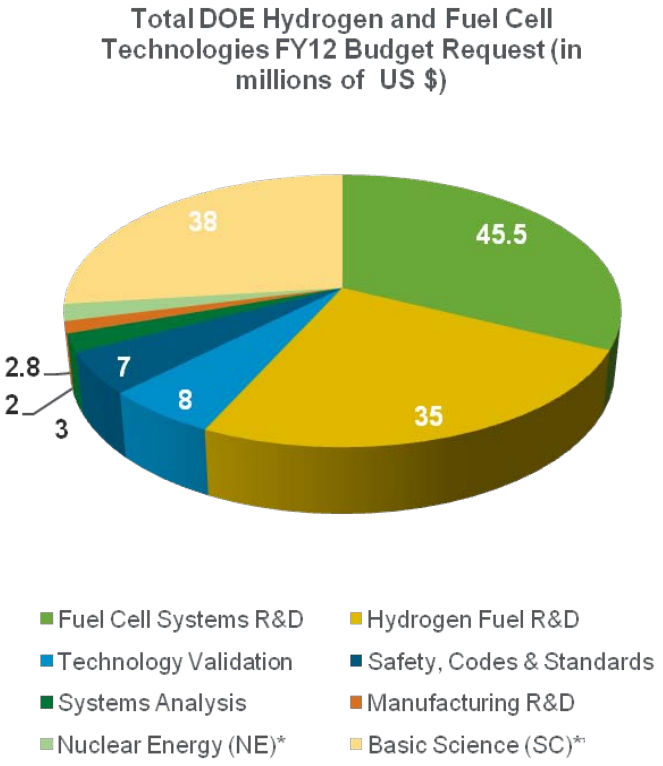
Source: FuelCellToday

H_2 & Fuel Cells Budget

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

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
Total	$170,297	$98,000	$100,450	$91,450	98,000



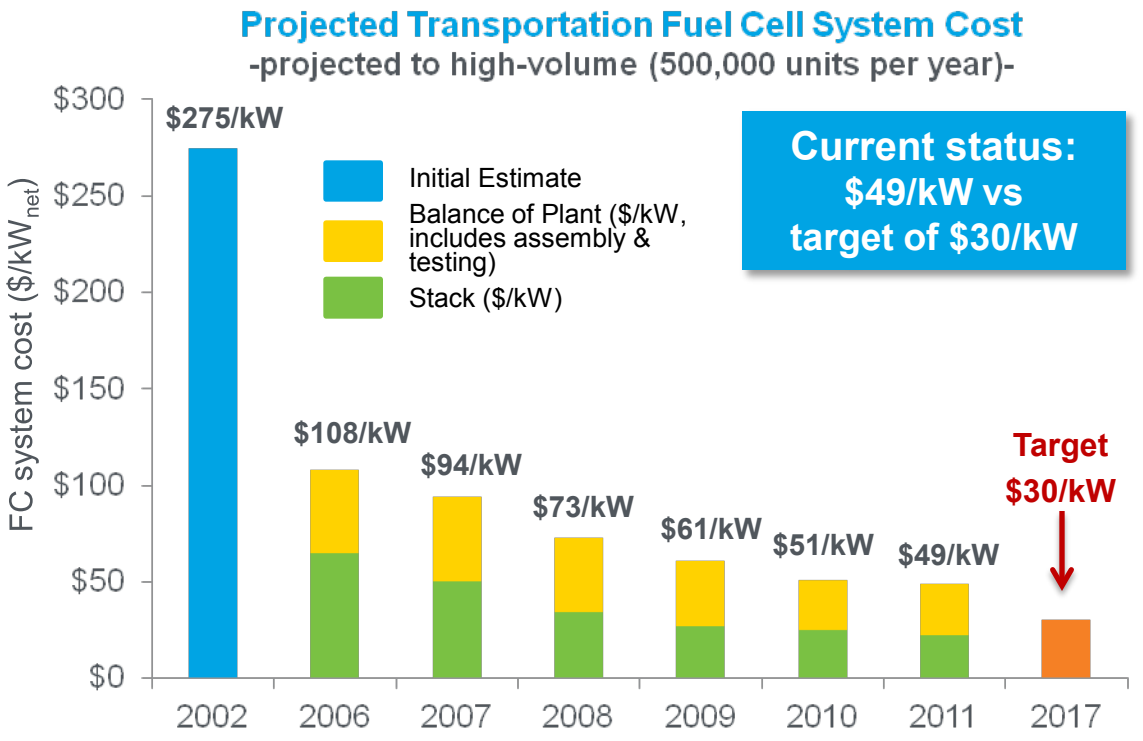
*Based on FY11 appropriations.

