



**U.S. DEPARTMENT OF  
ENERGY**

# **Hydrogen from Coal Program Overview and Accomplishments**

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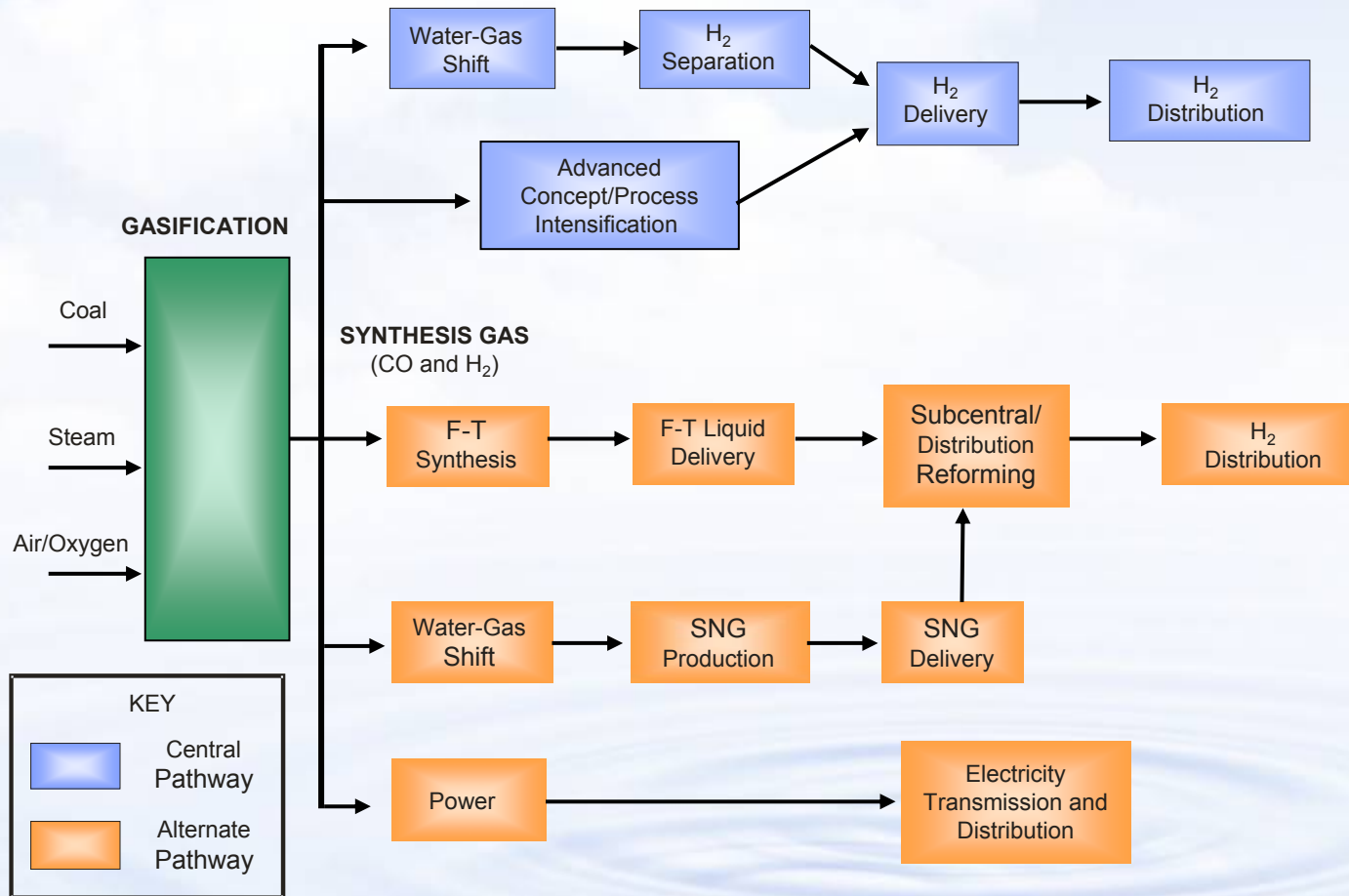
**Technology Manager, Hydrogen and Syngas  
U.S. Department of Energy**

**2007 DOE Hydrogen Program  
Merit Review and Peer Evaluation Meeting**

**May 15, 2007**



# Hydrogen from Coal Pathways



# Hydrogen from Coal

## Broad Technology Challenges

- Reduce the cost / Improve efficiency

- ➔ Clean synthesis gas production

- Advanced gasification
    - Oxygen production
    - Advanced gas cleaning

- ➔ Water Gas Shift reaction engineering
    - ➔ Hydrogen separation & purification
    - ➔ Process intensification
    - ➔ Alternative pathways; liquids & syngas
    - ➔ Hydrogen delivery, storage, and utilization

