President's Hydrogen Fuel Initiative

Valri Lightner—US Department of Energy

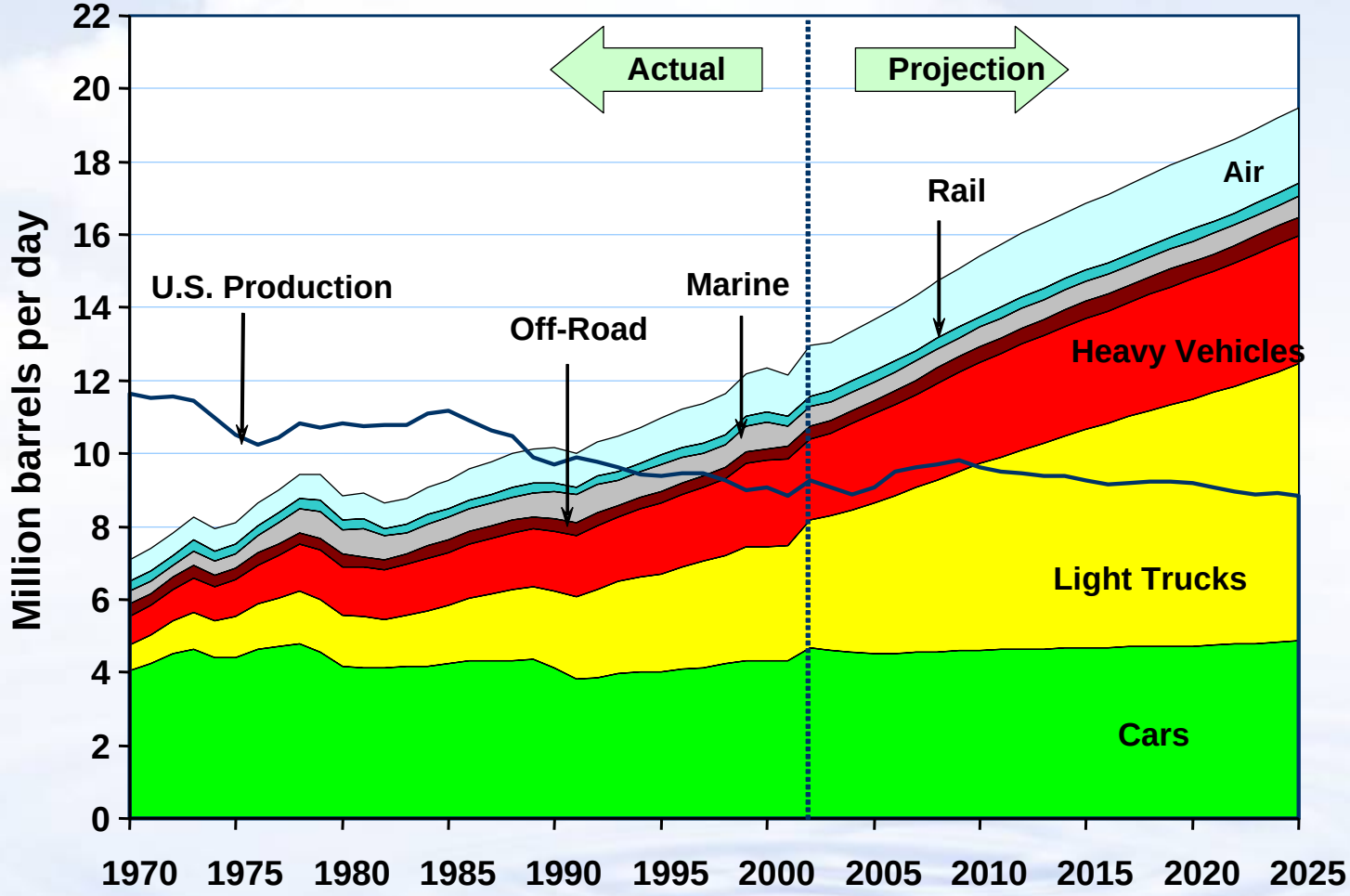
Walter Podolski—Argonne National Laboratory