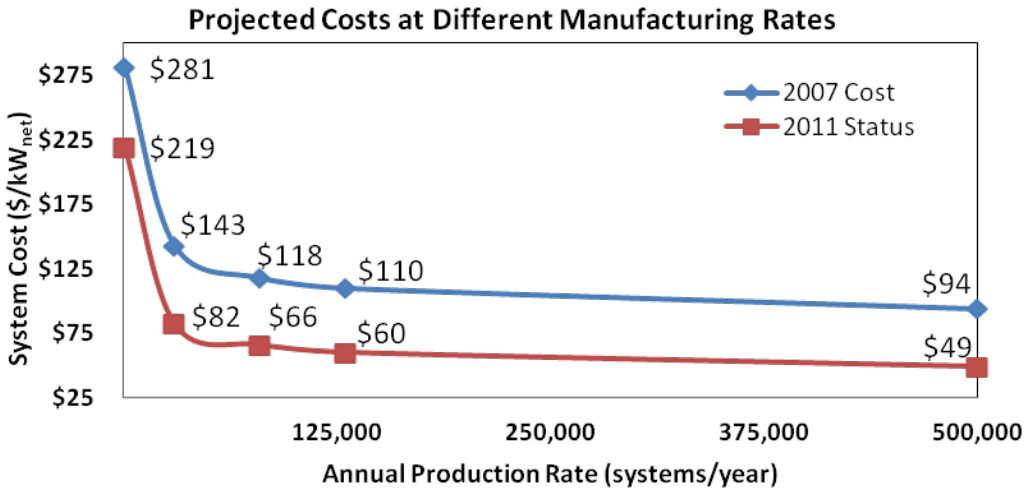
Notes: Hydrogen Fuel R&D includes Hydrogen Production , Delivery and Hydrogen Storage R&D. FY11, FY12 include SBIR/STTR funds to be transferred to the Science Appropriation; prior years exclude this funding

Progress – Fuel Cells

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***





***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.*

DOE Funded Accomplishments

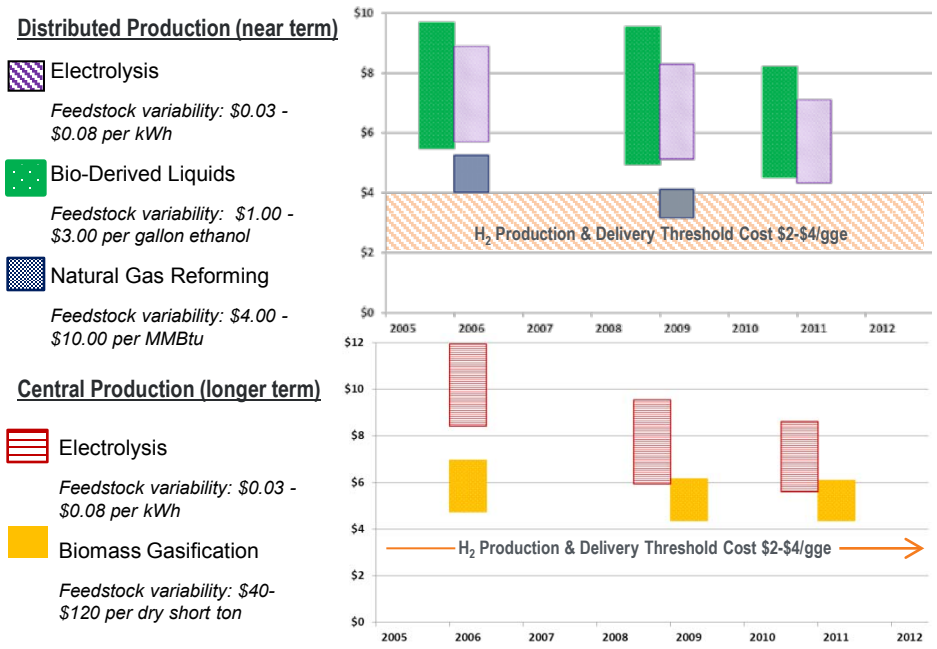
Reduced cost of H_2 production (multiple pathways)

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_2 fuel cell buses (w/ DOT) have a 42% to 139% better fuel economy when compared to diesel & CNG buses

Projected High-Volume Cost of Hydrogen Production1 (Delivered2)—Status



- **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**

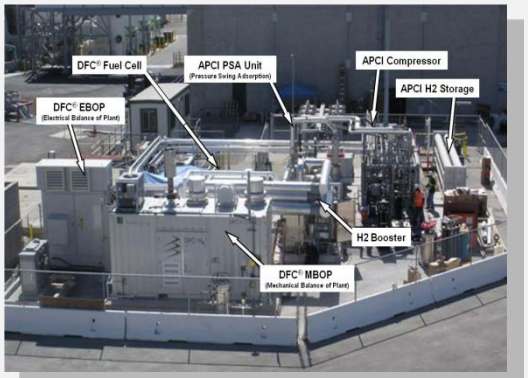
- **Demonstrated cycle-life of >50,000 refuelings of metal tanks for forklift applications**
- **Developed safety courses, educated >17,000 first responders and code officials through introductory web-based courses and advanced hands-on training**

