Manufacturing R&D for the Hydrogen Economy

National Science and Technology Council
Committee on Technology
Interagency Working Group on Manufacturing Research and Development
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IWG Task Team Leader
JoAnn Milliken, Chief Engineer
Hydrogen Program
US Department of Energy

Presentation Outline

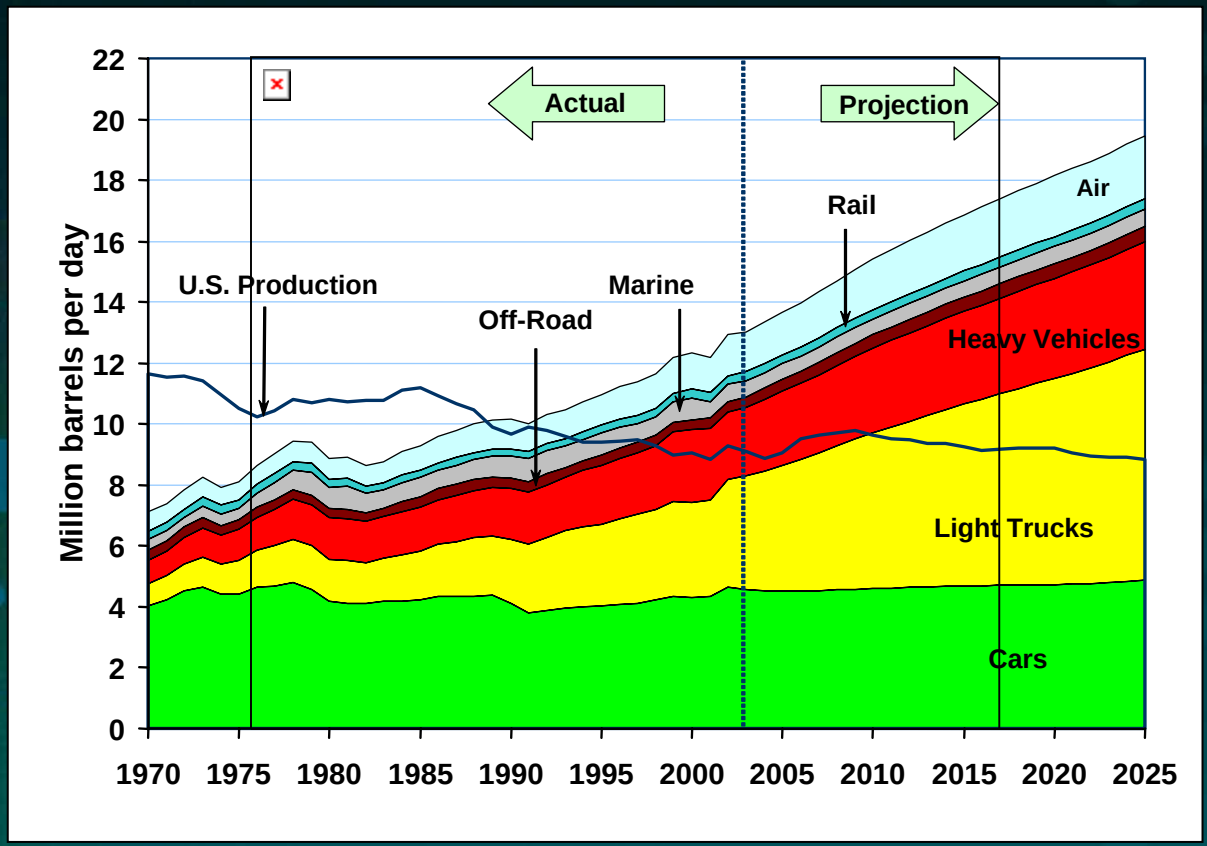
- Background - The Hydrogen Fuel Initiative (HFI)
  - Drivers, Goals, Challenges
- Manufacturing R&D for Hydrogen Technologies
  - Key Challenges/Needs
- Current Federal Efforts
- HFI and Manufacturing R&D Timelines
- Impacts/Benefits
- Next Steps/Summary

Hydrogen Fuel Initiative

- President Bush announced the Hydrogen Fuel Initiative in his January 2003 State of the Union Address.
- Accelerated, parallel track for R&D of fuel cell vehicle and hydrogen infrastructure technologies will enable industry commercialization decision by 2015.

