

# Coal Gasification: What Does It Mean for Wyoming?

## Research and Development Initiatives of the University of Wyoming

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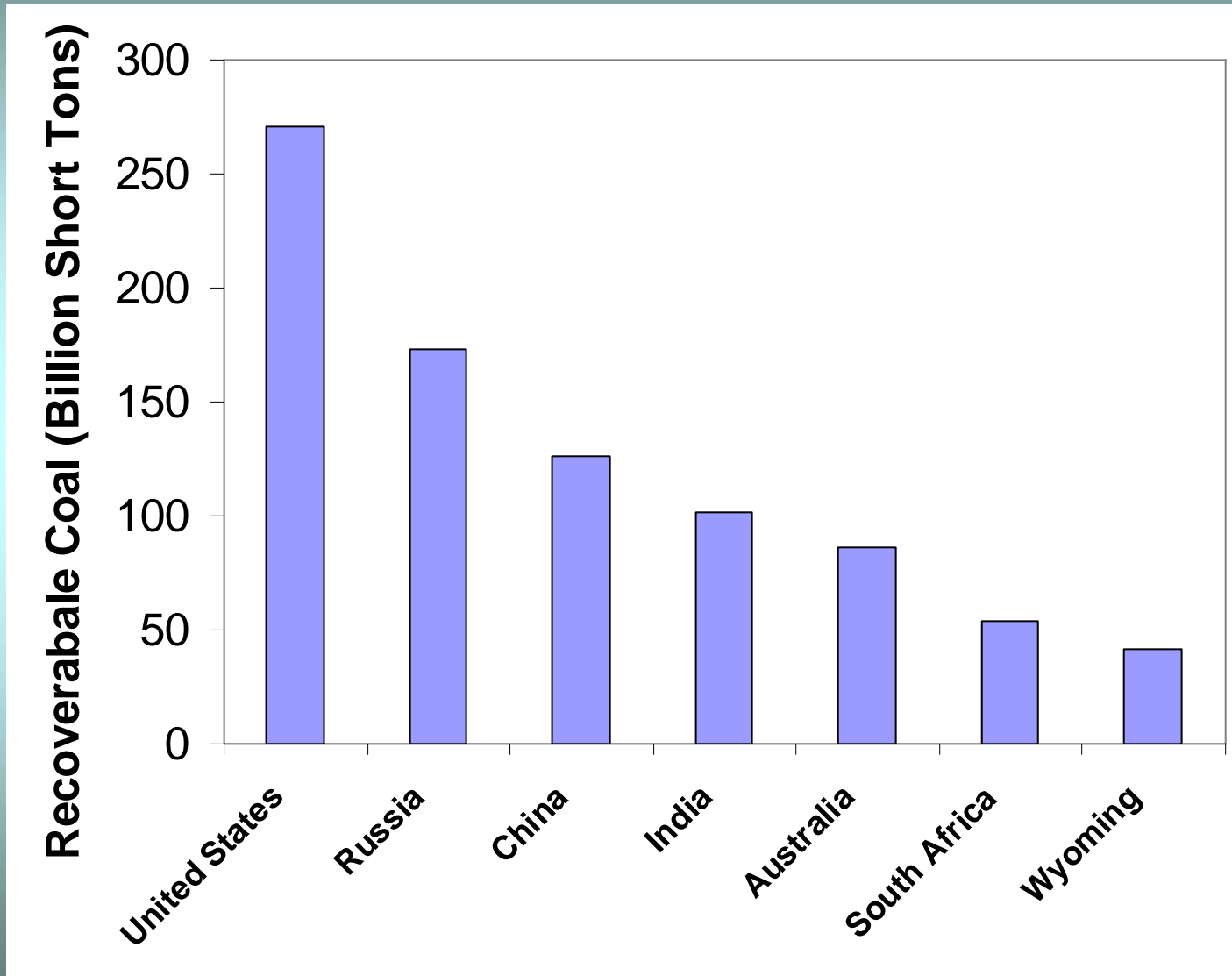
**School of Energy Resources Symposium**

