FreedomCAR: Re-Drawing the Transportation Energy Picture

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

Transportation Research Board
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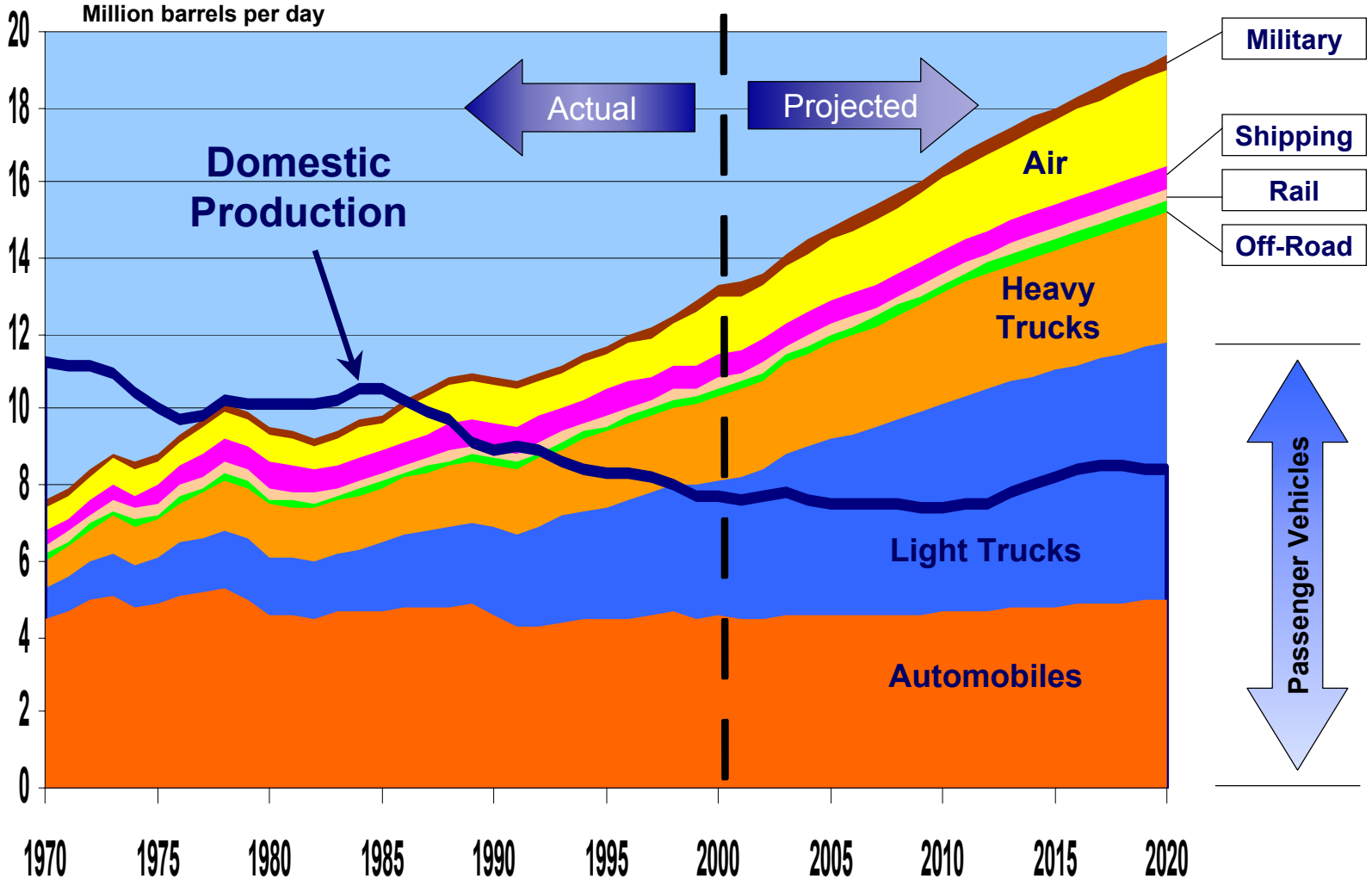
The Oil Imbalance

	Nations that **HAVE** oil	
	Saudi Arabia	26.4%
	Iraq	11.5%
64%	Kuwait	9.8%
	Iran	9.6%
	UAE	6.3%
	Russia	5.4%
	Venezuela	4.7%
	Libya	3.0%
	China	3.0%
	Mexico	2.7%
	Nigeria	2.4%
	U.S.	2.2%

Nations that **NEED** oil	
U.S.	24.9%
Japan	7.3%
China	6.4%
Germany	3.7%
Russia	3.4%
S. Korea	2.9%
Brazil	2.9%
France	2.7%
India	2.7%
Canada	2.6%
Italy	2.5%
Mexico	2.5%