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

U.S. Transportation Oil

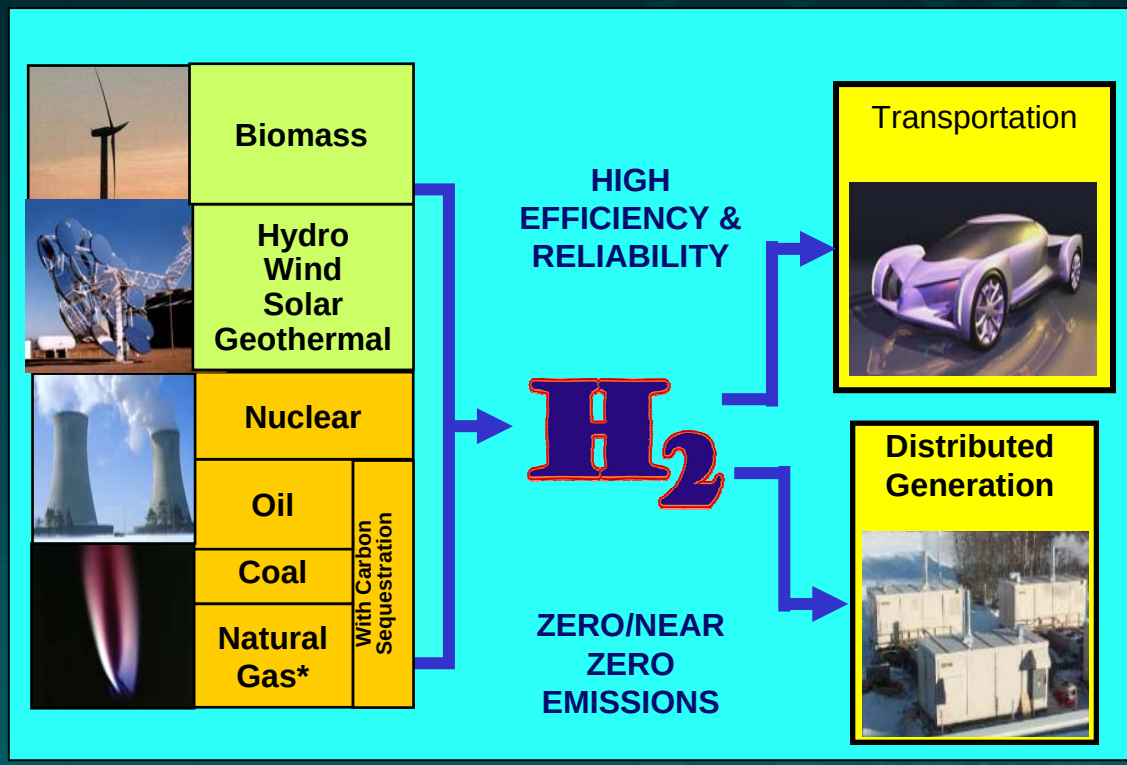


- Transportation accounts for 67% of the oil our nation uses each day.
- US oil imports are projected to rise from 55% today to 68% in 2025.
- Hybrid vehicles will slow the growth rate of oil use in the near term.

Petroleum substitution is needed to reduce oil dependence in the long term.