**Casper, WY**

**February 28, 2007**

**UNIVERSITY OF  
WYOMING**

# Wyoming has enormous reserves of coal



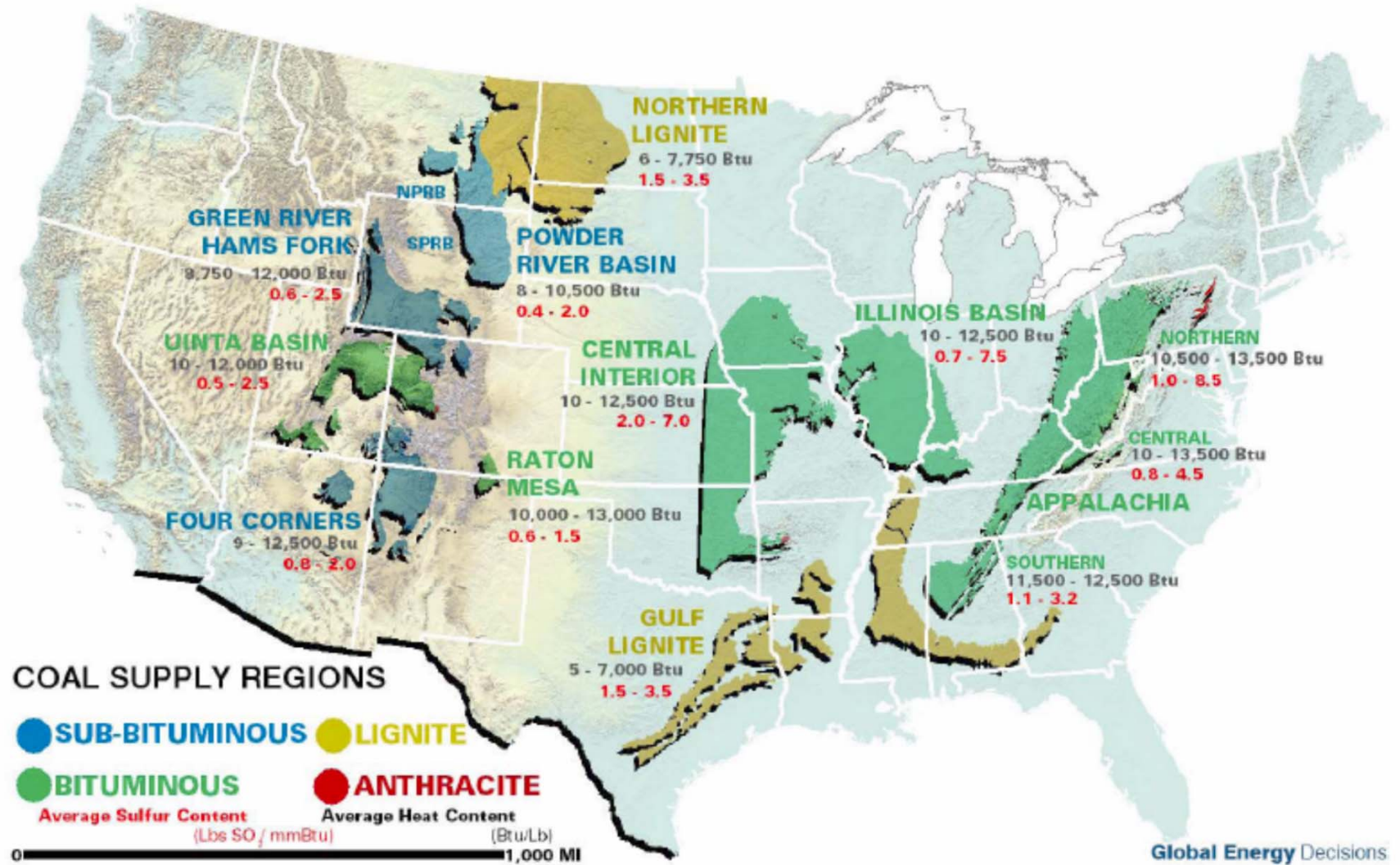
[www.eia.doe.gov/fuelcoal.html](http://www.eia.doe.gov/fuelcoal.html)