Source: EIA International Petroleum Information, December 2002. Data for 2000

Trends in Demand:
U.S. Transportation Petroleum Use



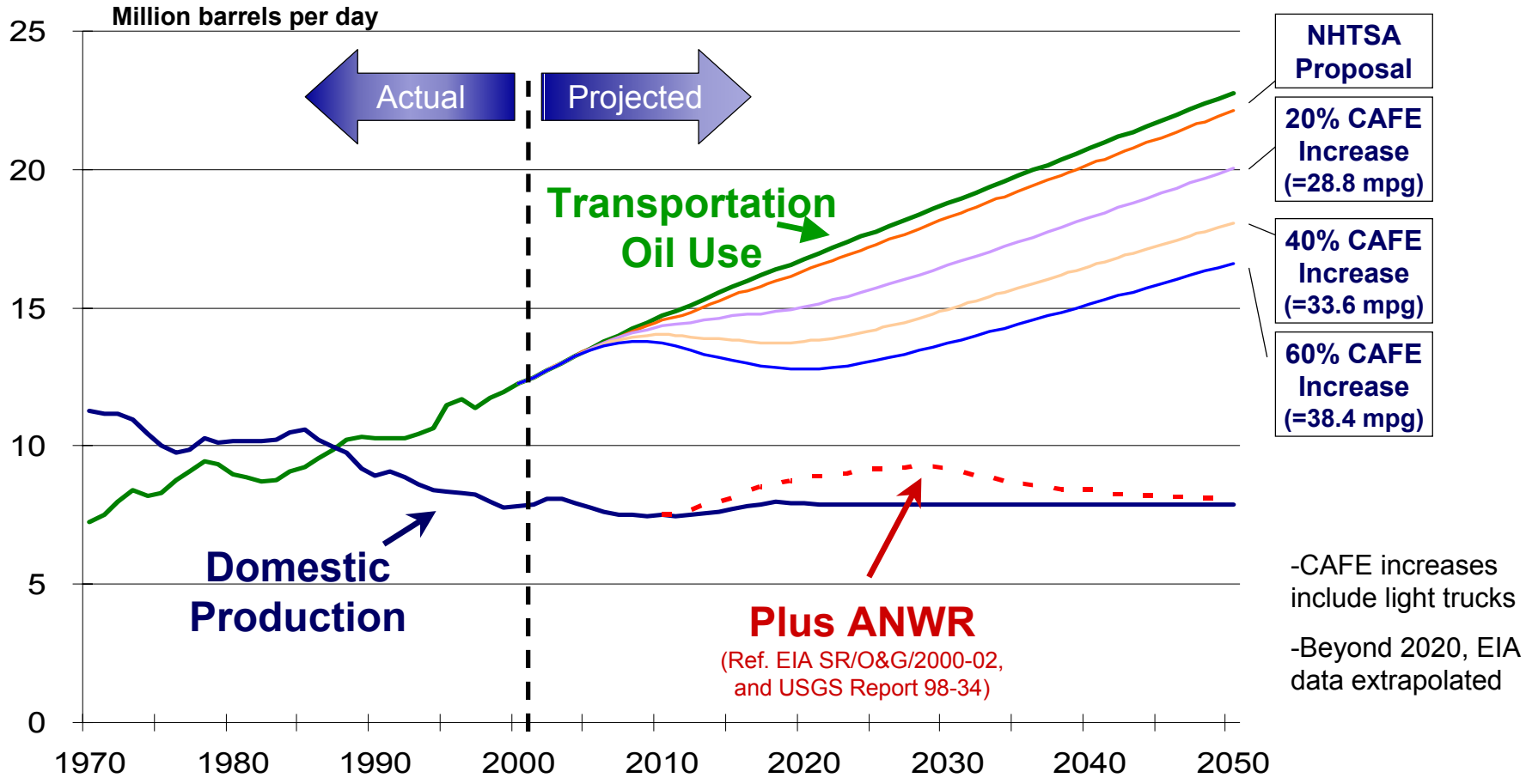
Sources: EIA Annual Energy Outlook 2002, DOE/EIA-0383(2002), Dec 2001
DOT 2002 Pocket Guide to Transportation, BTS02-02,February 2002

It's Not CAFE vs. ANWR

- Even an *immediate* 60% increase in Corporate Average Fuel Economy (CAFE) standards *and* new production from a 10 billion barrel (recoverable) oil field in the Arctic National Wildlife Refuge (ANWR) will not close the gap between demand and domestic production.

A TOTALLY NEW APPROACH IS NEEDED!

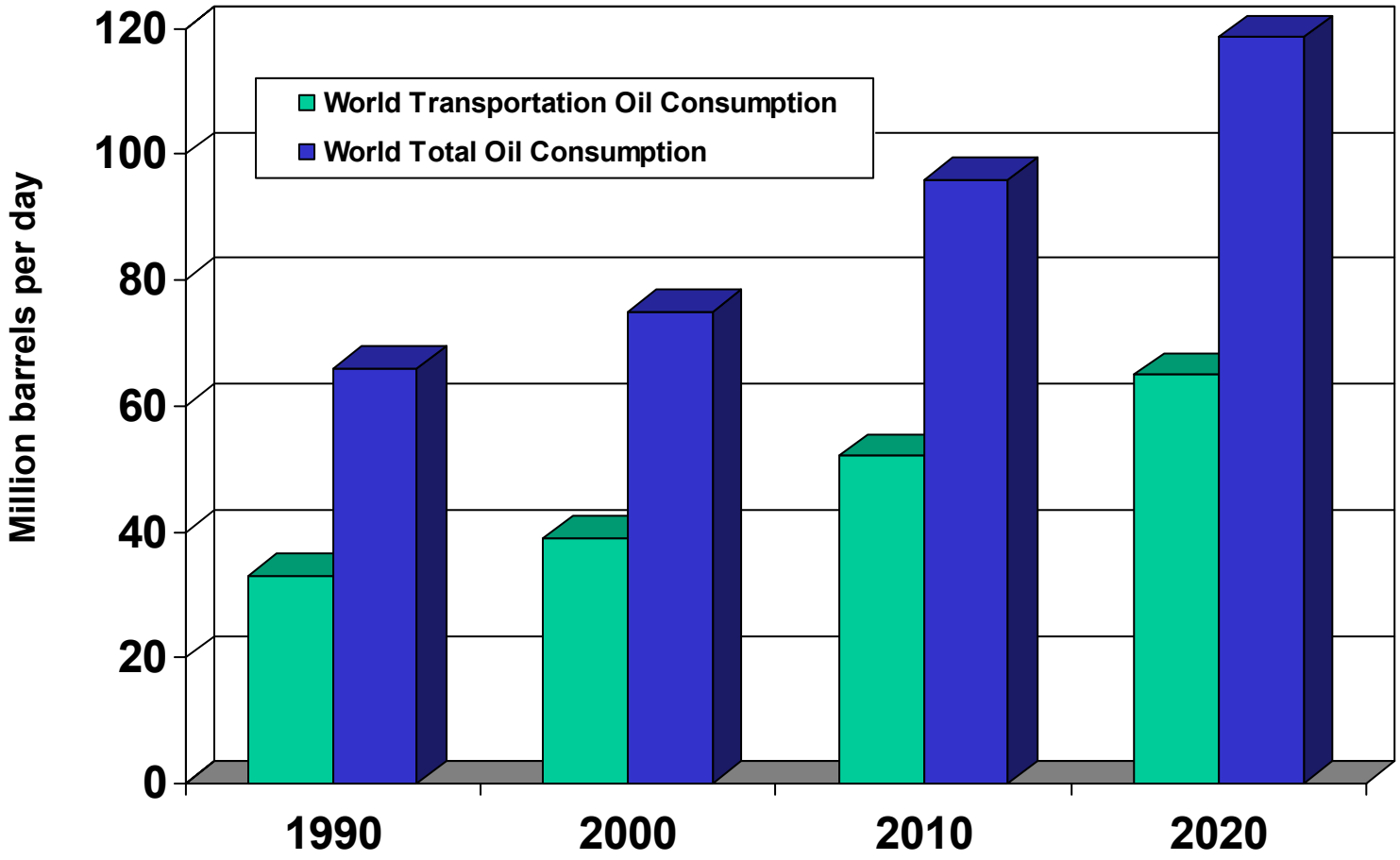
The Oil "Gap" Is Growing



-CAFE increases include light trucks

-Beyond 2020, EIA data extrapolated

Increasing World Oil Consumption



The Carbon Challenge:

To reach the stable carbon levels on the left,
world emissions need to decline as shown on the right.