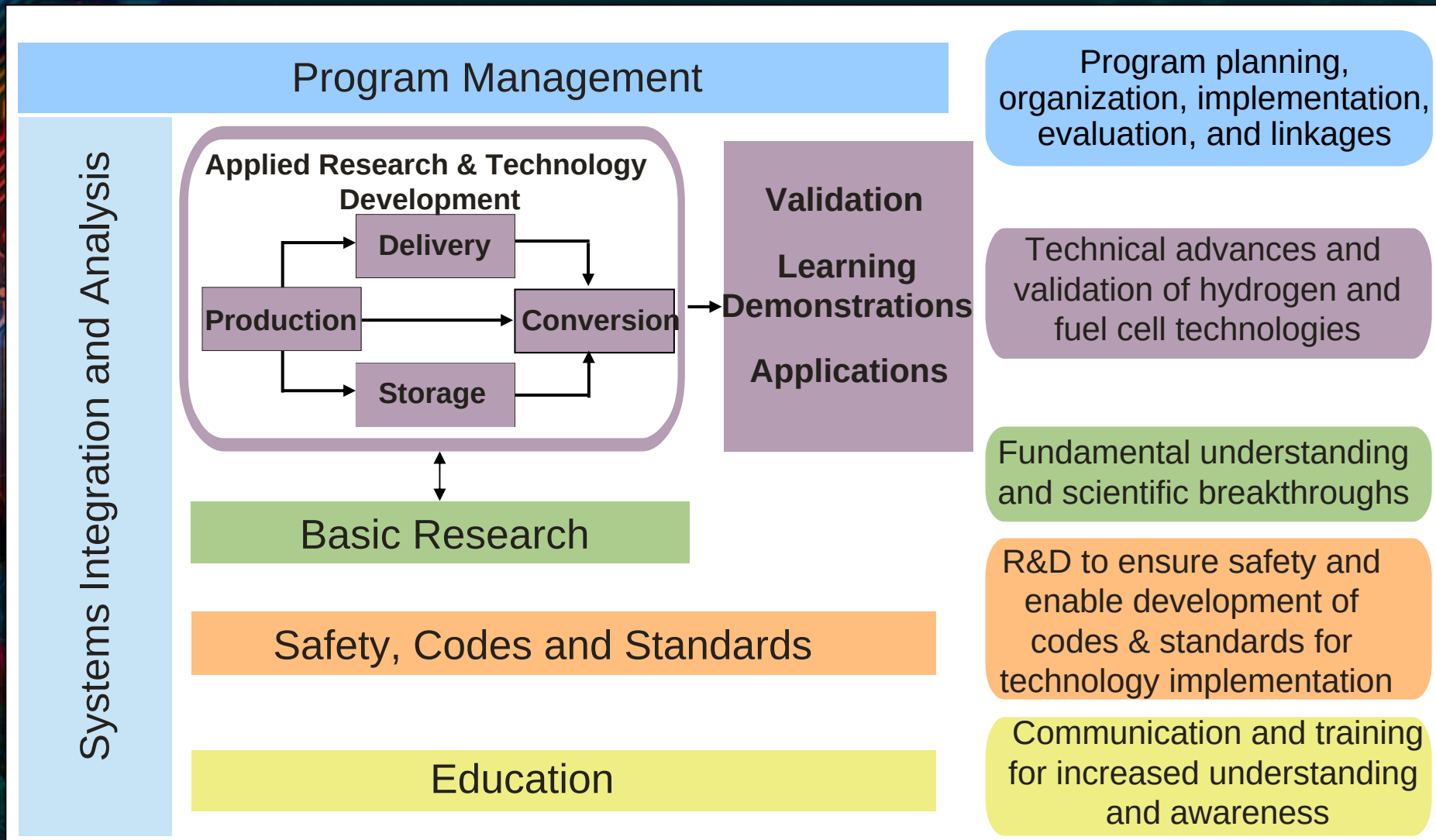
Hydrogen:
A Secure and Clean Energy Future

- **Energy Security**
  - Produced from diverse domestic resources
- **Environment**
  - Mobile criteria pollutants eliminated
  - Stationary emissions easier to control
  - Greenhouse gas emissions reduced
- **Economic Competitiveness**
  - Abundant, reliable, and affordable energy is an essential component in a healthy, global economy.



* H_2 from NG during transition phase

Hydrogen Fuel Initiative Program Elements



Key Hydrogen R&D Areas

Cost Reduction is a Primary R&D Driver

- **Hydrogen Production and Delivery**
  - Cost of hydrogen must be competitive with gasoline, without adverse environmental impacts
    - **$1.50/gge untaxed**
- **Hydrogen Storage**
  - Capacity must enable >300-mile range, and meet packaging, performance, and cost requirements
    - **$2/kWh (~ $300 for 5-kg H_2 storage system)**
- **Fuel Cells**
  - System cost must be competitive with ICE and meet performance and durability requirements
    - **$30/kW (~ $2400 for an automotive fuel cell system)**