EPA Air Innovations Conference

Chicago, IL

August 26, 2005

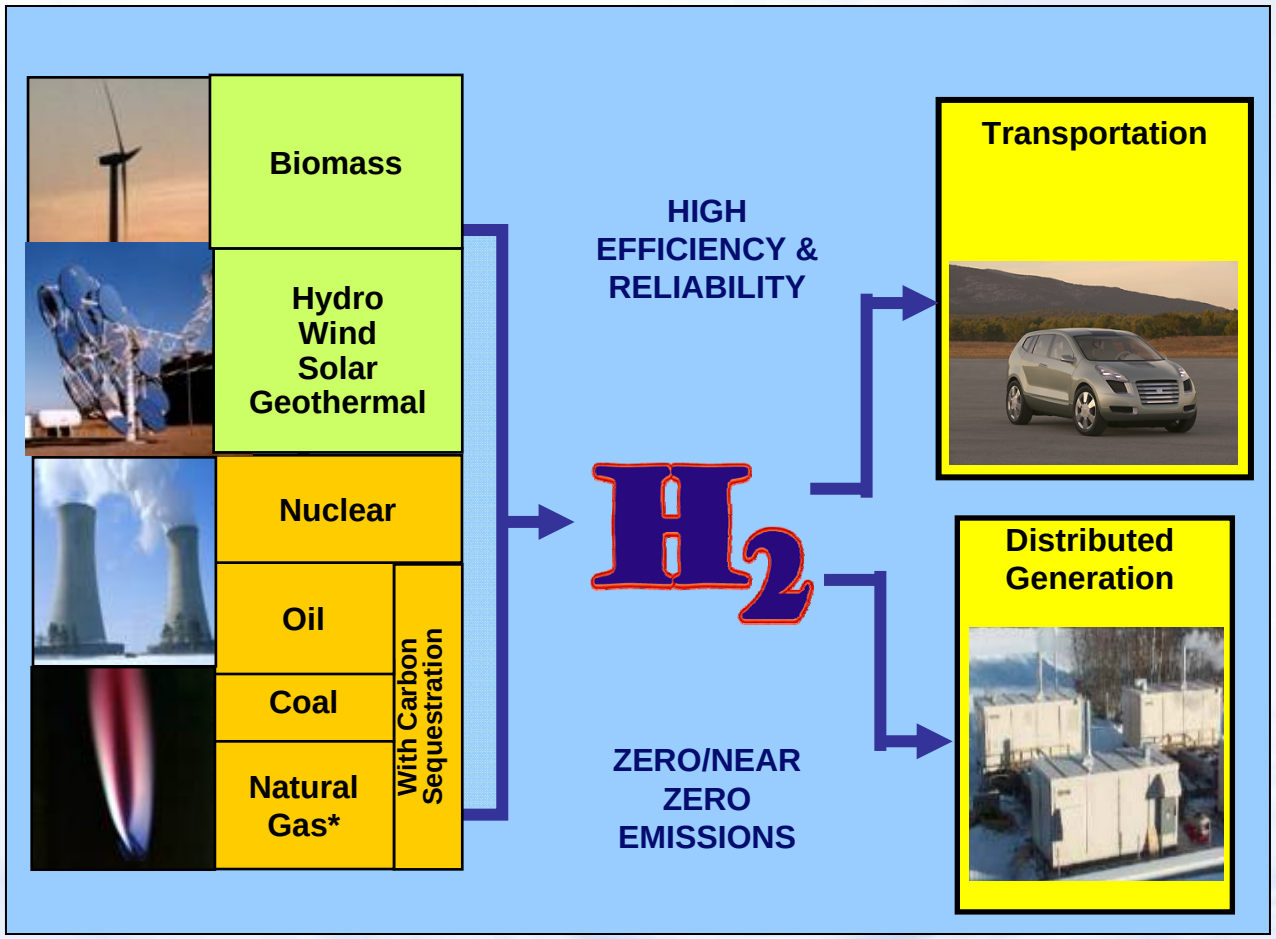
U.S. Energy Dependence is Driven By Transportation



- Transportation accounts for 2/3 of the 20 million barrels of oil our nation uses each day.
- The U.S. imports 55% of its oil, expected to grow to 68% by 2025 under the status quo.
- Nearly all of our cars and trucks currently run on either gasoline or diesel fuel.