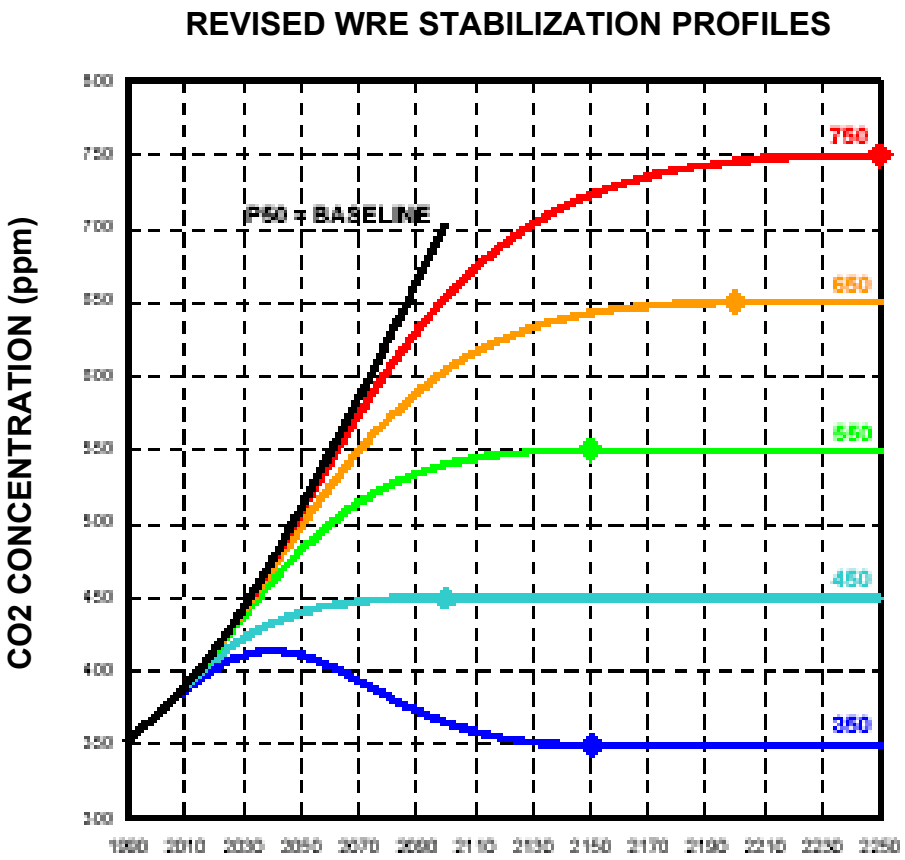
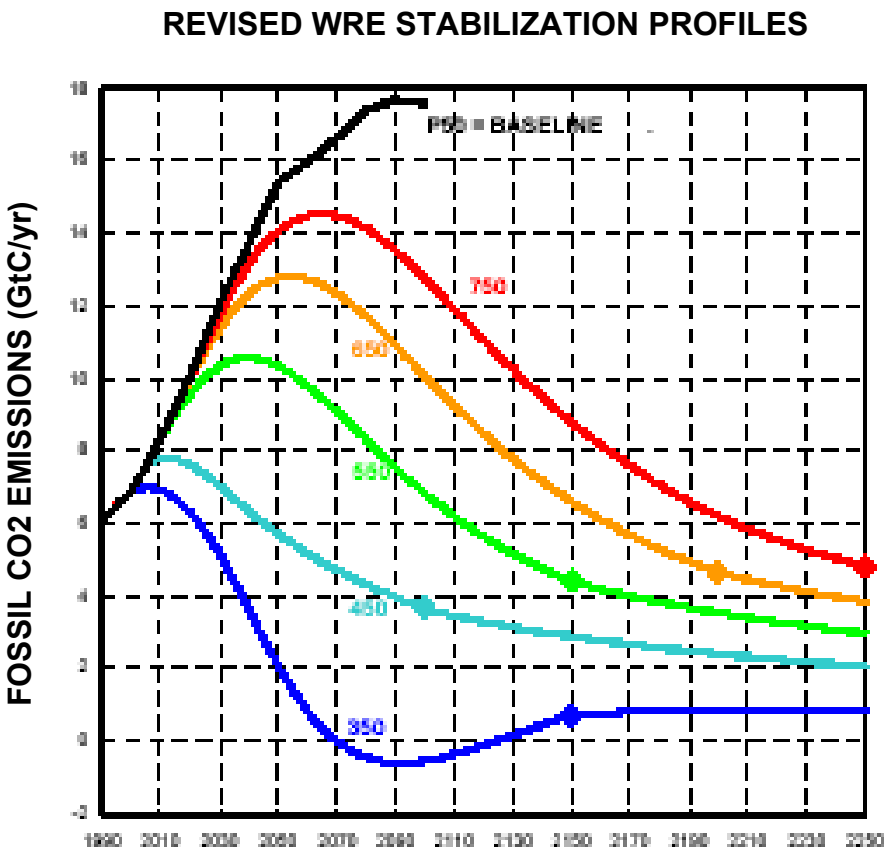


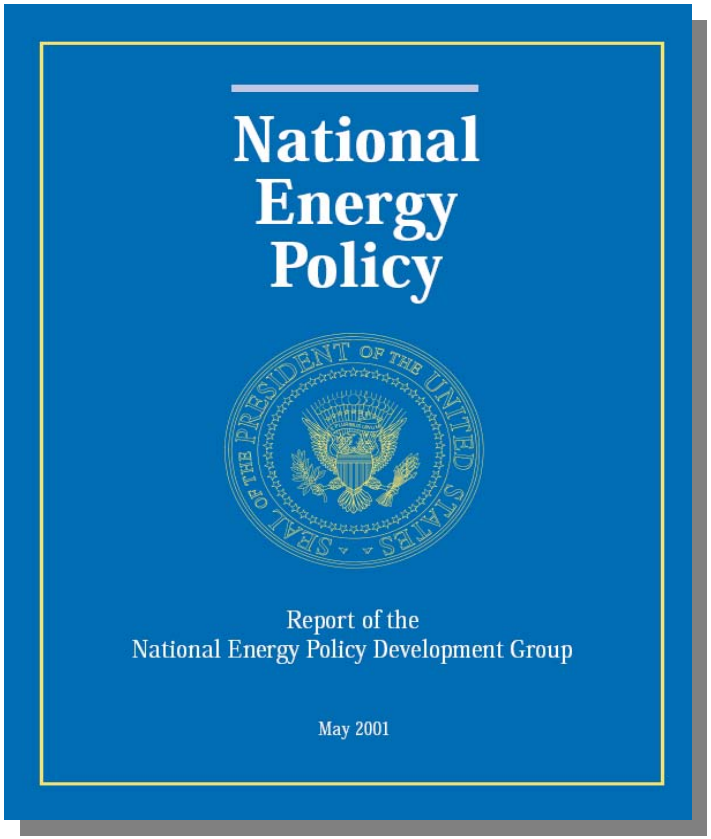
Figure A: Profiles for Various Stabilized CO_2 Concentration Levels



