U.S. Department of Energy

Fuel Cells for Portable Power

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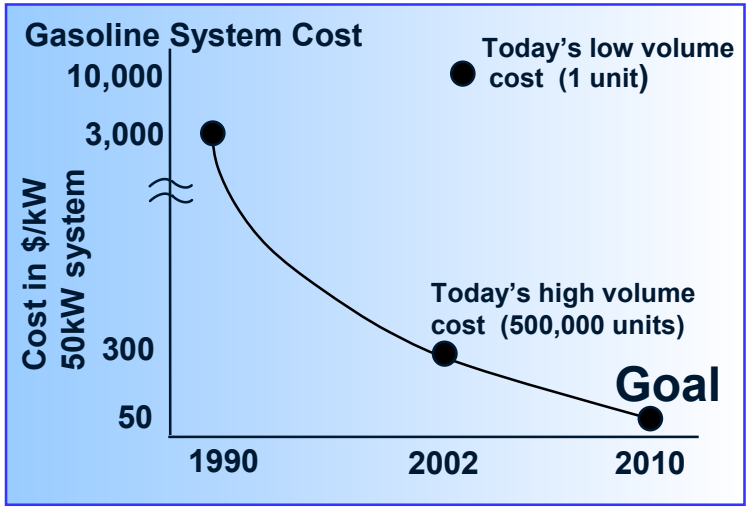
Presentation Outline

- **Why are we here?**
- **DOE Transportation Fuel Cell Program**
- **Workshop Objectives**
- **Guidelines for Workshop Product**
- **What have past DOE workshops achieved?**

Why are we here?

Government:

Cost - the primary barrier to commercialization of PEMFCs for automobiles



Industry:

Business plans include fuel cells or fuel cell powered products

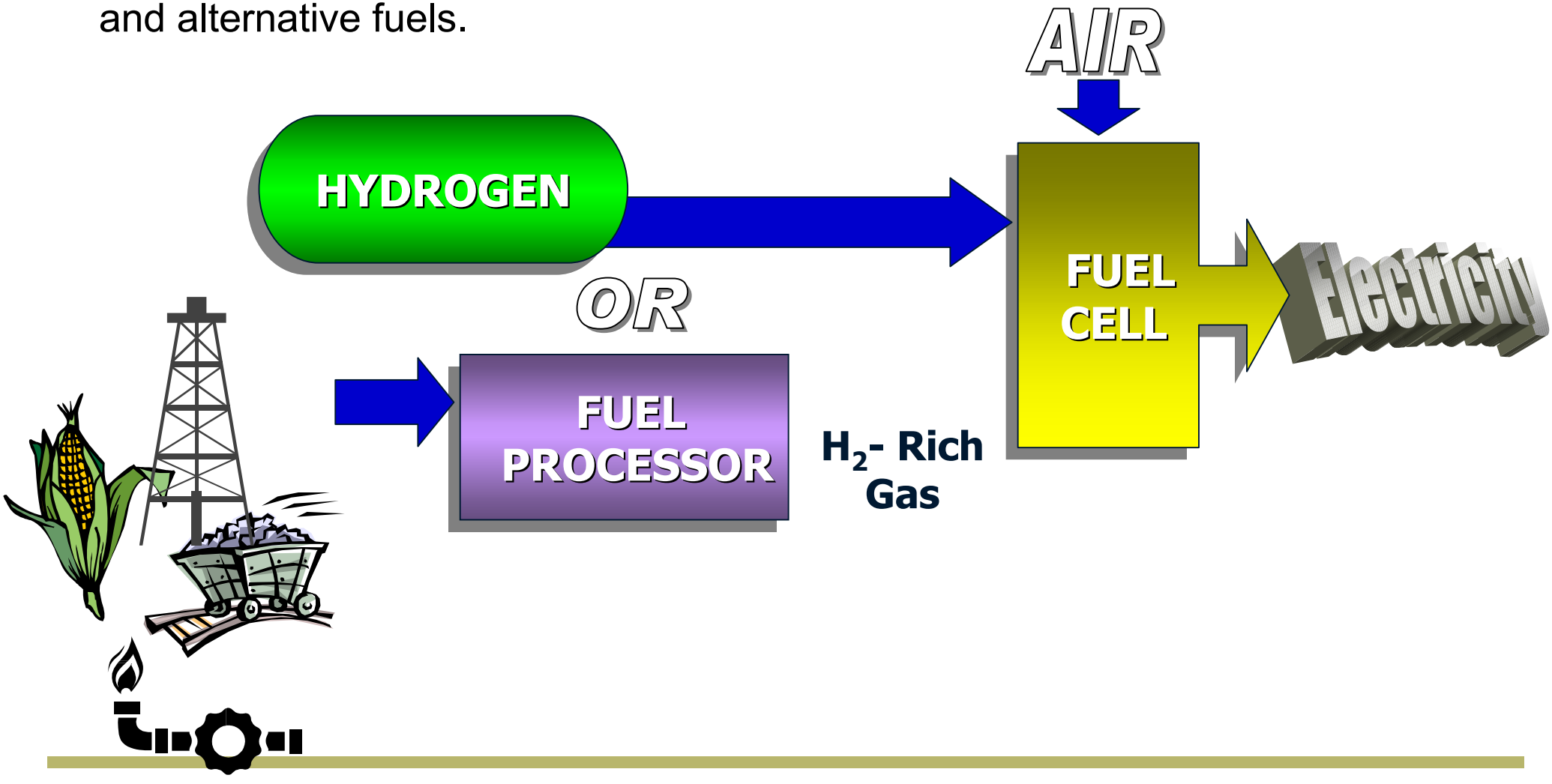
Industry/Academia/National Labs:

Funding opportunities for fuel cell research, development, demonstrations

Fuel Cells for Transportation

Program Goal/Fuel Strategy

Our goal is to develop highly efficient, low- or zero-emission, cost-competitive automotive fuel cell power system technologies that operate on conventional and alternative fuels.



FreedomCAR*:
Energy Security for America's Transportation

DRAFT

Vision:

Affordable full function cars and trucks are free of foreign oil and harmful emissions, without sacrificing freedom of mobility and freedom of vehicle choice.

Strategic Approach:

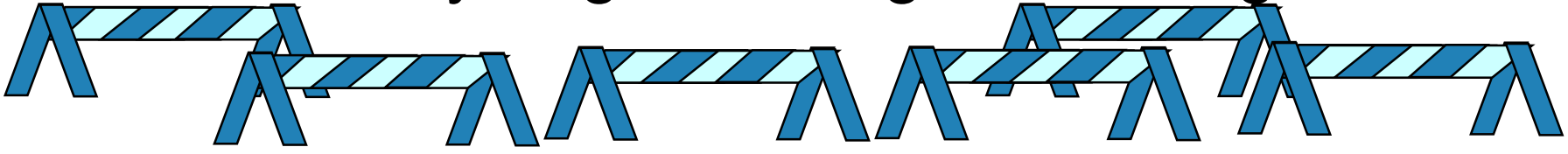
- Develop technologies to enable mass production of affordable hydrogen-powered fuel cell vehicles and assure the hydrogen infrastructure to support them.
- Continue support for other technologies to dramatically reduce oil consumption and environmental impacts. Adopt policies that stimulate consumer demand for vehicles and fuels that enhance energy security and reduce pollution.
- Instead of single vehicle goals, develop technologies applicable across a wide range of passenger vehicles.

*CAR = Cooperative Automotive Research

Automotive Fuel Cells
Key Technical Challenges

There are significant technical and economic barriers that will keep fuel cell vehicles from making significant market penetration for 10 years.

- Cost/Affordability (Platinum)
- Start-Up (Gasoline System)
- Durability
- Thermal/Water Management
  - heat rejection
- Air Management
- Hydrogen Storage/Refueling



Cost of Fuel Cell Systems

Status versus Targets

	Status	Targets
Projected Manufacturing Cost of Gasoline PEMFC Systems[1]	**~ $300/kW**	
DOE Automotive PEMFC Target[2]		**$45/kW**
Current manufacturing cost of portable power Li battery[3]		**~ $5,000/kW**

[1] Today's cost, based on 500,000 units/year
[2] 2010 target; cost-competitive with, not cost-equivalent to, internal combustion engines
[3] Estimated

Challenges/Strategy for Cost Reduction

Cost Challenges:

- ***high precious metal loading***
- ***low voltage cells, low power density → large number of cells in a stack***
- ***low activity, low durability shift catalysts***
- ***lack of high-volume fabrication processes for MEAs, bipolar plates***

R&D Activities:

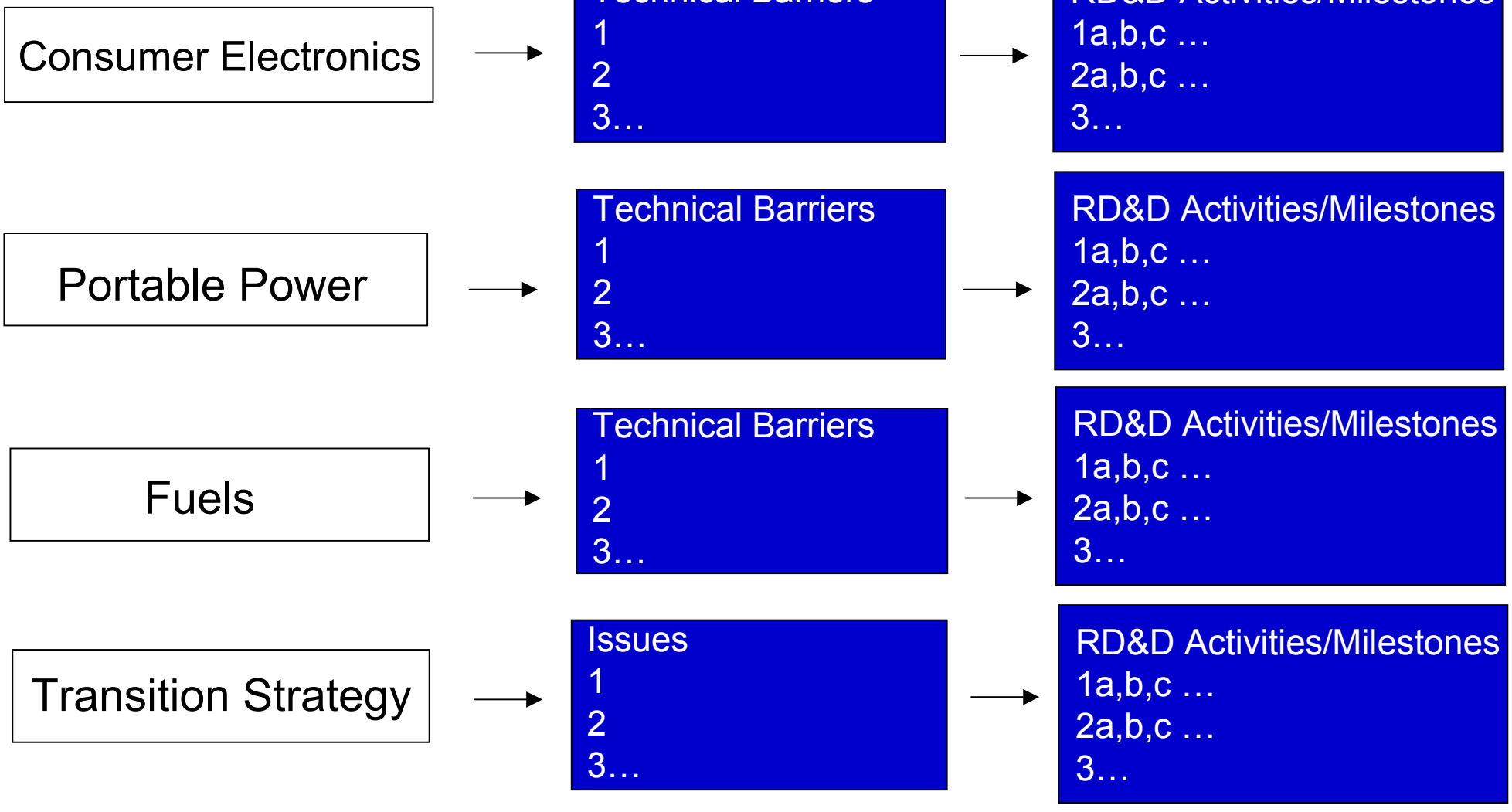
	Projected Cost*	Target
■ **High volume fabrication of MEAs with reduced Pt loading** - 3M, SwRI/W.L. Gore, IFC, DeNora/DuPont	MEA: $100/kW	$10/kW
■ **New cathode structures to improve cell performance** - 3M, IFC, DeNora, SMP,LANL, LBNL, BNL, NRL		
■ **Manufacturing capability for composite bipolar plates** – GTI, Porvair	BP: $10/kW	$10/kW
■ **Improved water-gas-shift catalysts** – ANL, NexTech, U. Michigan	WGS: $13/kW	$3/kW
➢ **Manufacturing Capability for Portable Power Fuel Cells.**		

* Based on ADL Cost Study

Workshop Objectives

- **Identify and prioritize the technical barriers to commercialization of PEMFCs for portable applications.**
- **Draft a research, development, and demonstration plan to overcome the barriers.**
- **Develop a strategy to use the commercialization of portable power fuel cells to facilitate commercialization of automotive PEMFCs.**

The Workshop Product will be a RD&D Roadmap....



And a Demonstration Plan with Transition Strategy

1/3/2002

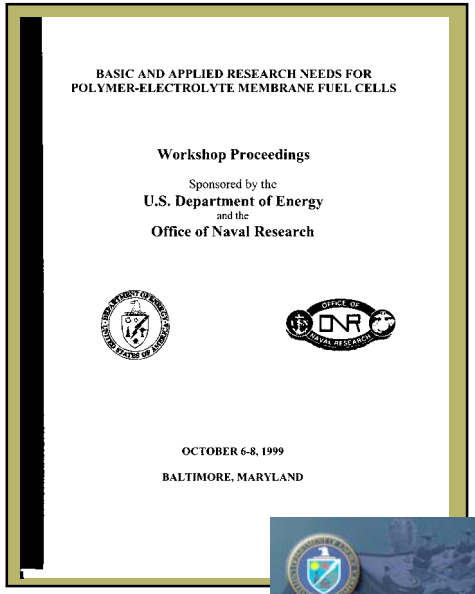
	2001 – Phase 1	2004 – Phase 2	2008 – Phase 3	2012
	Feasibility Demonstration	**Controlled Fleet Demonstrations**	**Commercial Fleet Demonstrations**	**Commercialization Phase**
Vehicles Objective	Test FC vehicle performance and feasibility	Demonstrate use of FC vehicles under real-world conditions.	Demonstrate commercial viability of FC fleet vehicles.	Investment to establish manufacturing plants and sales/service
Sites	1(CaFCP)	5-8; varying climates	2-3 states (networked sites)	
Number of Vehicles	<50	~500	~5000	
Infrastructure Objective	Demonstrate H_2 fueling station	Onsite generation from multiple feedstocks	Sufficient stations to provide consumer convenience	Investment for 25-50% of all stations H_2 capable
Hydrogen Source	Primarily trucked-in liquid H_2	Renewables and fossil fuels	Most cost effective sources	
Number of stations	3	5-10	20-30	
Government Role	Share management responsibilities Fuel Chain Analyses Education	Purchase Vehicles Cost share & operate H_2 fueling stations Data collection & dissemination Coordination of international codes & standards Education	Vehicle subsidy Cost shared infrastructure Education	Legislated incentives to consumers & industry Exercise capability for national energy security
Industry Role	Operate Vehicles and H_2 stations Primary Funding	Vehicle design, engineering & integ. Cost share fueling stations Identify service requirements Complete Codes & standards	Cost share vehicles Cost share fueling stations Gauge consumer acceptance Maintenance capability	Commercialization Phase Begins
Success Criteria [achieved through parallel technology development]				
Fuel Cell Cost (@ 500,000/year) Durability	$325/kW 1000 hrs	$125/kW 2000 hrs	$45/kW 5000 hrs	Industry Criteria
Onboard H_2 Storage Cost ($/kWh) Energy Density Specific Energy			$5/kWh 2000 Whkg 1100 Wh/L	Industry Criteria
Hydrogen Infrastructure Cost Greenhouse Gases	$40/GJ 118 g/km	$21/GJ 109 g/km	$12/GJ 98 g/km	Industry Criteria

Given the high risk nature of the accelerated timeline, careful decision criteria prior to each phase need to be jointly established by Industry and Government.

Previous DOE Workshops/Outcomes

Basic and Applied Research Needs for PEMFCs

- Established a high-temperature membrane (HTM) R&D program
  - LANL, multiple universities
  - Industry projects w/ 3M, UTC Fuel Cells, DeNora/DuPont
  - HTM Working Group
- Initiated projects to improve cathode
  - LANL, LBNL, Superior MicroPowders, other industry
- Expanded projects to reduce Pt content
  - NRL, BNL


BASIC AND APPLIED RESEARCH NEEDS FOR
POLYMER-ELECTROLYTE MEMBRANE FUEL CELLS

Workshop Proceedings

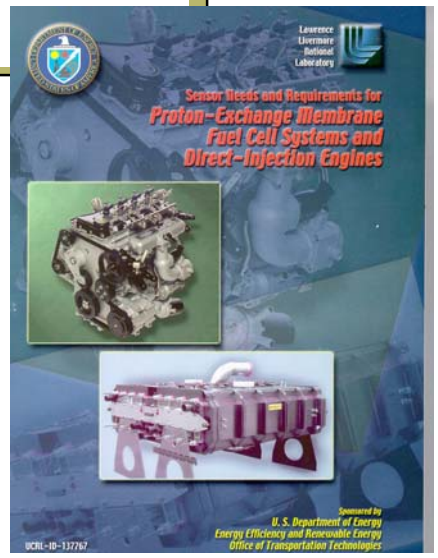
Sponsored by the
U.S. Department of Energy
and the
Office of Naval Research

OCTOBER 6-8, 1999

BALTIMORE, MARYLAND

Sensor Needs for PEM Fuel Cells and DI Engines

- Initiated a Sensor R&D Program
  - National Labs – LANL, LLNL
  - Industry – UTRC, Honeywell



For Further Information

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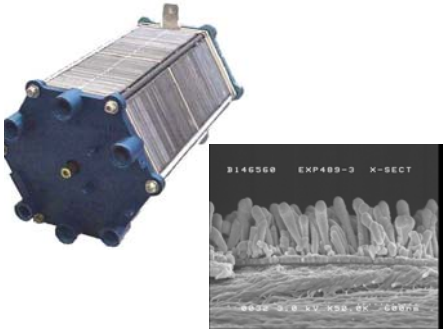
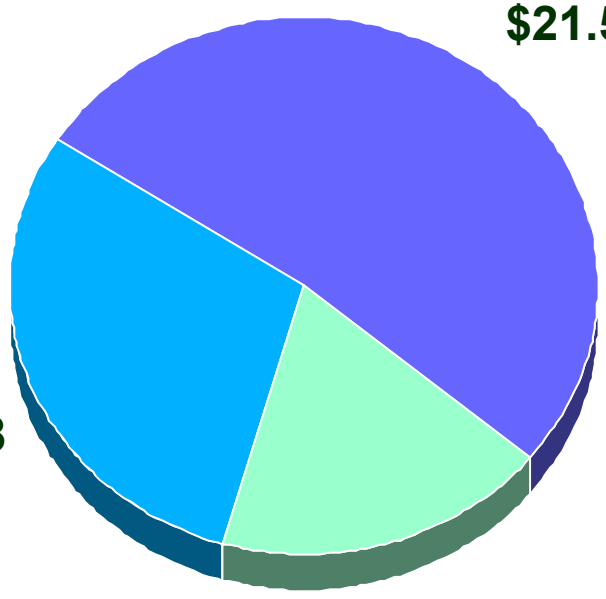
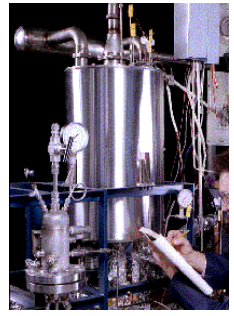
Additional Information

Program Activities – Fuel Cells

FY 2002 Budget = $41.9M





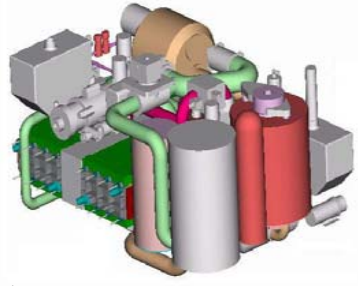


Fuel Processing/ Storage Subsystem

- Catalyst R&D
- Fuel Processor R&D
- Fuel Effects/Durability Studies
- Microchannel Components
- CO & Sulfur Management
- Hydrogen Storage R&D

Fuel Cell Stack Subsystem

- Catalyst R&D
- High Temperature Membrane R&D
- MEA/Bipolar Plate Manufacturing Processes
- Cost Reduction R&D
- Durability Studies
- Direct Methanol Fuel Cells



Systems

- System Validation
- System Modeling
- Ancillary Components (Compressors, Sensors)
- Cost Analyses
- Emissions Testing

Program Addresses Technical Challenges through cost-shared R&D with industry and applied research at national labs and universities

Challenge	Current R&D Projects
Cost	ADL/DTI – Cost Analyses 3M, SWRI/W.L. Gore – High Volume, Low Pt MEA Fabrication GTI, ORNL, Porvair – Bipolar Plates ANL, UMich, NexTech - Improved FP, WGS Catalysts LANL, NRL, BNL – Low Pt Electrodes
Durability	LANL, many industry projects are now addressing durability.
Air Management	IFC, ADL, Honeywell, Mechanology, Meruit – Compressors
Start-Up (Fuel Processing)	Nuvera, McDermott, Catalytica - fuel processing system/components ANL, UMich, NexTech - Improved FP, WGS Catalysts PNNL – Microchannel Fuel Processing
Thermal/Water Management	3M, IFC, DeNora/DuPont, ↘ LANL/Universities → High temperature membranes ORNL – Carbon foams for radiators, humidifiers
H_2 Storage, Refueling	UTRC, SwRI – H_2 Storage R&D, Testing Air Products, GE – Refueling technologies

Fuel Cell Program Implementation