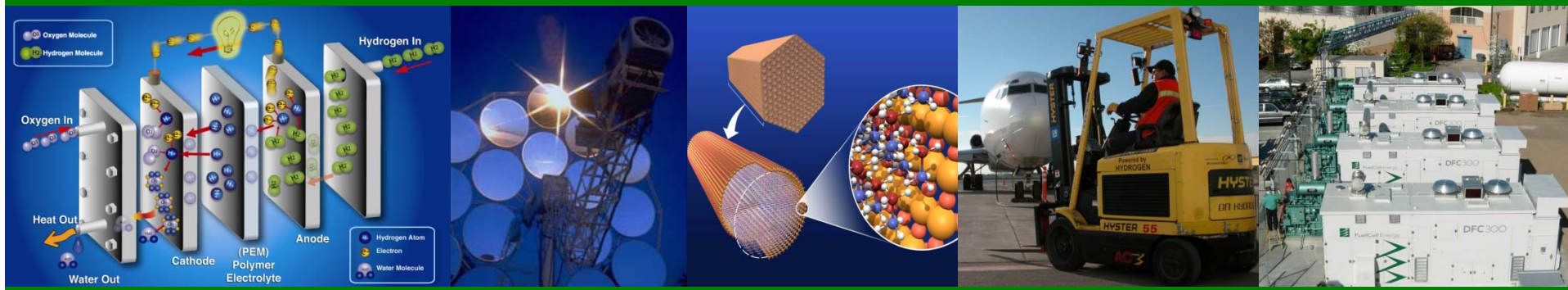




U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



An Introduction to the 2010 Fuel Cell Pre-Solicitation Workshop

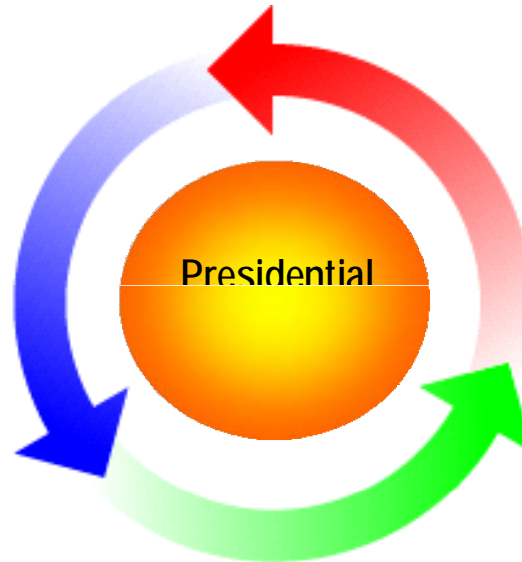
Dr. Dimitrios Papageorgopoulos
Team Lead Fuel Cells
US DOE Fuel Cell Technologies Program

Lakewood, Colorado
March 16, 2010

Energy efficiency and renewable energy research, development, and deployment activities help the Nation meet its **economic**, **energy security**, and **environmental** challenges concurrently.

Energy Security

- Deploy the cheapest, cleanest, fastest energy source – energy efficiency
- One million plug-in hybrid cars on the road by 2015
- Develop the next generation of sustainable biofuels and infrastructure
- Increase fuel economy standards



Economic

- Create green jobs through Recovery Act energy projects
- Double renewable energy generation by 2012
- Weatherize one million homes annually

Environmental

- Implement an economy-wide cap-and-trade program to reduce greenhouse gas emissions 80 percent by 2050
- Make the US a leader on climate change
- Establish a national low carbon fuel standard

The key program objective is to make fuel cells competitive with incumbent technologies and other advanced technologies in terms of lifecycle cost, performance, and market acceptance.

