Technologies of the Future: The Hydrogen Economy

Robert B. Shelton, Director of Programs
Engineering Science & Technology Division
June 10, 2004

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

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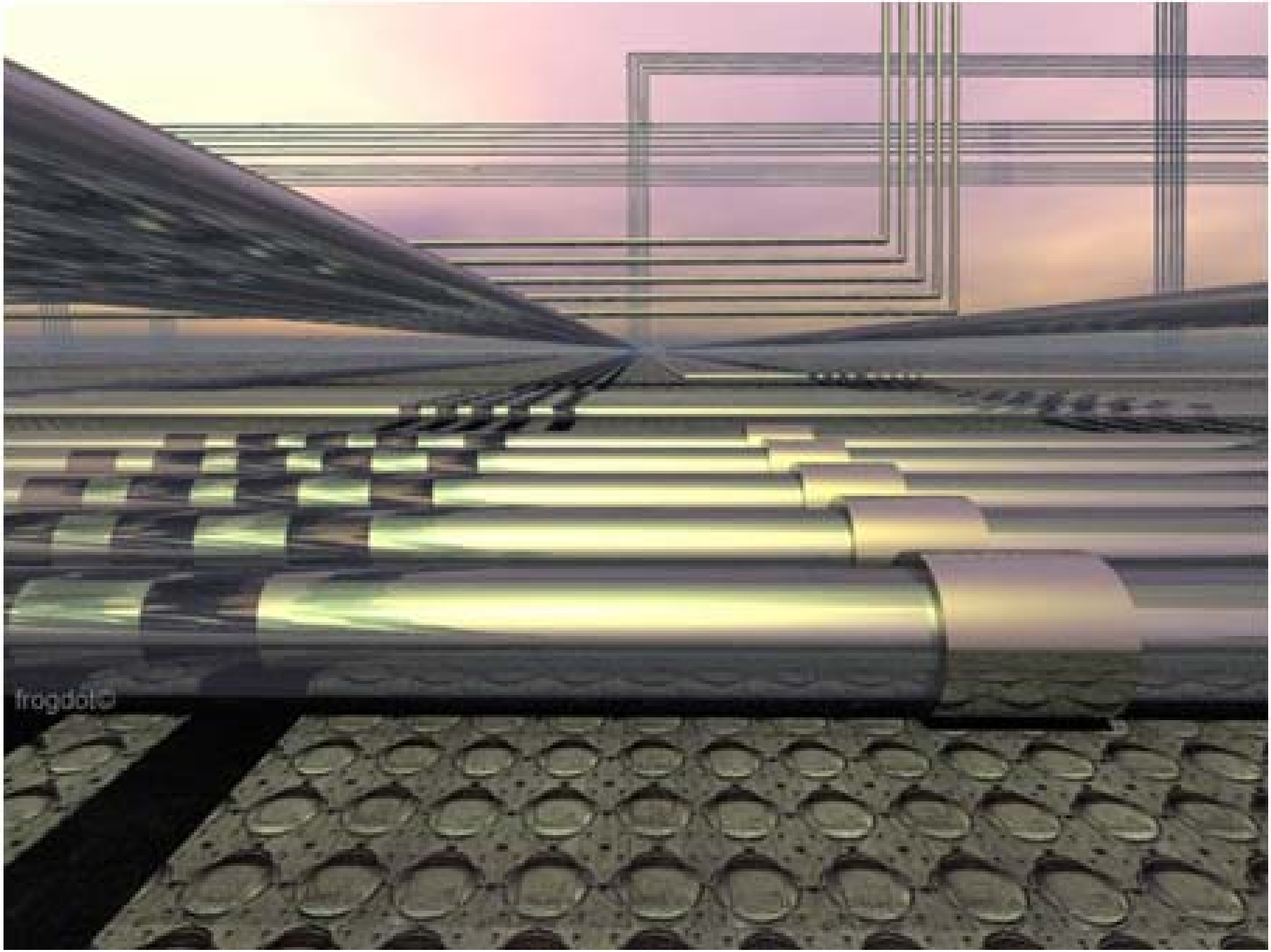
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President Bush Launches the Hydrogen Fuel Initiative

"Tonight I am proposing $1.2 billion in research funding ....

"With a new national commitment, our scientists and engineers will overcome obstacles to taking these cars from laboratory to showroom so that the first car driven by a child born today could be powered by hydrogen, and pollution-free.