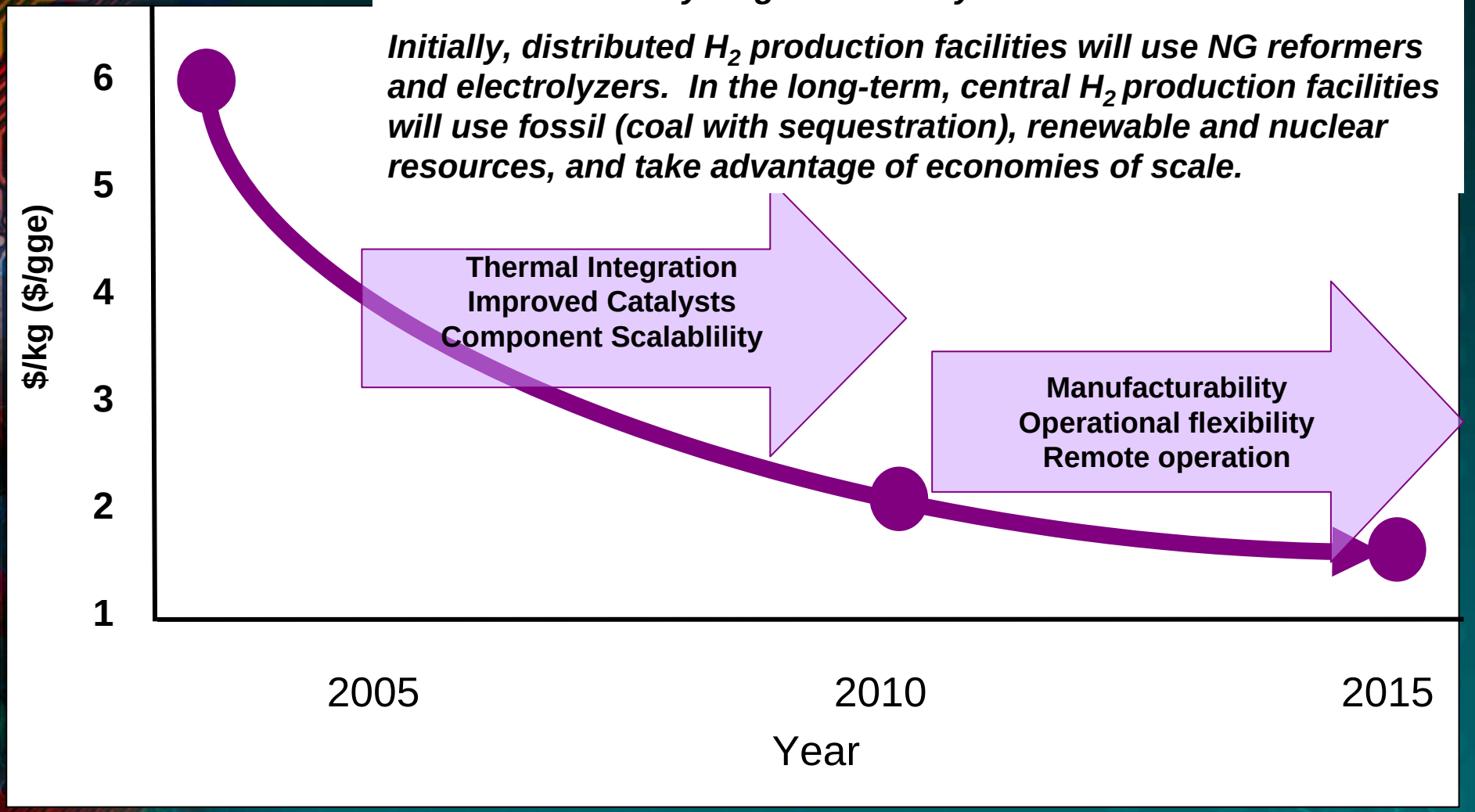
High-volume manufacturing processes are critical to meeting cost targets.

Hydrogen Production

3-4X gap between today's high volume cost and target

Transition to the Hydrogen Economy:

Initially, distributed H_2 production facilities will use NG reformers and electrolyzers. In the long-term, central H_2 production facilities will use fossil (coal with sequestration), renewable and nuclear resources, and take advantage of economies of scale.