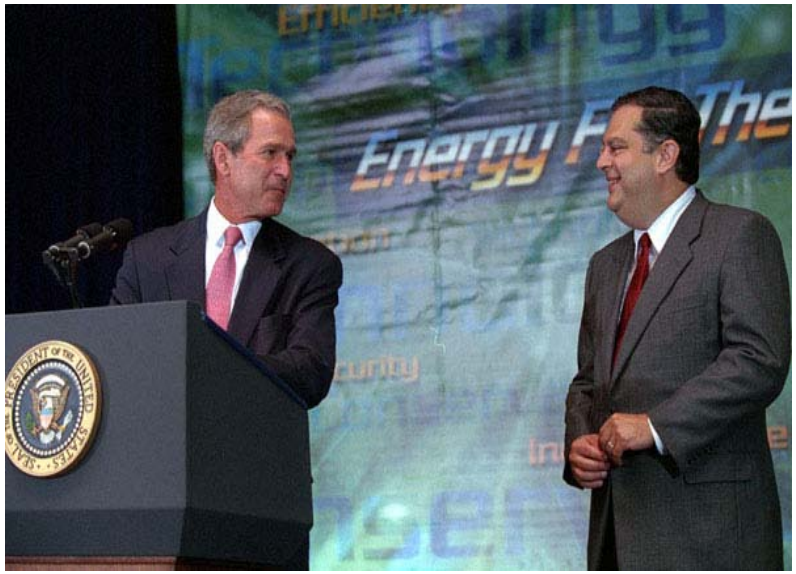
Emission Profiles for the Stabilized CO_2 Concentration Levels of Figure A

National Energy Policy

- Aggressively reduce demand through energy efficiency
- Increase energy supply
- Enhance diversity of energy sources
- Dramatically upgrade national energy infrastructure
- Build on record of environmental protection
- Create a new vision for our energy future



National Energy Policy



Directs the Secretary of Energy to:

"explore the possibility of a hydrogen economy…

"develop next generation technology including hydrogen…

"Focus research and development efforts on integrating current programs regarding hydrogen, fuel cells, and distribution…

Develop legislation to provide for a temporary income tax credit available for the purchase of new hybrid or fuel cell vehicles."

FreedomCAR Launched

January 9, 2002

Secretary Abraham announces the FreedomCAR Partnership

FreedomCAR (Cooperative Automotive Research) is a partnership between DOE and the U.S. Council for Automotive Research, a cooperative endeavor among DaimlerChrysler, Ford, and GM to conduct pre-competitive research

Our long term vision: A transportation system free from emissions and dependence on petroleum.

FreedomCAR's "Freedoms"

- Freedom from foreign petroleum dependence
- Freedom from pollutant and carbon dioxide emissions
- Freedom for Americans to drive where they want, when they want, in the vehicle of their choice
- Freedom to obtain fuel affordably and conveniently

FreedomCAR's 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 hybrid propulsion, advanced materials, and other technologies that can dramatically reduce oil consumption and environmental impacts in the nearer term.

- Instead of single vehicle goals, develop technologies applicable across a wide range of passenger vehicles.

FreedomCAR's Organization

FreedomCAR Executive Steering Committee

DOE EERE Assistant Secretary
OSTP Associate Director for Technology
USCAR Member Company Vice Presidents
Designated Observers -- OVP, OMB

Consultation with DOE Offices:

Fossil Energy
Office of Science,
Others

Consultation and Coordination:

Government Agencies
Energy Industry
Industry Supply Base
Technology Developers
Potential Stakeholders

FreedomCAR Operations Group

FreedomCAR Technical Teams

Potential Energy Industry Roles

- Assist in prioritizing Research, Development, and Deployment (RD&D) and establishing technology goals for FreedomCAR

- Develop and Evaluate Pre-Competitive Hydrogen Technologies
  - Production (Fossil, Nuclear, and Renewable Pathways) and Delivery
  - Hydrogen Storage (Off-board and On-board)
  - Vehicle/Refueling Interface Issues
  - Codes and Standards/Safety

Complete Establishment of FreedomCAR Technical Teams

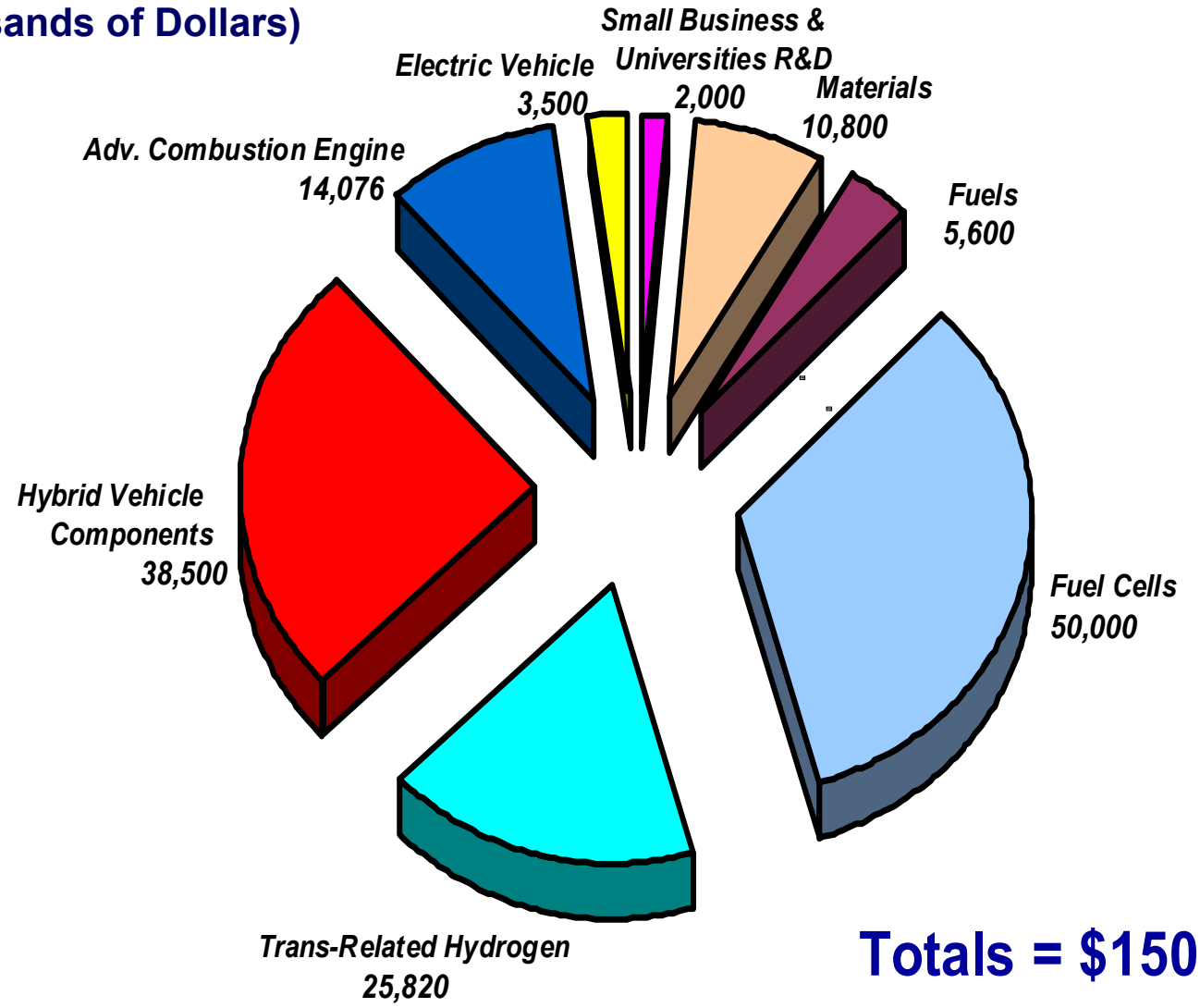
The FreedomCAR Partners have established the following technical teams:

- Fuel Cell Systems
- Hydrogen Storage and Vehicle Interface
- Advanced Combustion and Emissions Control
- Systems Engineering and Analysis
- Electrochemical Storage
- Materials
- Electrical and Electronics

The technical team structure will continue to be assessed and additional teams may be added to this list as the demands and needs of the FreedomCAR Partnership evolve.

FreedomCAR FY03 Budget Request Reflects Fuel Cell & Hydrogen Priorities

(Thousands of Dollars)



Totals = $150,296

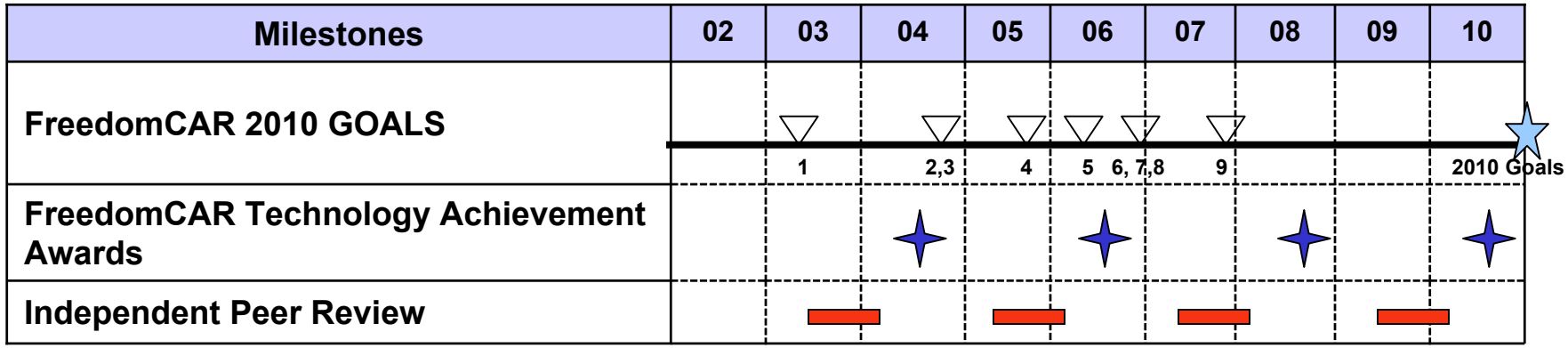
2010 FreedomCAR Technology Specific Goals

	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 $1.50/gal (gas equiv.)		
Electric Propulsion		≥55 kW 18 sec. 30 kW cont.		$12/kW peak	15 years	
Electric Energy Storage		25 kW 18 sec.	300 W-h	$20/kW	15 years	
Materials						50% less
Engine Powertrain System**	45% peak			$30/kW	15 years	

* Cost references based on constant 2001 dollar values

** Meets or exceeds emissions standards.

FreedomCar Partnership Interim Milestones



Interim Milestones

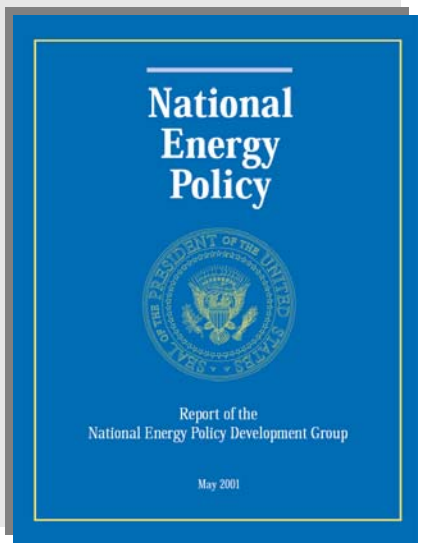
1) Pre-production prototypes of the Automotive Integrated Power Modules and Electric Motor Drive completed. (1Q, 2003)
2) Fuel Cell Advanced Fuel Processing Go/No-Go Decision and Technology Downselect to meet 2010 targets. (3Q,2004)
3) Full-scale lithium-ion battery pack demonstrated via Hardware-in-the-Loop. (4Q, 2004)
4) Validate fuel cell interim cost target of $125 per kW. (4Q, 2005)
5) Intermediate, Integrated, Series Electric Drive Systems Technology Validated. (2Q, 2006)
6) Downselect advanced hydrogen storage concepts showing potential to meet 2010 targets. (4Q, 2006)
7) Durable NOx and PM emission control technologies validated. (4Q, 2006)
8) Hardware-in-the-Loop testing of advanced energy storage device completed. (4Q, 2006)
9) Demonstrate integrated hydrogen refueling stations using advanced components to meet interim hydrogen fuel cost target. (4Q, 2007)