Why Hydrogen?

It's abundant, clean, efficient, and can be derived from diverse domestic resources



U.S. Energy Policy for hydrogen is focused on research

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

FreedomCAR and Fuel Partnership Established

New Energy Company/DOE Technical Teams

- Production
- Delivery
- Fuel Pathway Integration

New Joint Auto/Energy/DOE Technical Teams

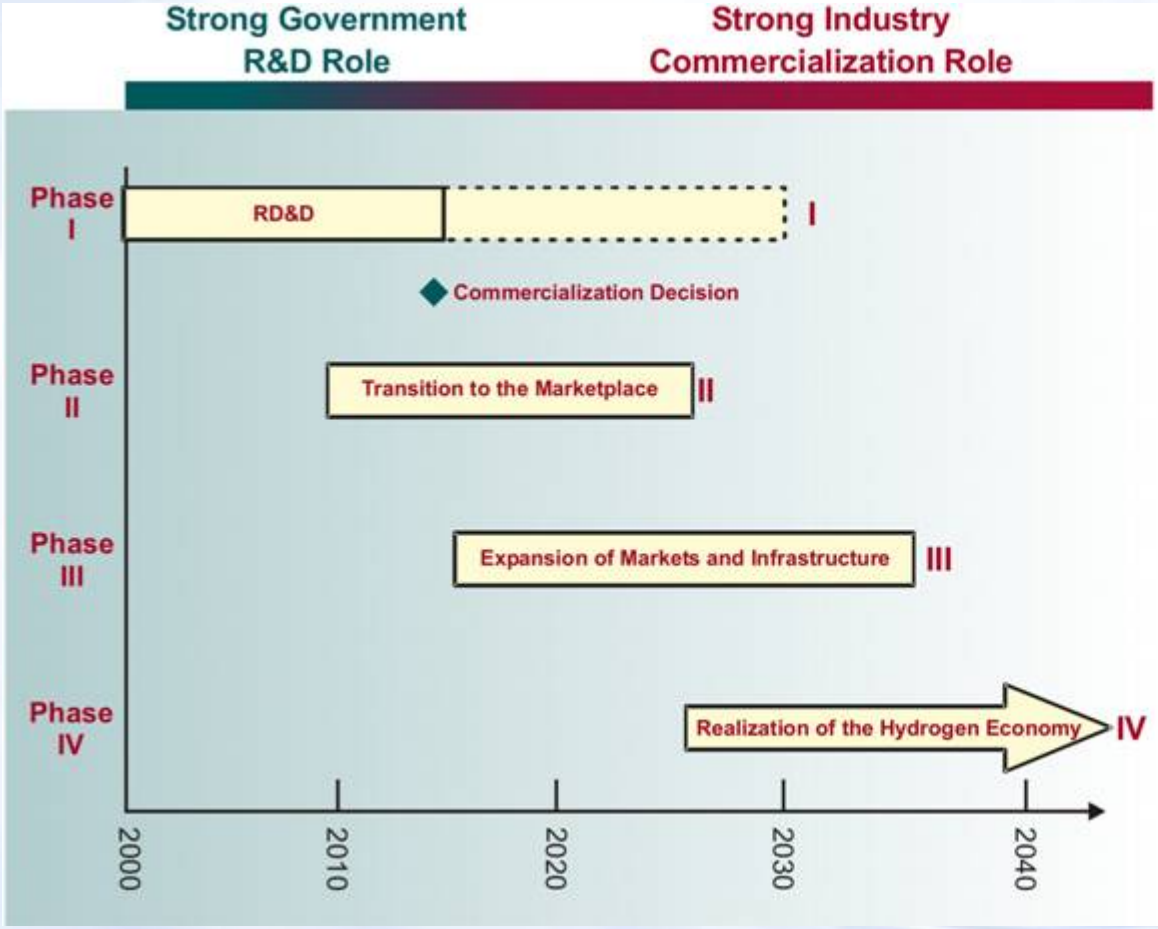
- Codes and Standards
- Storage

Auto/DOE Technical Teams

- Fuel Cells