- Capture and sequester carbon

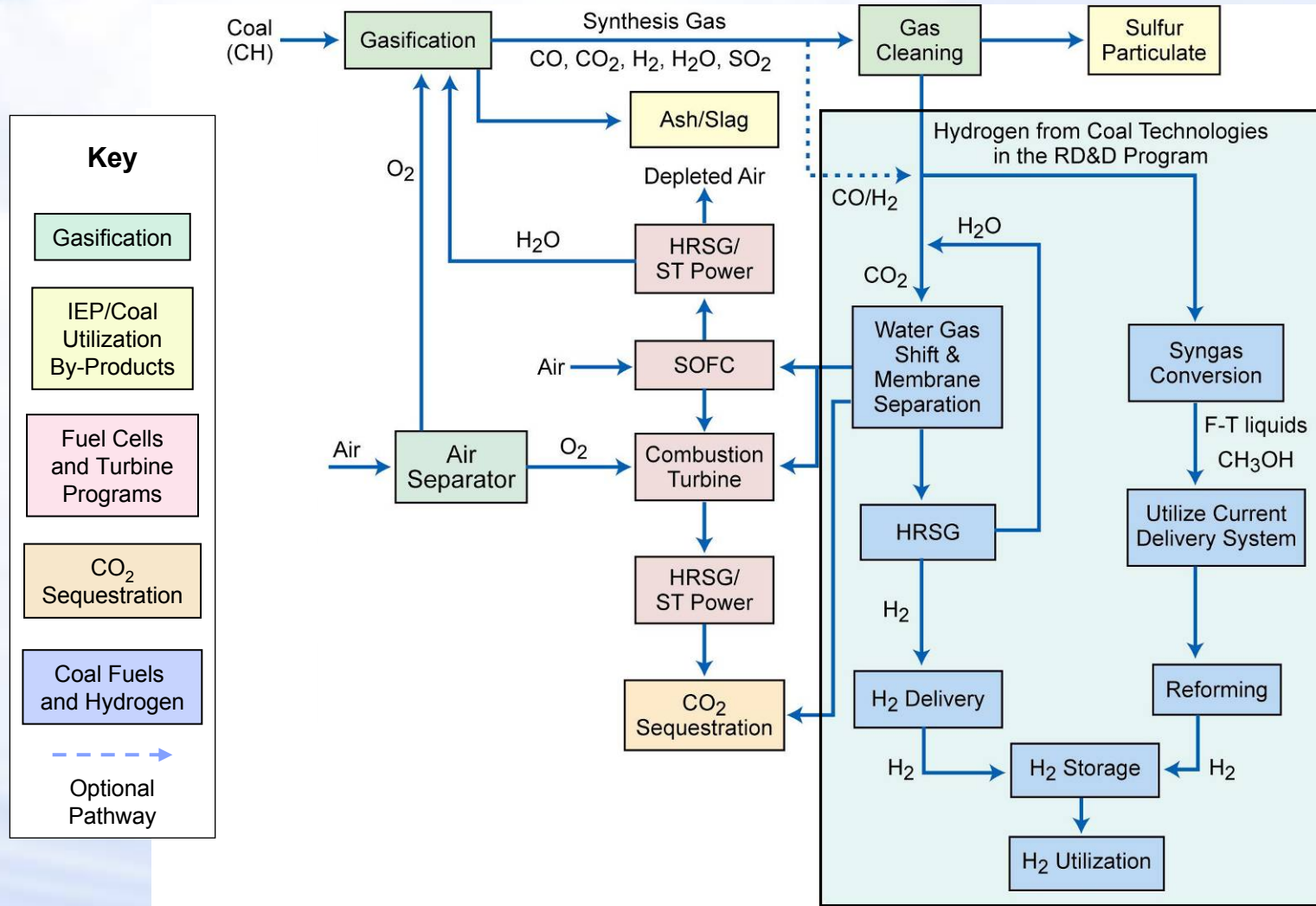
- Integrate technologies into FutureGen



H<sub>2</sub> from  
Coal  
Program



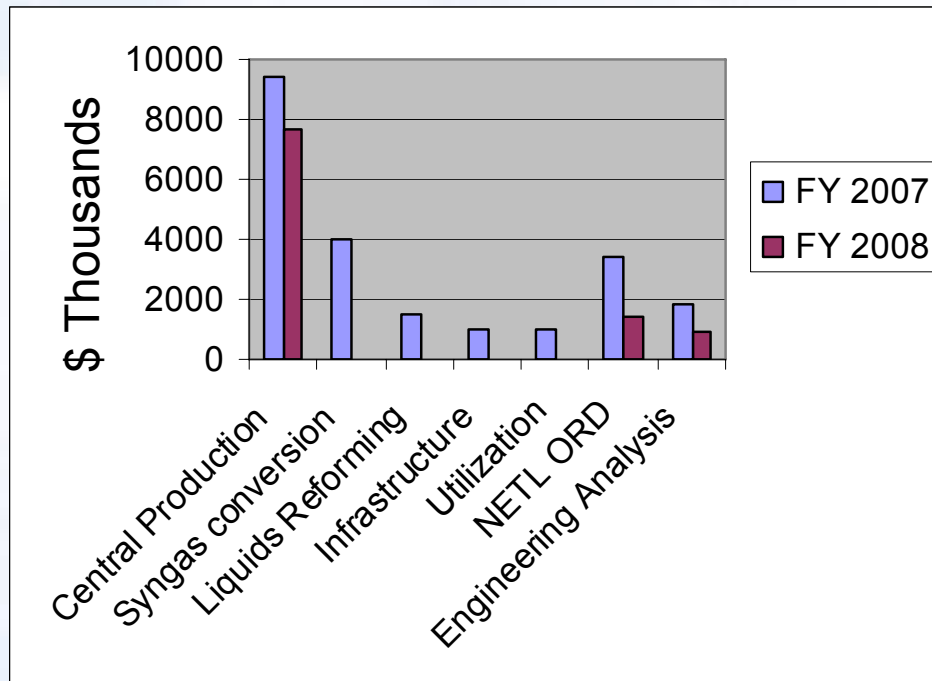
# Hydrogen from Coal: Technology



# Hydrogen from Coal: Research Areas

**FY 2008 Budget Request \$ 10.0 M**

**FY 2007 Appropriation \$ 22.1 M**



## ACTIVE PROJECTS \*

Membrane research	10
Module scale-up	5
Membrane reactors & process intensification	3
Novel H <sub>2</sub> sorbent	1
Liquid H <sub>2</sub> carriers	10
Storage	3
Utilization	6
<b>TOTAL ACTIVE</b>	<b>38</b>

\* Complementary projects are supported by the Gasification and Sequestration Programs

# 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 H<sub>2</sub> Production 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 Pathway*

- By 2012, complete tests and evaluations of the most promising hydrogen-rich, coal-derived liquids for reforming applications



# Recent Accomplishments

## Eltron Research Inc .

- Dense cermet membrane shows 2015 DOE Program performance flux targets met; demonstrated operation of a 1.46 lb/day H<sub>2</sub> separation facility to obtain engineering data.

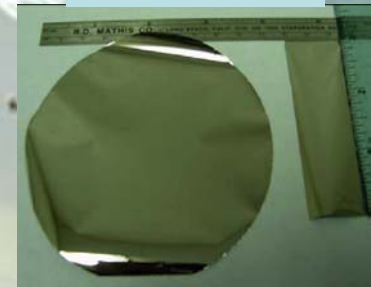
1.3 lb/day separation unit



## Southwest Research Institute

- Self-supported Pd-Cu alloy membrane meets 2010 DOE Program performance flux targets; reduced thickness (5 micron); successfully making large size membranes; maturing to engineering issues

SWRI  
membrane



# Recent Accomplishments

## Aspen Products Group

- Developing Pd/Cu coated Ta WGS/hydrogen separation membrane
  - Fabricated 26 tubular membranes with different catalyst coatings and layer thicknesses