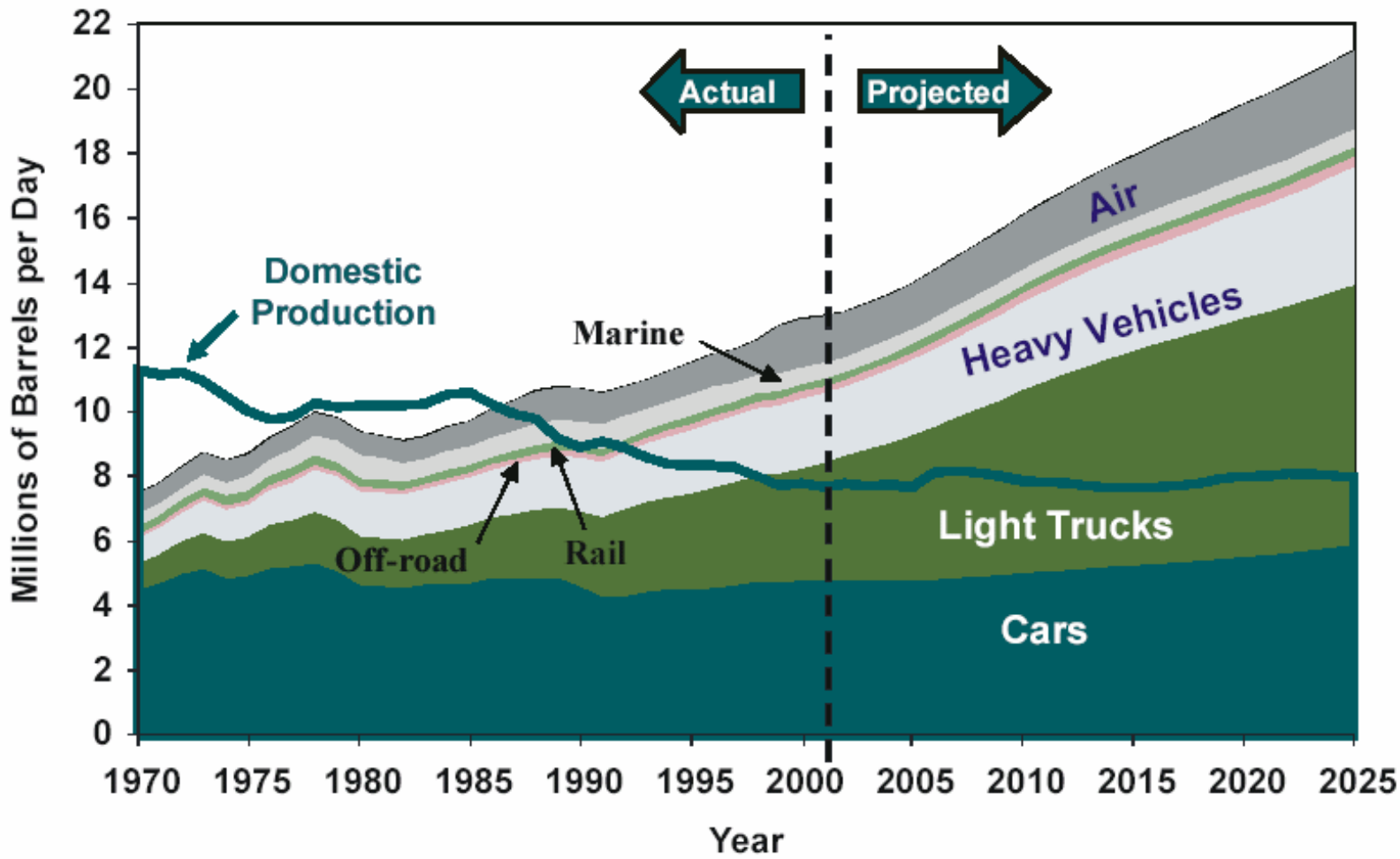
President George W. Bush
2003 State of the Union Address
January 28, 2003

Key Drivers for a Hydrogen-Based Energy System

- **Energy security**

Source: Hydrogen Posture Plan:
An Integrated Research, Development, and Demonstration
United States Department of Energy
February 2004