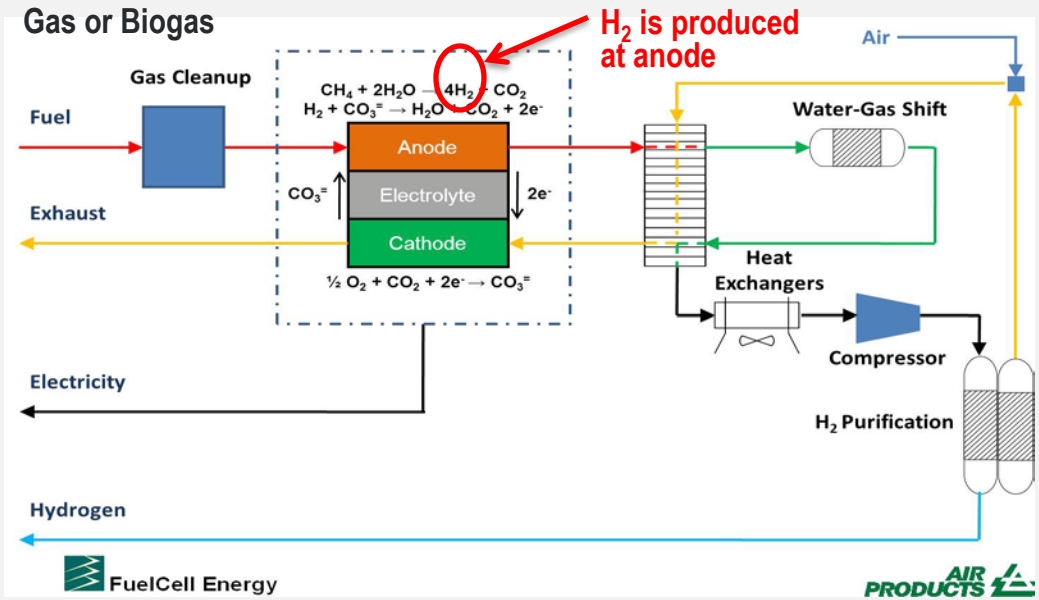
Technology Validation—Tri-Generation

"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-





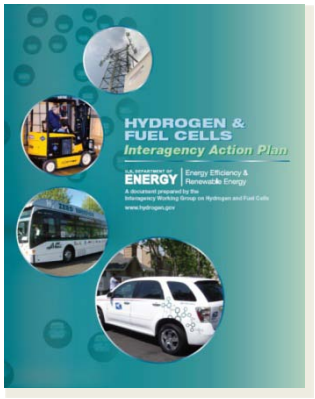
Fountain Valley demonstration

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

Program Updates

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

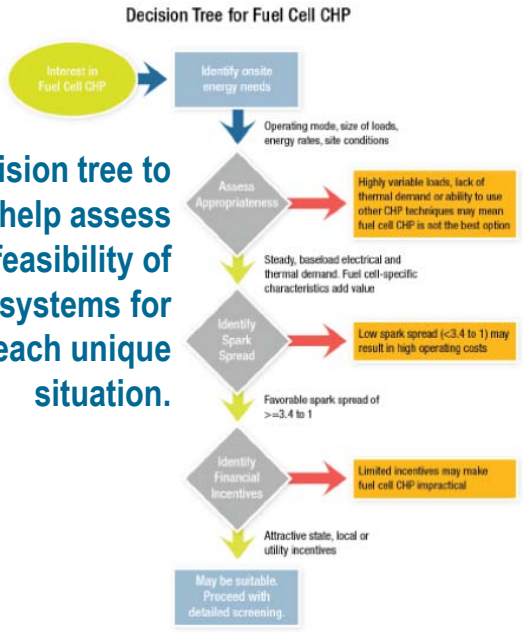
- Deployed ~830 fuel cells (primarily for lift trucks and back up power for cell phone towers)

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**



Decision tree to help assess feasibility of CHP systems for each unique situation.

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 as Catalyst for Deployments