  - Demonstrated high  $H_2$  membrane permeability in presence of  $H_2S$  and water
  - Completed construction of a 1 L  $H_2$ /hour reactor

## United Technologies Corp.

- Developing tri-metallic WGS/hydrogen separation membrane reactor
  - Compositions identified and patent application submitted
  - Compositions tested and 5 specific compositions identified based on Pt/Re with added Ce, Zr and Ti, developed to be sulfur and chlorine tolerant at low concentrations



# NETL Office of Research and Development (ORD)

## Using high pressure hydrogen test facility to verify contractor results

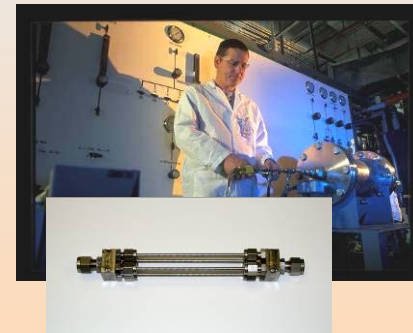
- Tested Eltron, ANL, and ORNL membranes
- Continuous, bench scale, T to 900°C, P to 1000 psi, disk & tubular membranes

## Molecular chemistry and lab testing of sulfur-resistant Pd-alloys for WGS membrane reactors

- Sulfur resistance observed for Pd-Cu alloys in presence of H<sub>2</sub>S
- Corrosion and/or catalytic poisoning play a significant role in the permeability decreases observed in the presence of H<sub>2</sub>S
- H<sub>2</sub> permeability of Pd-Cu strongly dependent on crystalline structure
- Demonstrated enhanced CO conversion in catalyst-free Pd-based MRs at elevated temperature in simulated coal-derived syngas

## NETL Hydrogen Membrane Test Unit

### Inset- membrane reactor



# New Activities

## ● Six new projects awarded in the area of Central Hydrogen Production

- ➔ Praxair
- ➔ Southwest Research Institute
- ➔ United Technologies Research Center
- ➔ Media and Process Technology
- ➔ Ohio State University
- ➔ Worcester Polytechnic Institute

## ● Projects are focused on:

- ➔ Ultra-Pure Hydrogen
- ➔ Process Consolidation