FreedomCAR 2010 Goals Demonstrated and Validated

FreedomCAR Technology Achievement Awards

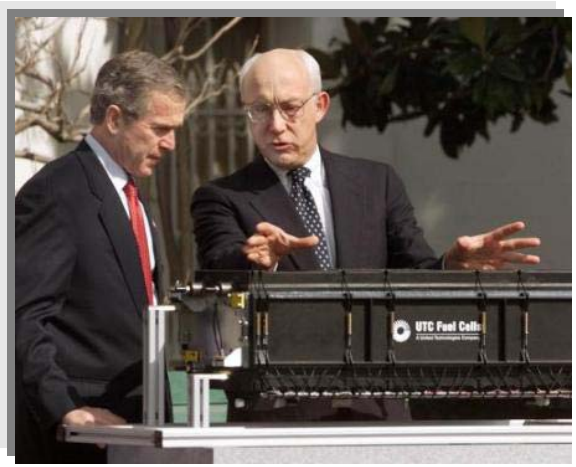
Independent Peer Reviews

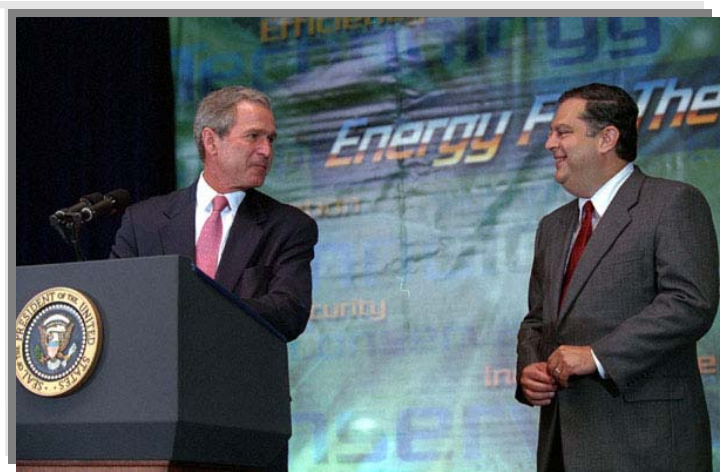
Strong Support for Hydrogen and Fuel Cell Technologies



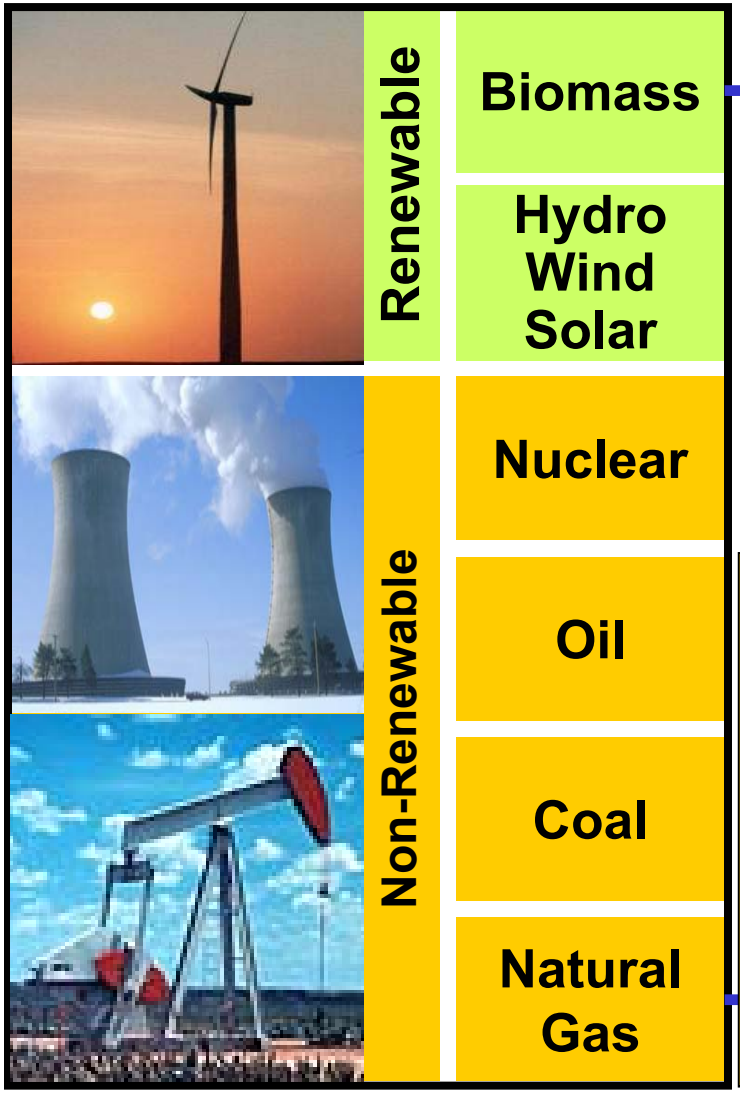
"We happen to believe that fuel cells … offer incredible opportunity. Now, there's a lot of obstacles that must be overcome in order to make fuel cells economically viable. And, therefore, we're promoting more research and development."

President Bush

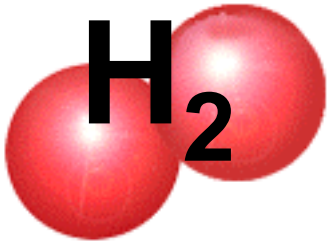




Hydrogen from Diverse Domestic Resources



HIGH EFFICIENCY & RELIABILITY



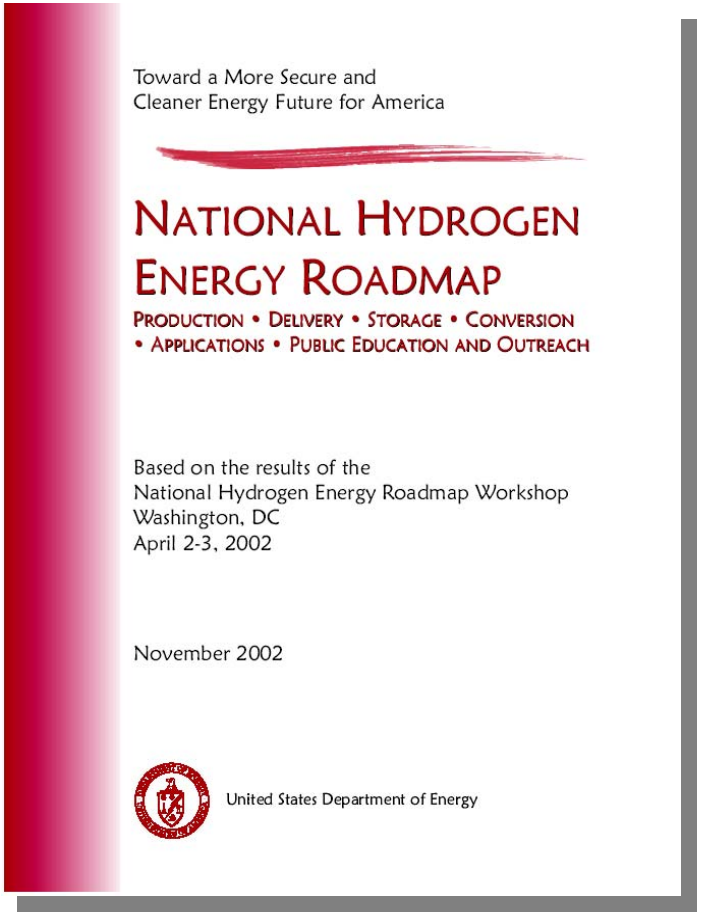
ZERO/NEAR ZERO EMISSIONS

Transportation

Distributed Generation

National Hydrogen Energy Roadmap

- Identifies the "challenges" and "path forward" to realizing vision of a Hydrogen Economy
  - Production
  - Delivery
  - Storage
  - Conversion
  - Applications
  - Education and Outreach
- Secretary Spencer Abraham announced November 12, 2002 at the Global Forum on Personal Transportation