Growing U.S. Transportation Oil Gap



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

Key Drivers for a Hydrogen-Based Energy System

- **Energy security**
- **Environmental quality, and**

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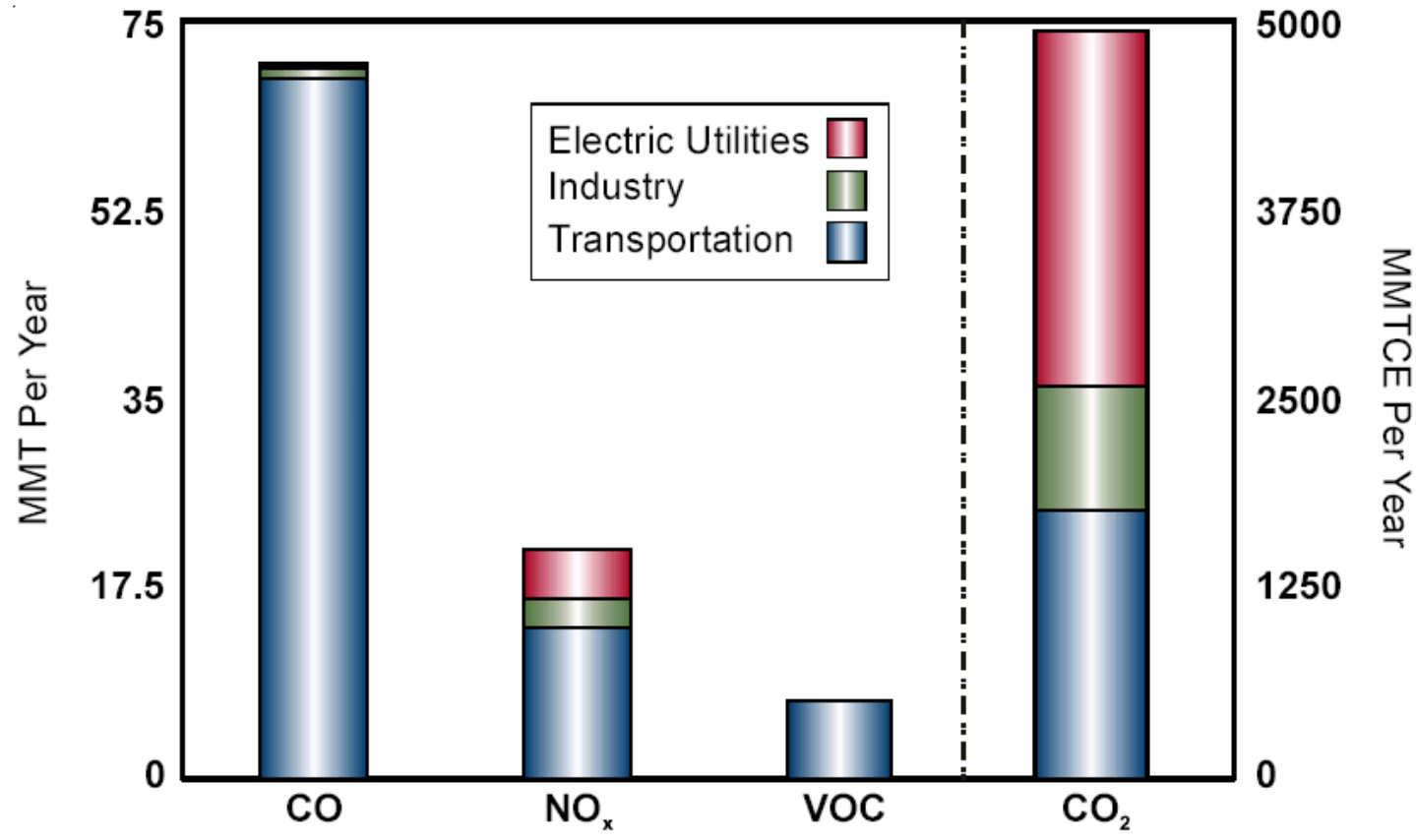
Emissions from Fossil Fuel Combustion



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000, *EPA-430-R-02-003, April 2002.*

Key Drivers for a Hydrogen-Based Energy System

- **Energy security**
- **Environmental quality, and**
- **International competitiveness**

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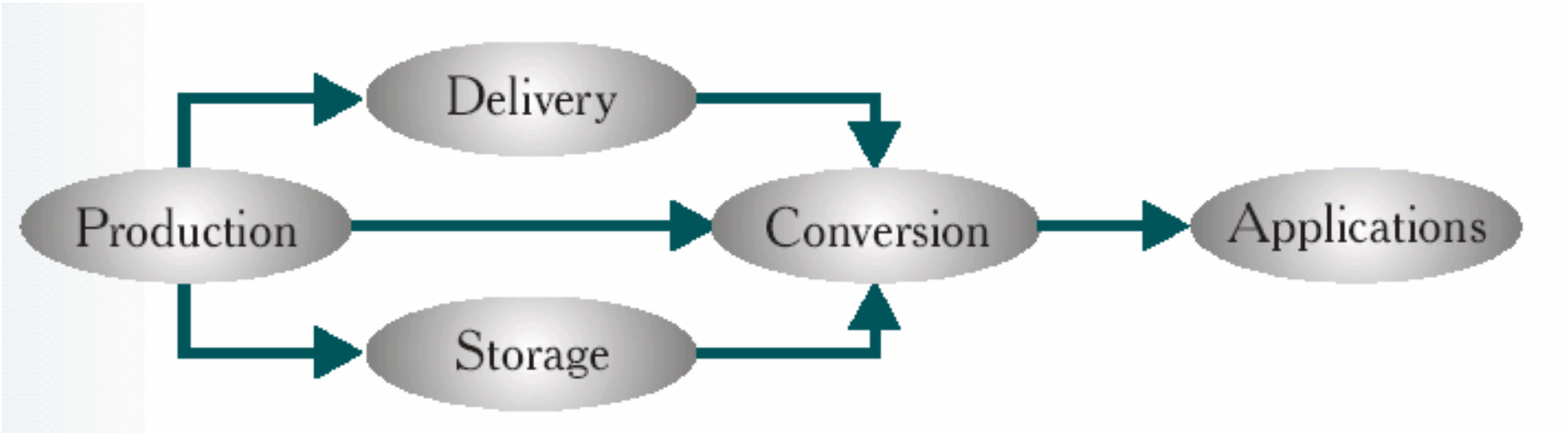
Elements of a Hydrogen Energy Infrastructure