[www.americanenergysecurity.org/Coal%20Reserve%20Report%202006.doc](http://www.americanenergysecurity.org/Coal%20Reserve%20Report%202006.doc)



# Coal deposits exist under ~54% of the state's land area, but most is inaccessible to conventional mining

## U.S. Coal Supply Regions



Global Energy Decisions

# Opportunities for more efficient use of Wyoming coal

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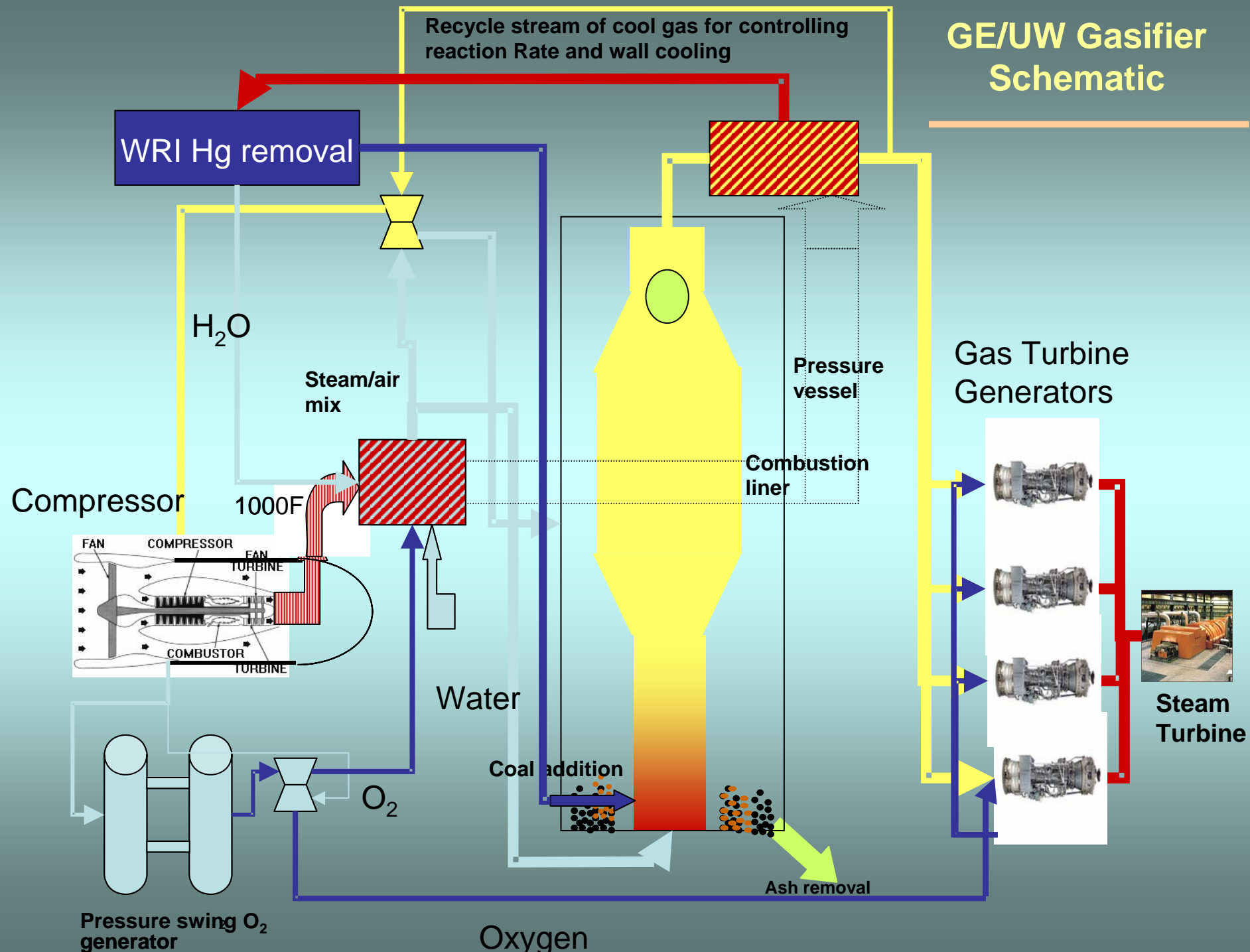
- **Wyoming produced 404 million tons of coal in 2005**  
[[www.eia.doe.gov/fuelcoal.html](http://www.eia.doe.gov/fuelcoal.html)]
  - **Highest production of any state, 36% of US supply**
  - **Virtually all burned in power plants to provide ~51% of US electricity**  
[A Concise Guide to Wyoming Coal 2006, Wyoming Mining Association  
<http://agecon.uwyo.edu/Econdev/PubStorage/Concise%20Guide%202006.pdf>]
- **Desirable to produce higher value products**
  - **More efficient power generation**
  - **Hydrocarbon liquids**
  - **Hydrogen**
- **The University of Wyoming has research efforts in all three areas**