Toward a More Secure and
Cleaner Energy Future for America

NATIONAL HYDROGEN
ENERGY ROADMAP

PRODUCTION • DELIVERY • STORAGE • CONVERSION
• APPLICATIONS • PUBLIC EDUCATION AND OUTREACH

Based on the results of the
National Hydrogen Energy Roadmap Workshop
Washington, DC
April 2-3, 2002

November 2002

United States Department of Energy

Online at: www.eren.doe.gov/hydrogen/

Program Strategy for Transitioning to a Hydrogen Economy

- **Conduct R&D to solve critical path technologies**
  - Hydrogen Storage (7.5 wt%; 1100 W-h/l, $5/kW-h)[Under discussion with FreedomCAR partners]
  - Hydrogen Production Cost (NG-based $1.50/gge untaxed)
  - Fuel Cell Cost (2010:$45/kW; 2015:$30/kW)

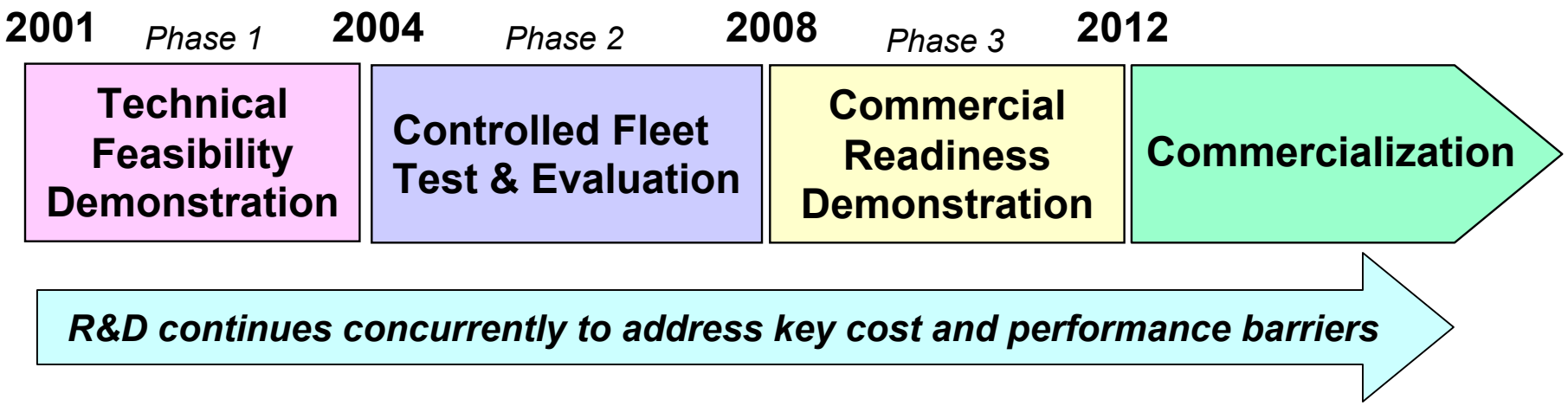
- **Validate technology development through "learning" demonstrations**
  - Centrally fueled vehicles and production/refueling infrastructure
  - Power park concept

- **Lead codes and standards development**

Field Demonstration Program

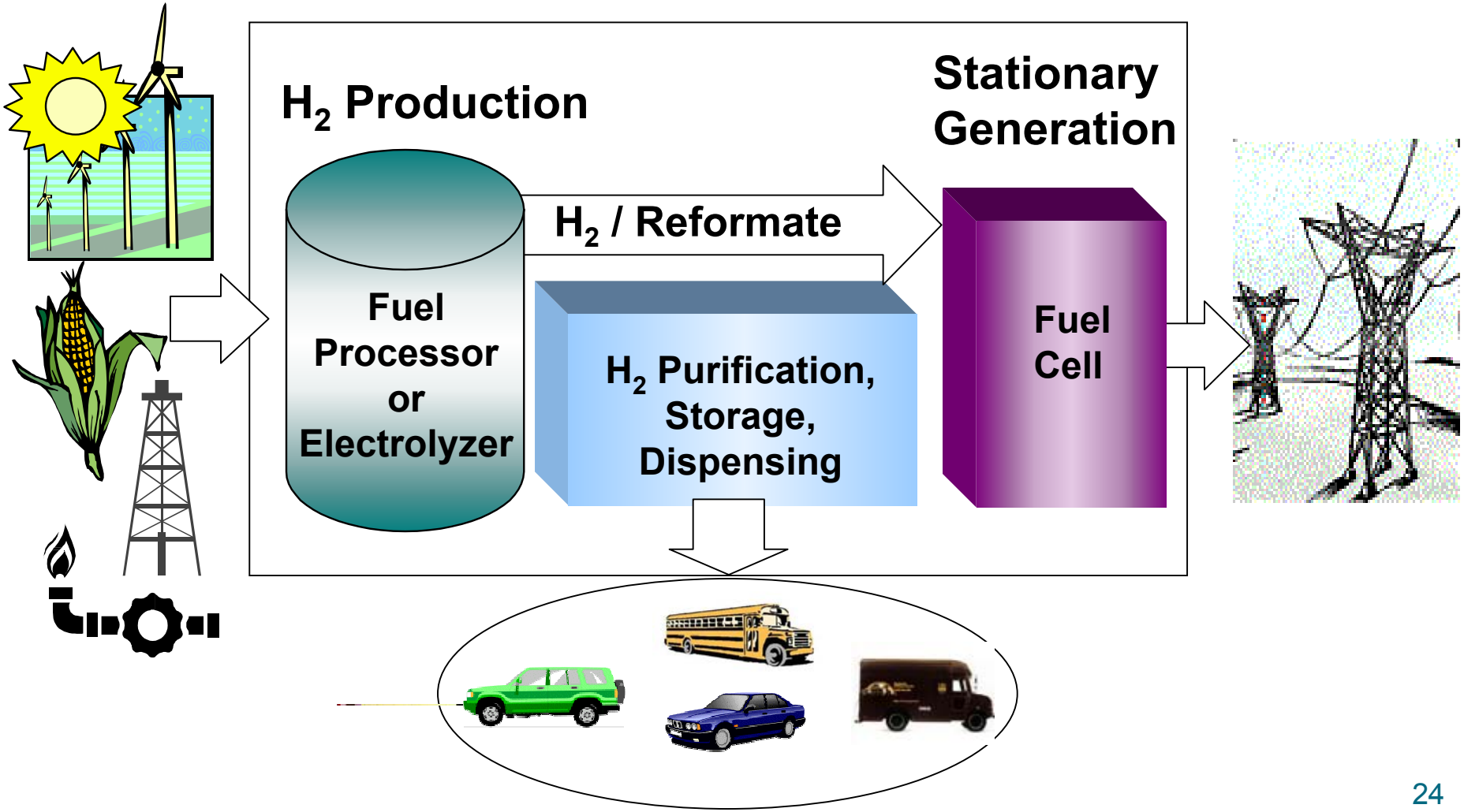
Goal: To determine if investment is warranted in fuel cell vehicles and hydrogen infrastructure technologies at commercial production volumes

