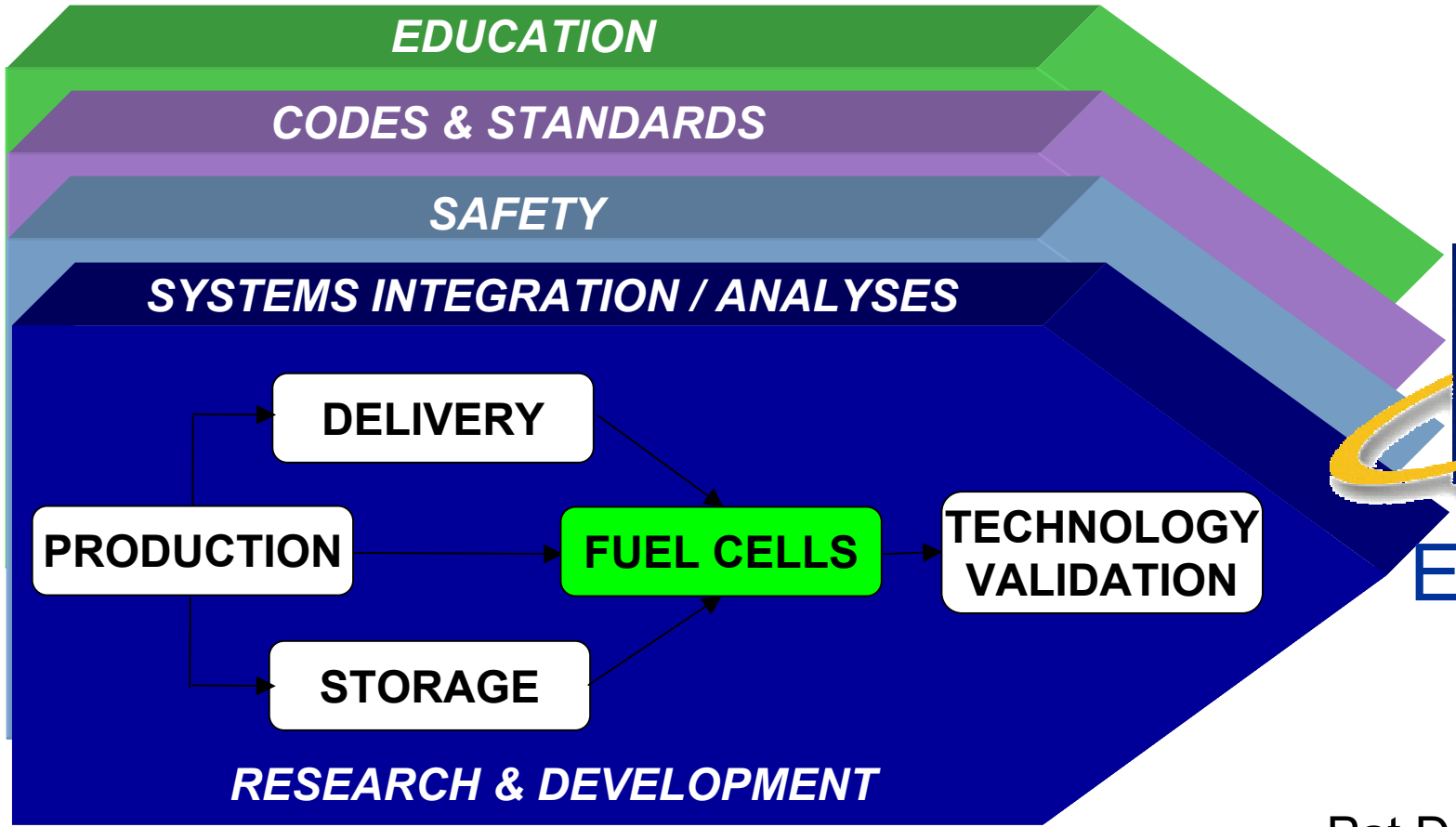
Fuel Cells



H_2 Economy

Pat Davis

Fuel Cells Technical Goals & Objectives

Goal : Develop and demonstrate fuel cell power system technologies for transportation, stationary, and portable applications.