# Advanced Gasifier Development

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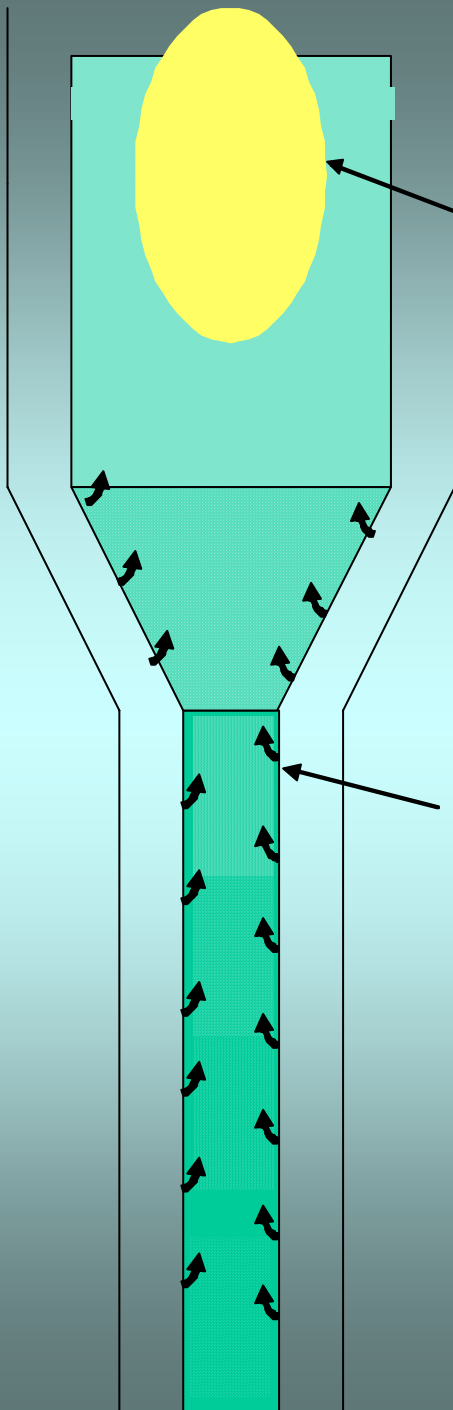
- **Under development by researchers at General Electric (GE) and the University of Wyoming (UW)**
- **Provides efficient Integrated Gasification Combined Cycle (IGCC) power generation or synthesis gas for chemical production**
- **Several design features based on aircraft gas turbines**

# GE/UW Gasifier Schematic



# GE/UW Gasifier Reactor Detail

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Integral Inlet Particle Separator to remove fly ash