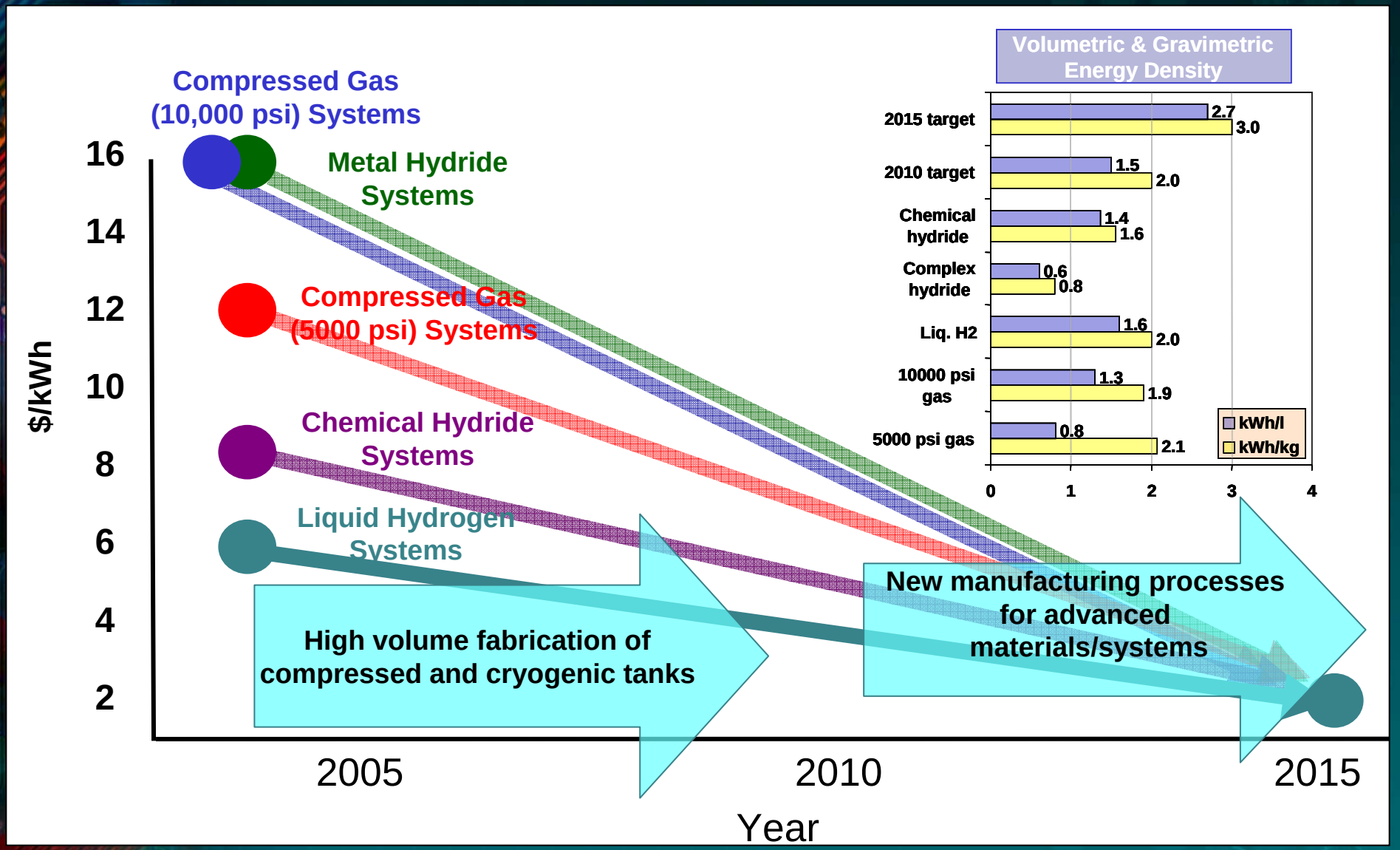


Manufacturing R&D - Challenges/Needs for Hydrogen Production

- **Status/Challenges**
  - ~9 billion kg of hydrogen produced annually
    - **~ 95% via methane steam reforming**
  - Capital contributes 20-50% to cost of hydrogen
    - **Small facilities require costly site-specific fabrication of reformer systems**
- **Needs**
  - Standardized component and system designs to facilitate manufacturability
  - Manufacturing systems designed for
    - **Mass production of small-scale reforming systems and electrolyzers**
    - **Manufacturing processes for renewable based systems**