Fuel Cells Technical Goals & Objectives

Objectives

- **Develop a 60% efficient, durable, direct hydrogen fuel cell power system for transportation at a cost of $45/kW (including hydrogen storage) by 2010.**
- **Develop a 45% efficient reformer-based fuel cell power system for transportation operating on clean hydrocarbon or alcohol based fuel that meets emissions standards, a start-up time of 30 seconds, and a projected manufactured cost of $45/kW by 2010.**
- **Develop a distributed generation PEM fuel cell system operating on natural gas or propane that achieves 40% electrical efficiency and 40,000 hours durability at $750/kW by 2010.**
- **Develop a fuel cell system for consumer electronics with an energy density of 1,000 W-h/L by 2010.**
- **Develop a fuel cell system for auxiliary power units (1-3kW) with a specific power of 150 W/kg and a power density of 150 W/L by 2010.**

2010 FreedomCAR Technology Specific Goals

	Efficiency	Power	Energy	Cost*	Life	Weight
Fuel Cell System	60% (hydrogen) 45% (w/ reformer)	325 W/kg 220 W/L		$45/kW (2010) $30kW (2015)		
Hydrogen Fuel/ Storage/ Infrastructure	70% well to pump		2 kW-h/kg 1.1 kW-h/L	$5/kW-h $1.25/gal (gas equiv.)		
Electric Propulsion		≥55 kW 18 s 30 kW cont.		$12/kW peak	15 years	
Electric Energy Storage		25 kW 18 s	300 W-h	$20/kW	15 years	
Materials						50% less
Engine Powertrain System**	45% peak			$30/kW	15 years	

* Cost references based on CY2001 dollar values

** Meets or exceeds emissions standards.

Technical Targets

See the Draft R&D Plan for a complete set of targets

Targets flow down from end use system specification (vehicle, power system, etc.)

Fuel Cell System

Targets for vehicles systems (hydrogen or reformate), stationary systems, APU's, consumer electronics

Sub-System

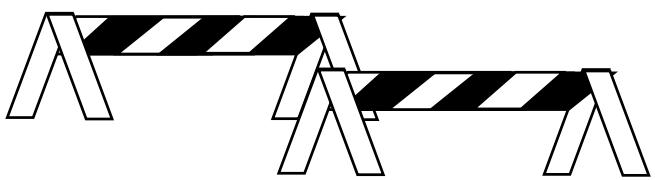
Targets for fuel processing sub-system and stack system

Component

Air management, sensors, MEA's, membranes, Bipolar Plates, fuel processor reactor zones, etc.

Fuel Cell R&D Activities are Based on the Critical Challenges

- Cost – Lowering the cost of technology to facilitate commercialization, $45/kW automotive.
- Durability – 5,000 hrs for automotive, 40,000 hrs for stationary
- Fuel Processing (start-up) – Major Go/No Go Milestone to meet 30 second automotive start-up.
- Air/Thermal/Water Management – improved air systems, high temperature membranes, heat rejection and humidification