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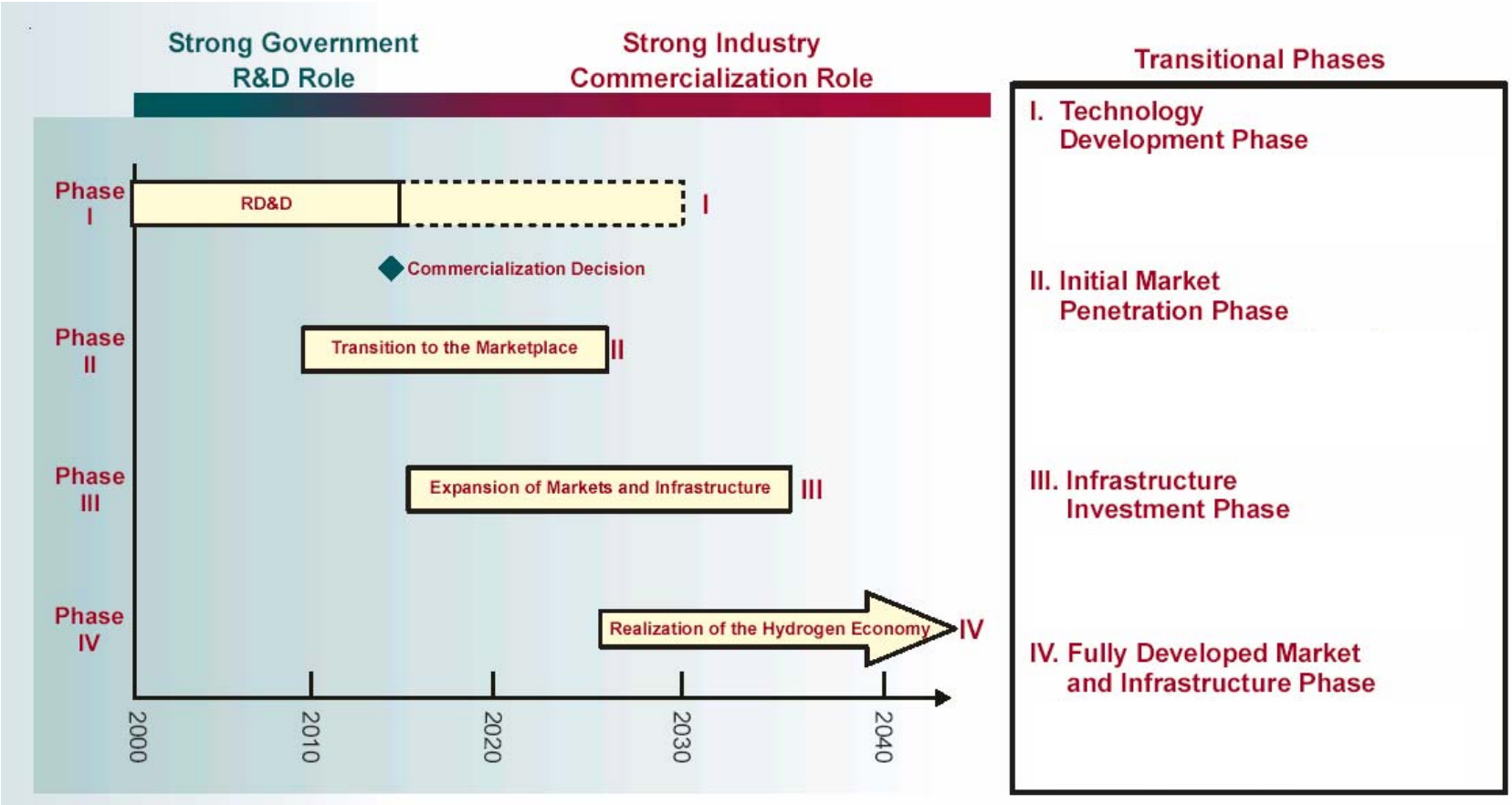
Government-Industry Roles in the Transition to a Hydrogen Economy



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"Critical Path" Technologies Necessary for Developing a Hydrogen Economy