Potential Demonstration Program



Subsequent phases only proceed if success criteria for the previous phase have been met.

Integrated Power Generation and Vehicle Refueling Station



Las Vegas Hydrogen Station

Completed 5-year project resulting in design, construction, and demonstration of a multi-purpose refueling station with capability of:

- On-site hydrogen production (natural gas reforming)
- Hydrogen/electricity co-production system operating a 50kW PEM FC
- Hydrogen/CNG blends and pure Hydrogen vehicle dispensers.

Dedicated November 2002

Future plans are to evaluate operability, reliability, economic feasibility, and to certify integrated power generation and vehicle refueling designs.

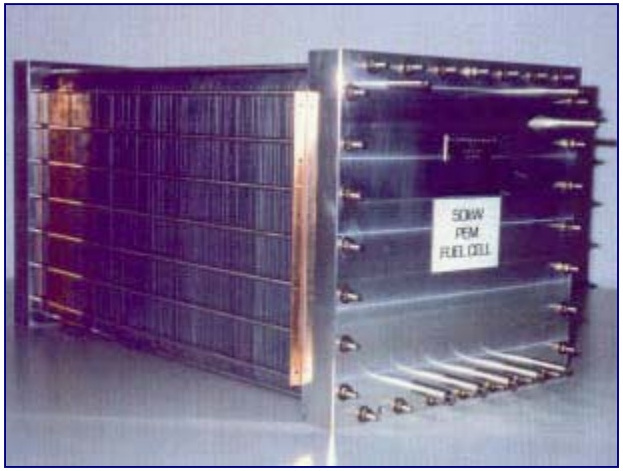
California Fuel Cell Partnership:
FreedomCAR & Vehicle Technologies

…a collaboration of auto companies, fuel providers, fuel cell technology companies, and government agencies that is placing fuel cell electric vehicles on the road in California

IEA Agreements

Hydrogen

- 12 Countries (including Japan & U.S.) and the European Commission
- Task-Shared, joint R&D funding of critical technologies in storage (carbon and hydrides) and production (renewables)



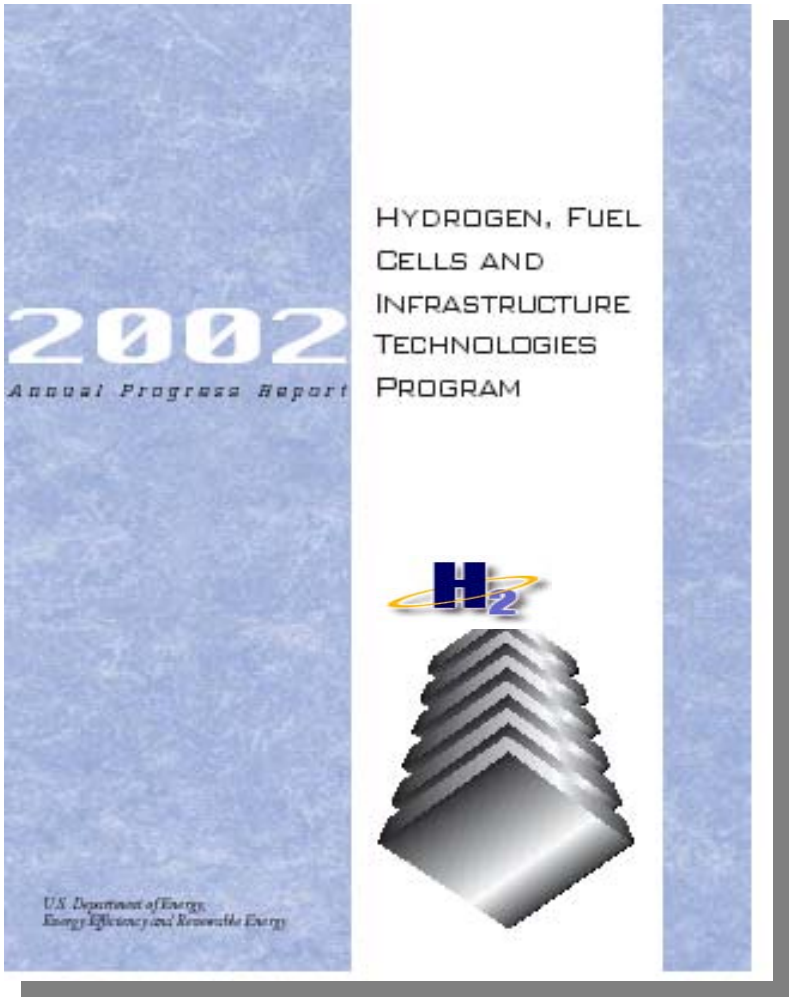
Fuel Cells

- 14 Countries, including Japan & U.S.
- Information exchange and joint workshops on PEM FCs, SOFCs, MCFCs, transportation and stationary fuel cell systems

For More Information…

A comprehensive annual report on all Hydrogen and Fuel Cell funded projects for FY 2002

www.eren.doe.gov/hydrogen



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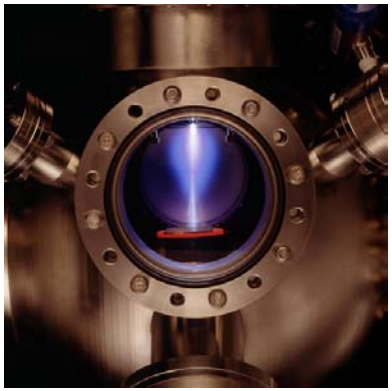

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable