Why Hydrogen? and When ?

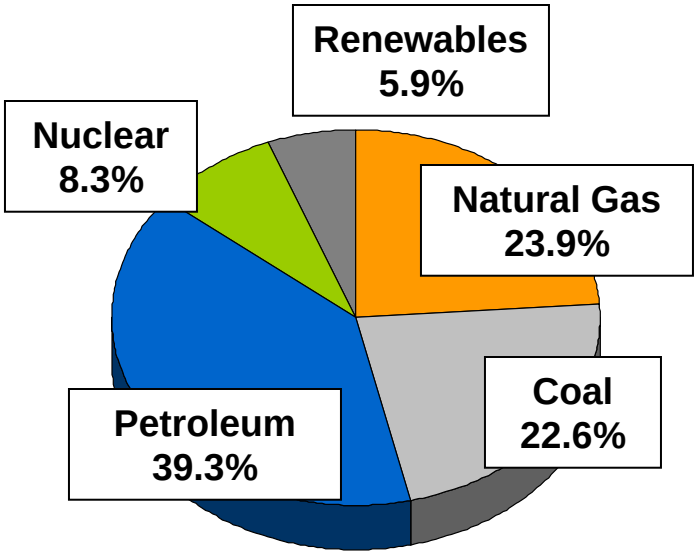
U.S. Department of Energy
Office of Hydrogen, Fuel Cells and Infrastructure Technologies

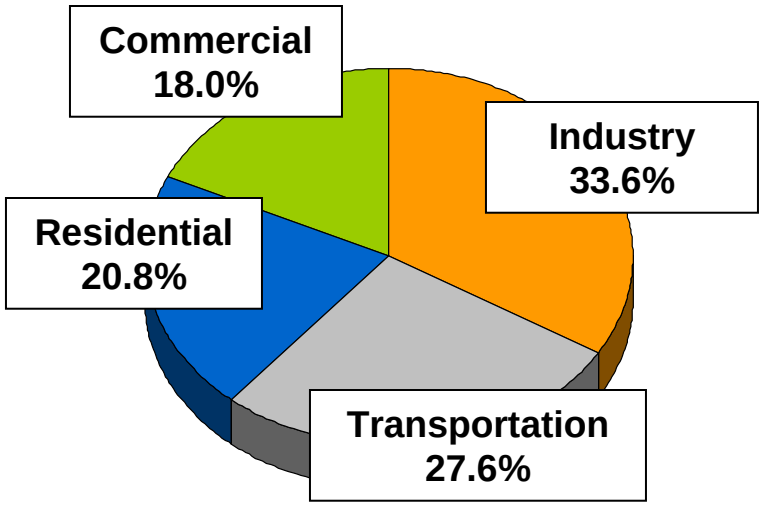
Mark Paster

Biomass R&D Technical Advisory Committee Meeting

July 13, 2004

Facts & Figures: U.S. Energy Use





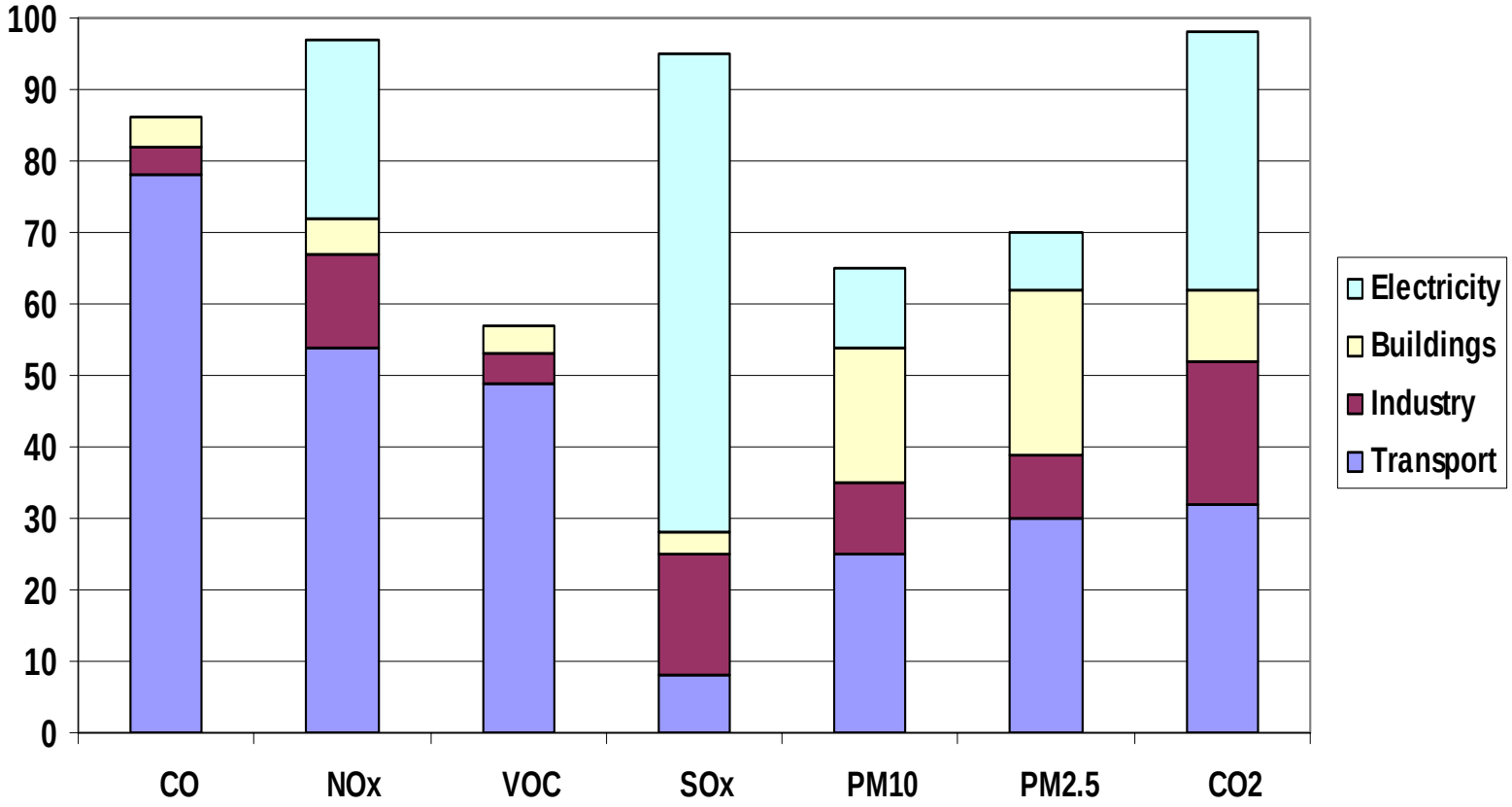
2001 U.S. Energy Use: 97 Quads

Population 284.8 million (July 2001)

341 million Btu/capita

Sources: Annual Energy Review, U.S. Department of Energy, Energy Information Administration, 2001.
National Population Estimates, U.S. Census Bureau, 2001.

U.S. 1998 Energy-Linked Emissions as Percentage of Total Emissions



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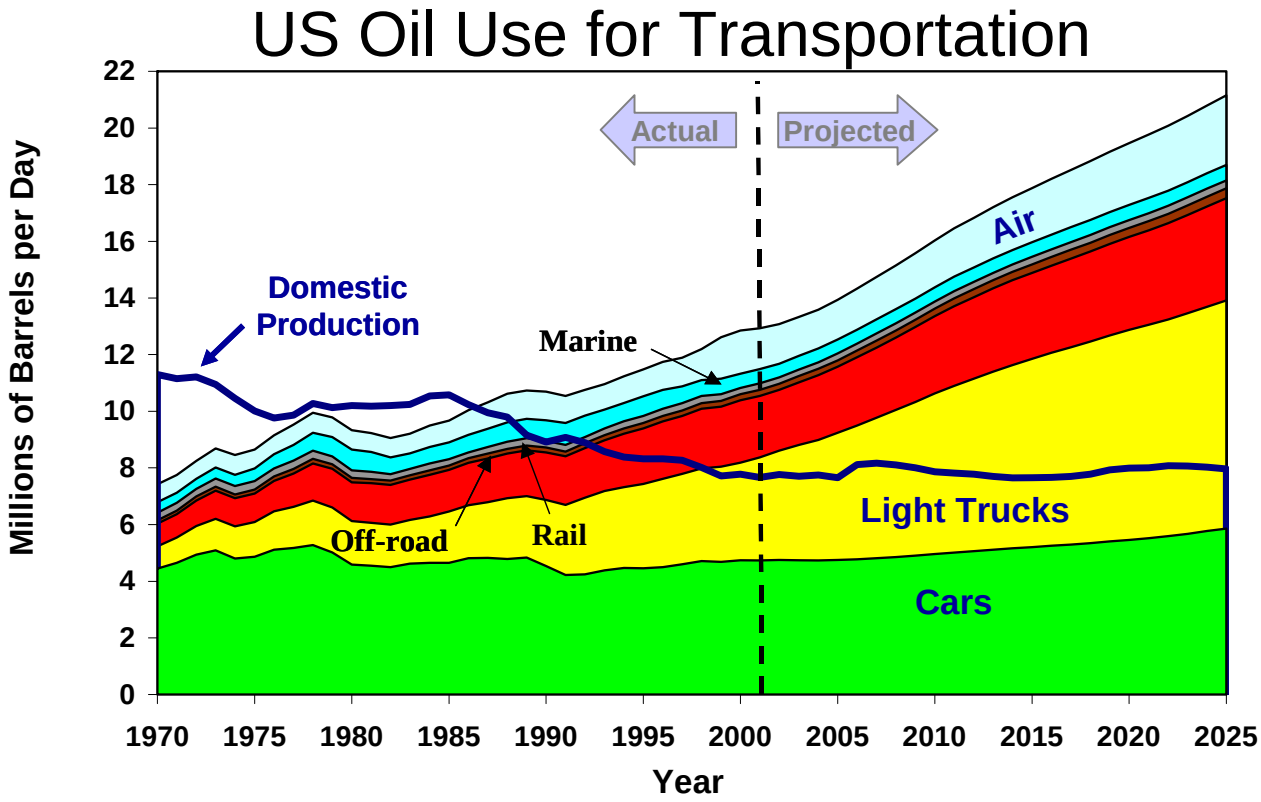
U.S. Energy Dependence is Driven By Transportation



Source: Transportation Energy Data Book: Edition 22, September 2002, and EIA Annual Energy Outlook 2003, January 2003

- Two-thirds of the 20 million barrels of oil Americans use each day is used for transportation
- America imports 55 percent of the oil it consumes, that is expected to grow to 68% by 2025.
- Nearly all of our cars and trucks run on gasoline or diesel.

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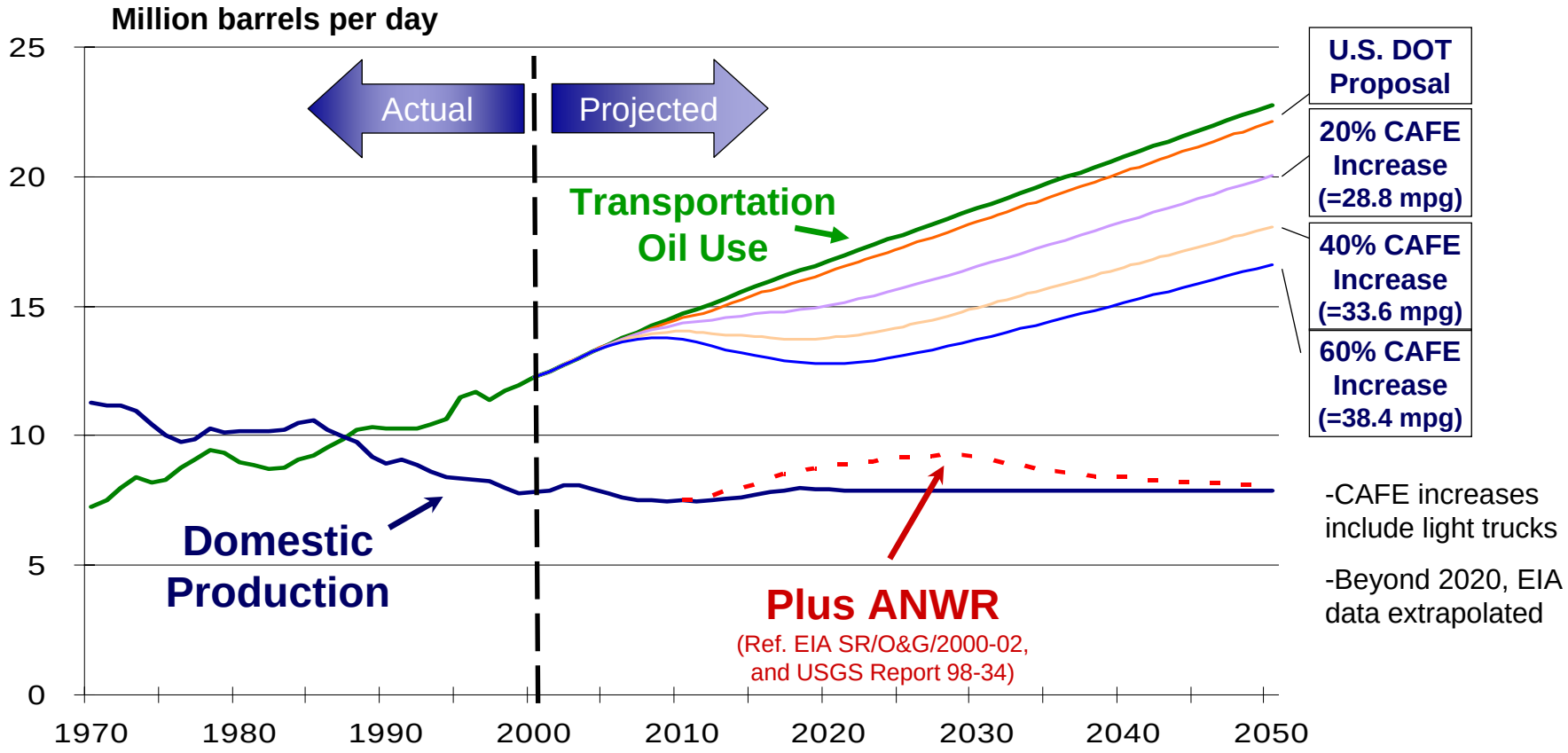
A Bold New Approach is Required