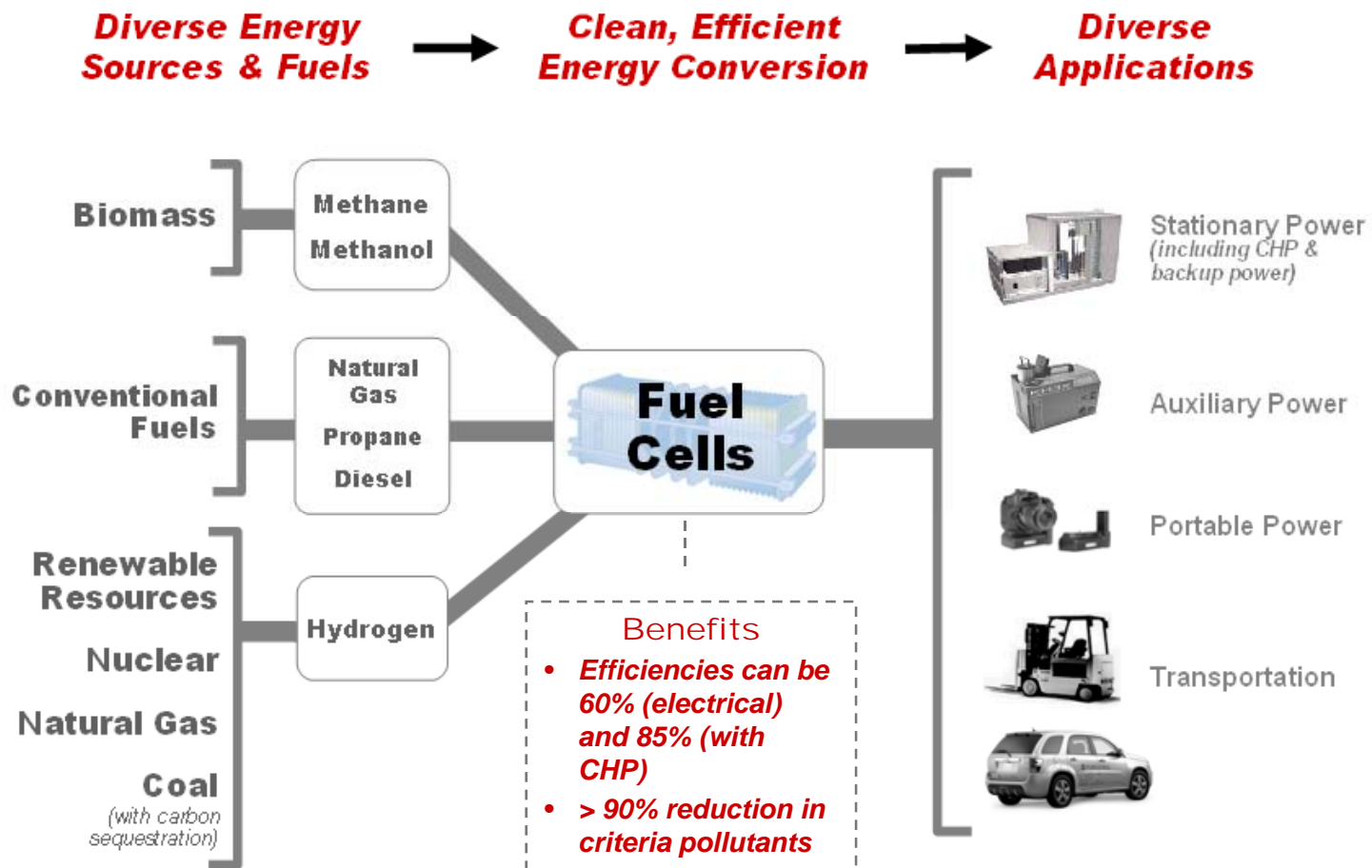
Fuel Cells: Addressing Energy Challenges

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.