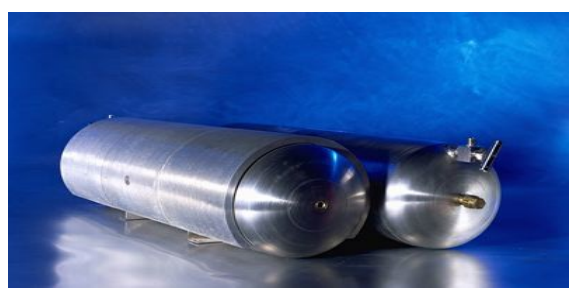
Hydrogen Storage

3-8X gap between today's storage system cost and target



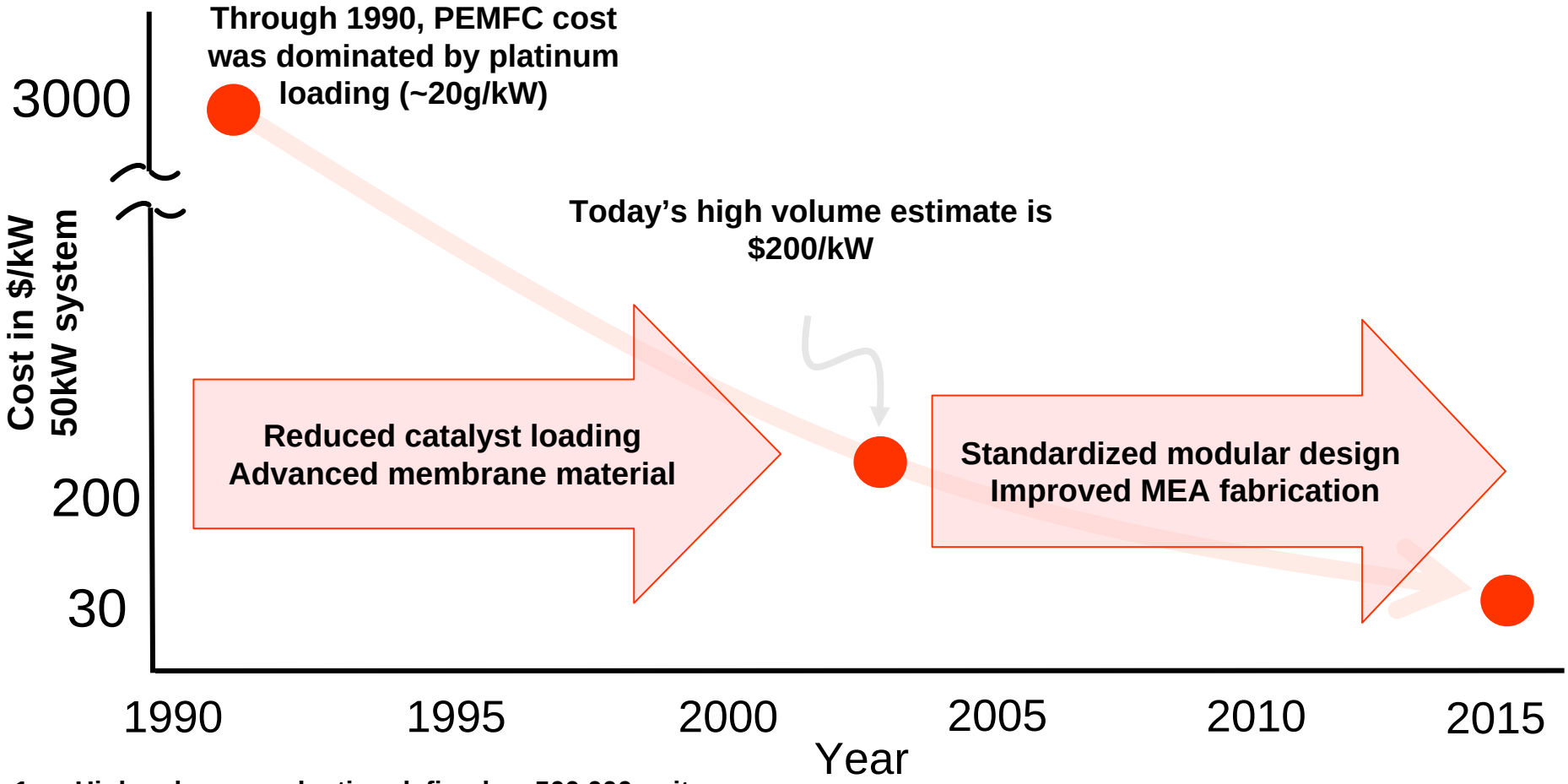
Manufacturing R&D - Challenges/Needs for Hydrogen Storage

- **Status/Challenges**
  - Pilot-scale production of composite tanks for compressed hydrogen storage
    - **Labor intensive production process**
    - **Pressure regulators and sensors add to complexity and cost of production**
- **Needs**
  - Manufacturing techniques for composite tanks
    - **Low-cost fibers and optimal winding technology**
    - **Metrology to control high-volume manufacturing**
  - New manufacturing methods as advanced materials-based storage systems are developed



PEM Fuel Cells

7X gap between today's high volume cost and target



1. High volume production defined as 500,000 units per year
2. Cost estimated by TIAX. System = fuel cell stack and all balance of plant components.

Manufacturing R&D - Challenges/Needs for Fuel Cells

- **Status/Challenges**
  - Limited supplies of fuel cells manufactured using scaled-up laboratory fabrication methods
    - **Labor-intensive assembly**
    - **Repetitive measurements of components and connections to assure system quality**
- **Needs**
  - **Standardization of fuel cell components to facilitate mass production**
  - **Transformation of laboratory fabrication methods to full-scale, high-volume processes**
    - **Methods for accurate measurement and process control**
  - **Development of supplier base/networks**

Overarching Manufacturing Challenges for Hydrogen Technologies

- Developing innovative, low-cost fabrication methods for new materials and applications
- Adapting laboratory fabrication methods to low-cost, high-volume production
- Establishing and refining cost-effective manufacturing techniques while hydrogen products are still evolving
- Meeting customer requirements for hydrogen systems
- Addressing the diversity and size of industries in both the manufacturing and energy sectors