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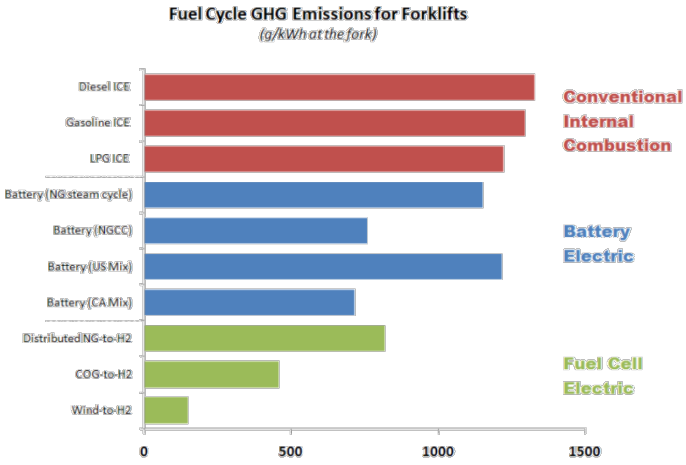
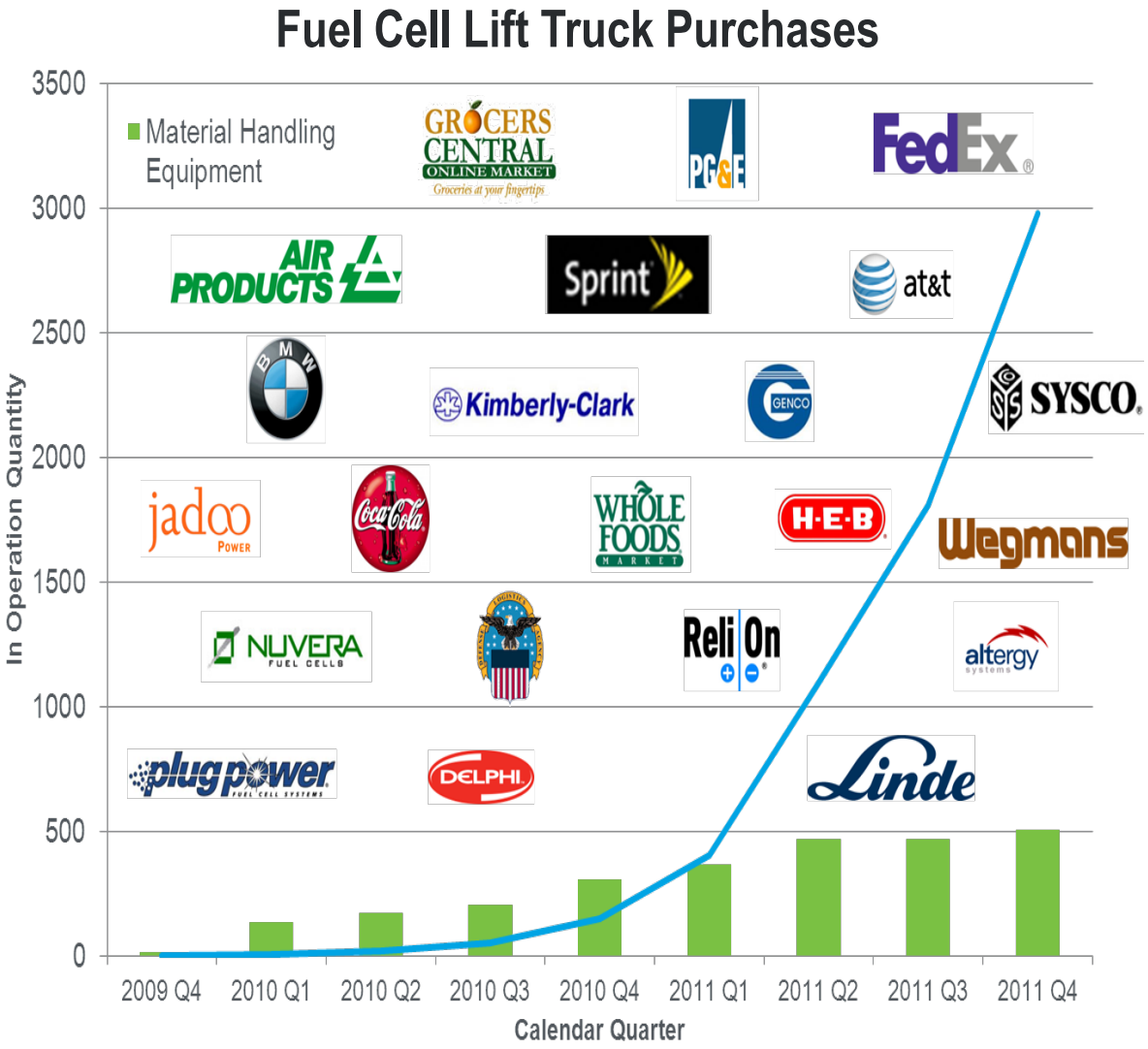
ARRA deployments of fuel cells for lift trucks (~400) led to industry purchases* of an estimated 3,000 additional fuel cell lift trucks with NO DOE funding