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

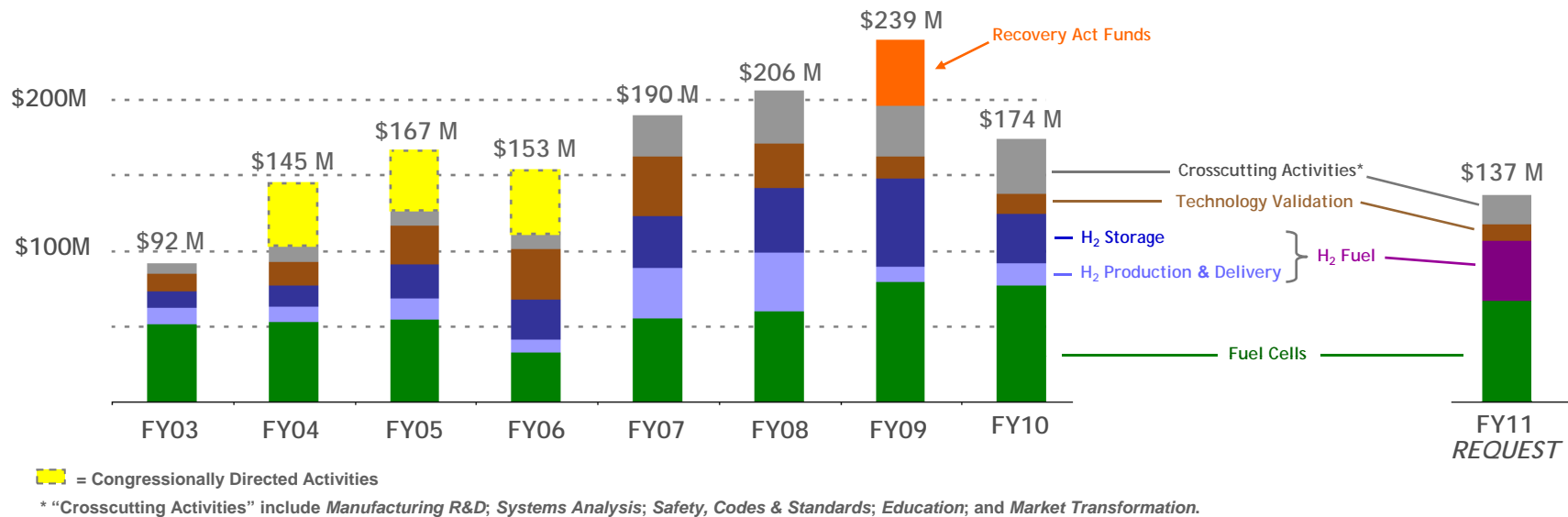
~ 60 fueling stations

Several manufacturers—including Toyota, Honda, Hyundai, Daimler, GM, and Proterra (buses)—have announced plans to commercialize vehicles by 2015.