Technology Roadmaps have been developed for each Technical Team

Hydrogen Economy Timeline



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

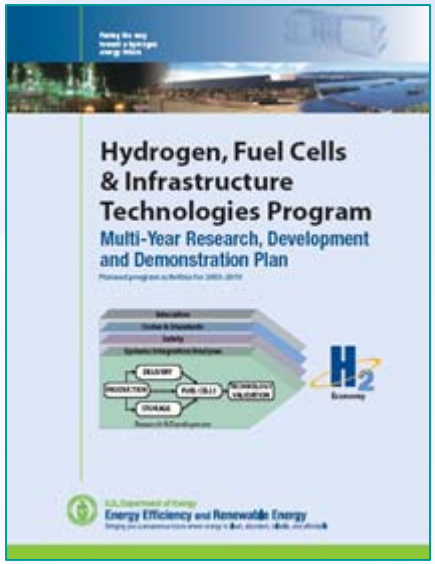
III. Infrastructure Investment Phase

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

Barriers to a Hydrogen Economy



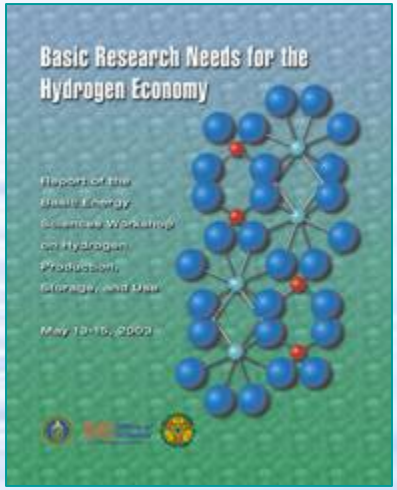
http://www.eere.energy.gov/hydrogenanfuelcells/mypp/

Critical Path Technology Barriers:

- Hydrogen Storage (>300 mile range)
- Hydrogen Production Cost ($2.00-3.00 per gge)
- Fuel Cell Cost (< $50 per kW)