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**



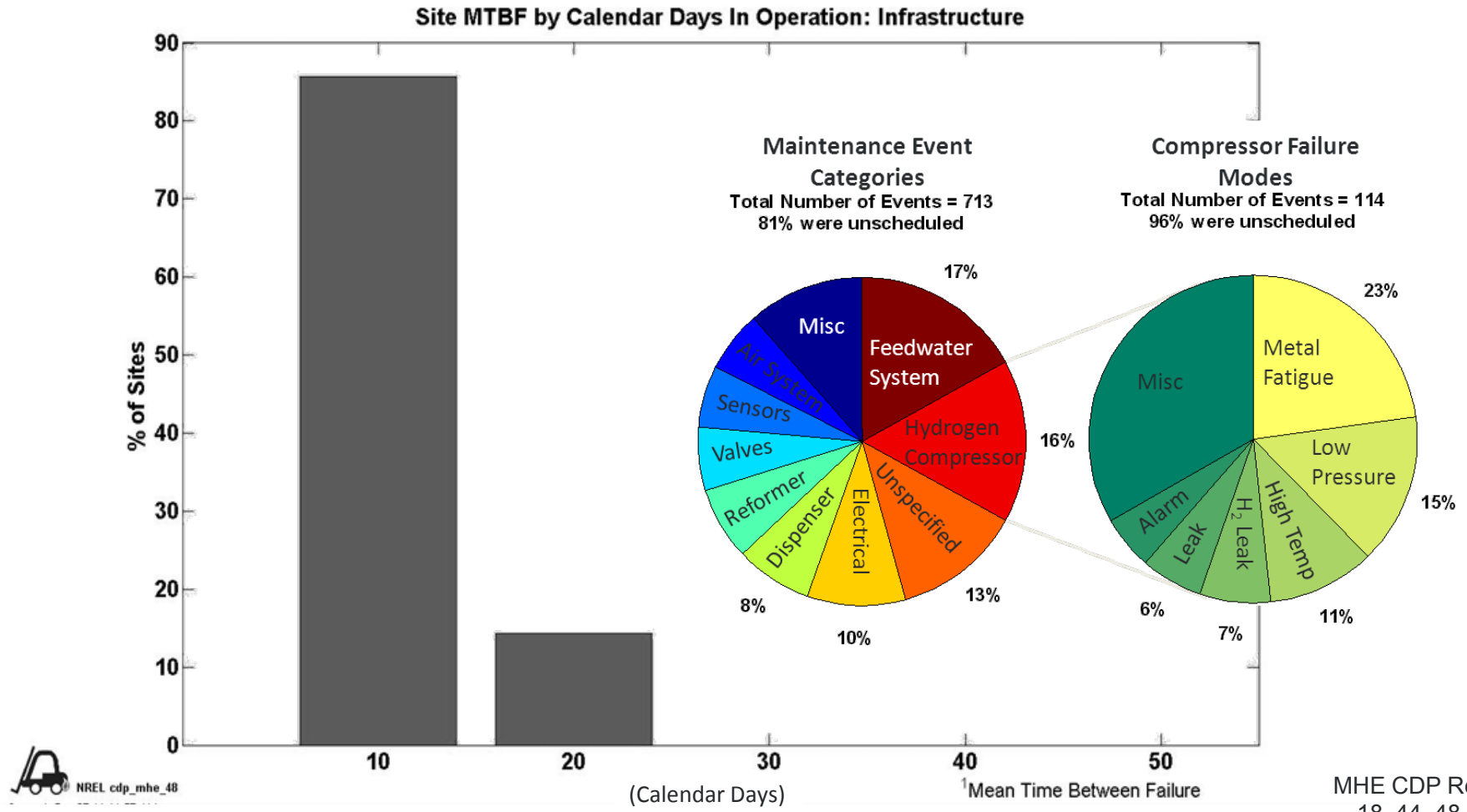
**Preliminary Analysis*



* Including deployed and on order

 Source: US DOE 11/8/2011

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.



