



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

# **Energy Innovation in the United States**

## ***Automotive Fuel Cells Applications***

**Patrick Davis**

**Fuel Cell Technology Team Leader**

**Office of Hydrogen, Fuel Cells and Infrastructure Technologies**

**Energy Efficiency and Renewable Energy**

**U. S. Department of Energy**

**UN/OECD Workshop on Fuel Cell Innovation**

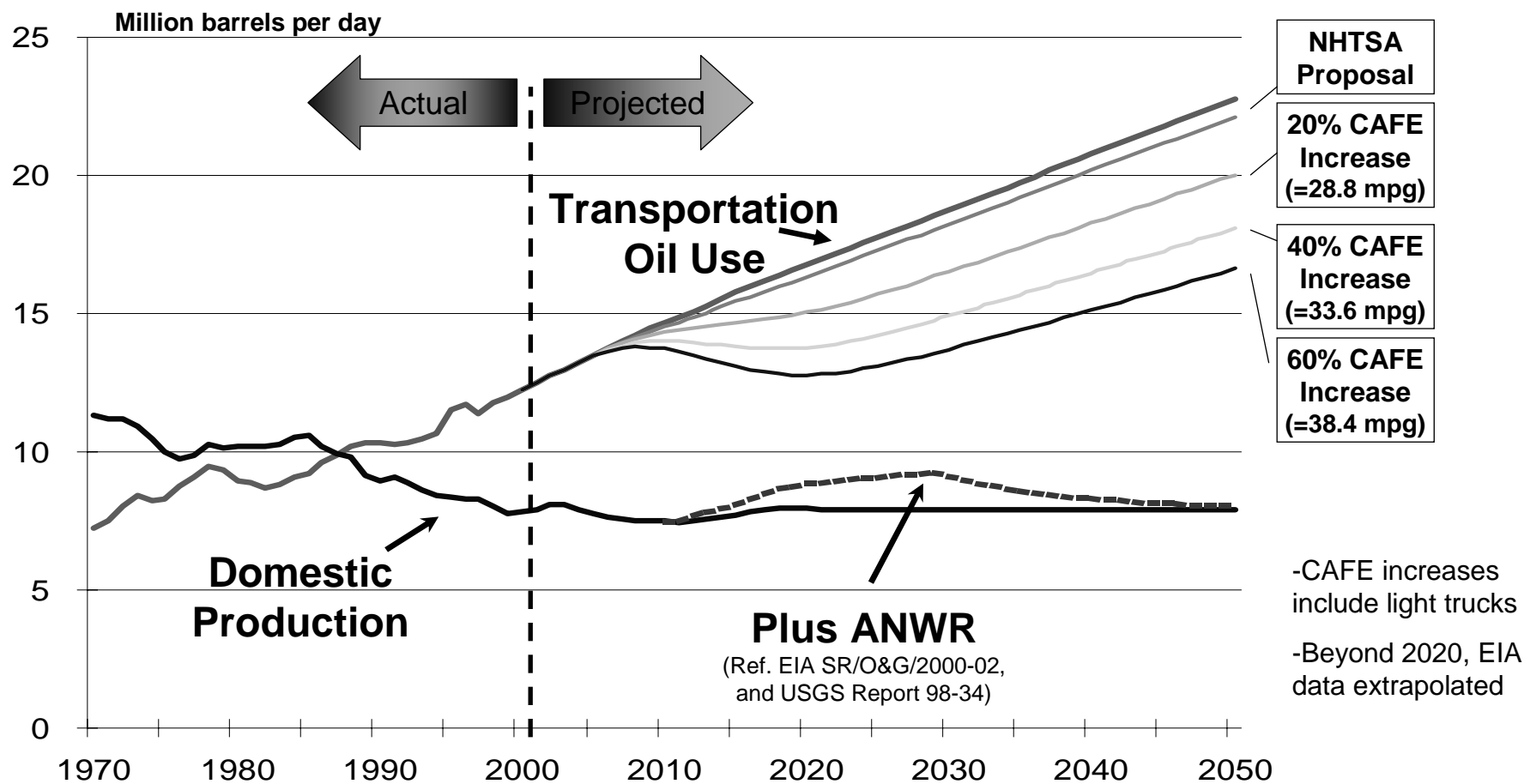
**September 29-30, 2003**

**Washington, D.C.**



# Oil Consumption Increasing: Energy Security and Emissions Issues

**Regulating fuel economy (CAFÉ) and drilling in the Arctic National Wildlife Refuge (ANWR) will help, but will not solve the problem.**





**VISION**  
**MISSION**  
**PLANNING**  
**GOALS & TECHNICAL TARGETS**  
**PARTNERSHIP DEVELOPMENT**  
**R&D**  
**TECHNICAL VALIDATION**  
***INDEPENDENT EVALUATION***