- **Lower cost of producing and delivering hydrogen**

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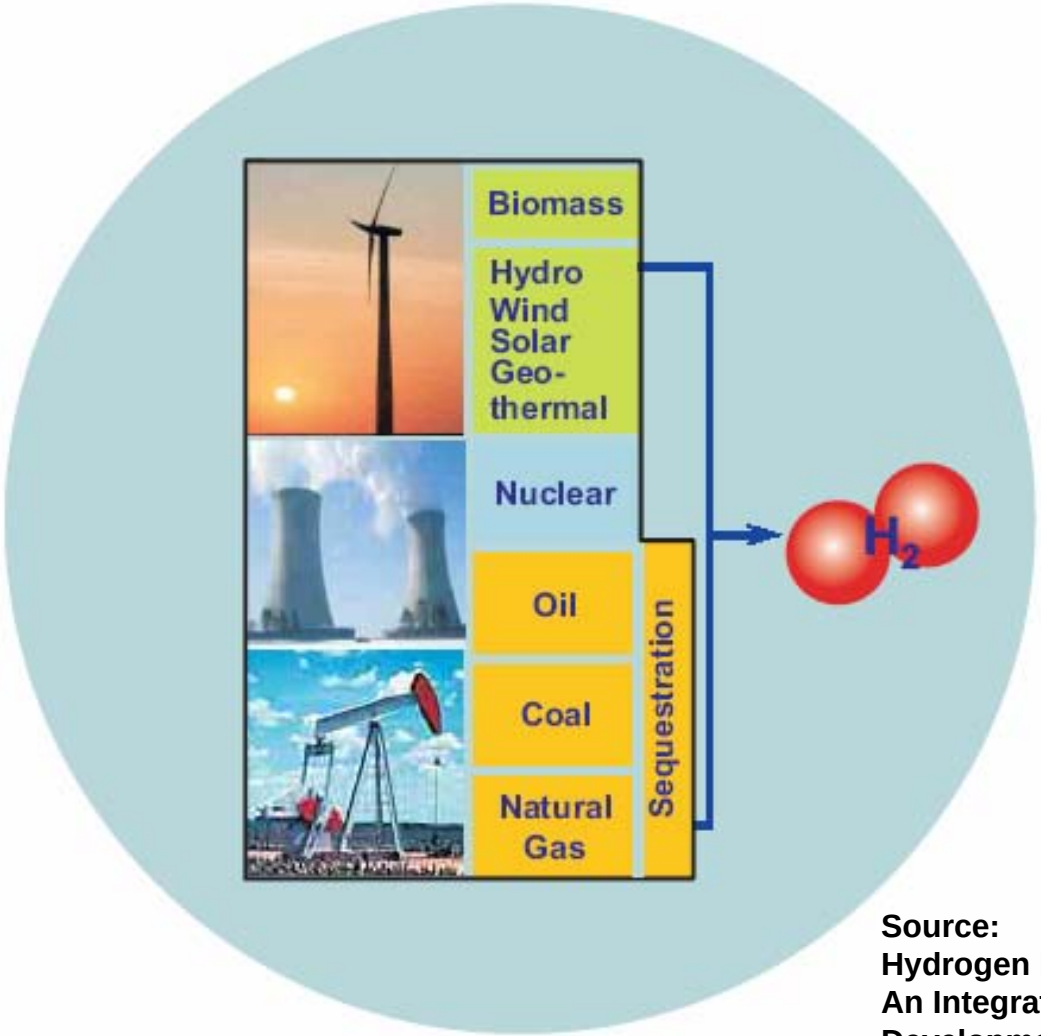
Domestic Hydrogen Production Options