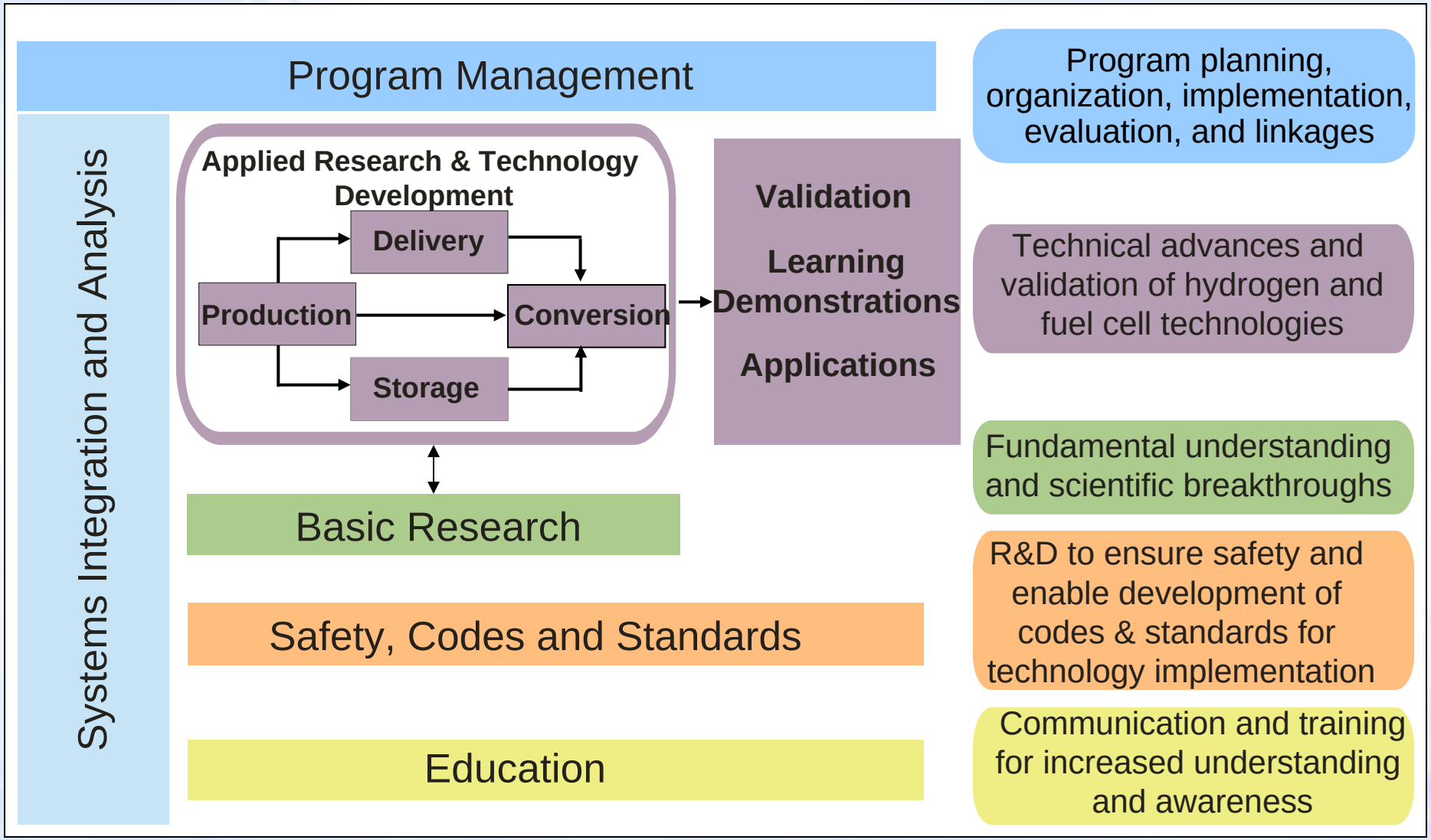
Economic/Institutional Barriers:

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



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

Program Implementation Approach



Hydrogen Production and Delivery

Distributed Reforming Using Natural Gas and Renewable Liquids

- Develop intensified, lower capital cost, more efficient NG reformer technology
- Develop improved catalysts and technology for renewable liquids reforming (e.g. ethanol, sugar alcohols, Bio-oil)
- Lead Partners: GE, APCi, H2Gen, Virent, Ohio State Research

Electrolysis

- Develop low cost and high efficiency materials and system designs
- Integrated compression
- Integrated wind power/electrolysis systems
- Lead partners: Teledyne, Giner, Materials and Systems Research

Biomass Gasification

- Developed integrated gasification, reforming, shift and separations technology to reduce capital and improve efficiency.
- Lead Partners: GTI, UTRC, SRI, Ceramatec, Arizona State U.

Solar/Photolytic

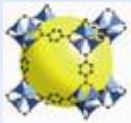
- Develop durable materials for direct photo-electrochemical solid state water splitting using sunlight
  - Lead Partners: Univ. of California, MV Systems, U, of Hawaii, Midwest Optoelectronics
- Research microorganisms that split water using sunlight
  - Lead Partners: Univ. of California, Craig Venter Inst.
- Research thermochemical cycles that split water using heat (600 – 2100 C) from solar concentrators
- Lead Partners: UNLV, U. of Colorado, SAIC