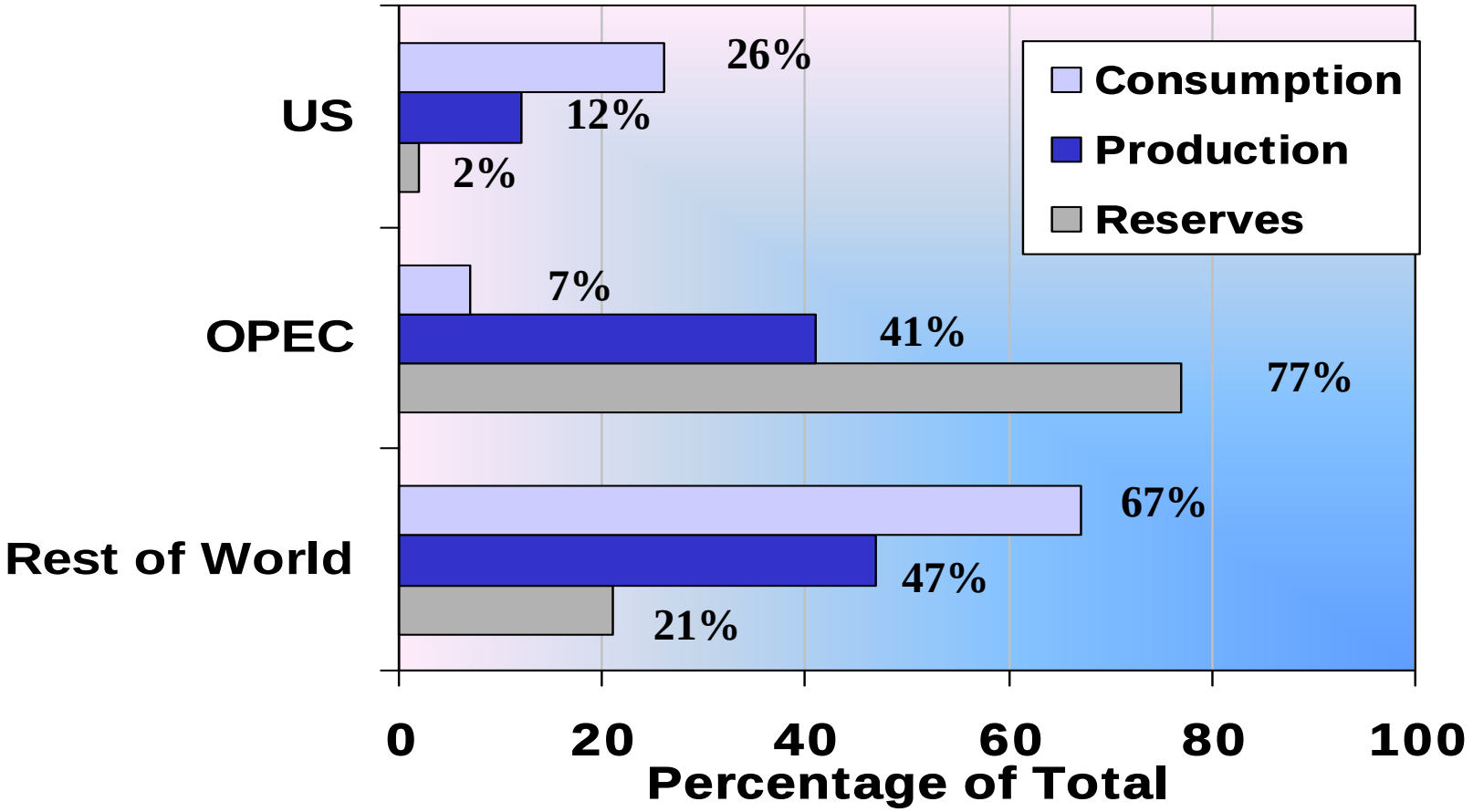


-CAFE increases include light trucks

-Beyond 2020, EIA data extrapolated

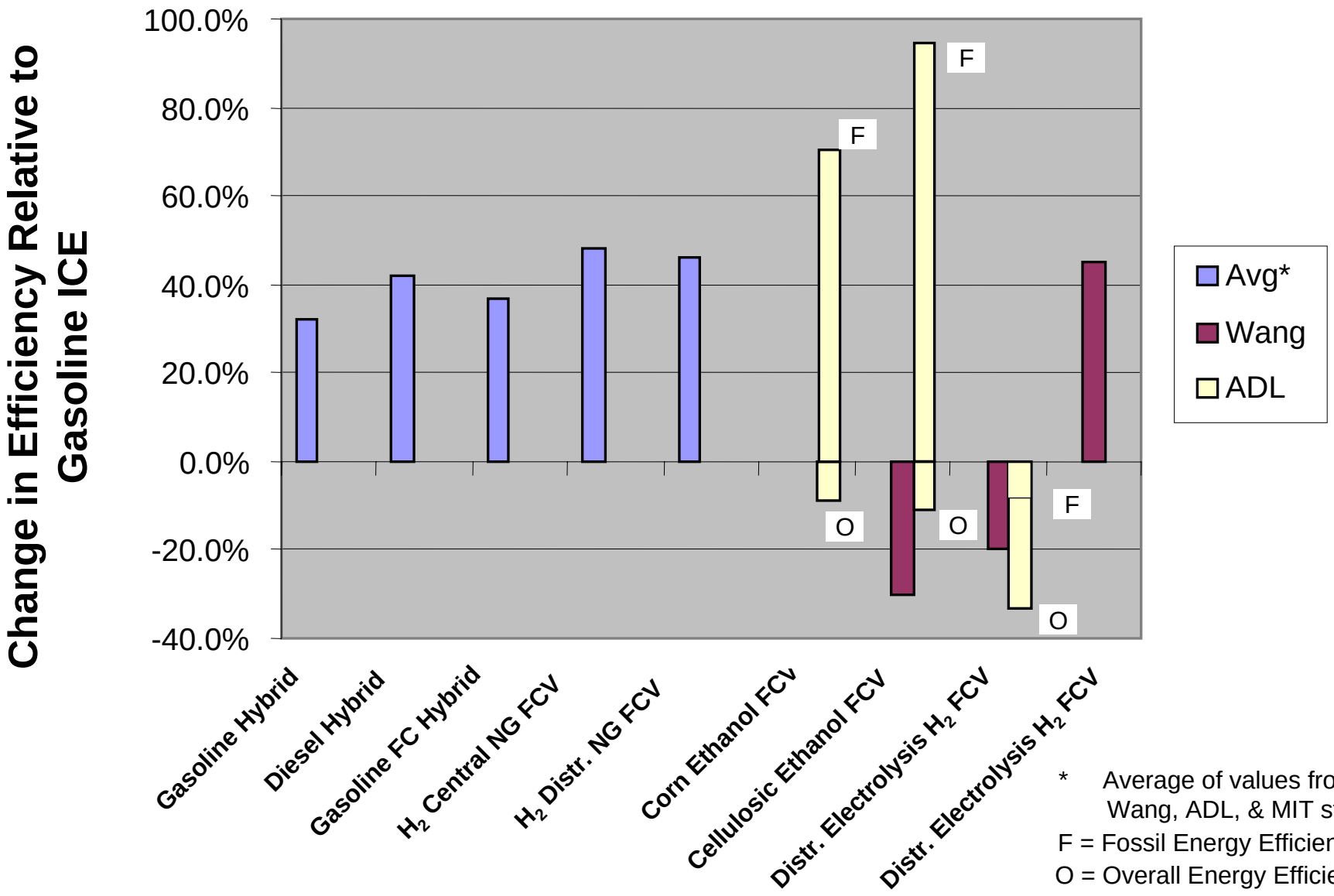
Even an *immediate* 60 percent increase in CAFE standards *and* new production from a 10 billion barrel (recoverable) oil field in ANWR will not close the gap between transportation demand and domestic production.

World Oil Reserves are Consolidating in OPEC Nations



Source: DOE/EIA, International Petroleum Statistics Reports, April 1999; DOE/EIA 0520, International Energy Annual 1997, DOE/EIA0219(97), February 1999.