Source:
Hydrogen Posture Plan:
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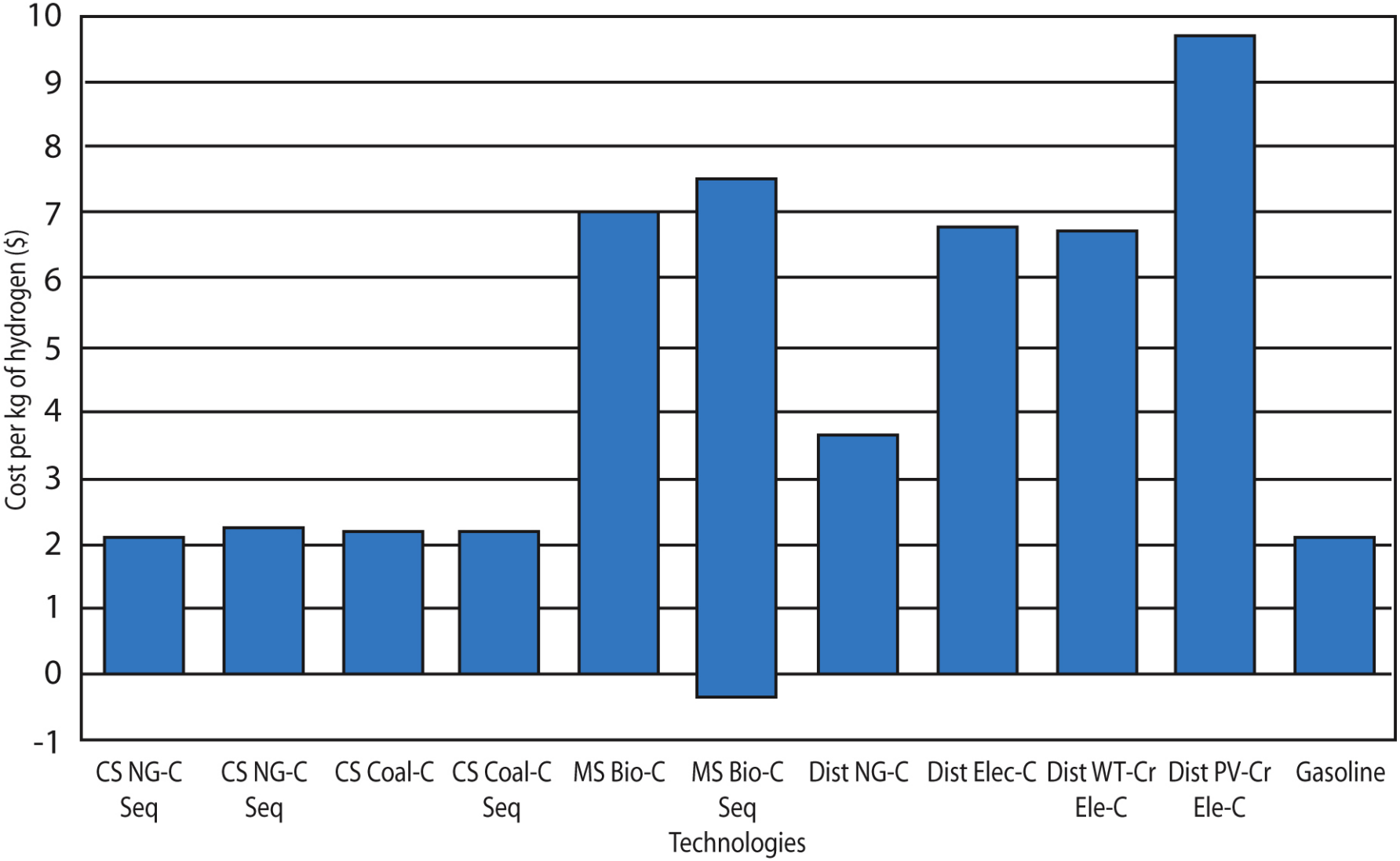
Unit Cost Estimates for Hydrogen Production



CS=Central Station
SEQ=Sequestration

MS=Midsize
Dist=Distributed

Elec=Electrolyzer
WT=Wind
PV=Photovoltaics

The Hydrogen Economy: Opportunities,Costs, Barriers, and R&D Needs (2004)

http://www.nap.edu/openbook/0309091632/html/96.html, copyright 2004, 2001 The National Academy of Sciences, all rights reserved

"Critical Path" Technologies Necessary for Developing a Hydrogen Economy

- **Lower cost of producing and delivering hydrogen**
- **More compact, light weight, lower cost, safe and efficient storage systems**

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"Critical Path" Technologies Necessary for Developing a Hydrogen Economy

- **Lower cost of producing and delivering hydrogen**
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- **More effective and lower cost carbon-capture and sequestration processes**