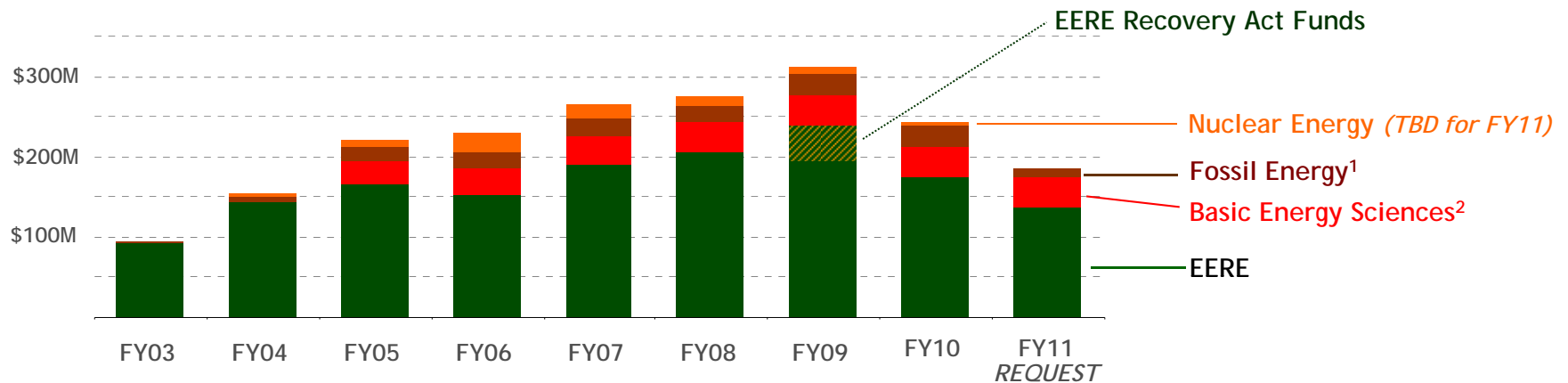


Funding History: *FY03 – FY11*

EERE Funding for Hydrogen & Fuel Cells



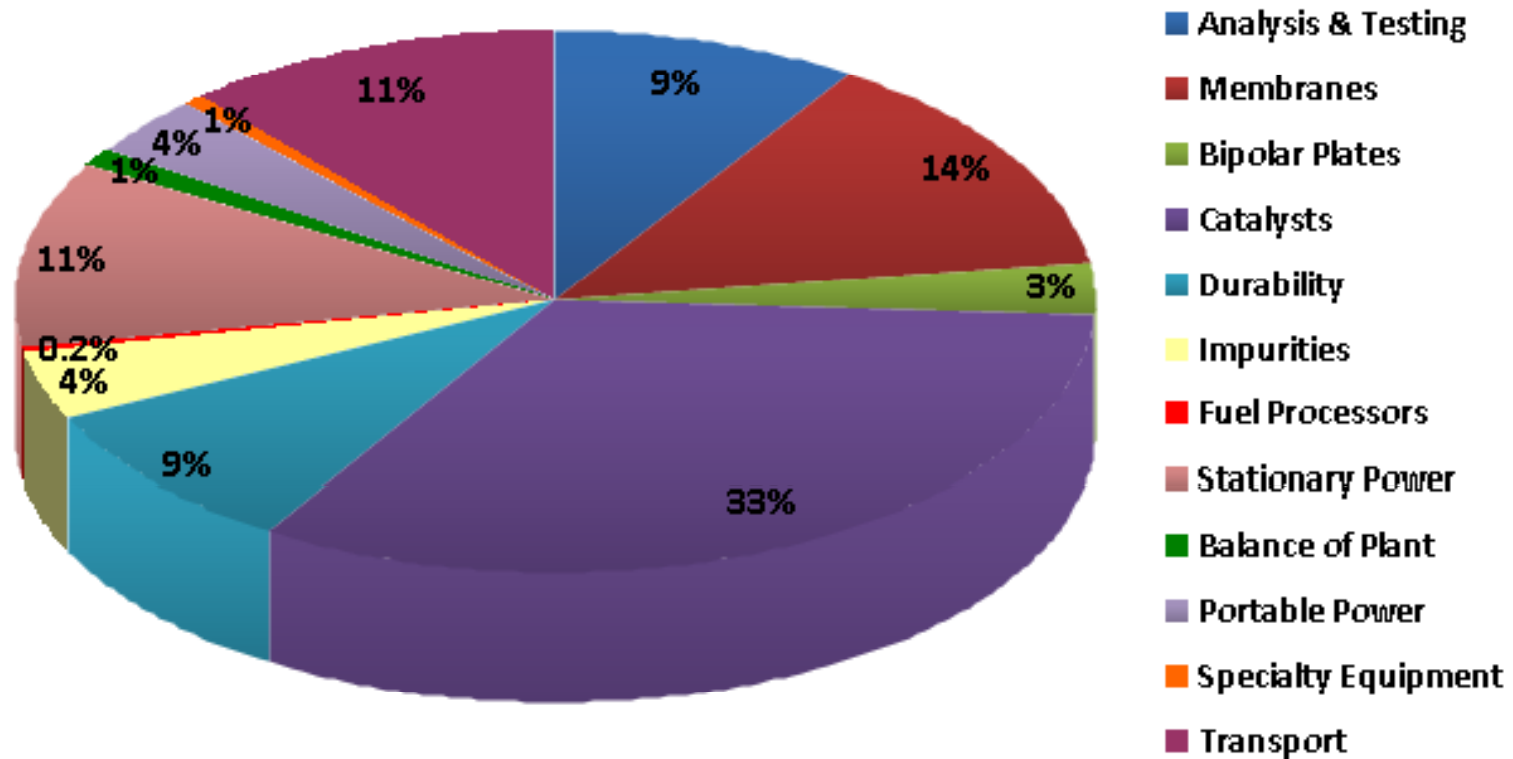
DOE Funding for Hydrogen & Fuel Cells



¹ FE also plans \$50M for SECA in FY11.

² The Office of Science also plans ~\$14M for hydrogen production research in the Office of Biological and Environmental Research in FY11.

2010 Funding Breakdown (Fuel Cells)



FY10 Appropriation : \$ 77.480 Million

EERE H₂ & Fuel Cells Budgets

Funding (\$ in thousands)				
Key Activity	FY 2008	FY 2009 ⁴	FY 2010	FY 2011 Request
Fuel Cell Systems R&D¹	-	-	-	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
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	14,789⁵	13,097	11,000
Market Transformation³	0	4,747	15,026	9,000
Safety, Codes & Standards	15,442	12,238 ⁵	8,839	-
Education	3,865	4,200 ⁵	2,000	-
Systems Analysis	11,099	7,520	5,556	5,000
Manufacturing R&D	4,826	4,480	5,000	5,000
Total	\$206,241	\$195,865	\$174,000⁶	\$137,000

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 Market Transformation will fund only Safety, Codes and Standards in FY 2011

⁴ FY 2009 Recovery Act funding of \$42.967M not shown in table

⁵ Under Vehicle Technologies Budget in FY 2009

⁶ Includes SBIR/STTR funds to be transferred to the Science Appropriation; all prior years shown exclude this funding

*Fuel Cell R&D is focused on a broad range of applications,
using a variety of technologies and fuels.*

EXAMPLES OF KEY TARGETS:

Distributed Power:

- \$750/kW by 2011
 - 40,000-hour durability by 2011
 - 40% efficiency by 2011
- TARGETS FOR RESIDENTIAL CHP ARE BEING DEVELOPED

Transportation:

- \$45/kW by 2010; \$30/kW by 2015
- 5,000-hour durability by 2015
- 60% efficiency

APUs:

- Specific power of 100 W/kg by 2010
 - Power density of 100 W/L by 2010
- TARGETS FOR APUs ARE BEING REVISED

Portable Power:

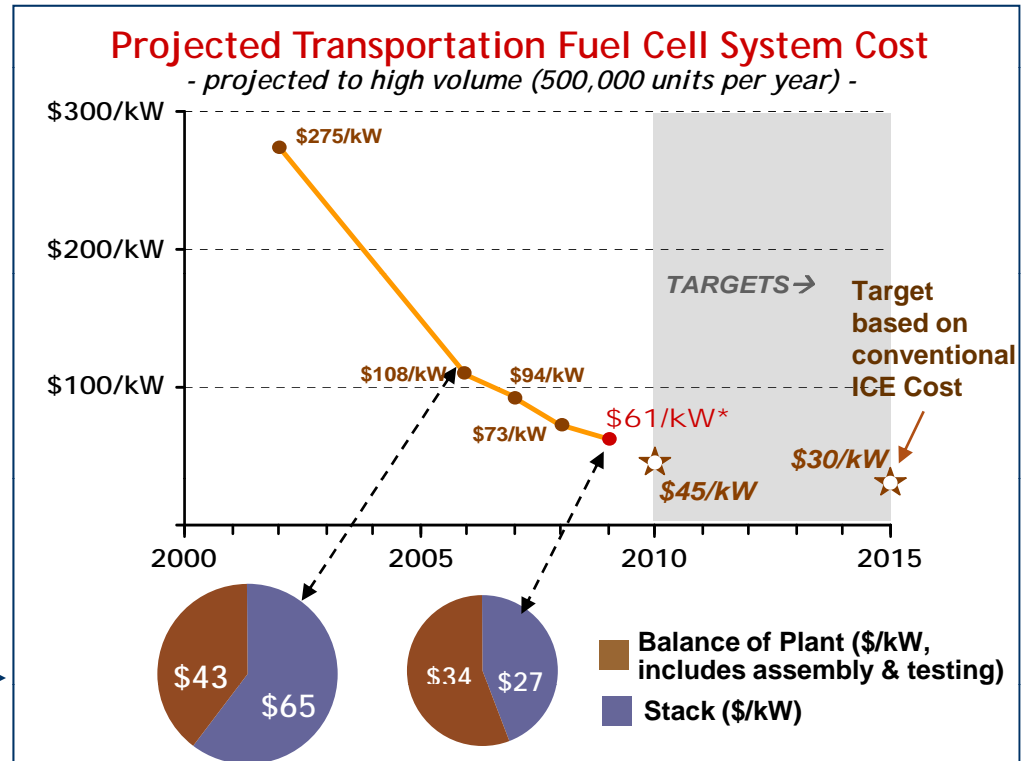
- Energy density of 1,000 W-h/L by 2010
- TARGETS FOR PORTABLE POWER ARE BEING REVISED



We've reduced the cost of fuel cells to \$61/kW*

- More than 35% reduction in the last two years
- More than 75% reduction since 2002
- 2008 cost projection was validated by independent panel**

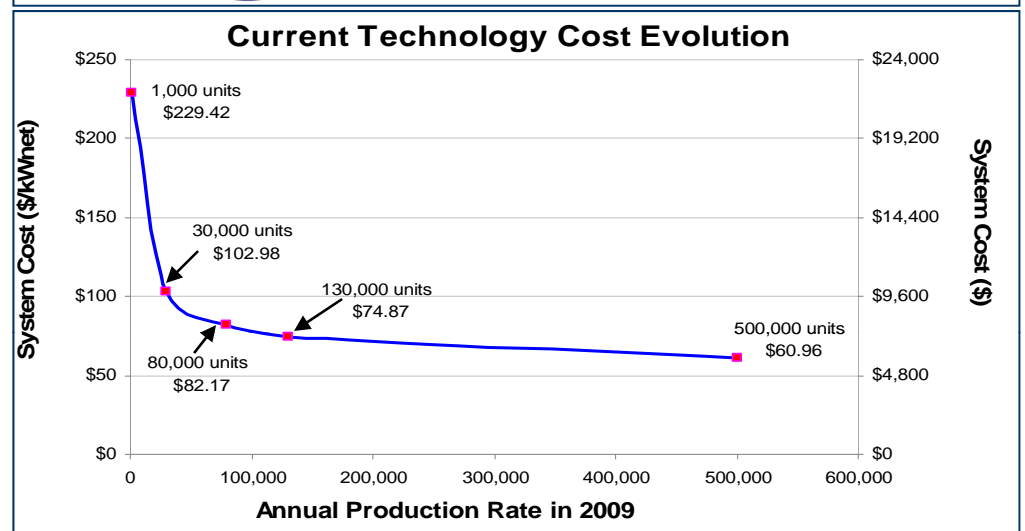
As stack costs are reduced, balance-of-plant components are responsible for a larger % of costs.