Current Federal Efforts

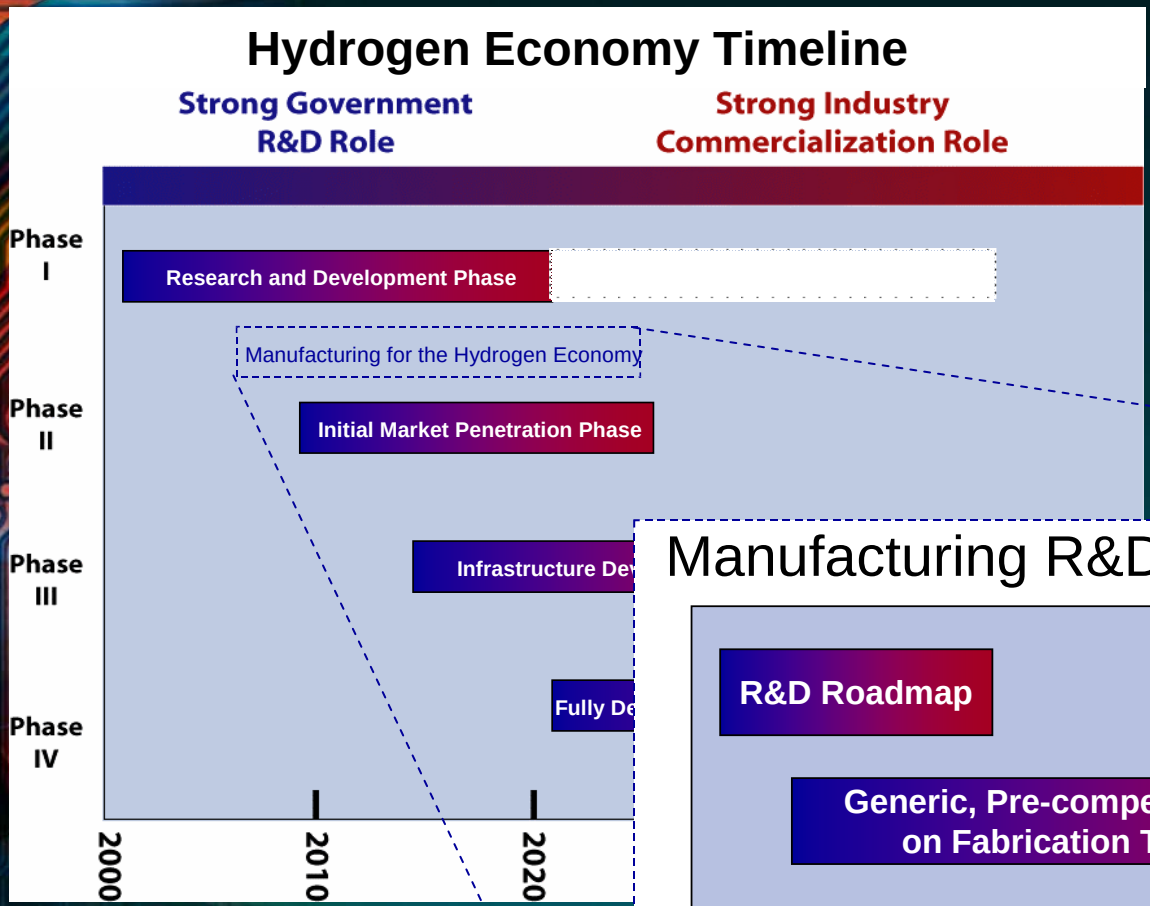
- Department of Energy
  - Hydrogen and Fuel Cell R&D to overcome the challenges
- Department of Commerce (NIST)
  - Measurements, standards and infrastructure technologies to facilitate high-volume manufacturing
  - Fuel Cell R&D
- Department of Defense
  - Manufacturing technologies for defense purposes
  - Fuel Cell R&D
- Department of Transportation
  - Safety in the transportation and supply chain related to hydrogen products
- National Science Foundation
  - Fundamental research on hydrogen, fuel cells, and manufacturing

