



Fuel Cell Operation at Sub-Freezing Temperatures

DOE Program/Targets and Workshop Objectives

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DOE Hydrogen Program



Sub-Freezing Temperature
Effects on Fuel Cells
Workshop
Phoenix AZ
February 1-2, 2005



Outline

- **Hydrogen Fuel Initiative**
- **The Hydrogen, Fuel Cells, and Infrastructure Technologies Program**
- **Technical Targets**
- **DOE Fuel Cell & Hydrogen Activities**
- **Workshop Objectives**



Hydrogen Fuel Initiative

- Presidential Initiative commits \$1.7 Billion over 5 years
 - \$1.2 Billion for hydrogen and fuel cells (Million in new money)
 - \$0.5 Billion for hybrid and vehicle technologies
- Enables commercialization decision by 2015
- Fuel cell vehicles in showroom and hydrogen at fuel stations by 2020





Hydrogen, Fuel Cells and Infrastructure Technologies Program

- The program's mission is to **research, develop, and validate fuel cell and hydrogen production, delivery, and storage technologies for transportation and stationary applications.**
- The program aims to have hydrogen from diverse domestic resources used in a clean, safe, reliable, and affordable manner in fuel cell vehicles, centralized power stations, and distributed combined heat and power applications.



DOE Hydrogen Program Budget

MAJOR LINE ITEMS	FY 04 Appropriations (\$000)	FY 05 Request (\$000)	FY 05 Appropriations* (\$000)
Production & Delivery R&D (EE)	\$22,564	\$25,325	\$14,363
Storage R&D (EE)	\$29,432	\$30,000	\$23,830
Safety, Codes & Standards, and Utilization (EE)	\$5,904	\$18,000	\$6,061
Infrastructure Validation (EE)	\$18,379	\$15,000	\$9,573
Systems Analysis (EE)	\$5,712	\$7,000	\$3,444
Earmarks (EE)			\$37,301
EERE Hydrogen Technology Subtotal– (EWD)	\$81,991	\$95,325	\$94,572
NE Hydrogen Subtotal – (EWD)	\$6,400	\$9,000	\$8,929
FE Hydrogen Subtotal – (Interior)	\$4,900	\$16,000	\$17,085
SC – (EWD)	\$0**	\$29,200	\$29,183
DOT			\$544
Hydrogen Technology Total	\$93,791	\$149,525	\$150,525

* Subject to approval; includes \$37M of earmarked projects. Eliminates education.

**Excludes \$8M of baseline activities not counted as part of initiative



DOE PEM Fuel Cell Program Budget

KEY ACTIVITY	FY 04 Appropriations (\$000)	FY 05 Request (\$000)	FY 05 Appropriations (\$000)
Transportation Systems	\$7,506	\$7,600	\$7,495
Distributed Energy Systems	\$7,408	\$7,500	\$6,902
Fuel Processor R&D	\$14,815	\$13,858	\$9,721
Stack Component R&D	\$25,186	\$30,000	\$32,541
Technology Validation	\$9,877	\$18,000	\$17,750
Technical Prog. Mgmt. Support	\$395	\$542	\$535
Fuel Cell Technology Total	\$65,187	\$77,500	\$74,944



FY 05 EERE Fuel Cell Activities

Fuel Processor R&D \$9,721K

- LPG or propane fuel processing technology for stationary applications
- Fuel processor catalysts

Distributed Energy Systems \$6,902K

- High efficiency PEMFC power systems as an alternative to grid-based electricity for buildings

Transportation Systems \$7,495K

- System analysis
- System sensors
- Compact humidifiers/heat exchangers
- Auxiliary power in trucks
- Portable power applications
- Full scale compressors