“Cold” wall pressure vessel

Expansion lowers velocity and increases residence time for low density char

Cooling holes provide uniform oxygen/steam pressure and temperature along length of reactor

Produces reaction along entire length & creates variable buoyancy fluidized bed

# Advantages of GE/UW Gasifier

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- **Low cost, modular design; robust for reduced maintenance**
    - Inexpensive materials of construction
      - + Cold wall pressure vessel
      - + Cool wall reaction vessel
      - + Non-slagging
  - **refractory/ceramic linings not required**
  - Relatively low pressure
  - Low thermal losses
  - Optimum temperature and velocity profile along reactor length
- 
- **Designed to operate on Western coals**
    - Design can be optimized for operation at higher elevations
    - Uses water in the coal
- 
- **Single pass operation (no recycle)**
- 
- **Flexible for IGCC or chemical products production (dual use)**



# Status of GE/UW Gasifier

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- **Early, conceptual design stage**
- **Next steps**
  - **Gather data to complete detailed design**
  - **Pilot scale testing**
  - **Commercialization**
- **Intellectual property/patent rights being pursued by GE**
- **Inventors**
  - **John Ackerman, GE and adjunct UW professor**
  - **Dave Bell, Brian Towler, and Morris Argyle of UW**

## Instead of IGCC, synthesis gas (syngas) from coal gasification can be used to produce liquid hydrocarbon products

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- **Fischer-Tropsch synthesis**
- **$n\text{CO} + 2n\text{H}_2 \rightleftharpoons (\text{CH}_2)_n + n\text{H}_2\text{O}$** 
  - Produces good diesel fuel blend stock with high cetane number and low sulfur
  - But, the product hydrocarbon is waxy and requires further processing for direct fuel use or for lubricants
  - Generally requires 2:1 hydrogen:carbon dioxide
- **High pressure catalytic process**
  - Exploring collaboration with Idaho National Laboratory and Brigham Young University to develop improved catalysts

# Fischer-Tropsch Synthesis and Product Refining Model

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- **Professor David Bell and graduate student Sara Costopolous are collaborating with INL to model Fischer-Tropsch processes**
  - **Computer model of liquid fuels and lubricant production from coal synthesis gas**
  - **Initial model development at INL**
- **Economic feasibility of the process will be compared to IGCC**
  - **In collaboration with the UW Agricultural and Applied Economics Department (Roger Coupal, David Taylor, and Tom Foulke)**
- **Funded by INL and UW School of Energy Resources**

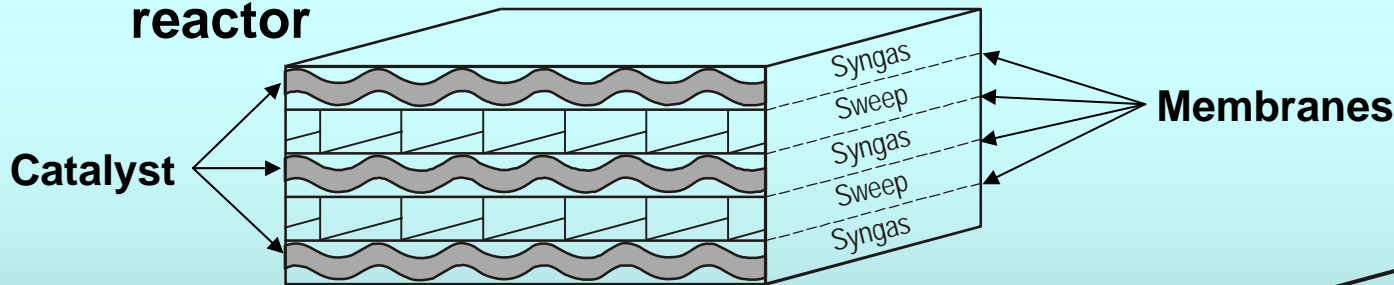
# Synthesis gas can be used to produce hydrogen (H<sub>2</sub>)

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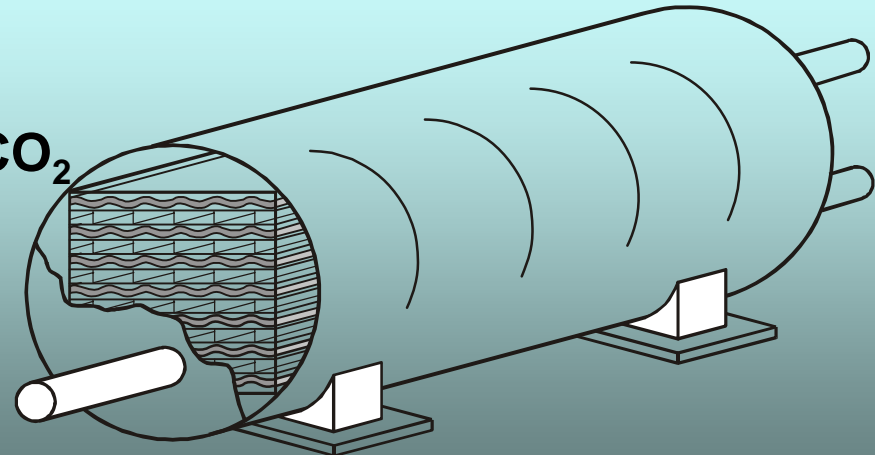
- **Water Gas Shift (WGS) Reaction**
  - $\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2$
  - Requires a catalyst for efficient H<sub>2</sub> production
- **“Hydrogen economy”**
  - Fuel cells
- **Significant industrial demands for H<sub>2</sub>**
  - Ammonia production
  - Petroleum refining
- **Additional hydrogen required for Fischer-Tropsch synthesis or direct liquefaction**

# UW and the Western Research Institute (WRI) are collaborating to produce hydrogen (H<sub>2</sub>) from coal synthesis gas

- Catalyst is being developed by UW
- Catalyst integrated with a metallic membrane to separate H<sub>2</sub> produced by reaction
- WRI developing brazing techniques to seal membrane and reactor



- Potential to produce pure H<sub>2</sub> and CO<sub>2</sub>
  - H<sub>2</sub> for fuel or chemical use
  - CO<sub>2</sub> for sequestration or enhanced oil recovery



- Funded by the Department of Energy National Energy Technology Laboratory



# WRI's Coal Gasifier



**Testing of combined catalyst/membranes on coal syngas in upcoming weeks**

# Catalytic Gasification

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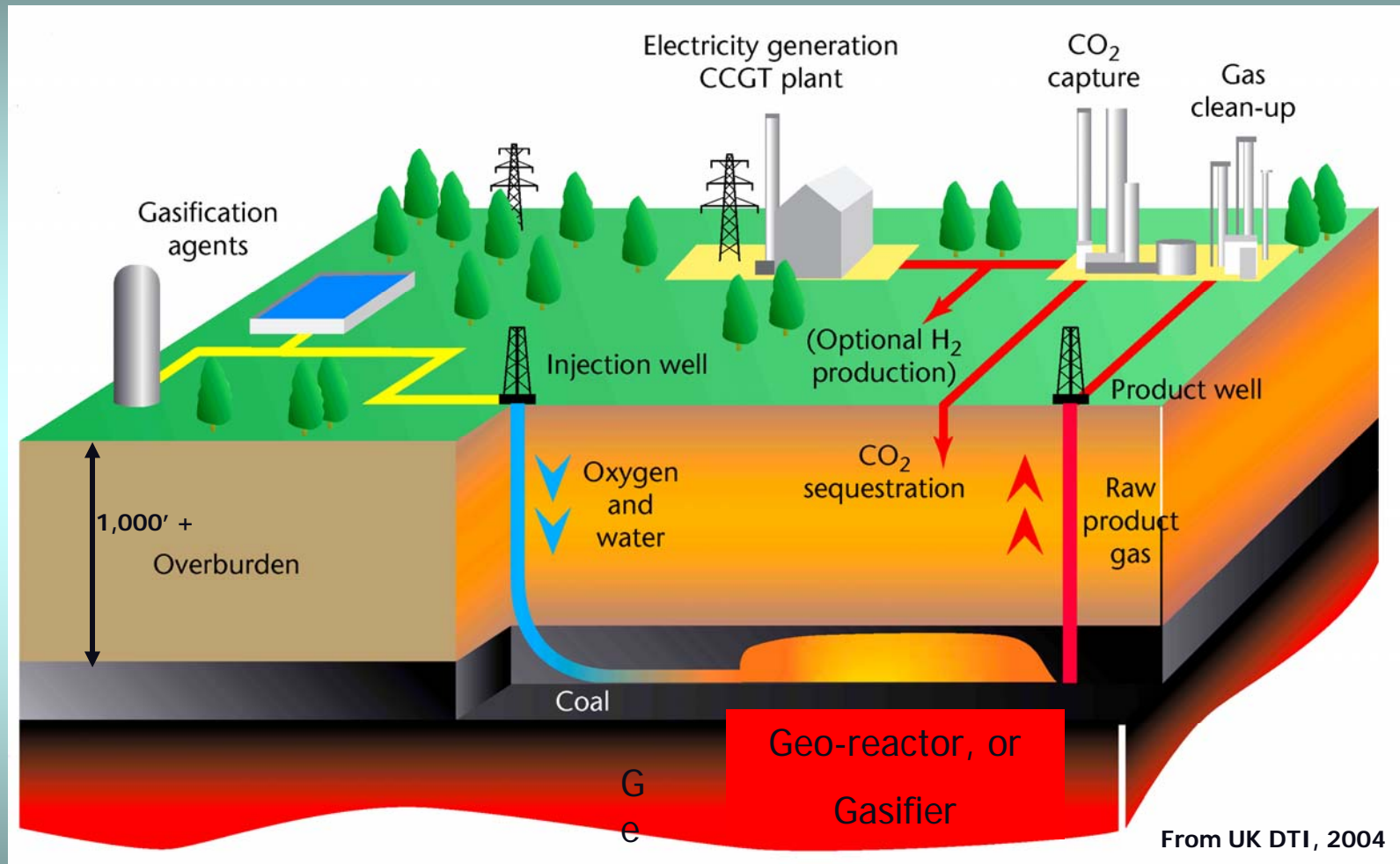
- **Some components of coal ash appear to catalyze (speed up) gasification reactions**
  - Calcium, for example, is effective, but at lower concentrations than are present in most coal ash
- **By analogy with petroleum coke, other metals may also be effective**
  - Nickel, present in crude oil, appears to promote gasification reactions
  - Potential to add catalyst to gasification process
- **Research is proposed to develop cost-effective catalysts**

## Other UW Research Initiatives

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- **Tax policies to encourage IGCC plant construction in Wyoming (Dave Bell and the Departments of Agricultural and Applied Economics and Economics and Finance)**
- **The Chemical and Petroleum Engineering Department is searching for a senior professor specializing in coal conversion (one of 12 distinguished SER chairs)**
- **Carbon dioxide (CO<sub>2</sub>) separation membranes (Maciej Radosz and Youqing Shen with the Enhance Oil Recovery Institute) and sequestration (Ruckleshaus Institute and Haub School of Environment and Natural Resources)**
- **Direct coal liquefaction (Morris Argyle)**
  - Building on work of emeritus professor Henry Haynes
  - Clever reactor design built by Ron Borgialli
  - Alternate technology to coal gasification for liquid hydrocarbon production

# Underground Coal Gasification Schematic



95% of world's coals too deep for conventional mining

Source: GasTech Inc., Casper, WY; Dr. Steve Morzenti, President



# Acknowledgments



*Above the clouds, but down to earth.*

**University of Wyoming  
School of Energy Resources**

**Western Research Institute**

**Idaho National Laboratory**

**U.S. Department of Energy**