Well-to-Wheels Energy Consumption

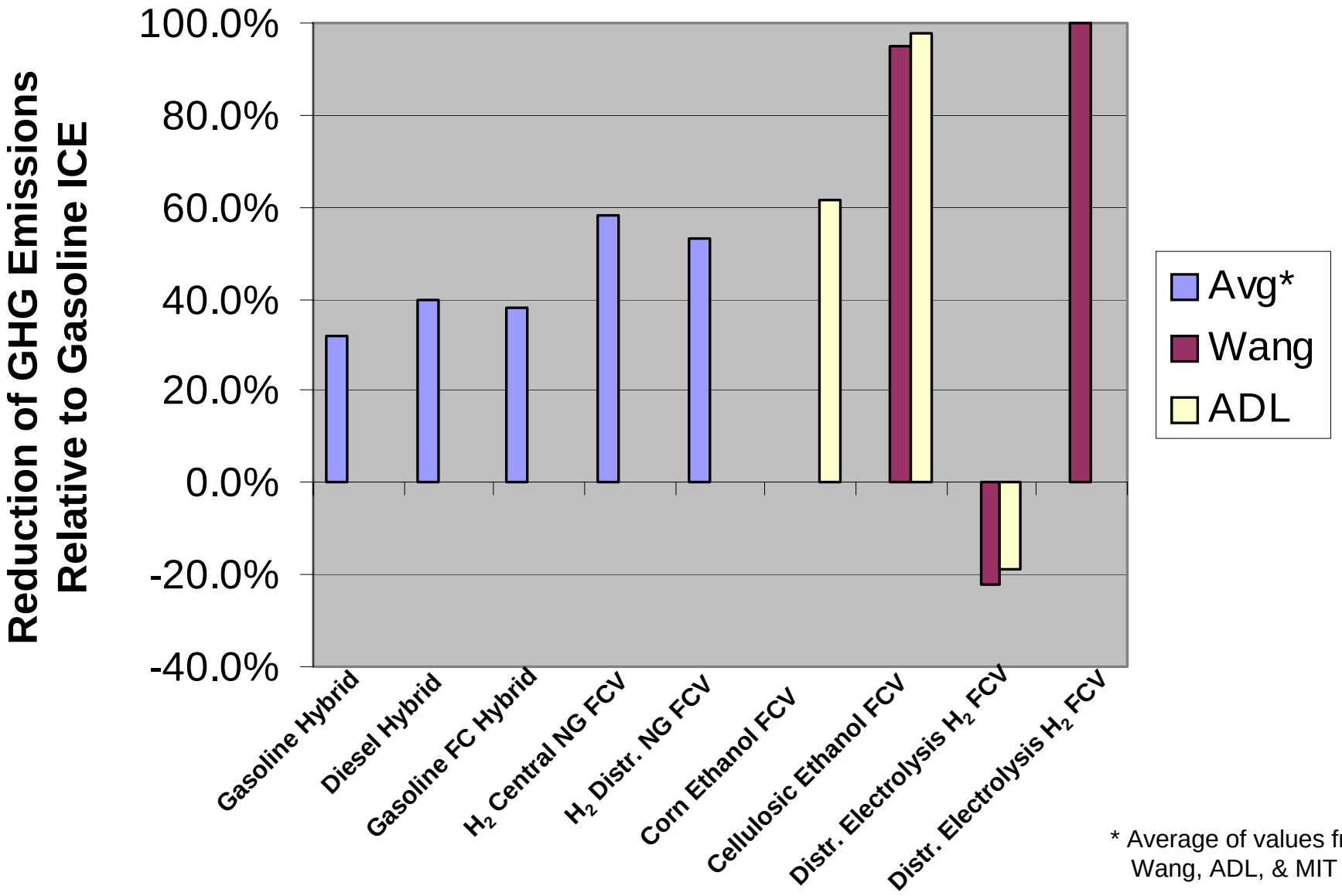


* Average of values from Wang, ADL, & MIT studies

F = Fossil Energy Efficiency

O = Overall Energy Efficiency

Well-to-Wheels GHG Emissions



* Average of values from Wang, ADL, & MIT studies

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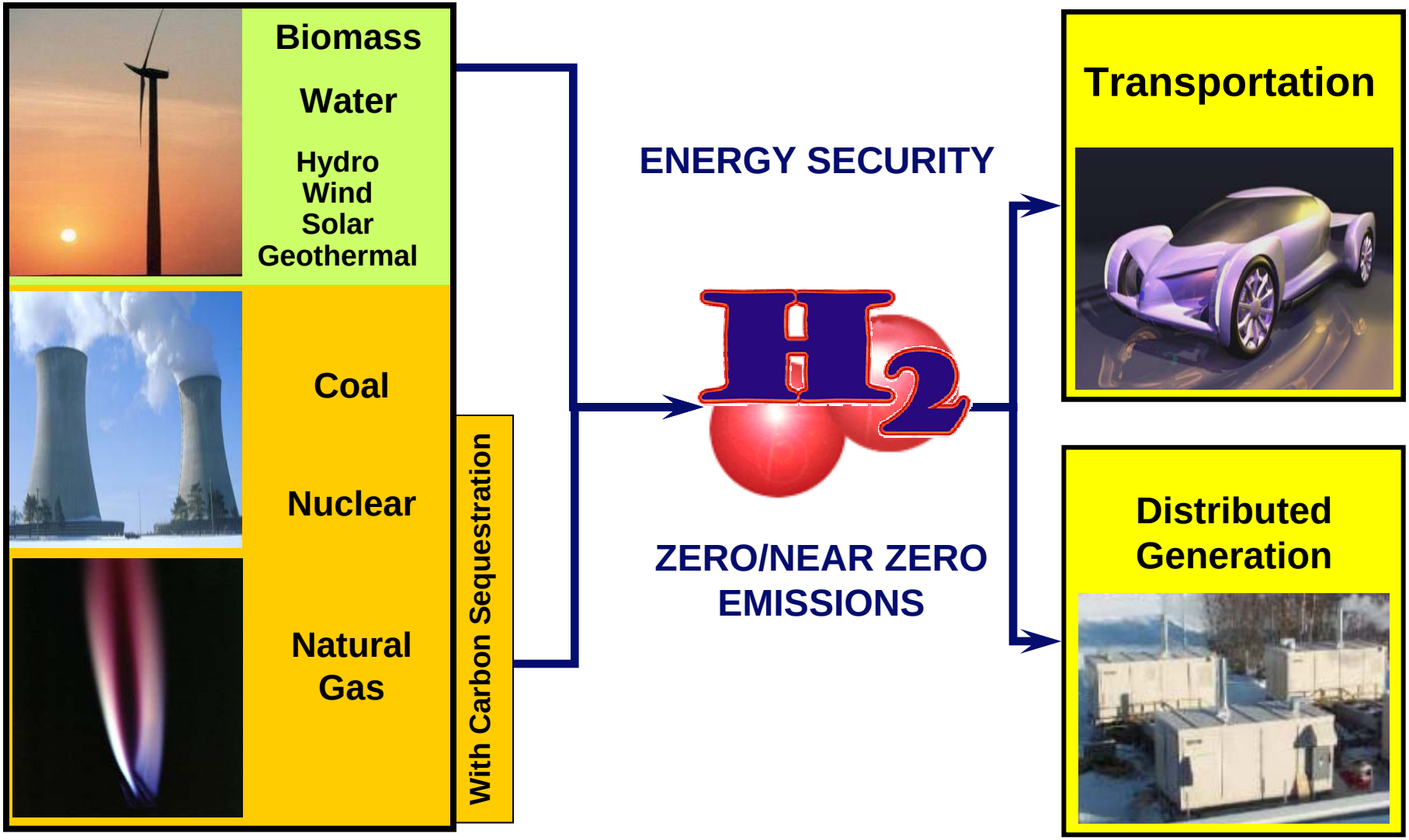
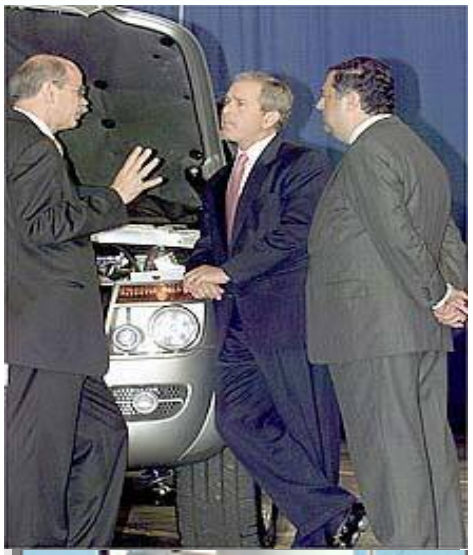
Why Hydrogen? It's abundant, clean, efficient, and can be derived from diverse domestic resources.