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

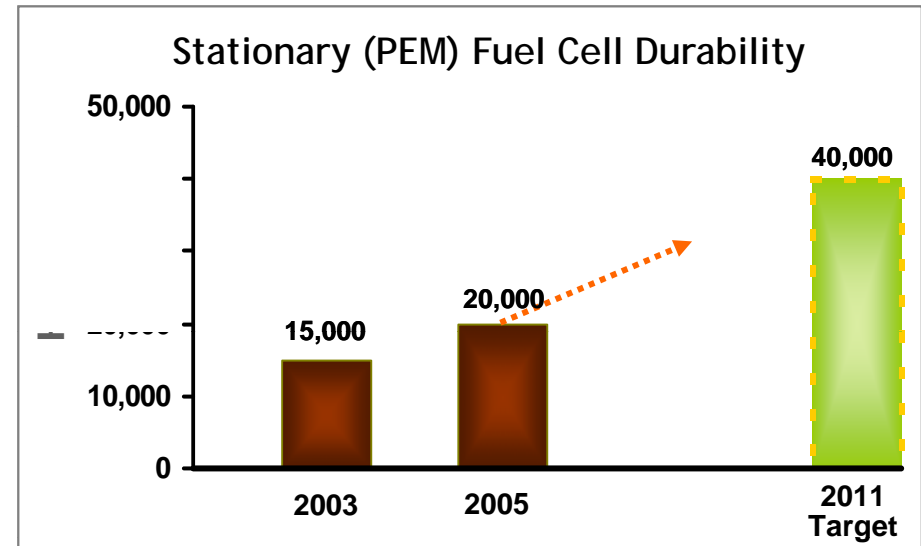
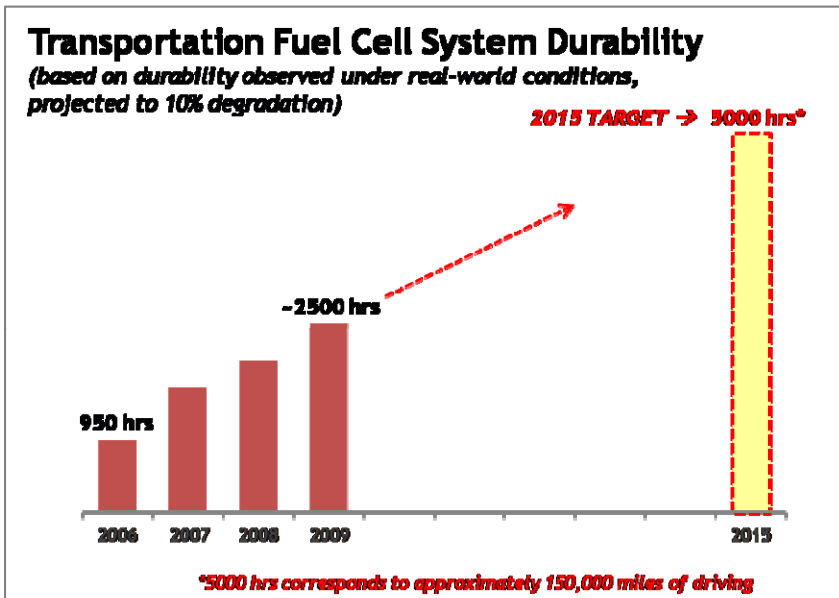
**Panel found \$60 – \$80/kW to be a “valid estimate”:
http://hydrogendoedev.nrel.gov/peer_reviews.html

- 2015 high-volume (500k/yr), 80-kW direct hydrogen transportation FC system cost target is **\$30/kW** to compete with conventional ICE



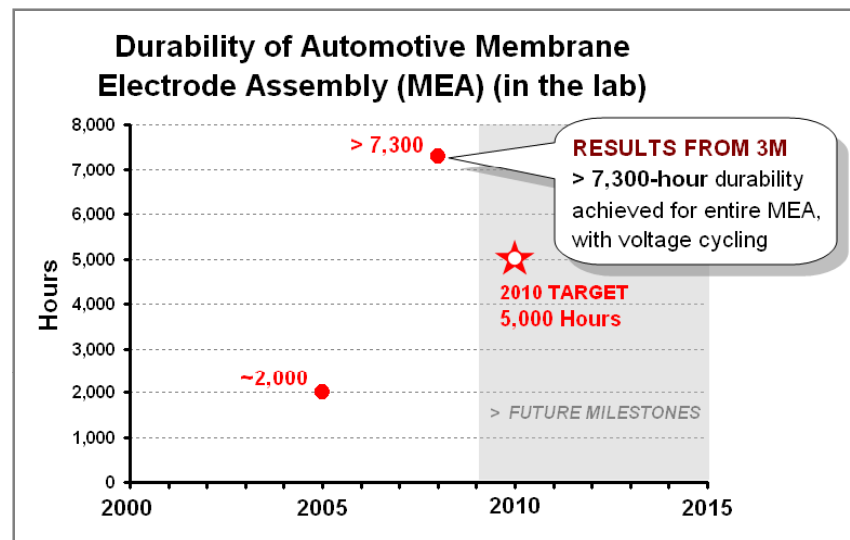
Fuel Cell R&D — Progress

We've greatly increased durability—including more than doubling the demonstrated durability of transportation fuel cells.



Demonstrated >7,300-hour durability →

This exceeds our target for MEA durability, in single-cell testing—and has the potential to meet the 2010 target for MEAs in a fuel cell system.





