Technical Targets of the President’s Freedom Car and Hydrogen Fuel Initiative

Arlene Anderson
Technology Development Manager

US Department of Energy
Hydrogen, Fuel Cells & Infrastructure Technologies

DOE Workshop on Hydrogen Separations and Purification Technologies
September 8-9, 2004
Arlington, Virginia
**Resources to Support the President’s Hydrogen Fuel Initiative**

<table>
<thead>
<tr>
<th>Major Line Items and Key Activities</th>
<th>FY 04 Appropriation ($K)</th>
<th>FY 05 Request ($K)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Cell Technologies</strong> : system components, stack components, fuel processors, technology validation</td>
<td>$65,187</td>
<td>$77,500</td>
</tr>
<tr>
<td><strong>Hydrogen Technologies</strong> : distributed natural gas and renewable production, delivery, storage, safety and codes/standards, infrastructure technology validation, education/analysis</td>
<td>$81,991</td>
<td>$95,325</td>
</tr>
<tr>
<td><strong>Coal-based Hydrogen Production</strong> : gasification, gas separation</td>
<td>$4,889</td>
<td>$16,000</td>
</tr>
<tr>
<td><strong>Nuclear-based Hydrogen Production</strong> : high temperature</td>
<td>$6,377</td>
<td>$9,000</td>
</tr>
<tr>
<td><strong>Basic Science</strong> : production, storage and use</td>
<td>$0*</td>
<td>$29,183</td>
</tr>
<tr>
<td><strong>Department of Transportation</strong> : safety, codes/standards</td>
<td>$555</td>
<td>$832</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$158,999</strong></td>
<td><strong>$227,840</strong></td>
</tr>
</tbody>
</table>

* Excludes about $8 million of baseline activities not counted as part of the Initiative.

** FY 04 Request = $181.7 M

Note: Some FY 04 numbers vary slightly due to RESCISSIONS AFTER appropriation and other reductions.
**Membrane Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>2003</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux Rate</td>
<td>scfh/ft²</td>
<td>60</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Cost</td>
<td>$/ft²</td>
<td>$150-$200</td>
<td>$100-$150</td>
<td>&lt;$100</td>
</tr>
<tr>
<td>Durability</td>
<td>hours</td>
<td>&lt;1,000</td>
<td>50,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>Degrees C</td>
<td>300-600</td>
<td>300-600</td>
<td>300-600</td>
</tr>
<tr>
<td>Parasitic Power</td>
<td>kWh/1,000 scfh</td>
<td>3.2</td>
<td>3.0</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Challenge:** Apply Membrane to Small-Scale Distributed Production in One-Step Shift Reactor that is Feedstock Flexible
FY 04 Separations Portfolio

- Ceramic Membrane Reactor
  ITM Syngas – APCI
- Pyrochlore/Perovskite
  PTM – ORNL
- Inorganic Membrane Porous Support Tubes – ORNL
- Defect-Free Thin Films – SNL
- Photopolymerization/Pyrolysis and Membrane Microstructure Development – LANL
- WGS Membrane Reactor Studies – NETL
• Distributed hydrogen production systems deserve increased R&D investments by DOE.

• Increased R&D efforts and accelerated program timing could decrease the capital cost and increase the energy efficiency of small-scale natural gas reformers and water electrolysis systems.

• Initiate a program to develop new concepts in distributed hydrogen production systems that have the potential to compete—in cost, energy efficiency, and safety—with centralized systems.
### Production Scales

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Production Capacity</th>
<th>Capacity Utilization</th>
<th>Total Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Plant</td>
<td>1,200,00 Kg per day</td>
<td>90% Capacity</td>
<td>2 million cars</td>
</tr>
<tr>
<td>Midsize Plant</td>
<td>24,000 Kg per day</td>
<td>90% Capacity</td>
<td>40,000 cars</td>
</tr>
<tr>
<td>Distributed Plants</td>
<td>1,500 Kg Per day</td>
<td>90% Capacity</td>
<td>3000 cars</td>
</tr>
</tbody>
</table>
Distributed Production of Hydrogen From Natural Gas and Liquid Fuels (up to 1,500 kg/day)

<table>
<thead>
<tr>
<th>Year</th>
<th>Status</th>
<th>2004</th>
<th>Target</th>
<th>2005</th>
<th>Target</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural Gas Cost</td>
<td>Reforming</td>
<td>Purification</td>
<td>Compression</td>
<td>Storage &amp; Dispensing</td>
<td>Other</td>
</tr>
<tr>
<td>2003</td>
<td>$5.00</td>
<td>$1.00</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$6.00</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>$6.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>$6.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td></td>
</tr>
</tbody>
</table>
Distributed Hydrogen Production From Natural Gas On Target

- APCI validated $3.60/gge hydrogen – delivered, untaxed, co-producing electricity at 8¢ per kWh.
- $3.00/gge target in 2005 within reach
- Reformer research
  - Optimized desulfurization, reformer, and shift catalysts
  - Improved heat recovery system
- PSA research
  - 99.999% pure H₂
  - 3x cost reduction compared to commercial units
  - Decreased size
  - 82% efficiency (64% in 2003)

In 2025, assuming FCVs represent 12% of LDV inventory, EIA estimates only 2.8% increase in natural gas demand compared to reference case.
Hydrogen Storage - $150M over 5 years
• Three Centers of Excellence for exploratory research; individual projects to explore new materials for hydrogen storage ($25M in cost share)

Vehicle and Infrastructure "Learning" Demonstration - $190M over 5 years
• Automobile/energy company teams will demonstrate integrated and complete system solutions in real world environments ($190M in cost share)

Fuel Cell Research - $13M over 2 years *in addition to $75M awarded in FY2003
• Consumer electronics, fuel cells for auxiliary power generation, and off-road fuel cell R&D ($9.5M in cost share)

Hydrogen Education - $4.5M over 5 years
• Curricula and teacher professional development, education materials, co-sponsorship of events ($800K in cost share)

Active DOE Solicitations

Production and Delivery: August, 2004 - SELECTIONS
Hydrogen from Nuclear: September, 2004 - SELECTIONS
Codes and Standards: October, 2004 - SELECTIONS
Basic Research: 2005 SELECTIONS
Hydrogen from Coal: OPEN Until October
DOE Hydrogen Production Team

Arlene Anderson: Hydrogen Separations, Distributed Production from Natural Gas

Mark Paster: Distributed, Regional and Central Production from Biomass, Hydrogen Delivery

Roxanne Danz: Photobiological Production

Peter Devlin: Team Leader

www.eere.energy.gov/hydrogenandfuelcells
• THE FOLLOWING ARE BACKUP OVERHEADS
Cost of a fuel cell prototype remains high (~$3,000/kW), but the high volume production cost of today’s technology has been reduced to $225/kW. Through 1990, PEM cost was dominated by platinum loading (~20g/kW). Today’s high volume estimate is $225/kW and is attributed to platinum and membrane cost. Cost improved through Platinum reduction to 0.8 g/kW. Further platinum reduction to goal of 0.2g/kW, and reduced membrane cost. Cost goal of $30/kW approximates the cost of conventional engine technology.