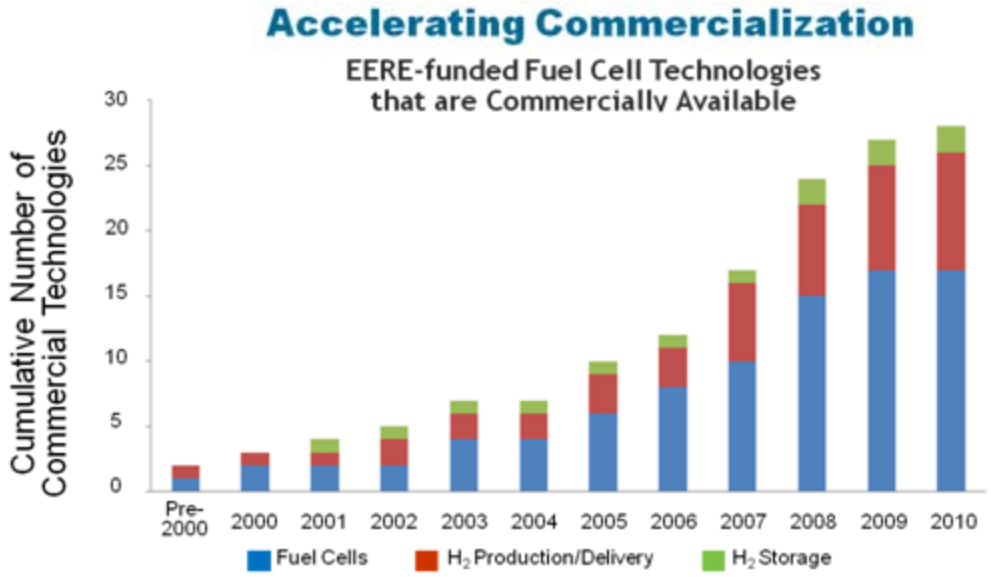
MHE CDP Ref #s:
18, 44, 48, & 52

Assessing the Impact of DOE Funding - *Commercializing Technologies*

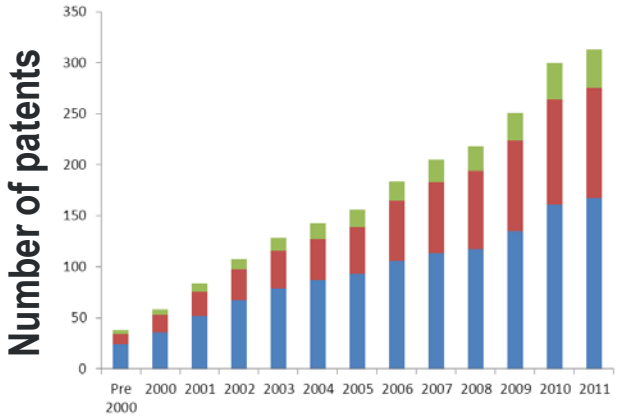
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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.



Source: Pacific Northwest National Laboratory
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_success_hfcit.pdf



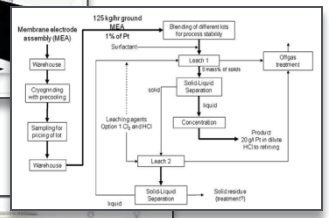
>300 PATENTS resulting from EERE-funded R&D:

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

Examples

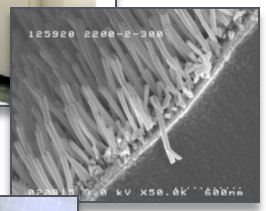
DuPont

BASF Catalysts LLC

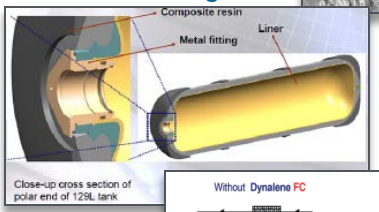


Proton Energy Systems

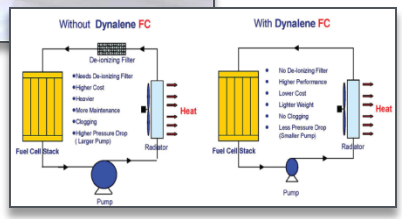
3M



Quantum Technologies



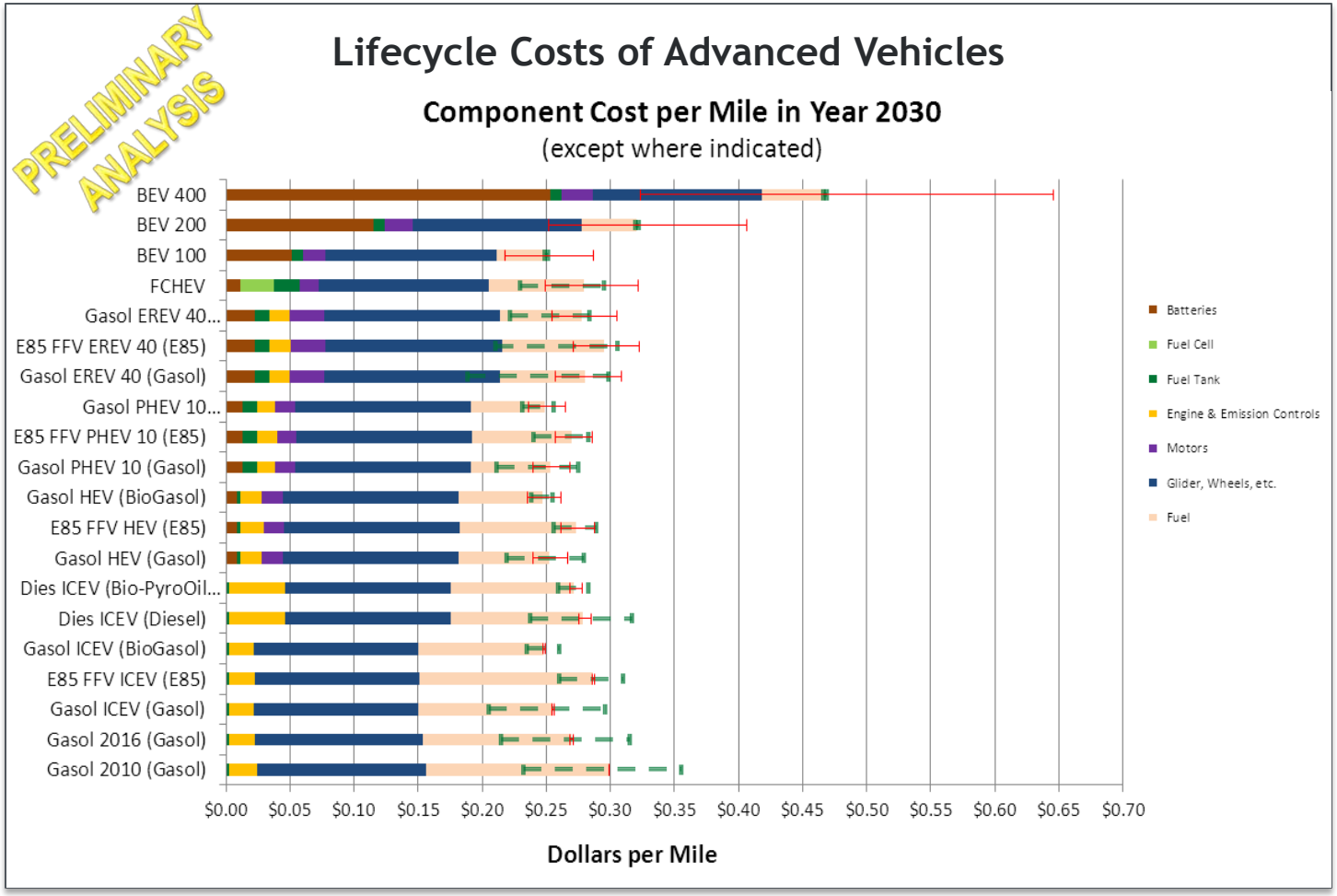
Dynalene, Inc.



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

RFI Closes: December 16, 2011

For Questions, Email: TCORFI@go.doe.gov



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

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.

Natural Gas and Hydrogen Infrastructure Opportunities

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

U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

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_2 use
- Identify and prioritize specific actions to address barriers
- Identify the roles of government and industry in promoting growth of natural gas and H_2 infrastructure

Tuesday, October 18th and Wednesday, October 19th 2011
Argonne Facilities, Chicago, Illinois
Organized by the Argonne National Laboratory for the U.S. Department of Energy

JOBS Fuel Cell Model

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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

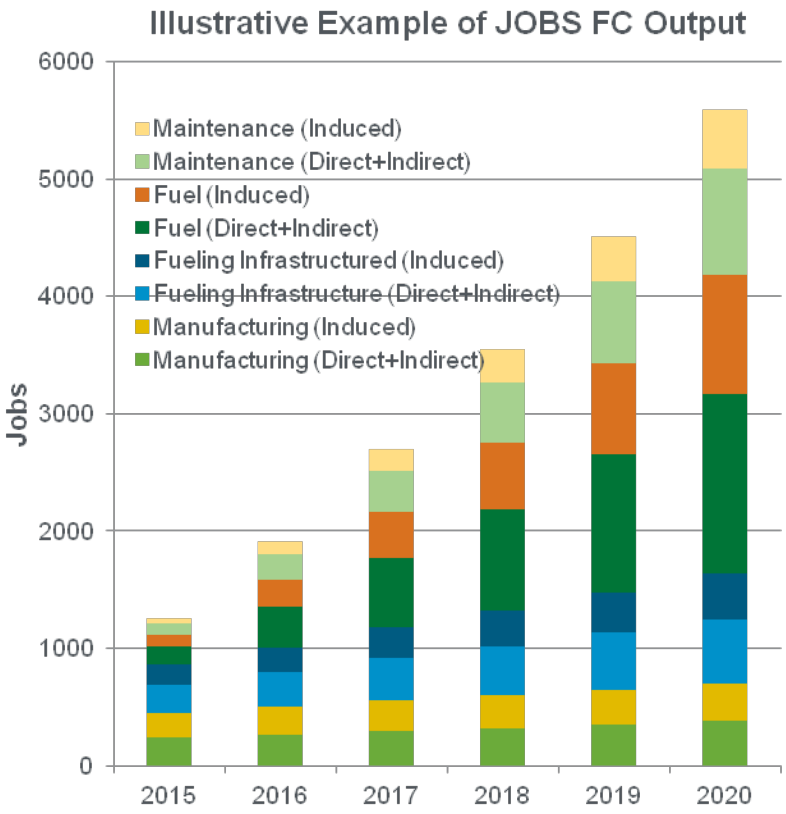
Step 1	Select State or Region:	<Please select>

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 prodution facility(s) in region