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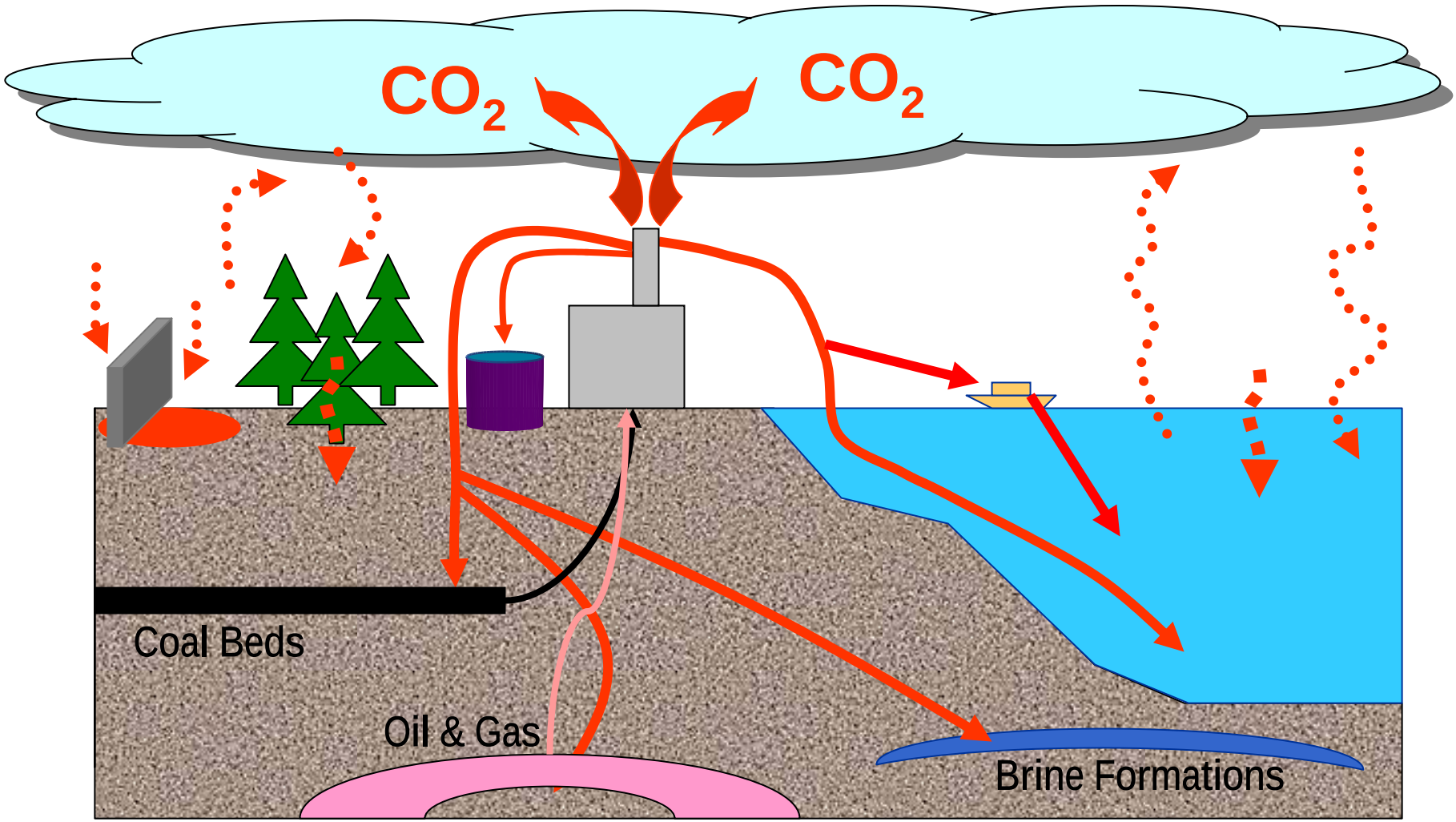
Carbon Sequestration: What is it?



Where are they going now?

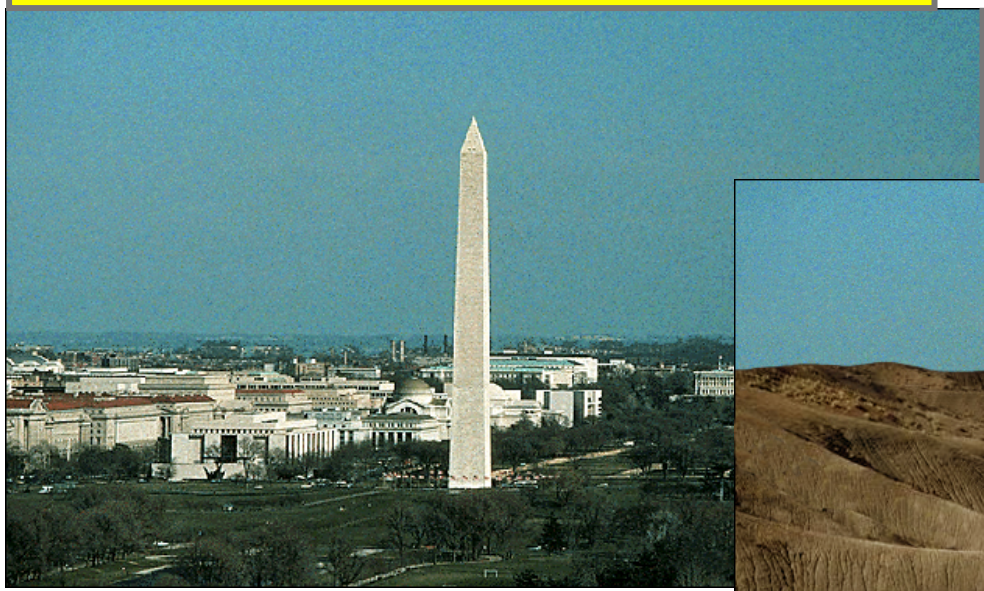
775 GtC or 365 ppm

+ 3.5 GtC/year or + 1.6 ppm/year

Fossil Fuel, etc	**+6.0 Gt C/year**
Land Use Change	**+1.4 Gt C/year**
Ocean Uptake	**-2.2 Gt C/year**
Terrestrial Uptake	**-1.7 Gt C/year**

How Much is a Gt C?

Enough soil to cover Washington, DC 100 m thick…



Which happens to be the annual amount of global soil erosion (CNIE 1998)

Carbon Sequestration –

"THE" question is …

Can enough CO_2 be put where you want it for a long enough time with acceptable risks and potential impacts ($$$, GHG costs, environmental, etc.)?