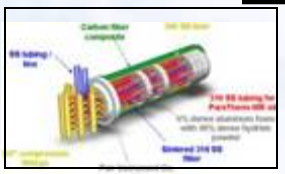
Delivery

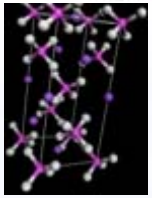
- Infrastructure options and trade-offs analysis
- Develop lower cost and robust technology for pipelines, compression, off-board storage, carriers, and liquefaction
- Lead Partners: Nexant, Gas Equipment Engineering Corp, NCRC Corp., APCI, SECAT, U. of Illinois

Hydrogen Storage

Focused on *materials-based* technologies for >300-mile range

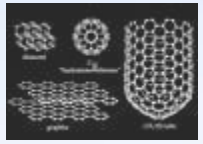


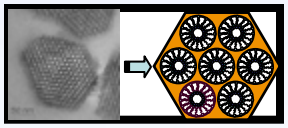




National Hydrogen Storage Project

- **Centers of Excellence**
- **Independent Projects**
- **Testing & Analysis Cross Cutting**
- **Metal hydrides**
- **Chemical Hydrogen Storage**
- **Carbon-Based Materials**
- **Basic Science**
- **New materials/processes for on-board storage**
- **Compressed/Cryogenic & Hybrid approaches**
- **Off-board storage systems**





Materials reversible on-board

- Can "refill" H_2 at the fueling station, directly onto the vehicle
- Advanced metal hydrides (alanates, borohydrides, Li-Mg amides)
- Carbon-based materials, high surface-area adsorbents
- Focus on capacity and thermal management

Materials regenerable off-board

- Take depleted material off vehicle & regenerate off-board
- Liquid or solid materials, high binding energy of hydrogen, high capacity
- Organic liquids, boron-based materials, polymeric systems
- Focus on capacity and regen efficiency

New Materials and Concepts: Nanoporous materials, clathrates, MOFs, perhydrides, other

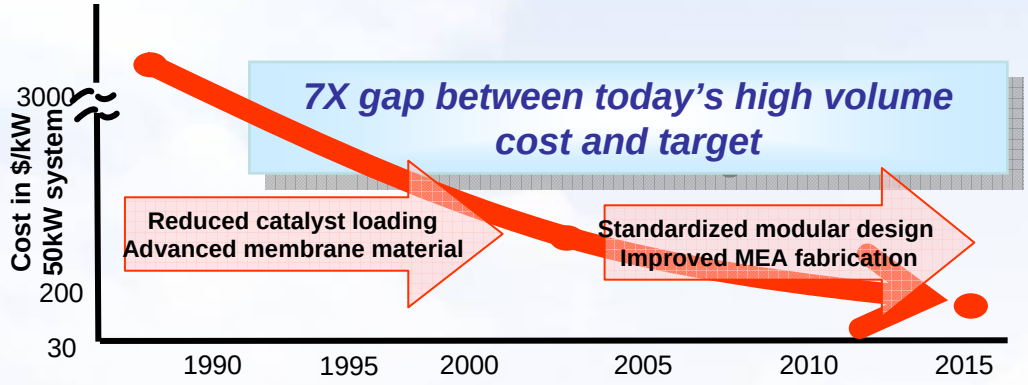
PEM Fuel Cell Activities

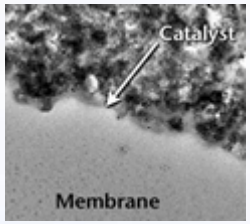
Focused on Removing Technical Barriers: Cost & Durability

Stack Component R&D

UTC Fuel Cells, 3M, DeNora, Cabot Superior Micropowders, Englehard, Arkema (previously Atofina) Chemicals, DuPont, Plug Power, Ion Power, Ballard, U. of South Carolina, Porvair, LANL, NIST, NRL, NASA, ANL, LBNL, ORNL, PNNL, NREL, SNL and BNL

- polymers, proton conducting membranes
- MEAs in high volume manufacturing
- electrocatalysts, platinum recycling
- bipolar plates





