Hydrogen from Coal Program
Overview and Accomplishments

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Hydrogen from Coal Pathways

Gasification

Coal
Steam
Air/Oxygen

Synthesis Gas (CO/H₂)

F-T Synthesis
F-T Liquid Delivery
Subcentral/Distribution Reforming
SNG Production
SNG Delivery
Power
Electricity Transmission and Distribution

Water-Gas Shift
H₂ Separation
H₂ Delivery
H₂ Distribution

Advanced Concept/Process Intensification

KEY
Central Pathway
Alternate Pathway
Hydrogen from Coal: Technology Challenges

- Reduce the cost/improve efficiency
  - Clean synthesis gas production
    - Advanced gasification
    - Oxygen production
    - Advanced gas cleaning
  - Hydrogen separation & purification
  - Process intensification
- Capture and store carbon
- Integrate technologies into FutureGen
Hydrogen from Coal: Technology

Key

Gasification
IEP/Coal Utilization By-Products
Fuel Cells and Turbine Programs
CO₂ Sequestration
Coal Fuels and Hydrogen
Optional Pathway

Coal (CH) → Gasification → Synthesis Gas (CO, CO₂, H₂, H₂O, SO₂) → Gas Cleaning → Sulfur Particulate

Air Separator → O₂ (Depleted Air) → HRSG/ST Power

SOFC → Air → Combustion Turbine → HRSG/ST Power → CO₂ Sequestration

Hydrogen from Coal Technologies in the RD&D Program

Water Gas Shift & Membrane Separation → CO₂ → CO/H₂ → H₂O

HRSG → H₂ Delivery

H₂ Storage → H₂ Utilization

Syngas Conversion
F-T liquids CH₃OH

Utilize Current Delivery System
Reforming

Coal Fuels and Hydrogen Optional Pathway
## Hydrogen from Coal: Research Areas

<table>
<thead>
<tr>
<th>Research Area*</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membrane research</td>
<td>6</td>
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<tr>
<td>Module scale-up</td>
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<tr>
<td>Membrane reactors &amp; process intensification</td>
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<tr>
<td>CO₂ removal</td>
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<tr>
<td>Novel sorbent</td>
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<td>Co-production</td>
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<tr>
<td>Liquid H₂ carriers</td>
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<tr>
<td>Storage</td>
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<tr>
<td>Utilization</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>32</strong></td>
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</tbody>
</table>

* Complementary projects are supported by the Gasification and Sequestration Programs

FY 2007 Budget Request $22.1 M  
FY 2006 Appropriation $ 28.7 M  
FY 2005 Appropriation $ 17.0 M
Hydrogen From Coal: Goal

Facilitate the transition to a sustainable hydrogen economy through the use of coal, our largest domestic fossil resource

Objectives

Production: Central Pathway

- By 2015, demonstrate a 60% efficient, zero-emission, coal-fueled hydrogen and power co-production facility that reduces the cost of hydrogen by 25% compared to current coal-based technology.

Production: Alternative Hydrocarbon Pathway

- By 2011, an alternative hydrocarbon pathway and reforming system for sub-central/decentralized hydrogen from coal is available.
FY2005 Accomplishments

Completed update of the Hydrogen from Coal RD&D Plan – September 2005

Sampling of Project Accomplishments

Media and Process Technology, Inc.: H₂ Production via a Commercially-Ready Inorganic Membrane Reactor

- 100-hour field test of a carbon sieve-based membrane
- Showed excellent H₂ selectivity and permeance in presence of H₂S, NH₃, and hydrocarbons
- Can potentially combine WGS, separation, CO₂ capture, and contaminant removal in single step
- Mathematical model developed is consistent with experimental data
FY2005 Accomplishments (cont.)

Sampling of Project Accomplishments (cont.)

➔ Siemens Power Corp.: Novel Gas Cleaning and Conditioning for IGCC
  10 tons/day pilot plant test at Gas Tech. Inst.
  Pre-combustion gas-cleaning concept
  Reduced contaminant levels to 10-50 parts per billion by volume

➔ NETL: Novel Hydrocarbon Reforming Catalyst for Synthesis Gas Production
  Demonstrated exceptionally stable performance of a hydrocarbon reforming catalyst
  Catalyst is expected to be more robust and tolerant of carbon and sulfur
FY2006 Activities

Four new projects awarded in co-production to improve plant economics

- **Research Triangle Institute (H₂-Electricity Co-production)**
  - Reduction and oxidation of iron-based catalysts to process coal-derived synthesis gas

- **Research Triangle Institute (Substitute Natural Gas (SNG)-Electricity Co-production)**
  - Pre-processing conversion of coal to gaseous mixture followed by conversion to SNG

- **Arizona Public Service (SNG-Electricity Co-production)**
  - Utilizing hydro-gasification technology

- **West Virginia University Research Corp. (Novel products to improve economics)**
  - Utilizes small amount of produced hydrogen to co-produce high-value industrial products
Recent Solicitations

Central Production

- Two areas of focus: Novel polishing filters and process intensification
- Closes June 8, 2006

Alternate Production and Utilization

- Closed on May 11, 2006
Hydrogen from Coal – Clean, Secure, Affordable Energy for the Future

http://fossil.energy.gov/programs/fuels/