November 6, 2009 Palm Springs Convention Center Objectives

- Provide an overview of the state-of-the-art and most recent technical progress
- Identify critical areas, key barriers and gaps in current technology related to the fuel cell
- Identify opportunities for progress in these areas
- Promote potential research collaborations and create and strengthen partnerships

Final report released March 2010

Workshop Purpose:

To gather input from the research community and relevant stakeholders regarding pre-competitive R&D needs and technical barriers related to fuel cells and fuel cell systems designed for stationary and transportation applications as well as cross-cutting stack and BOP component technology

Breakout Group Objectives:

- To list key technical barriers
- Determine R&D needs and priorities

Tuesday, March 16

- 12:30 Welcome and Introduction– Dimitrios Papageorgopoulos, *DOE*
- 12:45 Summary of Input from the DOE Request for Information – Greg Kleen, *DOE*
- 1:00 Automotive Fuel Cell R&D Needs– Craig Gittleman, *General Motors, USCAR*
- 1:45 Integration of MEA components – Mark Debe, *3M*
- 2:30 *Break*
- 2:45 Balance of Plant Needs and Integration of Stack Components for Stationary Power Applications – Chris Ainscough, *Nuvera*
- 3:15 Fuel Processor RD&D Needs – Pinaken Patel, *FuelCell Energy*
- 3:45 Solid Oxide Fuel Cell Balance of Plant and Stack Component Integration – Norman Bessette, *Acumentrics*
- 4:15 *Break*
- 4:30 Long-Term Innovative Technologies -Bryan Pivovar, *NREL*
- 5:00 Facilitated Open Discussion – Shawna McQueen, *Energetics*
- 5:30 Adjourn

Wednesday, March 17

8:00 Description of Breakout Groups Logistics and Purpose – Shawna McQueen,
Energetics

8:15 Facilitated **Breakout Groups** (suggested):

- 1) **System BOP and Fuel Processors for Stationary Applications**
- 2) **System BOP for Automotive Applications**
- 3) **SOFC System BOP and Stack Component Integration for Stationary**
- 4) **Applications**
- 5) **MEA/Stack Component Integration for PEM Systems**
- 6) **Long-Term Innovative Technologies (AFC, HT membranes, non-PGM catalysis, etc.)**

12:00 *Lunch (on your own)*

1:15 Breakout Group Reports (15 min each, 10 min report plus 5 min questions)

2:45 *Break*

3:00 Facilitated Open Discussion – Shawna McQueen

3:25 Wrap Up -- Dimitrios Papageorgopoulos

3:30 Adjourn

Please sign up for the Breakout Group that you are most interested in

DOE Fuel Cell Manufacturing R&D Webinar Invitation Released



All DOE Fuel Cell Pre-Solicitation Workshop Attendees are invited to a Webinar from 2 to 3:30 PM on Tuesday, March 23, 2010 to participate in a discussion of **manufacturing technique** or **process improvements** needed to accelerate fuel cell adoption for stationary, distributed electric power generation. We will discuss fuel cell manufacturing topical areas in preparation for subsequently issuing a formal Request For Information. Sources of questions and comments will be held in confidence.

Pete Devlin

DOE Fuel Cell Technologies, Manufacturing R & D Team

LOGIN INFORMATION:

1. Please join my Webinar.

<https://www.gotowebinar.com/register/148719456>

2. You will be connected to audio using your computer's microphone and speakers (VoIP). A headset is recommended.

Or, you may select "Use Telephone" after joining the Webinar.

Dial 312-878-0222

Access Code: 414-678-851

Audio PIN: Shown after joining the meeting

Webinar ID: 148-719-456

A few key things:

* Matt Simon from Energetics, Inc. will be running and supporting the webinar. If at anytime you are having technical issues, please contact him (note: Matt will be seen as Shawna McQueen on the webinar).

* If you have any technical problems with the webinar, please call Matt's cell phone (his office line will be busy). Matt's cell number is 206-910-7757. You may also e-mail him at matthew.simon@ee.doe.gov.

* If you call in (rather than use a computer mic), once you log into the webinar, call the number below. Enter the access code (6 digits) when prompted. Then enter your two digit PIN that will show up after you have logged into the webinar. If you cannot find it, contact Matt Simon and he can tell you what it is.

* If you have a question/comment to make during the Question & Answer session of the presentation, please type your question into the webinar question box. To ensure confidentiality, Matt will read the questions aloud verbatim rather than have attendees ask themselves. Only Matt will have access to these questions.

* All registration information entered by attendees will only be available to Matt. To ensure confidentiality, at the conclusion of the webinar all personal contact information linked to the webinar and questions will be erased.