Distributed Energy Systems

IdaTech, UTC Fuel Cells, Plug Power, ANL, NREL, and Battelle

- demonstrations of integrated stationary systems
- modeling and analysis

Transportation Systems

UTC Fuel Cells, Honeywell, Delphi Automotive Systems, Cummins Power Generation, PolyFuel, MTI MicroFuel Cells, IdaTech, Mechanology, NREL, LLNL, PNNL, ANL, LBNL and ORNL

- system modeling & analyses
- physical and chemical sensors
- turbo compressor / expander
- compact humidifiers / heat exchangers
- auxiliary power in trucks
- portable power applications

Fuel Processor R&D

Nuvera, Texaco Energy Systems, Catalytica, University of Michigan, ANL, LANL, PNNL and ORNL

- fuel processor catalysts & systems for stationary applications
- diesel or propane fuel processing for APUs

Technology Validation

Strategy: Conduct learning demonstrations of hydrogen infrastructure in parallel with hydrogen fuel cell-powered vehicles to enable and assess technology readiness for a 2015 commercialization decision.

Major Objectives

- Obtain detailed component data under real-world conditions (climatic, geographic etc.) to re-focus the Department's hydrogen and fuel cell component and materials research
- Validate the technology against time-phased performance-based targets

<u>Learning Demonstration Teams</u>

- General Motors and Shell 40 vehicles/7stations
- Ford and BP 26 vehicles/7 stations
- DaimlerChrysler and BP 36 vehicles/8 stations
- ChevronTexaco and Hyundai 32 vehicles/6 stations

Hydrogen Generation Technologies

- Electrolysis powered by: Photovoltaics, Wind, Biomass, Electric Grid
- Reforming
  - Steam Methane (SMR) of natural gas
  - Autothermal (ATR)
    - natural gas
    - planned upgrades to use ethanol
- Delivered: Liquid, Compressed

$170M over 6 years government share
50/50 cost share by industry
By 2009: 2000 hour fuel cell stack durability, 250+ mile vehicle range and $3.00 gge hydrogen production

Hydrogen Vehicles

DaimlerChrysler

Ford Motor Company

Hyundai

General Motors

Photo: Shell Hydrogen

Hydrogen Refueling Infrastructure

DTE/BP Power Park, Southfield, MI

BP LAX refueling station

Shell hydrogen and gasoline station, WA DC

Photo:Shell Hydrogen

ChevronTexaco, Chino, CA

Photo: H2CarsBiz

Extensive Coordination

International Partnership for the Hydrogen Economy

- IPHE.net

Interagency Hydrogen Research and Development Task Force (OSTP lead)

- www.hydrogen.gov

Federal/State/local (Example)

- California Fuel Cell Partnership
- California Hydrogen Highway Network

DOE Hydrogen Program Website

DOE Hydrogen Program Home Page - Microsoft Internet Explorer

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- Systems Integration

DOE Hydrogen Program

Announcements

DOE Hydrogen Annual Merit and Peer Review to be May 23-26, 2005 in Washington, D.C.

News

Progress on Solid Oxide Fuel Cells

Achievement brightens prospects for environmentally clean technology to move into mainstream energy markets...
January 3, 2005 More >

Nuclear Hydrogen Research Awards Announced

DOE announced 35 research awards to U.S. universities totaling $21 million over three years...
December 23, 2004 More >

Office of Science Hydrogen Awards to be Announced in June 2005

The 227 full proposals are in the process of undergoing external peer review... More >

DOE Office Hydrogen Plans

Nuclear Hydrogen R&D Plan
(Office of Nuclear Energy, Science & Technology)
March 2004
(PDF 1.82 MB)

Hydrogen, Fuel Cells & Infrastructure Technologies

President's Hydrogen Fuel Initiative

Hydrogen.gov

National Energy Policy (PDF 3.05 MB)

DOE Strategic Plan (PDF 1.68 MB)

Hydrogen Vision (PDF 1.022 KB)

Hydrogen Roadmap (PDF 1.96 MB)

http://www.hydrogen.energy.gov/production.html Internet

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