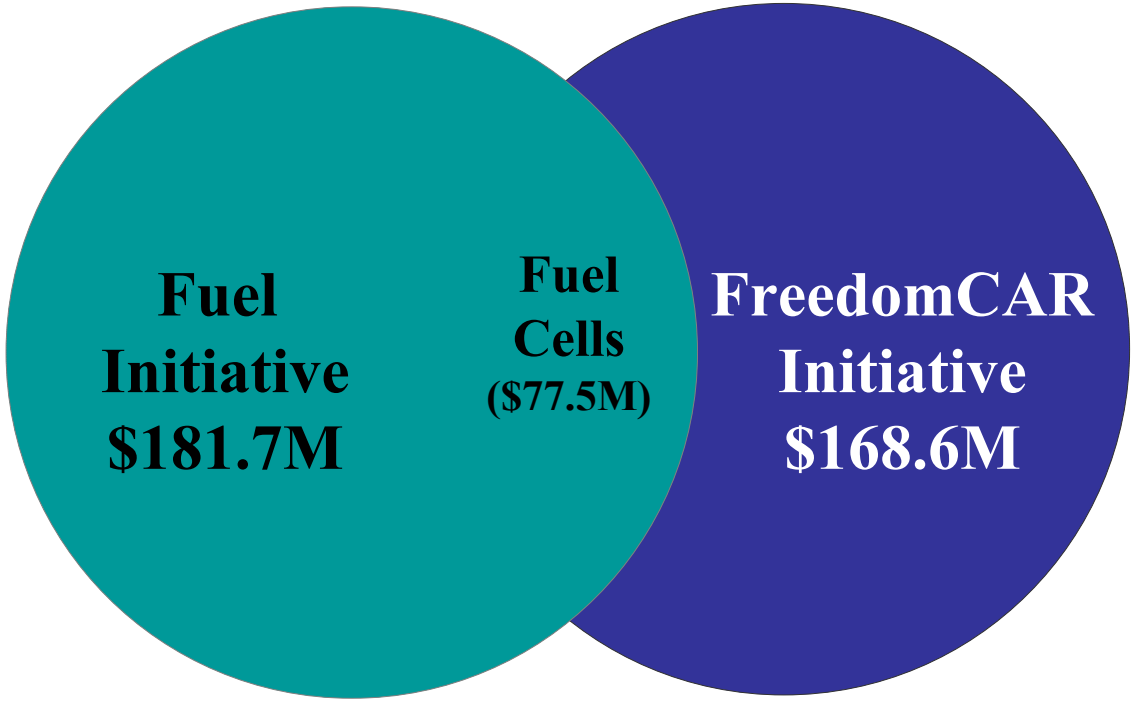


Fuel Cells Key Milestones

Milestone	Description	Quarter (Calendar Year)
9	Go/No Go. Determine whether to continue funding of DMFC R&D for transportation applications.	3Q, 2003
11	Benchmarking of UTC Fuel Cells atmospheric 50kW system	4Q, 2003
14	Verify reproducibility of full-size bipolar plates in high-rate manufacturing processes	4Q, 2003
16	Fuel Processing Go/No Go Decision	2Q, 2004

FY 04 FreedomCAR and Fuel Initiative ($272.8 M)
FY04-08 Commitment ($1.7B Total, $1.2B for Fuel Initiative)

Hydrogen Fuel Initiative = Hydrogen ($104.2M) + Fuel Cells ($77.5M) = $181.7M



FreedomCAR = Fuel Cells ($77.5M) + Vehicle Technologies ($91.1M) = $168.6 M

FY 04 Hydrogen Fuel and FreedomCAR Initiatives
Hydrogen* ($104.2M)+ Fuel Cells ($77.5M) + Vehicle Technologies ($91.1M) = $272.8M

* Includes EERE ($88.0M), FE ($11.5M), NE ($4.0M) and $0.7M DOT/RSPA

Fuel Cell Funding

Program	FY 2003	FY 2004 Request	
Interior Appropriations in $ Millions			
Transportation Systems	$6.2	$7.6	
Components	$14.9	$28.0	
Fuel Processing	$24.7	$19.0	
Tech Validation	$1.8	$15.0	
Distributed Generation Sys.	$7.5	$7.5	
Technical Support	$0.4	$0.4	
TOTAL	$55.5	$77.5	