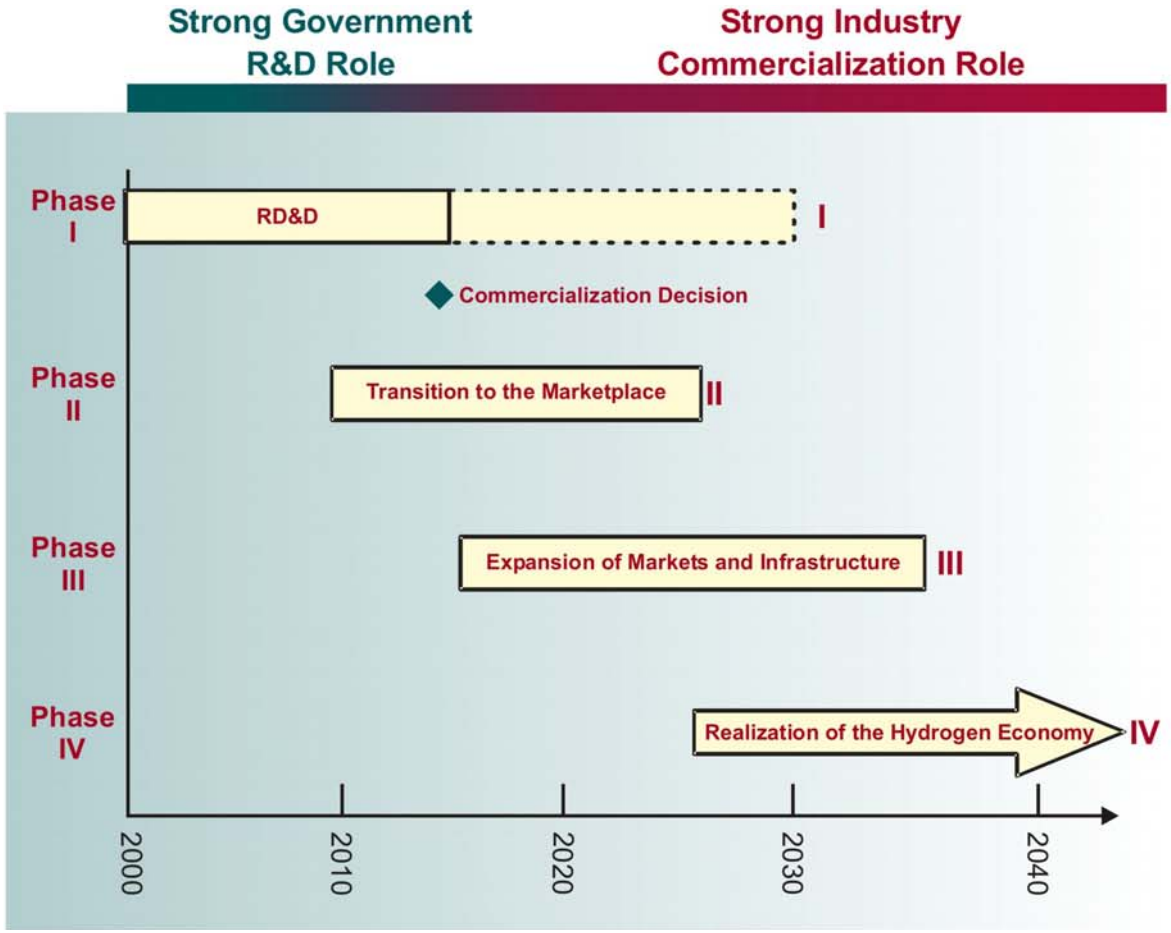


Hydrogen Infrastructure and Fuel Cell Technologies put on an Accelerated Schedule

- **President Bush commits a total $1.7 billion over first 5 years:**
  - **$1.2 billion for hydrogen and fuel cells RD&D ($720 million in new money)**
  - **$0.5 billion for hybrid and vehicle technologies RD&D**
- **Accelerated, parallel track enables industry commercialization decision by 2015.**

Fuel Cell Vehicles in the Showroom and Hydrogen at Fueling Stations by 2020





Transitional Phases

I. Technology Development Phase

Research to meet customer requirements and establish business case lead to a commercialization decision

II. Initial Market Penetration Phase

Portable power and stationary/ transport systems begin commercialization; infrastructure investment begins with governmental policies

III. Infrastructure Investment Phase

H_2 power and transport systems commercially available; infrastructure business case realized

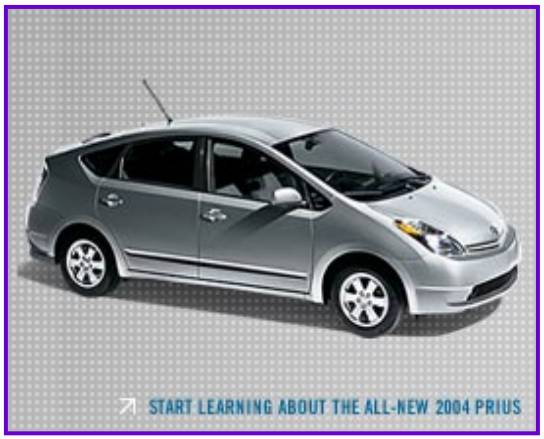
IV. Fully Developed Market and Infrastructure Phase

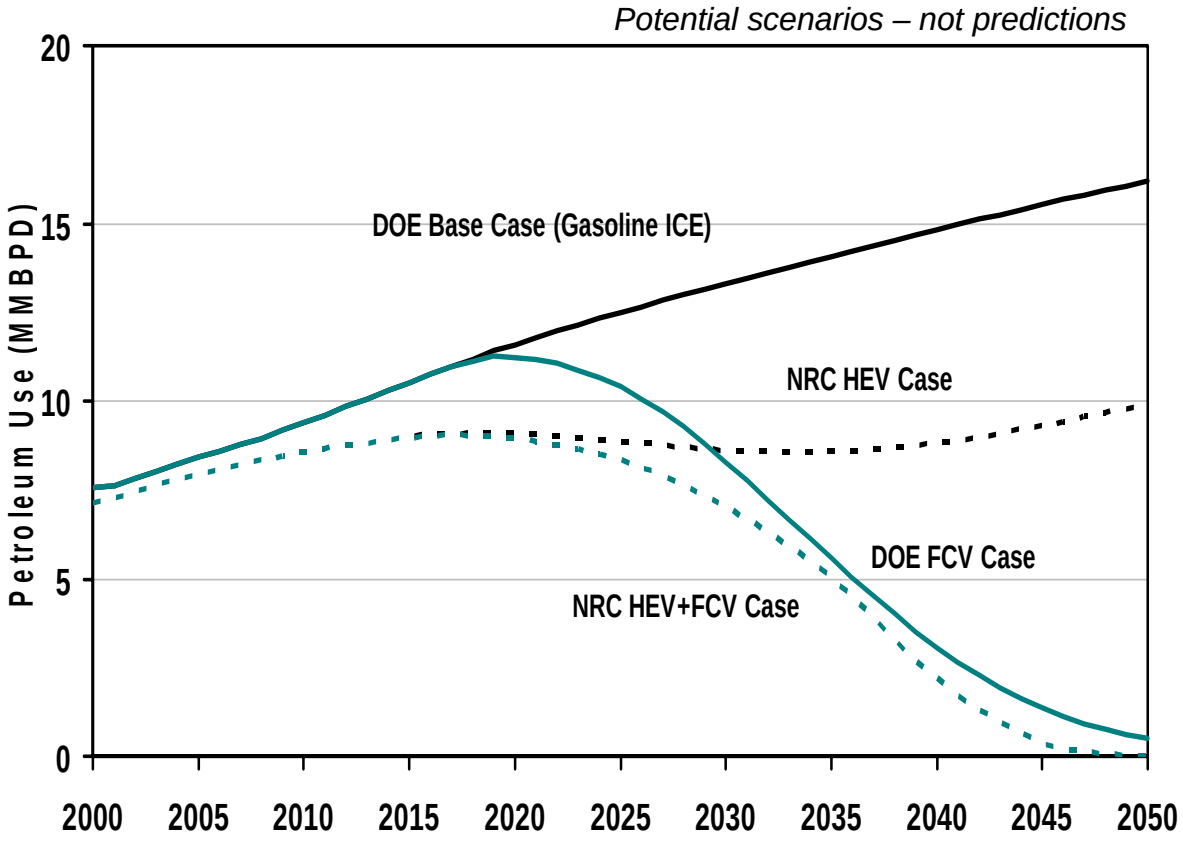
H_2 power and transport systems commercially available in all regions; national infrastructure

Positive commercialization decision in 2015 leads to beginning of mass-produced hydrogen fuel cell cars by 2020

Hybrids are a Bridge

***Hybrid vehicles** are a bridge technology that can reduce pollution and our dependence on foreign oil until long-term technologies like hydrogen fuel cells are market-ready.*





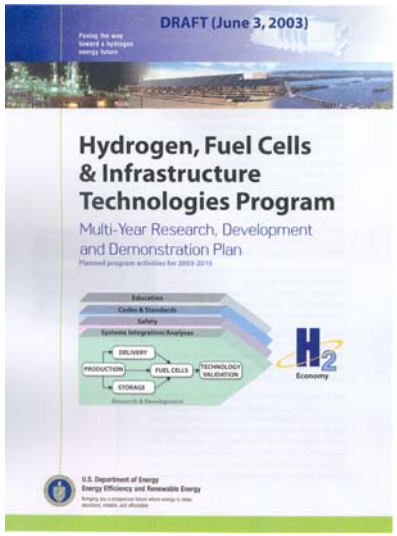
Barriers to a Hydrogen Economy

Critical Path Technology Barriers:

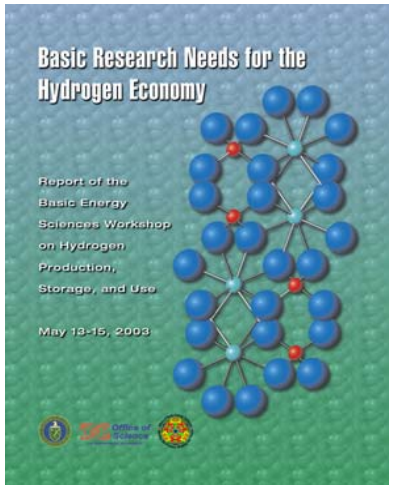
- Hydrogen Storage (>300 mile range)
- Hydrogen Production & Delivery Cost ($1.50-2.00 per gge)
- Fuel Cell Cost (< $50 per kW)

Economic/Institutional Barriers:

- Codes and Standards (Safety, and Global Competitiveness)
- Hydrogen Delivery (Investment for new Distribution Infrastructure)
- Education



http://www.eere.energy.gov/hydrogenanfuelcells/mypp/



http://www.er.doe.gov/production/bes/hydrogen.pdf

PEM Fuel Cell Cost: A 7X gap between today's high volume cost and the target

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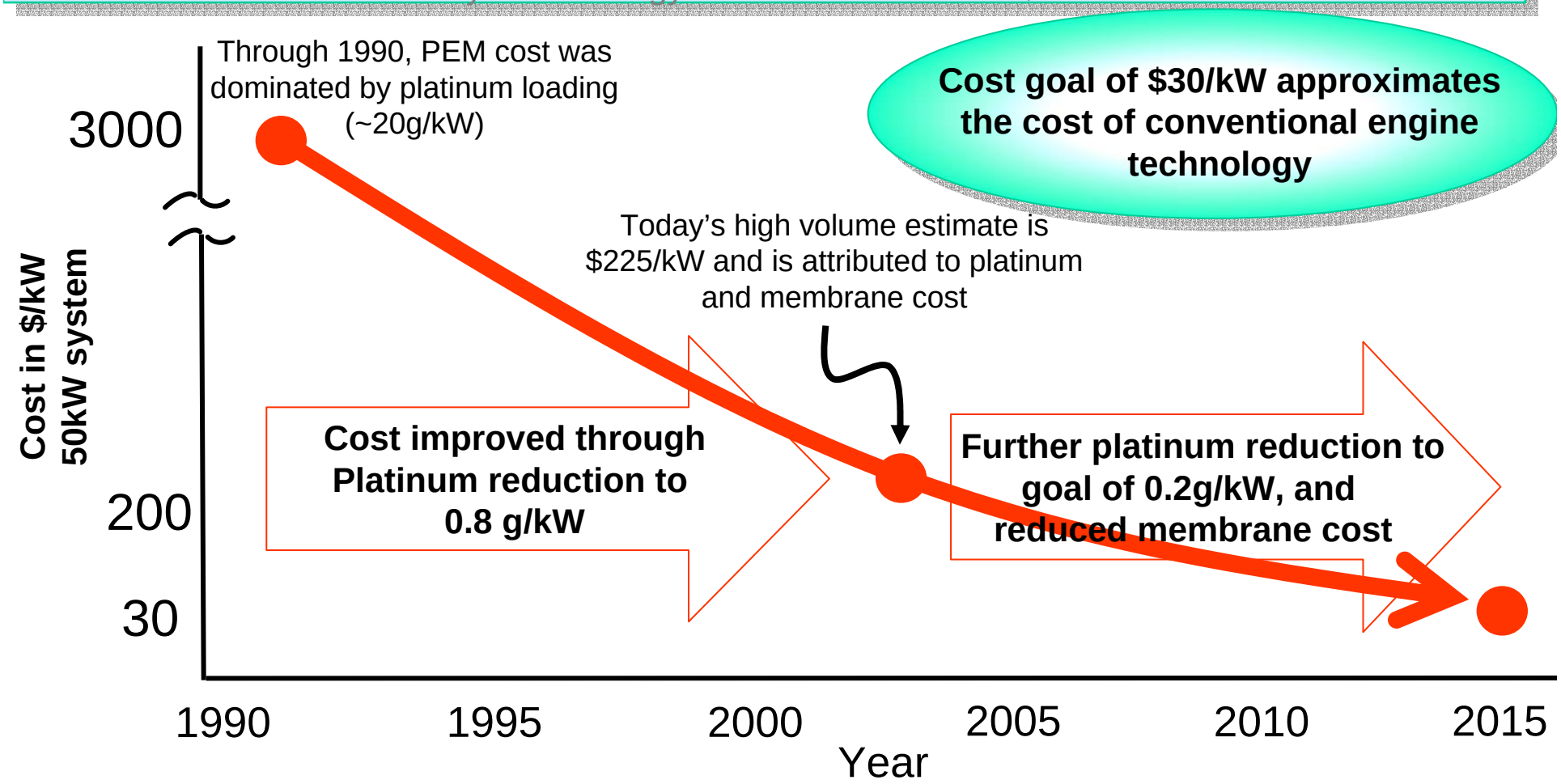
Cost of a fuel cell prototype remains high (~$3,000/kW), but the high volume[1] production cost of today's technology has been reduced to $225/kW



1. High volume production defined as 500,000 units per year
2. Cost estimated by TIAX with enhanced hydrogen storage..

Hydrogen Production

2050: Assume 330M H2 FC LDV's on the road

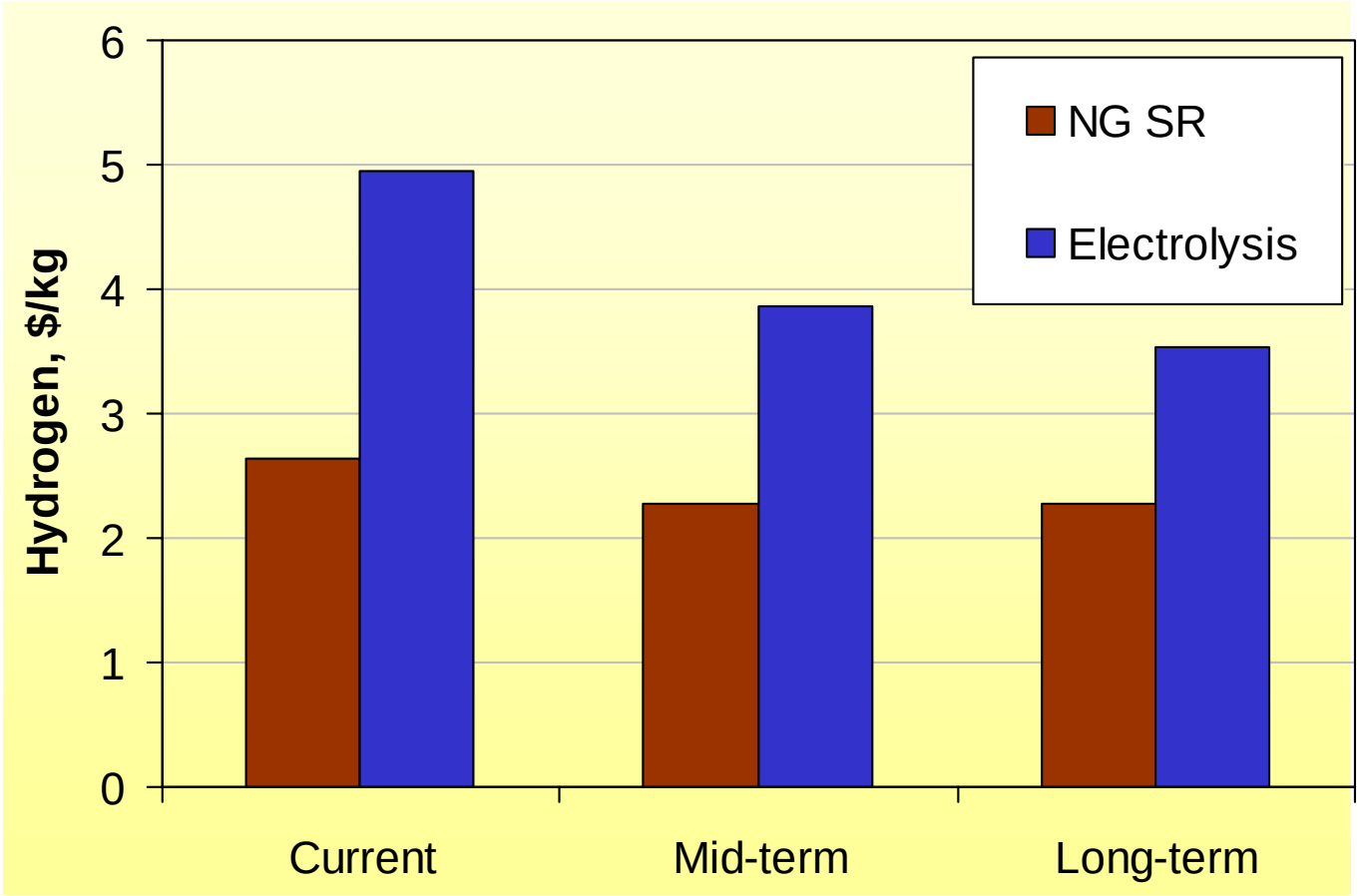
- 100M tons/yr of H2
- 15-29 Quads of Primary Energy (40-80% "cradle" to pump efficiency range)