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

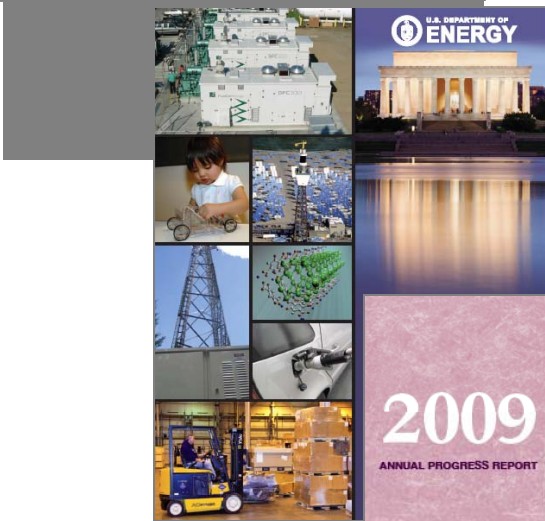


Annual Merit Review Proceedings

Includes downloadable versions of all presentations at the Annual Merit Review

→ Latest edition released June 2009

www.hydrogen.energy.gov/annual_review09_proceedings.html

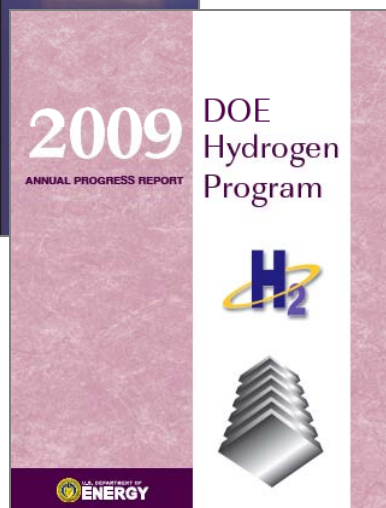


Annual Merit Review & Peer Evaluation Report

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: June 7 - 11, 2010

Washington, D.C.

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

Thank you

Dimitrios.Papageorgopoulos@ee.doe.gov

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

Targets are continually assessed and refined.

Recent Request for Information (RFI) on **proposed technical and cost targets for fuel cells for combined heat and power and auxiliary power applications** generated responses from 18 entities, including a variety of industrial and government laboratory representatives.

Based on responses, a **revised set of targets has been prepared** that will appear in final form in the next revision of the Fuel Cell Technologies program Multi-Year Research, Development and Demonstration Plan, which is due to be released in 2010.

Technical Targets: 1 – 10 kW_e Fuel Cell **Auxiliary Power Units** Operating on Standard Ultra-low Sulfur Diesel Fuel

	2008 Status	2012	2015	2020
Electrical efficiency at rated power ^[1]	25%	30%	35%	40%
Power density	17 W/L	30 W/L	35 W/L	40 W/L
Specific power	20 W/kg	35 W/kg	40 W/kg	45 W/kg
Factory Cost ^[2]	\$750/kW	\$700/kW	\$600/kW	\$500/kW
Transient response (10 - 90% rated power)	5 min	4 min	3 min	2 min
Start-up time from 20°C ambient temperature	50 min	30 min	10 min	5 min
Degradation with cycling ^[3]	2.6%/1000 h	2%/1000 h	1.3%/1000 h	1%/1000 h
Operating lifetime ^[4]	~3000 h	10,000 h	15,000 h	20,000 h
System availability	97%	97.5%	98%	99%

^[1] Regulated DC net/LHV of fuel.

^[2] Cost includes materials and labor costs to produce stack, plus any balance of plant necessary for stack operation. Cost defined at 50,000 unit/year production (250 MW in 5-kW modules).

^[3] Based on operating cycle to be released in 2010.

^[4] Time until >20% net power degradation

Targets are continually assessed and refined.

Technical Targets: 1 – 10 kW_e Residential **Combined Heat and Power** Fuel Cells Operating on Natural Gas[1]

	2008 Status	2012	2015	2020
Electrical effi. at rated power ^[2]	34%	40%	42.5%	45%
CHP energy efficiency ^[3]	80%	85%	87.5%	90%
Factory Cost ^[4]	\$750/kW	\$650/kW	\$550/kW	\$450/kW
Transient response (10 - 90% rated power)	5 min	4 min	3 min	2 min
Start-up time from 20°C ambient temperature	60 min	45 min	30 min	20 min
Degradation with cycling ^[5]	< 2%/1000 h	0.7%/1000 h	0.5%/1000 h	0.3%/1000 h
Operating lifetime ^[6]	6000 h	30,000 h	40,000 h	60,000 h
System availability	97%	97.5%	98%	99%

[1] Standard utility natural gas delivered at typical residential distribution line pressures

[2] Regulated AC net/LHV of fuel.

[3] Only heat available at 80 °C or higher is included in CHP energy efficiency calculation.

[4] Cost includes materials and labor costs to produce stack, plus any balance of plant necessary for stack operation. Cost defined at 50,000 unit/year production (250 MW in 5-kW modules).

[5] Based on operating cycle to be released in 2010.

[6] Time until >20% net power degradation.

Fuel Cell Cost Breakdown

DOE continues to track cost projections & estimated cost reductions, on track towards reaching long-term targets. Continued efforts on cost and durability are required.