Activities Focus on Removing High Risk Technical Barriers

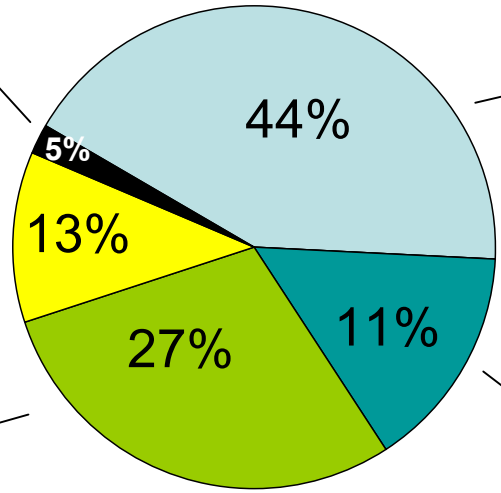
FY 2003 Budget = $55.5M

Tech Validation

- Learning Demonstrations

Distributed Generation (DG)

- Reforming Technology (NG)
- Critical Components
- Systems Development



Transportation Fuel Processing/Storage Subsystem

- On-Board Fuel Processor R&D
  - gasoline, diesel, methanol

Transportation Fuel Cell Stack Subsystem

- Catalyst Loading Reduction
- MEA/Bipolar Plate Manufacturing
- Durability Studies
- Non-Platinum Catalysis

Transportation System

- Modeling/Validation
- Cost Analyses
- Critical Components (Compressors, Sensors)

R&D is carried out by industry suppliers, national labs and universities.

Projects – Transportation Fuel Cells

Fuel Processing

Catalytica – Plate Reformer
Nuvera – STAR Fuel Processor
Nuvera – Hi-Q
U. Of Michigan – Microchannel
UTRC – Hydrogen Enhancement
U. Of Kentucky – H2 Enhancement
Air Products – Off-board Reforming
McDermott – Autothermal
ANL
PNNL
LANL

Air Management

Honeywell – Turbocompressor
Mechanology – TIVM
UTC Fuel Cell – Blowers
TIAX – Hybrid
ANL

Membranes & Electrodes

3M – MEA's and production techniques
3M – Improved Cathodes & Hi-Temp
DeNora/DuPont – Adv. MEA's
UTC Fuel Cells – Improved Cathodes & Hi-Temp
Superior Micropowders – Low Pt
SWRI/Gore – Pilot production methodes
ANL
LANL

Bipolar Plates/Components

Porvair
Honeywell – sensors
UTC Fuel Cells - sensors
ORNL

Studies

TIAX
BTI
DTI

Fuel Cell Solicitations

- Stationary & transportation fuel cell solicitation (under evaluation).
  Contact: Kathi Epping, 202-586-7425

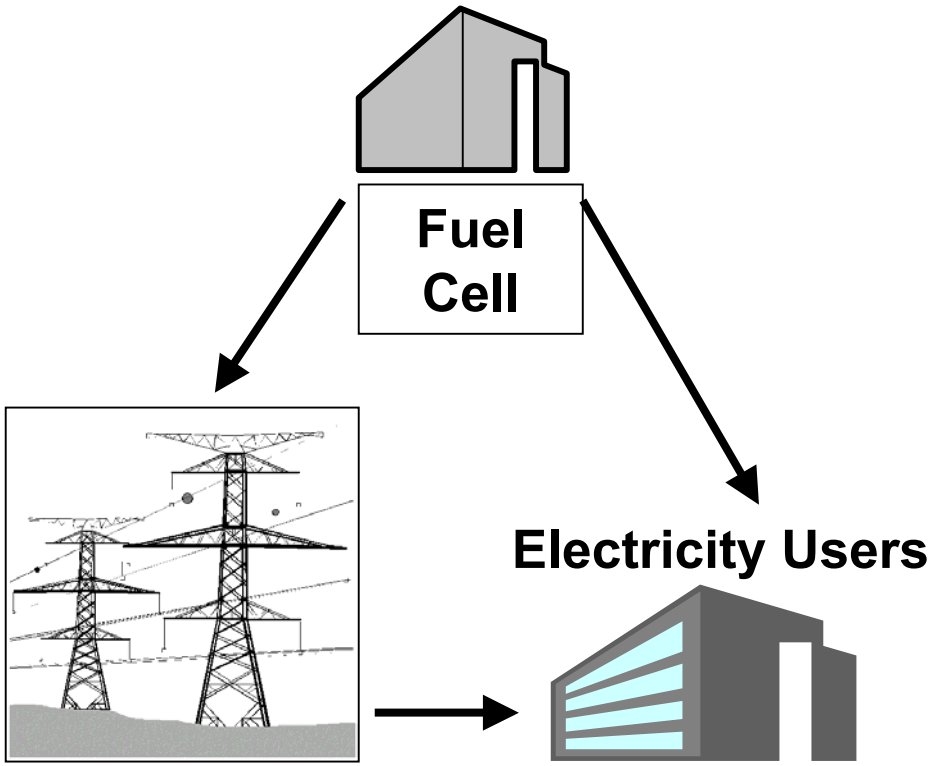
- Fuel Cell Portable & Auxiliary Power. Open: due date extended to June 26. ***Contact: John Garbak 202-586-1723***