Step 4	Needed Capacity	What is the maximium 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	
					5 kW unit equivalent ratio	5 kW unit equivalents
	Class I/II forklift fuel cells (units/year)					-
	Class III forklift fuel cells (units/year)					-
	Backup power fuel cells (units/year)					-
					Total Needed Capacity	-

Step 5	Current Capacity	What is the maximium 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	
					5 kW unit equivalent ratio	5 kW unit equivalents
	Class I/II forklift fuel cells (units/year)					-
	Class III forklift fuel cells (units/year)					-
	Backup power fuel cells (units/year)					-
					Total Current Capacity	-



Jobs tools to be available for BETA testing December 2011.

www.hydrogen.energy.gov

Communication & Outreach

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

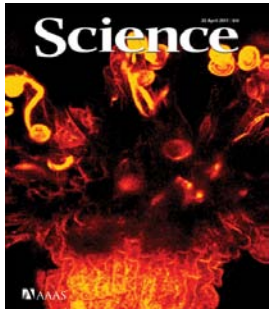
Communication and Outreach Activities include:

- 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_2 Student Design Contest: Registration closes November 15, 2011
- Portland Community College: Installed 1st 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

"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."



Progress in low and zero Pt catalysts highlighted in Science

Hydrogen fuel cells providing critical backup power

Hydrogen power lights at the space shuttle launch

Additional Information

EERE Budget: *FY10 - FY12*

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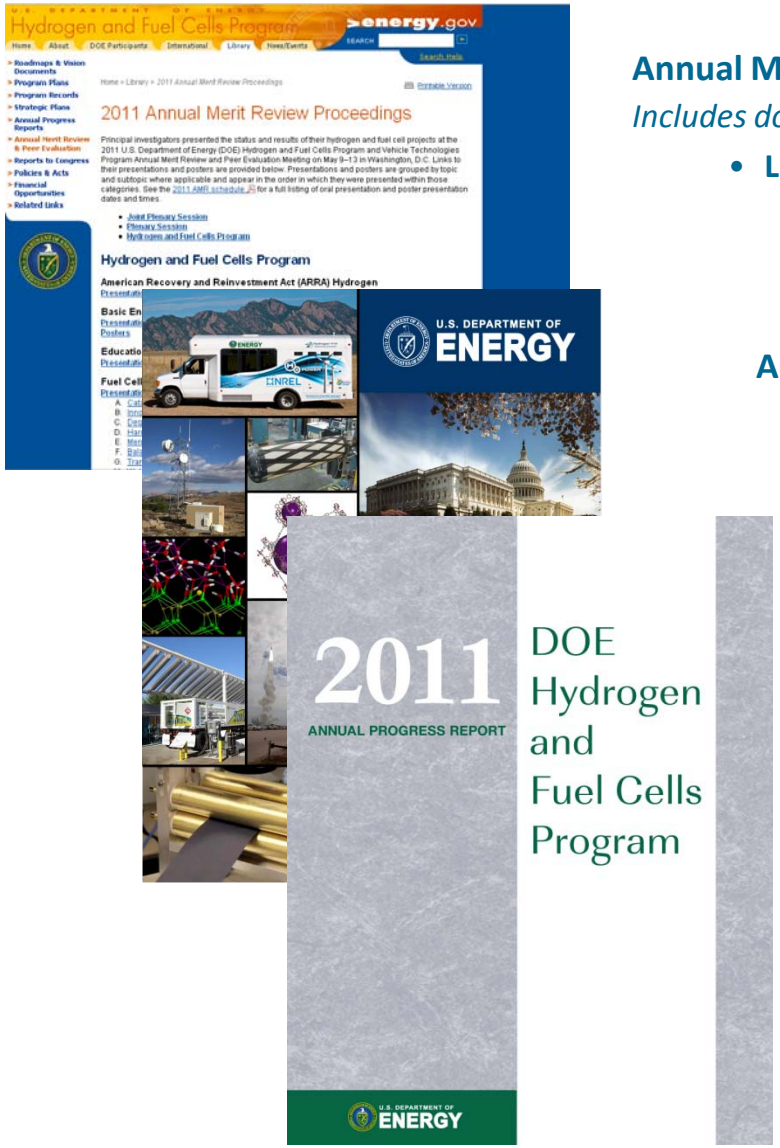
Funding *($ in thousands)*			
Activity	**FY 2010**	**FY 2011**	***FY 2012 Request***
Biomass and Biorefinery Systems	216,225	182,695	340,500
Building Technologies	219,046	210,500	470,700
Federal Energy Management Program	32,000	30,402	33,072
Geothermal Technology	43,120	38,003	101,535
Hydrogen and Fuel 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
Total	**$2,216,392**	**$1,795,641**	**$3,200,053**

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

Key Program Documents



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

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

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

Next Annual Review: May 14 – 18, 2012

Arlington, VA

http://annualmeritreview.energy.gov/