The good news: There are many ways to produce H2 using domestic resources

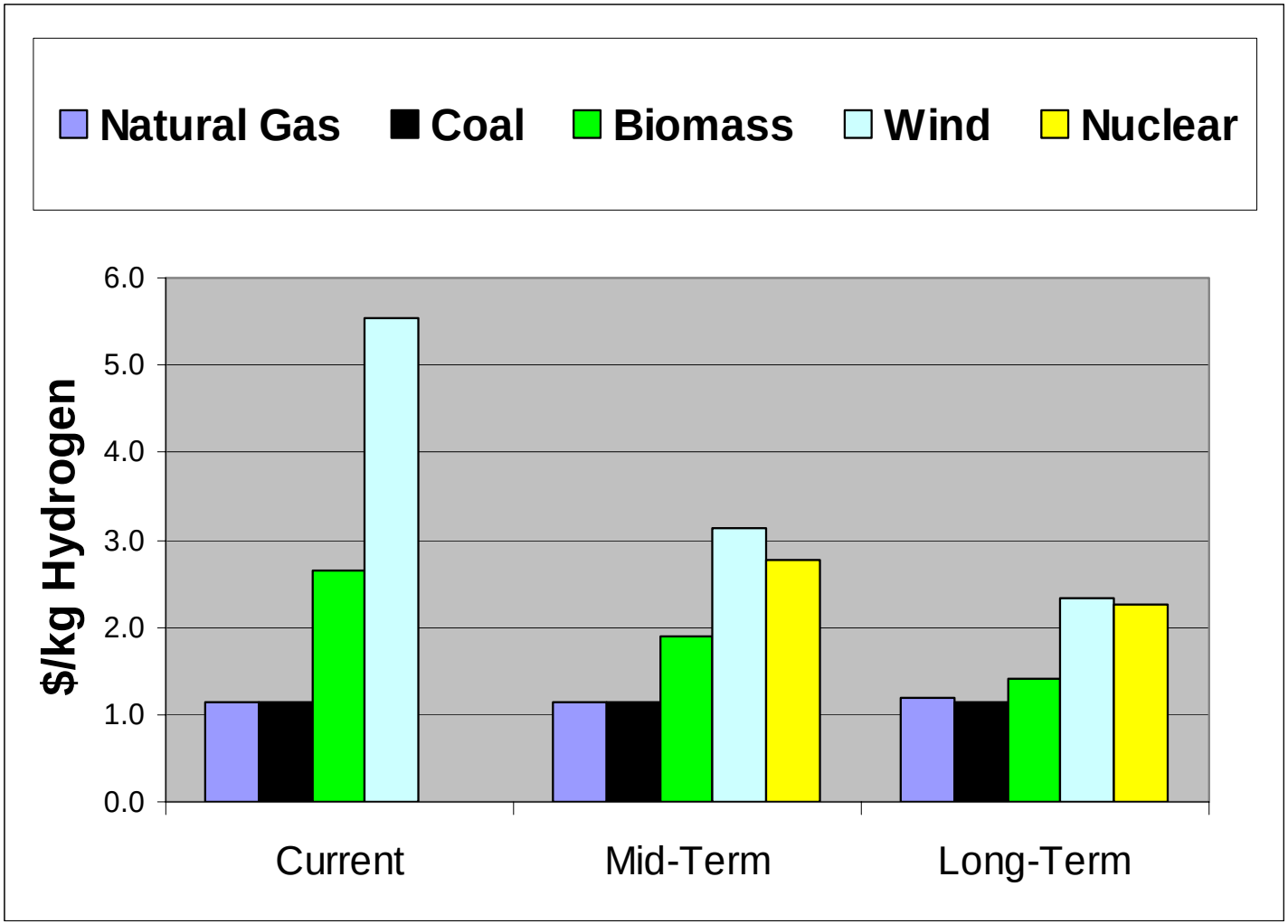
- Distributed Production
  - Natural Gas: Reforming
  - Electrolysis
  - Liquids Reforming: ethanol, sugar alcohols, bio-oil, F-T liquids derived from biomass or coal

- Central Production
  - Coal gasification with carbon sequestration
  - Biomass gasification
  - Biomass fermentation: aerobic, anaerobic
  - Wind/solar based electrolysis
  - Photolytic: photobiological, photolytic
  - HT thermochemical cysles: nuclear, solar or other

H2A Base Case Results Distributed Production



H2A Base Case Results: Central Production



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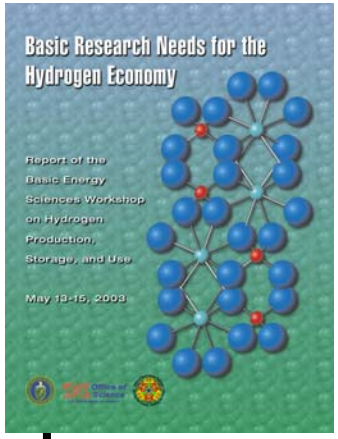
Summary of Planning and Implementation

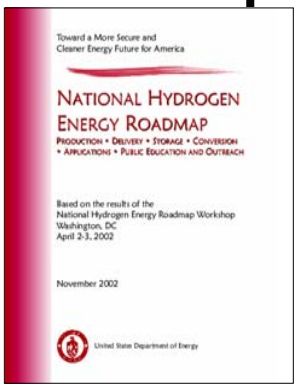
President's Hydrogen Fuel Initiative

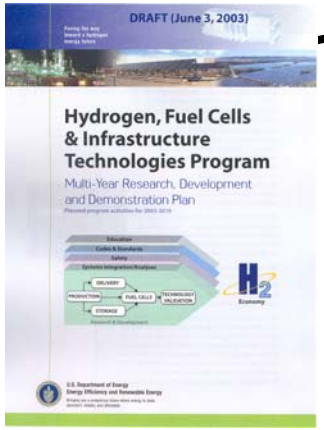
FreedomCAR

FutureGen

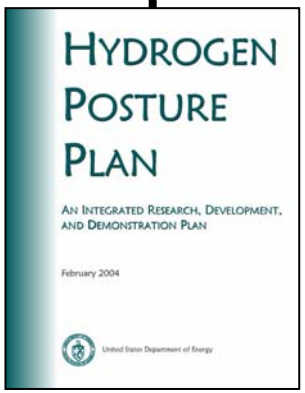


Jan'02 | **Nov'02** | **Jan'03** | **Feb'03** | **May'03** | **Nov'03** | **Feb'04**





