



**U.S. DEPARTMENT OF
ENERGY**

Hydrogen from Coal Program Overview and Accomplishments

Dr. Lowell Miller

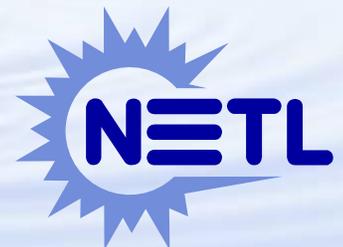
**Director, Office of Sequestration, Hydrogen, & Clean Coal Fuels
and**

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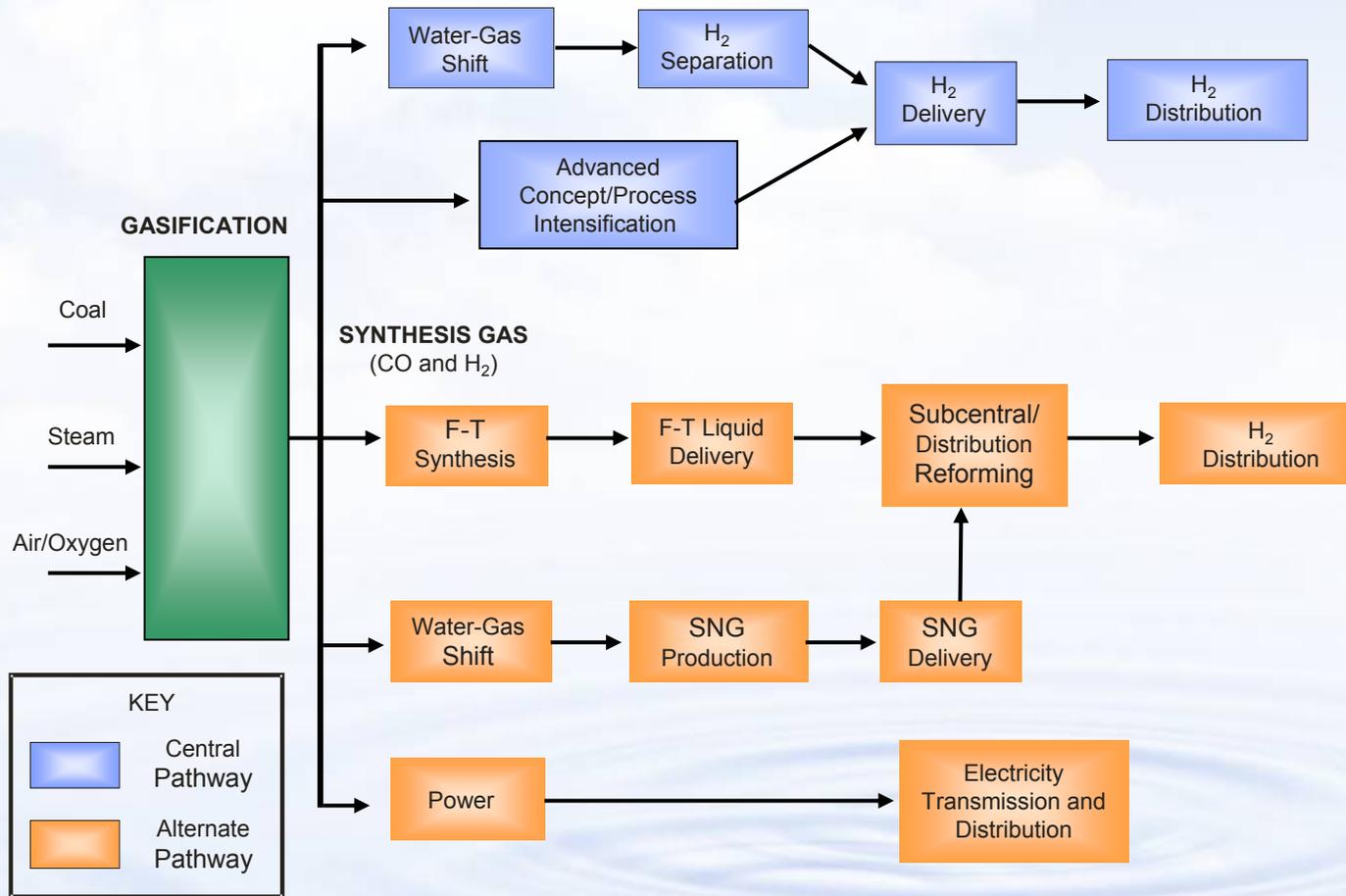
**Technology Manager, Hydrogen and Syngas
U.S. Department of Energy**

**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

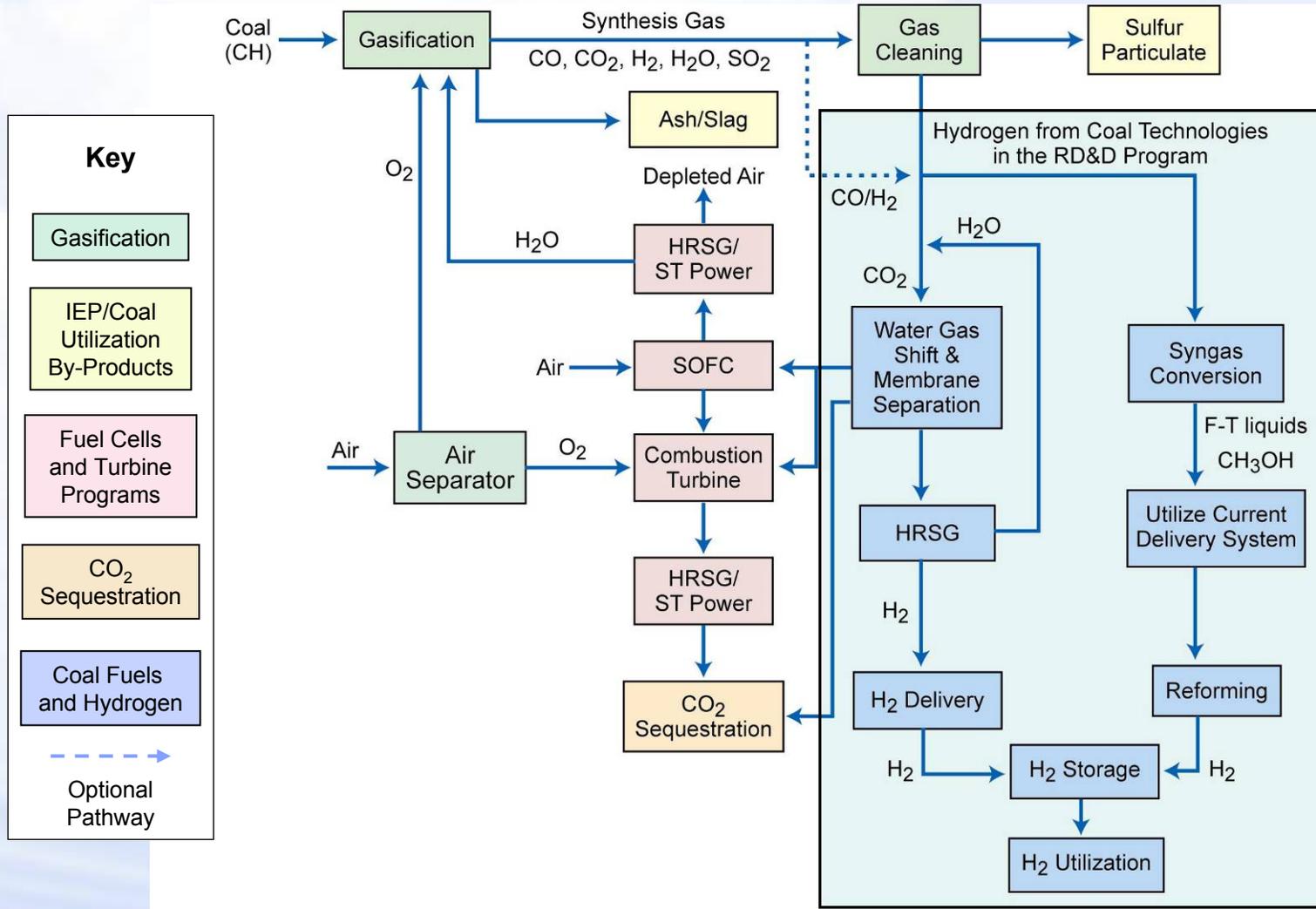
- Integrate technologies into FutureGen



H₂ from
Coal
Program



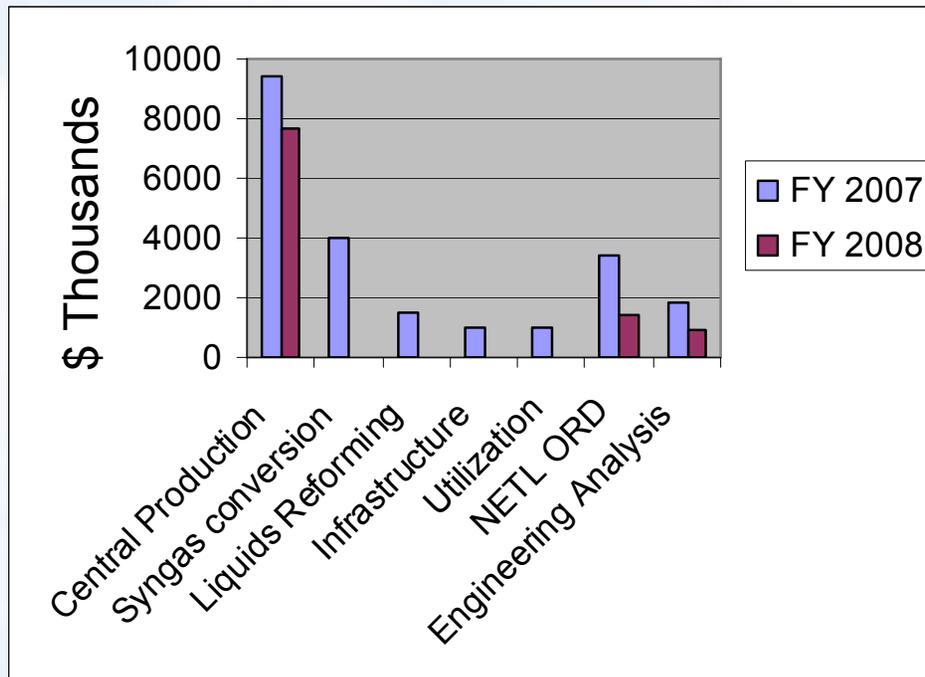
Hydrogen from Coal: Technology



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 ₂ sorbent	1
Liquid H ₂ carriers	10
Storage	3
Utilization	6
TOTAL ACTIVE	38

* 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 H₂ 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 H₂ 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 H₂ membrane permeability in presence of H₂S and water
 - Completed construction of a 1 L H₂/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

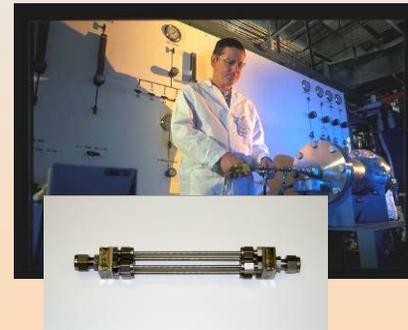
- Tested Eltron, ANL, and ORNL membranes
- Continuous, bench scale, T to 900°C, P to 1000 psi, disk & tubular membranes

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

- Sulfur resistance observed for Pd-Cu alloys in presence of H₂S
- Corrosion and/or catalytic poisoning play a significant role in the permeability decreases observed in the presence of H₂S
- H₂ 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