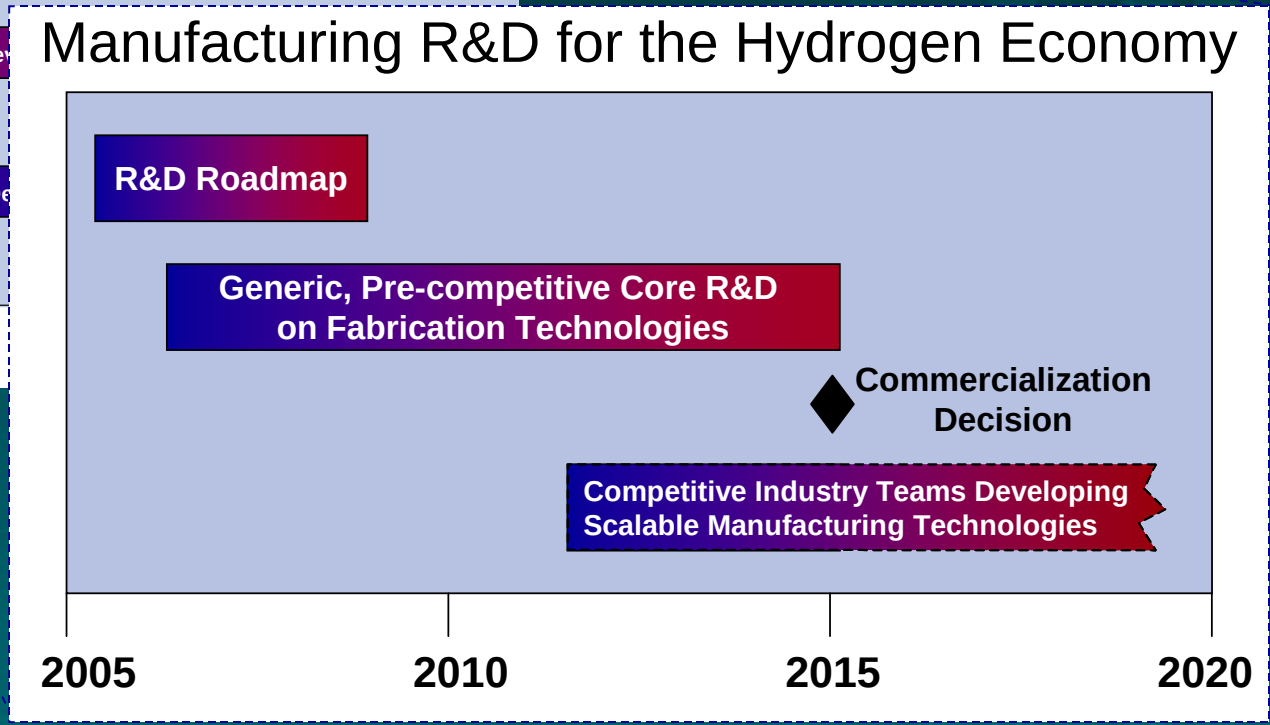
Current Federal Efforts (cont.)

- Department of Agriculture
  - Biomass energy research
- Environmental Protection Agency
  - Testing and evaluation of fuel cell vehicles
- National Aeronautics and Space Administration
  - Advanced technologies for manufacturing safe, low cost space transportation systems
  - Experience in safe handling of hydrogen
  - Fuel cell R&D
- National Science Foundation
  - Fundamental research on hydrogen, fuel cells, and manufacturing

The White House Office of Science and Technology Policy coordinates all federal hydrogen and fuel cell activities through an Interagency Task Force.

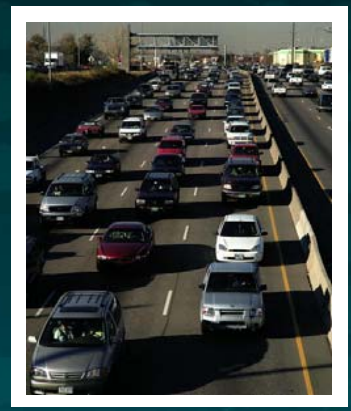
Manufacturing R&D - Connected To Hydrogen Economy Timeline





Expected Impacts/Benefits

- Accelerates Market Entry and Growth
  - Jump-starting manufacturing infrastructure for hydrogen systems
  - Facilitating 2015 commercialization decision and subsequent market expansion
- Accelerates Achievement of Energy Security and Environmental Goals
  - Reducing dependence on imported oil
  - Improving air quality and reducing GHG emissions
- Enhances Economic Competitiveness in Global Economy
  - Transforming portions of manufacturing sector
  - Increasing US leadership in manufacturing



Next Steps for Federal Role
Manufacturing R&D for the Hydrogen Economy

- Develop R&D Roadmap with stakeholders and experts in industry, academia, and government
  - Workshop planned for July/August 2005
- Define Core Manufacturing Technology Needs through a rigorous gap analysis
- Promote a coordinated, broad-based national R&D effort
  - Generic, pre-competitive core R&D on fabrication processes
  - Industry-led teams to develop manufacturing capability through cost-shared financial agreements

Conclusion

- High-Volume Manufacturing Processes Are Critical to Meeting Cost Goals and Commercializing Hydrogen and Fuel Cell Technologies

- Manufacturing R&D for the Hydrogen Economy Addresses Critical Gaps:
  - Moving laboratory processes to high-volume manufacturing
  - Standardizing components and systems
  - Developing a manufacturing infrastructure for hydrogen systems
  - Developing supplier base/networks

Hydrogen Manufacturing Task Team

- Department of Commerce
- National Science Foundation
- Department of Transportation
- National Aeronautics and Space Administration
- Department of Defense
- Department of Agriculture
- Office of Science and Technology Policy
- Office of Management and Budget
- National Renewable Energy Laboratory
- Department of Energy (Chair)