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- **More compact, light weight, lower cost, safe and efficient storage systems**
- **Lower cost materials for advanced conversion technologies, especially fuel cells**
- **More effective and lower cost carbon-capture and sequestration processes**
- **Designs and materials that maximize the safety of hydrogen use**

Source: Hydrogen Posture Plan:
An Integrated Research, Development, and Demonstration
United States Department of Energy
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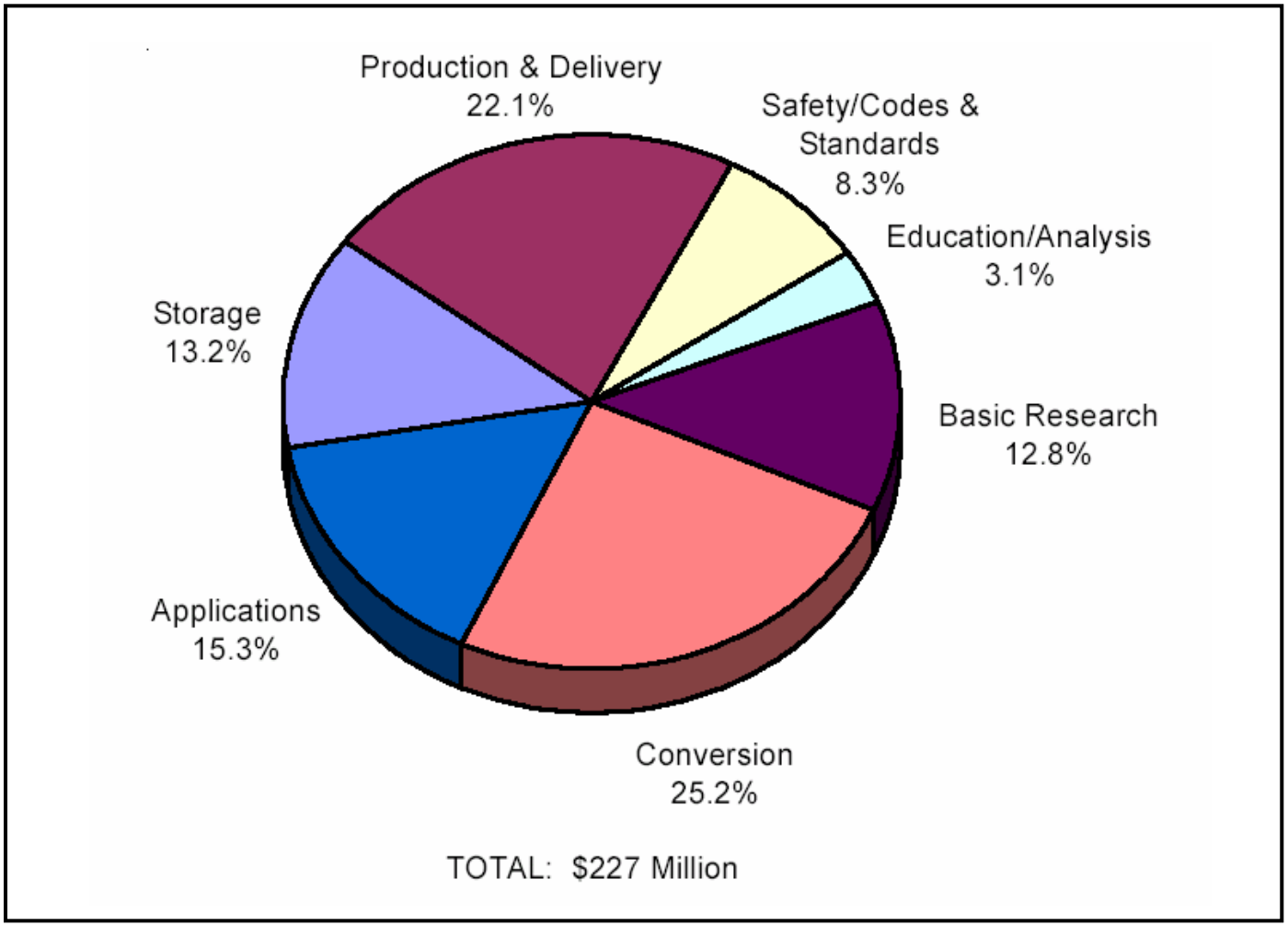
DOE Hydrogen Technology Budget Request – FY05 (%)



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Four Pivotal Questions

- **When will vehicular fuel cells achieve the durability, efficiency, cost, and performance needed to gain a meaningful share of the automotive market?**
- **Can carbon be captured and sequestered in a manner that provides adequate environmental protection but allows hydrogen to remain cost-competitive?**

Four Pivotal Questions (continued)

- **Can vehicular hydrogen storage systems be developed that offer cost and safety equivalent to that of fuels in use today?**
- **Can an economic transition to an entirely new energy infrastructure, both the supply and the demand side, be achieved in the face of competition from the accustomed benefits of the current infrastructure?**

The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs,
National Academy of Engineering