- Vehicle Demonstration, Infrastructure and Co-production: Open: due date August 14. ***Contact: Sig Gronich, 202-586-1623***

Future Directions

- Continue to focus on resolution of fundamental technology barriers and component development
- On-board fuel processing go/no go decision impacts
- Durability improvements and cost reduction through membranes and catalyst development.
- Development of portable power and APU systems technology

Distributed Energy Fuel Cells



DOE Hydrogen and Fuel Cells Coordination Meeting

June 2-3, 2003

Kathi Epping

Objectives & Barriers
Distributed Energy

OBJECTIVES

- Develop a distributed generation PEM fuel cell system operating on natural gas or propane that achieves 40% electrical efficiency and 40,000 hours durability at $400-750/kW by 2010.

BARRIERS

- Durability
- Heat Utilization
- Power Electronics
- Start-Up Time

Targets and Status

Integrated Stationary PEMFC Power Systems

Operating on Natural Gas or Propane Containing 6 ppm Sulfur

Characteristics	Units	2003 status	2005	2010
Small (3-25 kW) Systems				
Electrical Efficiency	%	30	32	35
Cost	$/kWe	3,000	1,500	1,000
Durability	Hours	>6,000	30,000	40,000
Large (50-250 kW) Systems				
Electrical Efficiency	%	30	32	40
Cost	$/kWe	2,500	1,250	750
Durability	Hours	15,000	30,000	40,000

Projects
Distributed Energy

• Proton Exchange Membrane Fuel Cell Power System on Ethanol	Caterpillar
• Ultra-thin Composite Membrane for High Temperature Operation in PEMFCs	Fuel Cell Energy
• Fuel Cell Distributed Power Package Unit: Fuel Processing Based On Autothermal Cyclic Reforming	General Electric

Solicitation Status

Solicitation for "Research and Development for Fuel Cells for Stationary and Automotive Applications"

- Solicitation issued on 24 January 03, closed on 27 Mar 03
- Solicitation focuses stationary fuel cell R, D, and D, including cross-cutting stationary and automotive R&D.
- Selection of up to 20 awards is expected Summer 03
- Awards will have a term up to 5 years
- Total Estimated government funding is approximately $70M
- Cost Share varies from 20-50%, depending on the topic, based on risk (with the exception Economic Analysis Topic)

SOLICITATION TOPICS

- Development of Stationary PEM Fuel Cell Power System
- Development of Back-up Fuel Cell Power System
- Development of Materials for High Temperature Membranes and PEM Stack Durability for Stationary & Transportation Applications
- Fuel Processing Technology for Stationary Applications
- Stationary Fuel Cell Demonstration
- Platinum Recycling Technology Development
- Non-Precious Metal Catalyst Development
- Water and Thermal Management
- Economic Analysis of PEM Fuel Cell Systems