The President’s Hydrogen Fuel Initiative

Workshop on Manufacturing R&D for the Hydrogen Economy
Washington, DC
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Planning
The U.S. imports 55% of its oil; expected to grow to 68% by 2025 under the status quo.
Transportation accounts for 2/3 of the 20 million barrels of oil our nation uses each day.
Gasoline hybrid electric vehicles will help in the near–mid term; a replacement for petroleum is needed for the long-term.
Hydrogen Provides a Solution

Producing hydrogen from domestic resources, including renewable, nuclear, and coal with carbon sequestration, can reduce dependence on petroleum, and yield virtually zero criteria and greenhouse gas emissions.

**Coal**
- Only with carbon capture & sequestration
- Gasification process produces hydrogen directly
- Electricity not produced as an intermediary

**Distributed Natural Gas**
- Transition strategy
- “Well-to-wheels” greenhouse gas emissions substantially less than gasoline hybrid-electric vehicle
- Not a long-term source for hydrogen (imports and demand in other sectors)

**Nuclear/Renewable**
- Electrolysis (one option)
- Electricity not necessarily produced as an intermediary, options being pursued include:
  - Gasification of biomass
  - Reforming of renewable liquids
  - Photoelectrochemical
  - Photobiological
  - Thermochemical (solar and nuclear)
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
Policy and R,D&D Planning

Policy

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Nuclear Hydrogen R&D Plan
Basic Research Needs for the Hydrogen Economy
FreedomCAR and Fuel Partnership Established

Energy Company/DOE Technical Teams
• Production
• Delivery
• Fuel Pathway Integration

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

Phase I: RD&D
- 2000
- Commercialization Decision

Phase II: Transition to the Marketplace
- 2010

Phase III: Expansion of Markets and Infrastructure
- 2020

Phase IV: Realization of the Hydrogen Economy
- 2030
- 2040

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
Implementation
Cost Reduction is a Primary R&D Driver

Key Hydrogen R&D Challenges Identified

- **Hydrogen Production and Delivery**
  - Cost of hydrogen must be competitive with gasoline, without adverse environmental impacts
    - $2.00-3.00/gge untaxed

- **Hydrogen Storage**
  - Capacity must enable >300-mile range, and meet packaging, performance, and cost requirements
    - $2/kWh (~ $300 for 5-kg H₂ 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.
Program Structured to Address Challenges

Program Management

Systems Integration and Analysis

- Applied Research & Technology Development
  - Delivery
  - Production
  - Conversion
  - Storage

- Basic Research

- Safety, Codes and Standards

- Education

Program planning, organization, implementation, evaluation, and linkages

Technical advances and validation of hydrogen and fuel cell technologies

Fundamental understanding and scientific breakthroughs

R&D to ensure safety and enable development of codes & standards for technology implementation

Communication and training for increased understanding and awareness
Projects in Place to Overcome Challenges

Putting in place the projects that support the plans
Initial solicitations are complete; yearly solicitations will continue

- Initiated over $510M in new projects ($755M with private cost share) to overcome critical technology challenges. Includes:
  - Hydrogen Storage Centers of Excellence
  - New projects in hydrogen production
  - New fuel cell R&D projects
  - Learning demonstrations to evaluate technologies in real-world operating conditions, measure progress toward targets, and help focus R&D
  - Basic research addressing:
    - Novel Materials for Hydrogen Storage
    - Membranes for Separation, Purification, and Ion Transport
    - Design of Catalysts at the Nanoscale
    - Solar Hydrogen Production
    - Bio-Inspired Materials and Processes

Next: Manufacturing R&D
Manufacturing R & D for the Hydrogen Economy

Manufacturing challenges:

- 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
- Developing a supplier network
Hydrogen Production

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

Transition to the Hydrogen Economy:

Initially, distributed H₂ production facilities will use NG reformers and electrolyzers. In the long-term, central H₂ production facilities will use fossil (coal with sequestration), renewable and nuclear resources, and take advantage of economies of scale.
3-8X gap between today's storage system cost and target

High volume fabrication of compressed and cryogenic tanks

New manufacturing processes for advanced materials/systems

Volumetric & Gravimetric Energy Density

2015 target
2010 target
Chemical hydride
Complex hydride
Liq. H2
10000 psi gas
5000 psi gas

$/kWh

$/kWh

2005
2010
2015

Year
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.
Next Steps

- **Develop R&D Roadmap** with stakeholders and experts in industry, academia, and government
  - Workshop in July 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
Hydrogen Economy Timeline

Manufacturing R&D for the Hydrogen Economy

R&D Roadmap

Generic, Pre-competitive Core R&D on Fabrication Technologies

Competitive Industry Teams Developing Scalable Manufacturing Technologies

2005 2010 2015 2020

Manufacturing R&D - Connected To Hydrogen Economy Timeline

Manufacturing R&D for the Hydrogen Economy

Commercialization Decision

2005 2010 2015 2020