Technical/Program Management Support \$535K

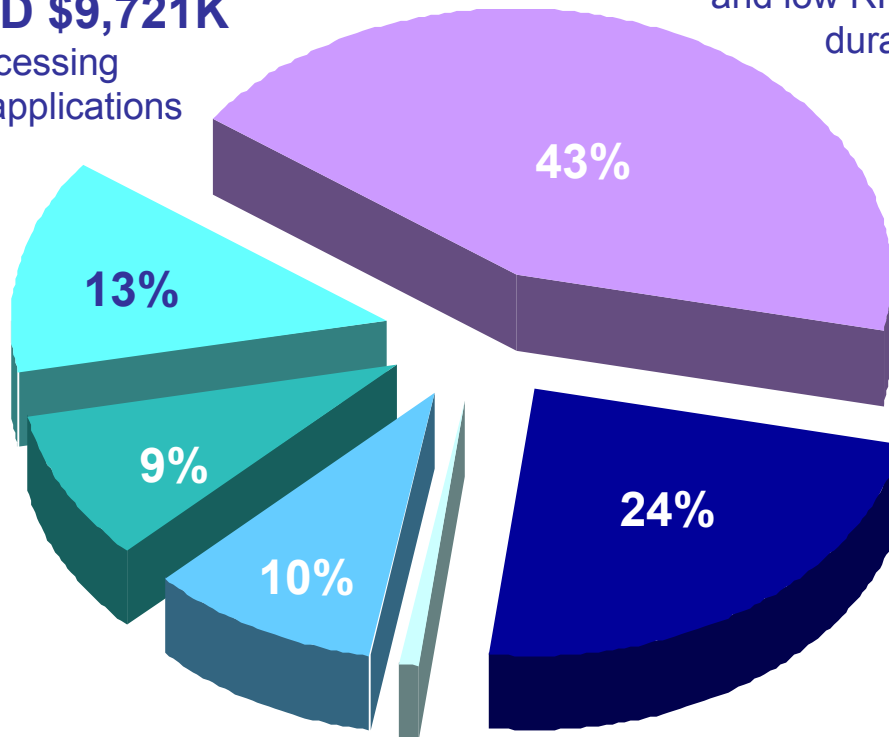
- Program, strategic & operating plans

Stack Component R&D \$32,541K

- Membranes that operate at high temperature and low RH, with lower cost and improved durability and tolerance to feed gas impurities
- Improved understanding of proton conduction and membrane degradation
 - Cost reduction using non-precious metal catalysts and ultra-low platinum loading

Technology Validation \$17,750K

- First and second generation fuel cell vehicles
- Validate performance and durability of fuel cell systems





DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Staff

Steve Chalk, Program Manager
JoAnn Milliken – Chief Engineer
Fred Joseck – Technology Analyst
Lindsay Roland (On detail) – Policy/Int'l Support

Technology Validation Manager - Sigmund Gronich
Education - Christy Cooper
Safety, Codes/Standards - Patrick Davis
Safety Engineer – Antonio Ruiz

Hydrogen Production Team

Pete Devlin, *Team Leader*
Arlene Anderson
Chris Bordeaux
(detailed to IP)
Roxanne Danz
Matt Kauffman
Mark Paster

Hydrogen Storage Team

Sunita Satyapal,
Team Leader
Tony Bouza
John Petrovic (LANL)
Carole Read

Fuel Cell Team

Valri Lightner,
Team Leader
Kathi Epping
John Garbak
Nancy Garland
Donna Ho
Amy Manheim



Technical Targets: 80-kW_e (net) Integrated Transportation Fuel Cell Power Systems Operating on Direct Hydrogen

Characteristics	Units	2004 Status	2005	2010	2015
Energy efficiency @ 25% rated power	%	59	60	60	60
Energy efficiency @ rated power	%	50	50	50	50
Power density	W/L	450	500	650	650
Specific power	W/kg	420	500	650	650
Cost	\$/kW _e	120	125	45	30
Transient response (time from 10% to 90% rated power)	s	<1.5	2	1	1
Durability	hours	~1000	2000	5000	5000
Cold start-up time to 90% rated power					
@ -20°C ambient temperature	s	120	60	30	30
@ +20°C ambient temperature	s	60	30	15	15
Survivability	°C	-20	-30	-40	-40



2004 Programmatic Highlights

Financial Assistance Awards: over \$425 million (\$675 with cost share)

- **Hydrogen production and delivery** technologies
- **Hydrogen storage** “Centers of Excellence” and materials development
- Demonstrate and **validate fuel cell vehicle and infrastructure technologies** under real-world conditions
- **Fuel cells for consumer electronics** and other applications

Research, Development and Demonstration Plan:

- NRC recommendations
- New systems analysis and system integration functions

On-board Fuel Processing R&D Go/No-Go Decision:

- Technical evaluation of status, progress, and potential
- Independent review panel recommended R&D discontinued

Workshops:

- *Hydrogen Production (4):* hydrogen separations and purification, water electrolysis by utilities, renewable electrolysis, and hydrogen production via direct fermentation
- *Codes & Standards:* understand and organize fuel purity codes & standards efforts
- *Systems Analysis:* identify and better coordinate systems analysis efforts

IPHE: scoping papers approved; joint projects to kick-off in '05

IATF (through OSTP): new web site - www.hydrogen.gov



Workshop on Fuel Cell Operation at Sub-Freezing Temperatures

- Transportation (and stationary) fuel cells need to operate in environments where ambient temperatures will fall below 0°C. Surprisingly little data exist to quantify the effects of sub-freezing temperatures on fuel cell operations.
- The goal of this workshop is to **identify and prioritize the technical barriers associated with freezing or sub-freezing temperatures and to develop an RD&D plan to overcome these barriers.**
- Results of this workshop will most likely be a topic in **an FY 2006 solicitation** to be released by the DOE's OHFCIT.



Key Points

The focus of this workshop is prediction of the likely effects of freezing temperatures on fuel cell operation and identification of technology tasks to mitigate these effects.

This is a working meeting - not an information meeting. We ask that everybody open up and contribute.

System level targets must be considered.



Thanks!!!

Workshop Organizing Committee

- Bryan Pivovar (LANL)
- Larry Blair (consultant to DOE)
- Doug Wheeler (consultant to NREL)
- Keith Wipke (NREL)



For More Information

HYDROGEN POSTURE PLAN

AN INTEGRATED RESEARCH, DEVELOPMENT,
AND DEMONSTRATION PLAN

February 2004



United States Department of Energy

The cover features a vertical strip of images on the left: a hydrogen fuel cell, a hydrogen pipeline, a group of people, solar panels, a hydrogen station, and a hydrogen car. The main text reads: "DOE Hydrogen Program 2004 Annual Merit Review and Peer Evaluation Report" with the date "May 24-27, 2004 Philadelphia, Pennsylvania". It includes the H₂ logo and the U.S. Department of Energy logo at the bottom.

The cover has a green textured background. The main text reads: "DOE HYDROGEN PROGRAM 2004 Annual Progress Report". It features the H₂ logo and a stylized stack of metal plates. The U.S. Department of Energy logo is at the bottom.

www.eere.energy.gov/hydrogenandfuelcells



Agenda

Tuesday, February 1, 2005

- 8:30 Welcome– Workshop Expectations
Nancy Garland, DOE
- 8:45 Glenn Skala, General Motors
- 9:10 Jeremy Meyers, UTC Fuel Cells
- 9:35 Ballard Contribution presented by Larry
Blair, DOE consultant
- 9:55 Richard Gaylord, Plug Power
- 10:15 Break
- 10:30 Tom Zawodzinski, CWRU
- 10:50 Phil Ross, LBNL
- 11:10 Bryan Pivovar, LANL
- 11:30 Rajesh Ahluwalia, ANL
- 11:50 Lunch
- 12:45 Open Discussion Moderated by Doug
Wheeler (NREL consultant)

- 1:45 Breakout Group Assignments and
instructions – Shawna McQueen,
Energetics
- 2:00 Breakout Groups (Effects)
- 3:00 Break
- 3:20 Breakout Groups (Challenges)
- 4:30 Reconvene/Discuss break out group
findings

Wednesday, February 2, 2005

- 8:00 Breakout Groups (Research Directions)
- 10:00 Break
- 10:15 Breakout Groups (Top 10 Analysis)
- 11:15 Reconvene/ Wrap-up/ Next Steps
- 12:15 Adjourn