International Partnership for the Hydrogen Economy



For More Information

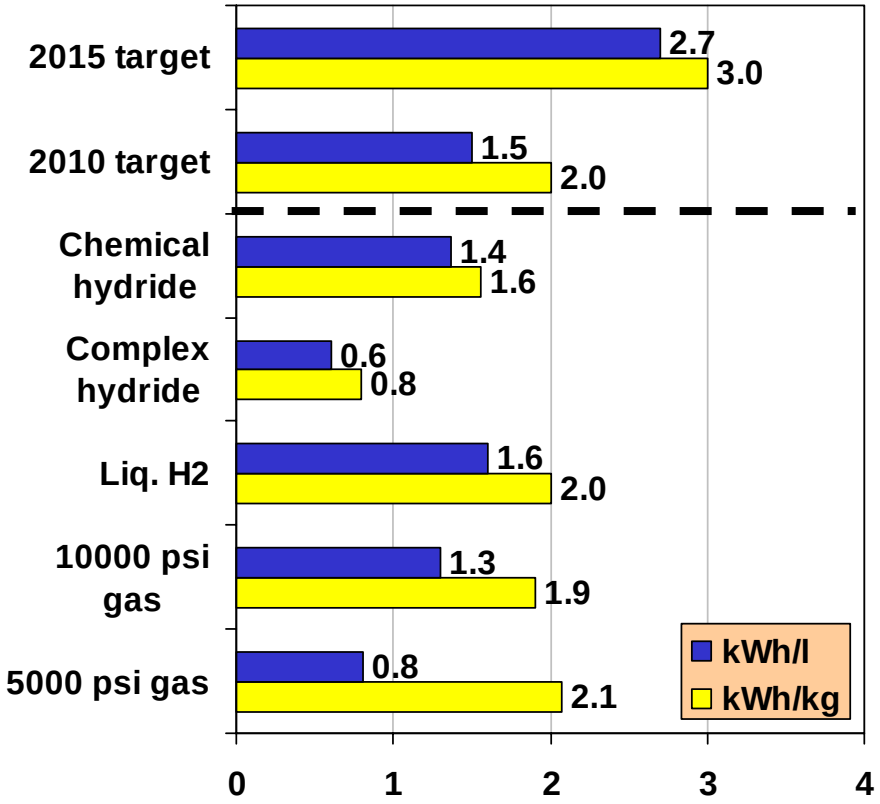
www.eere.energy.gov/vehiclesandfuels (FreedomCAR)
www.eere.energy.gov/hydrogenandfuelcells
www.fe.doe.gov

www.nuclear.gov
www.sc.doe.gov/bes/hydrogen.html

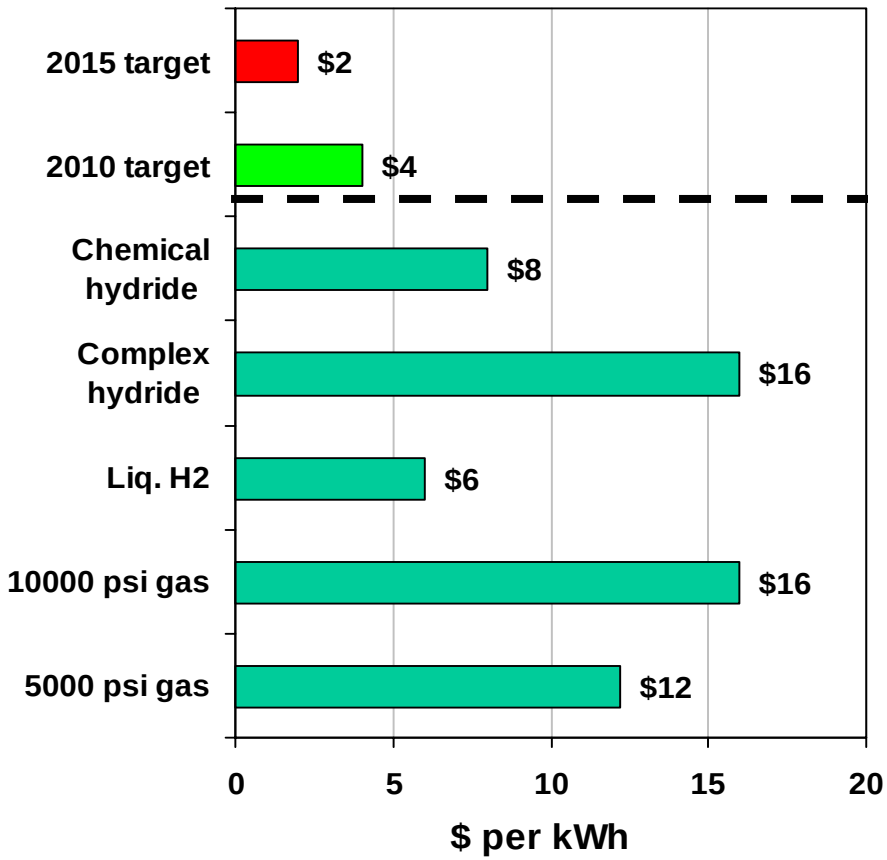
Backup Slides

No current H_2 storage technology meets the targets

Volumetric & Gravimetric Energy Density



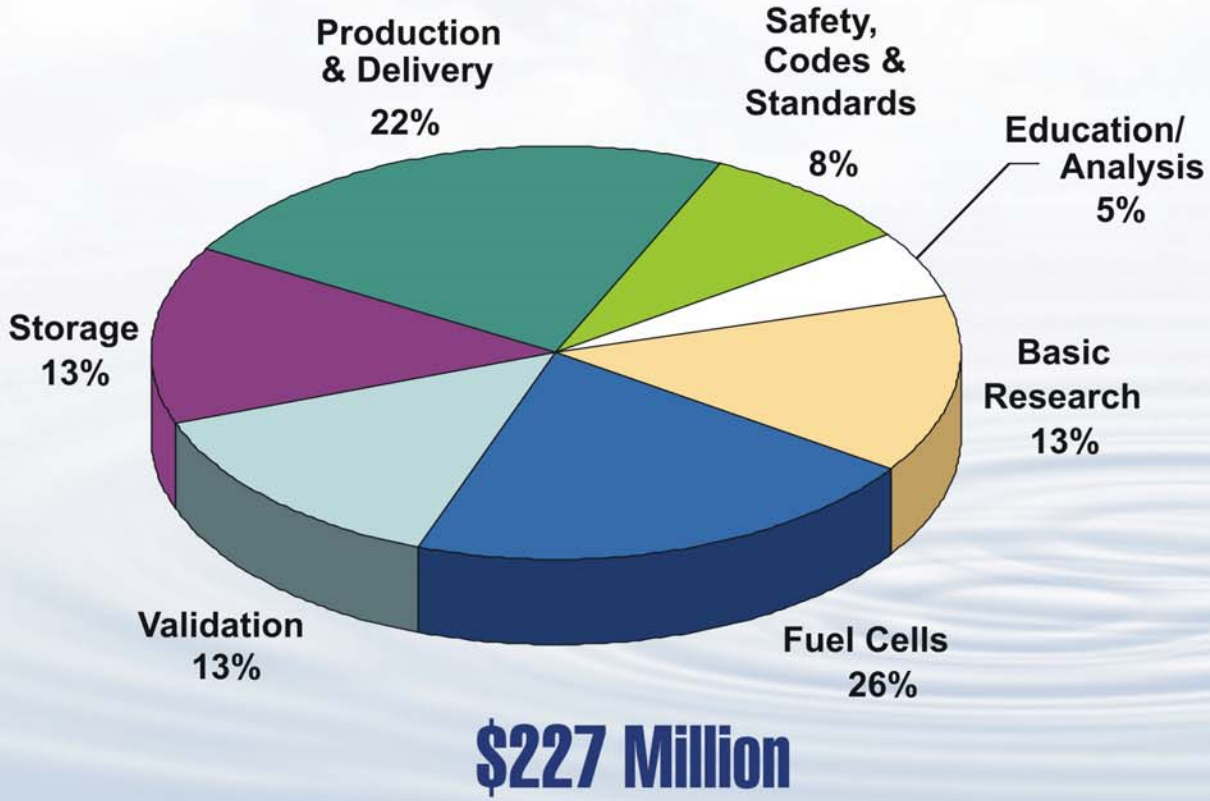
Cost per kWh, $/kWh



President's FreedomCAR & Fuel Initiative

Major Line Items	FY 04 Appropriation	FY 05 Request
Fuel Cells Technologies – stack, component, fuel processor development (DOE/EERE:OHFCIT)	$65,187,000	$77,500,000
Hydrogen Technologies – production, storage, delivery, safety codes and standards, technology validation, education, and analysis (DOE/EERE/OHFCIT)	$81,991,000	$95,325,000
Vehicle Technologies – hybrid and advanced combustion technology development (DOE/EERE/Vehicles Technology)	$89,736,000	$91,400,000
Hydrogen Production from Coal – gasification technologies (DOE/FE)	$4,889,000	$16,000,000
Hydrogen Production from Nuclear – high temperature thermochemical technologies (DOE/NE)	$6,377,000	$9,000,000
Basic Energy Science – fundamental materials and science research (DOE/OS)	$0	$29,183,000
Department of Transportation	$555,000	$832,000
Total	$248,735,000	$319,240,000

DOE FY05 Hydrogen Technology Budget Request



$227 Million