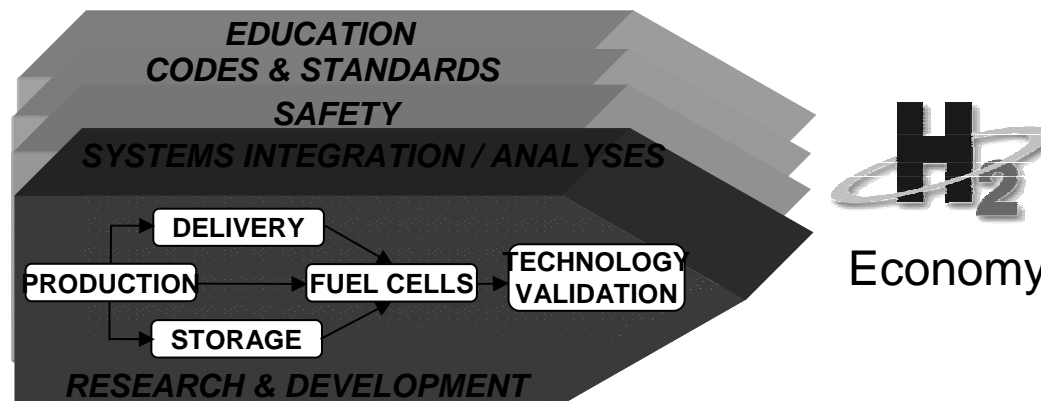
# Hydrogen Fuel Cells and Infrastructure Technologies Program

## Mission Statement

The mission of the Hydrogen, Fuel Cells & Infrastructure Technologies Program is to research, develop, and validate fuel cells and hydrogen production, delivery, and storage technologies for transportation and stationary applications.

The Program supports EERE Strategic Goals:

- Dramatically reduce dependence on foreign oil
- Promote the use of diverse, domestic, and sustainable energy resources
- Reduce carbon emissions from energy production and consumption
- Increase the reliability and efficiency of electricity generation

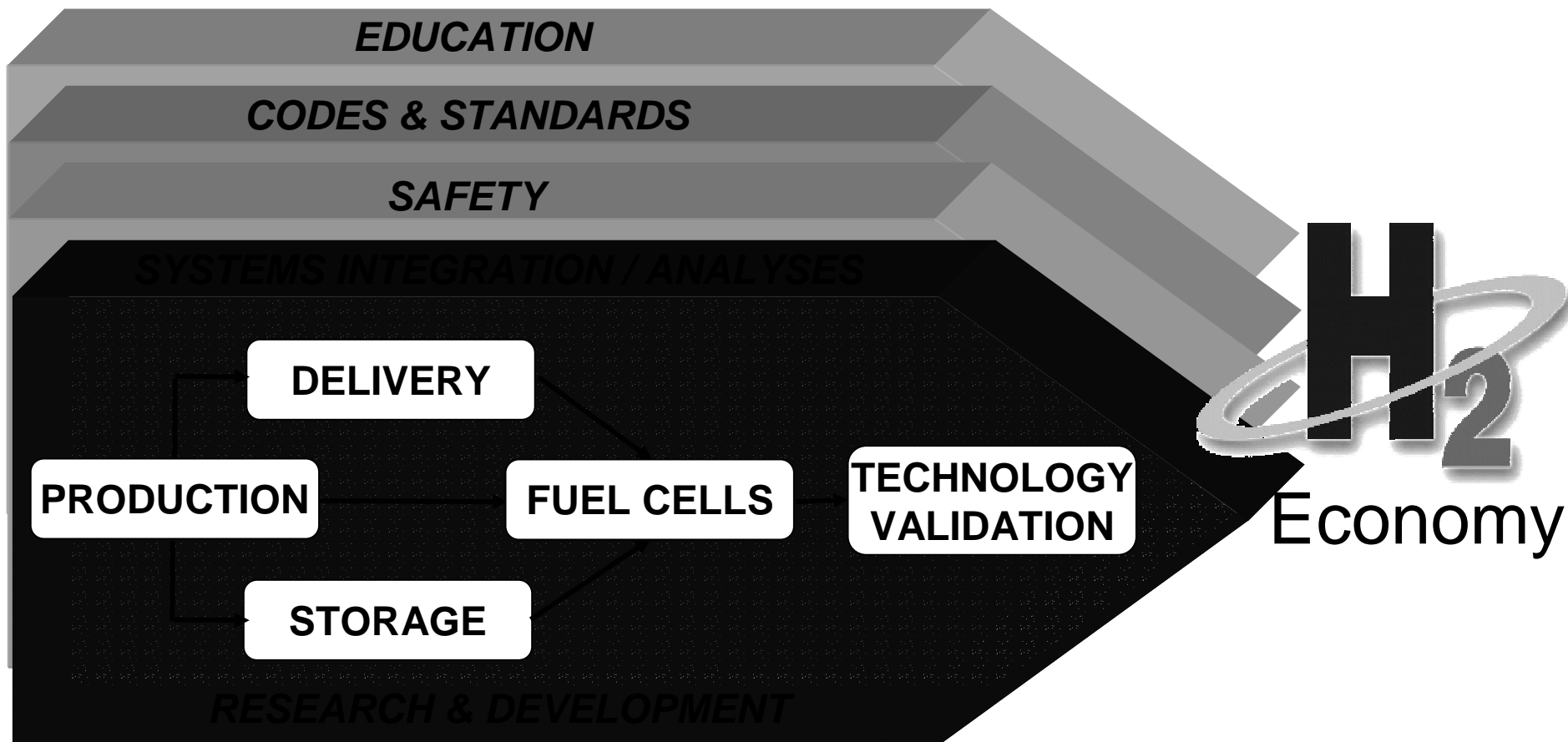




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# Hydrogen, Fuel Cells, and Infrastructure Technologies Program

## Structure

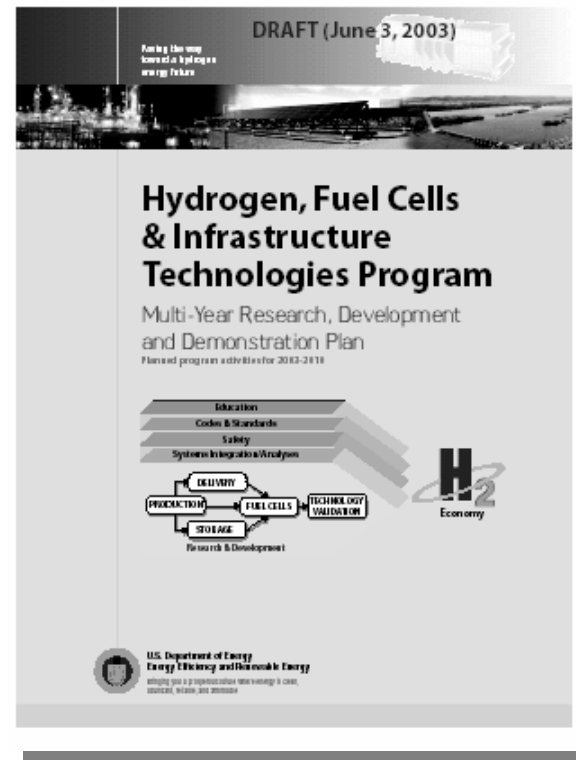






# Draft Multi-year Research, Development and Demonstration Plan

- Introduction
- Program Benefits
- Technology Development and Management Approach
- Technical Plan
  - Hydrogen Production
  - Hydrogen Delivery
  - Hydrogen Storage
  - Fuel Cells
  - Technology Validation
  - Codes & Standards
  - Safety
  - Education
- Systems Integration & Analyses



[www.eere.doe.gov/hydrogenandfuelcells](http://www.eere.doe.gov/hydrogenandfuelcells)



# ***Fuel Cells Technical Goals & Objectives***

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

## **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.

***Technical Targets: Over 100 Individual Technical  
Targets Established for the Fuel Cell Sub-Program***



- **Federal Public Policy**
  - National Energy Policy Act of 1992
  - National Energy Policy of 2001
  - Energy Security
  - Environmental Benefits
- **State's Public Policy**
- **Government R&D Funding**
- **Regulatory Regimes**
  - 1990 California ZEV
  - Codes and Standards
- **Markets**
  - Public Benefits
  - Market Pull
- **International Competition**



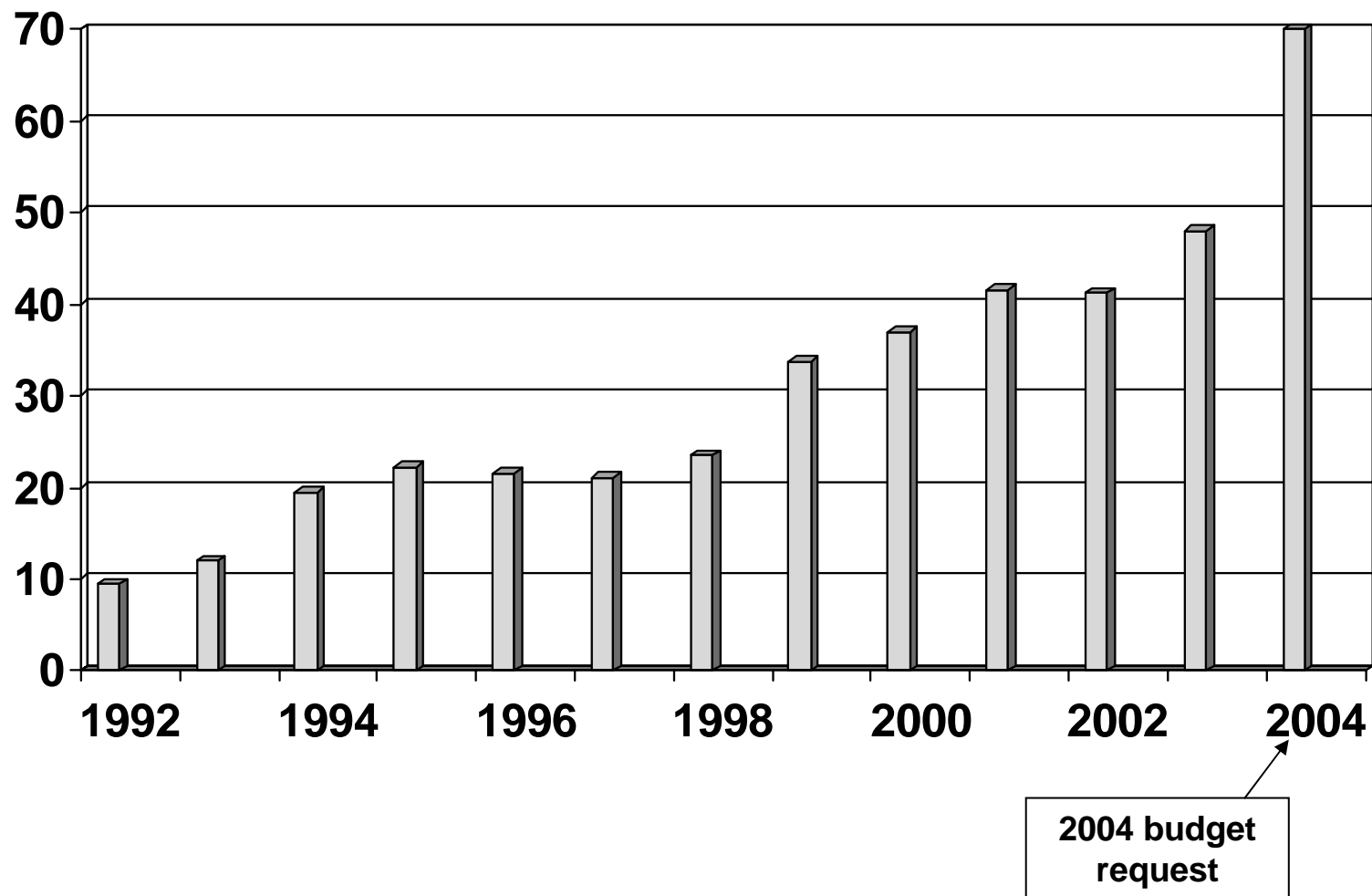
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# ***Government Role in Driving Innovation***

- Funding High-Risk, Long-Term Research
- Identification of Technical Targets and Barriers Through
  - Technical Workshops
  - Industry Partnerships
- Formal Review Process



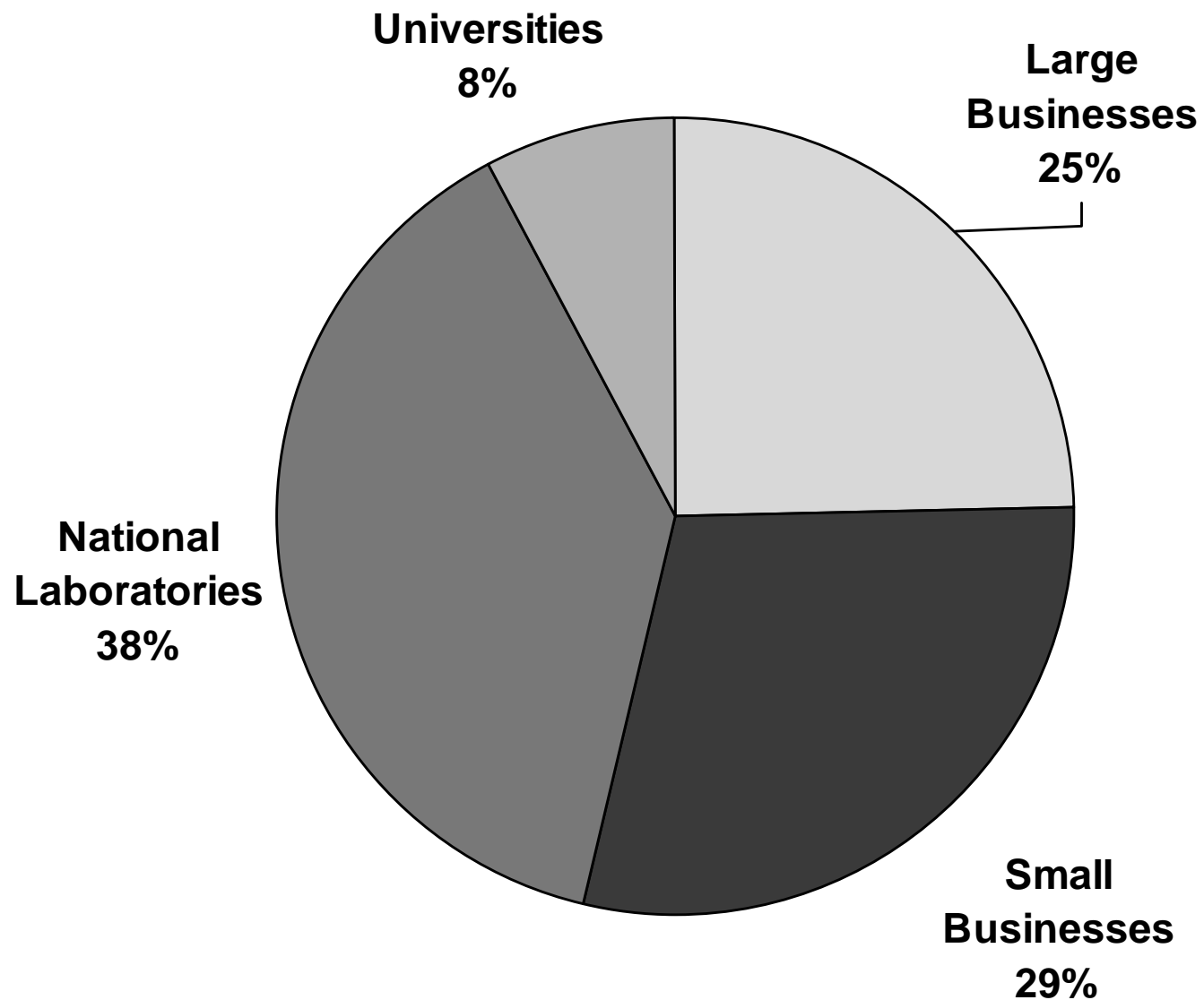
## PEM Transportation Fuel Cell Funding \$ Million





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# ***FY 2003 Budget Distribution (Estimated)***





# *Public/Private Partnerships*

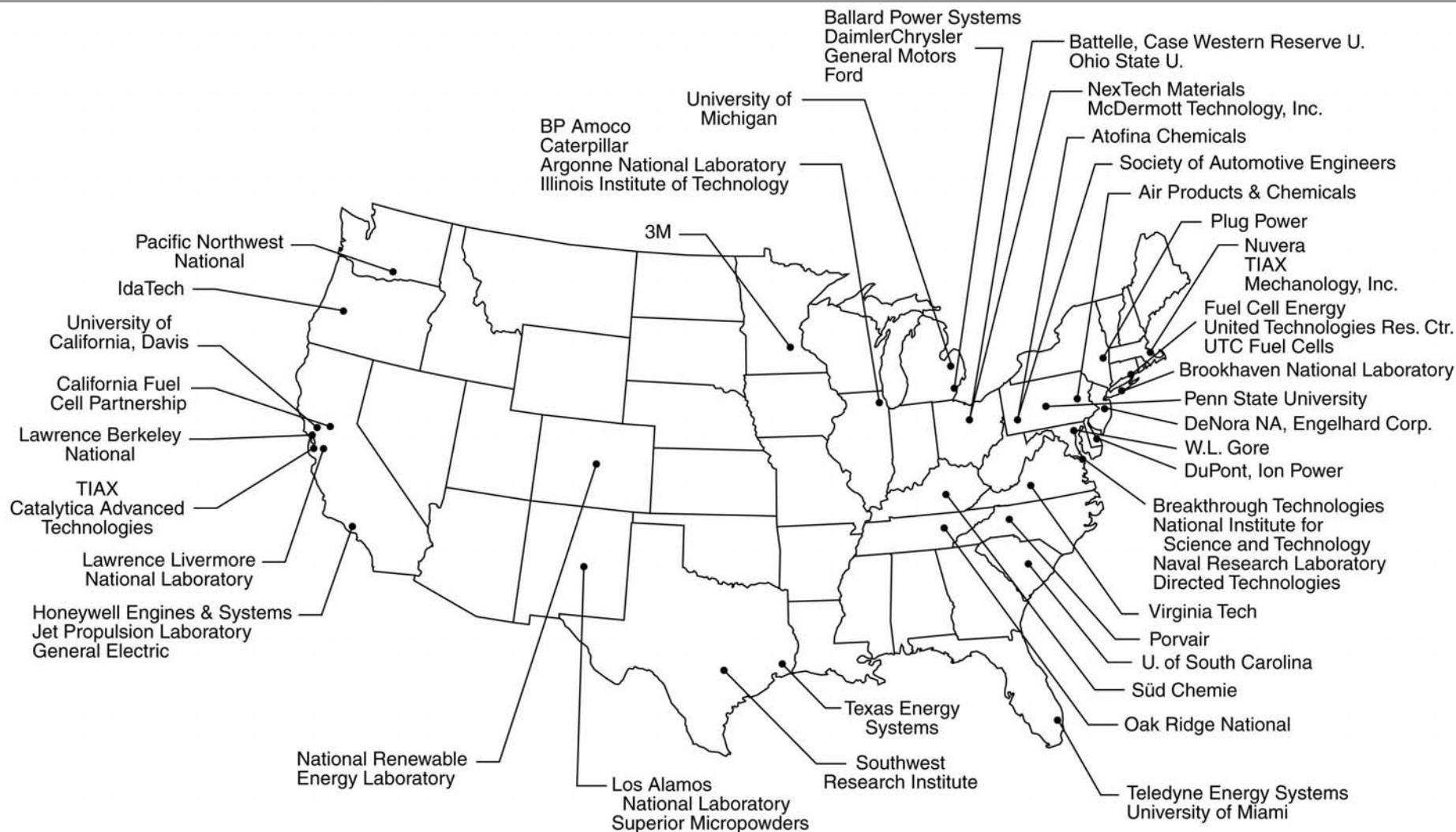
- **Industry-wide**
  - FreedomCAR
  - Hydrogen Fuel Initiative
- **Technical Working Group**
  - High-Temperature Membrane Working Group
  - Non-Platinum Electrocatalyst Workshop
- **Grants, cooperative agreements, and cost-shared contracts**
  - Industry
  - Universities
- **National laboratory partnerships**
  - Crada's
  - Work for Others
  - Intralab projects



- **Interagency Cooperation**
  - **Environmental Protection Agency**
  - **Department of Transportation**
  - **Department of Defense**
  - **Office Science and Technology Policy**
  - **Inter-Agency Advanced Power Group**
  
- **International cooperation**
  - **European Community**
  - **International Energy Agency**
  - **International Partnership for a Hydrogen Economy**
  - **OECD Case Studies**
  
- **States**
  - **California Fuel Cell Partnership**



# Fuel Cell Partners





## **Membranes & Electrodes**

3M – MEAs and production techniques

3M – Improved cathodes and high-temp MEA

Atofina Chemicals – Membrane durability

DeNora/DuPont – Advanced MEAs

Fuel Cell Energy – High-temp membrane

Plug Power – High-temp membrane

UTC Fuel Cells – Improved cathodes and high-temp membrane

Superior Micropowders – Low Pt cathode

SWRI/Gore – Pilot production methods

## **Fuel Processing**

Catalytica – Plate reformer

Nuvera – STAR fuel processor

Nuvera – Hi-Q fuel processor

U. Of Michigan – Microchannel

UTRC – Hydrogen enhancement

Ohio State U. – H<sub>2</sub> enhancement

McDermott – Autothermal reforming

Texaco Energy Systems – reforming



## **Bipolar Plates/Components**

Porvair – Low-cost, mass-produced plates

Honeywell – Sensors

UTC Fuel Cells – Sensors

Engelhard – Platinum recycling

Ion Power – Platinum recycling

## **Analysis**

TIAX – Costing, Pt cost and availability, fuel effects

Breakthrough Technologies Inc – Foreign transportation FC programs

Directed Technologies – Transportation FC costs

Battelle – Economic analysis

## **Systems Integration**

UTC Fuel Cells

Caterpillar – Ethanol

GE Honeywell

IdaTech – Stationary

Plug Power – Stationary

## **Air/Water Management**

Honeywell – Turbocompressor, water management

Mechanology – TIVM

UTC Fuel Cell – Blowers

TIAX – Hybrid



# HFCIT National Laboratory Priorities -PEMFC

Laboratory	Priority
Argonne	Systems Analysis Fuel Proc Catalysts Fast-Start Fuel Proc
Brookhaven	Low-Pt Electrodes
Oak Ridge	Hydrogen Production Stack Materials Stack Components
Lawrence Berkeley	Electrocatalysts
Lawrence Livermore	Sensors Hydrogen Storage

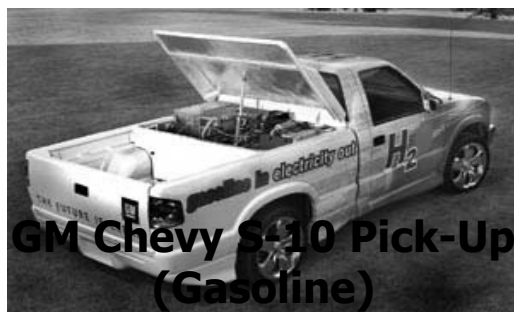
Laboratory	Priority
Los Alamos	Sensors Improved Cathodes High-Temp Membrane Durability Studies Fuels Effects
Energy Technology	Fuel Processing
Renewable Energy	Vehicle Analysis Hydrogen Production Hydrogen Storage
Pacific Northwest	Microchannel Fuel Processing
Sandia	Hydrogen Purification Hydrogen Storage



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## ***DOE Role in Fostering Public/Private Partnerships***

- Interagency cooperation
- Cooperative Research and Development Agreements (CRADA) between Industry and National Laboratories
- Solicitation Teaming Requirements
- Technical Workshops
- Case Studies
  - UTC Fuel Cells
  - General Motors/Los Alamos National Lab





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# Program/Partnership Evolution

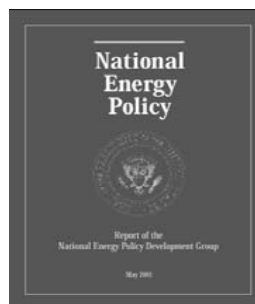


UNITED STATES ADVANCED BATTERY CONSORTIUM

January 1991



September 29, 1993



May 16, 2001

*FreedomCAR*



January 9, 2002

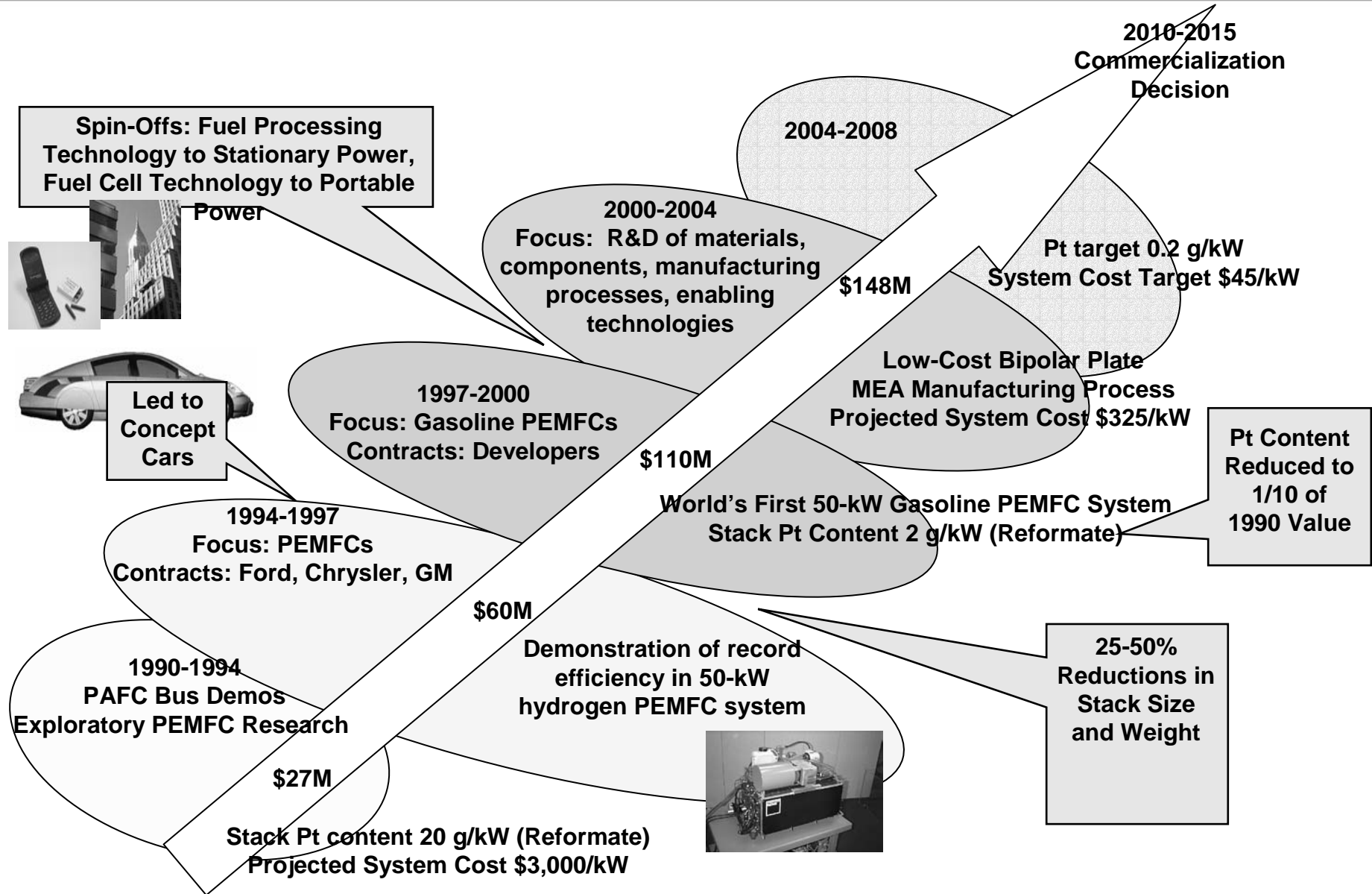
January 28, 2003  
President Bush announces  
*FreedomCAR and Fuel  
Initiative*

**H<sub>2</sub>**





# Program Timeline – Fuel Cells





## Industry Projects

Quarterly Reviews, including  
Annual FreedomCAR  
Tech Team Review

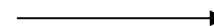
## National Lab/University Projects

Mid-Year Review by  
FreedomCAR Tech Team

Annual Merit Peer Review  
and Evaluation

Annual Progress Report  
(written)

Bi-annual National  
Academy of Sciences  
Review



[www.eere.energy.gov/hydrogenandfuelcells/](http://www.eere.energy.gov/hydrogenandfuelcells/)



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**Energy Efficiency and Renewable Energy**  
*Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable*

EERE Home

## Hydrogen, Fuel Cells & Infrastructure Technologies Program

About the Program
Information Resources
Financial Opportunities
Technologies

Hydrogen and fuel cells have the potential to solve several major challenges facing America today: dependence on petroleum imports, poor air quality, and greenhouse gas emissions. The Hydrogen, Fuel Cells & Infrastructure Technologies Program is working with partners to accelerate the development and successful market introduction of these technologies.

**Hydrogen** ▶  
Hydrogen is a clean and sustainable form of energy that can be used in mobile and stationary applications.

**Fuel Cells** ▶  
Fuel cells harness the chemical energy of hydrogen to generate electricity without combustion or pollution.

**Safety, Codes & Standards** ▶  
Codes and standards ensure the safe use of hydrogen and fuel cells.

**For Students and Teachers** ▶  
Learn the basics of hydrogen and fuel cells and view a [fuel cell animation](#).

Sign up for on-line news.

The vision of a new energy economy based on clean, renewable hydrogen is described in the [National Hydrogen Energy Vision document \(PDF 1 MB\)](#).

Although we have a vision for a [hydrogen economy](#), changing the way we produce and use energy is not a simple or overnight task. The [National Hydrogen Energy Roadmap \(PDF 2 MB\)](#) outlines the challenges we face and suggests a path forward to achieve the promise of hydrogen and fuel cells.

The first steps toward the hydrogen future are already underway. The [2002 Annual Progress Report](#) provides a complete list of DOE-funded hydrogen and fuel cell projects for 2002.

- In November 2002, the world's first energy station featuring hydrogen and electricity co-production opened in Las Vegas, Nevada. [More info](#)
- In December 2002, DOE's education workshop kicked off a new coordinated effort to educate key audiences about hydrogen and fuel cells. [More info \(PDF 284 KB\)](#)

Some of the above documents are available as Adobe Acrobat PDFs. [Download Acrobat Reader](#)

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April 2003

Energy Secretary's Road to...  
April 14, 2003

Portable Power Units, and RSC Cell Applications  
April 9, 2003

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2003 Hydrogen Merit Review  
May 19-22, 2003

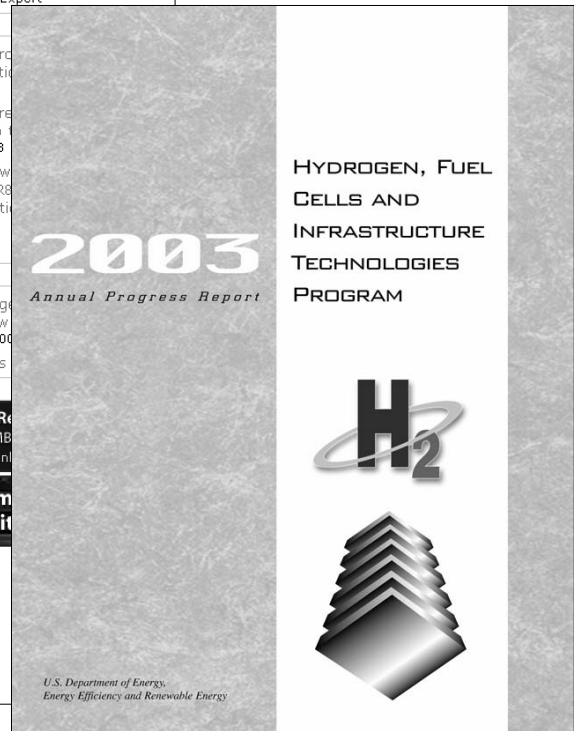
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**Fuel Cell Roadmap**  
(PDF 1.18 MB)  
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**Freedom Fuel Initiative**

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