

# **Coal-to-Liquids**

## **Addressing National Demand for Liquid Fuels**

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# What is Coal-to-Liquids (CTL)?

- ▶ Catalytic-based chemical process to turn coal into synthetic gas (syngas) and then into liquid diesel, other hydrocarbons and/or hydrogen
  - Process developed in Germany in early 20<sup>th</sup> century by Franz Fischer and Hans Tropsch.
  - The Fischer-Tropsch (FT\*) process is the key to turning CTL.
  - Part of a parallel development of coal hydrogenation to make aviation fuel and motor gasoline.
  - Nine CTL plants were constructed in Germany prior to 1945.
  - Today—oldest and largest CTL plant using the FT process is in South Africa.
    - 45 million tons coal/year producing 150,000 bpd liquids or ~28% of diesel fuel needs.



Franz Fischer

Hans Tropsch

\*FT process can also be used with natural gas feedstock; this is gas-to-liquids (GTL)

# What are the Benefits of CTL Products?

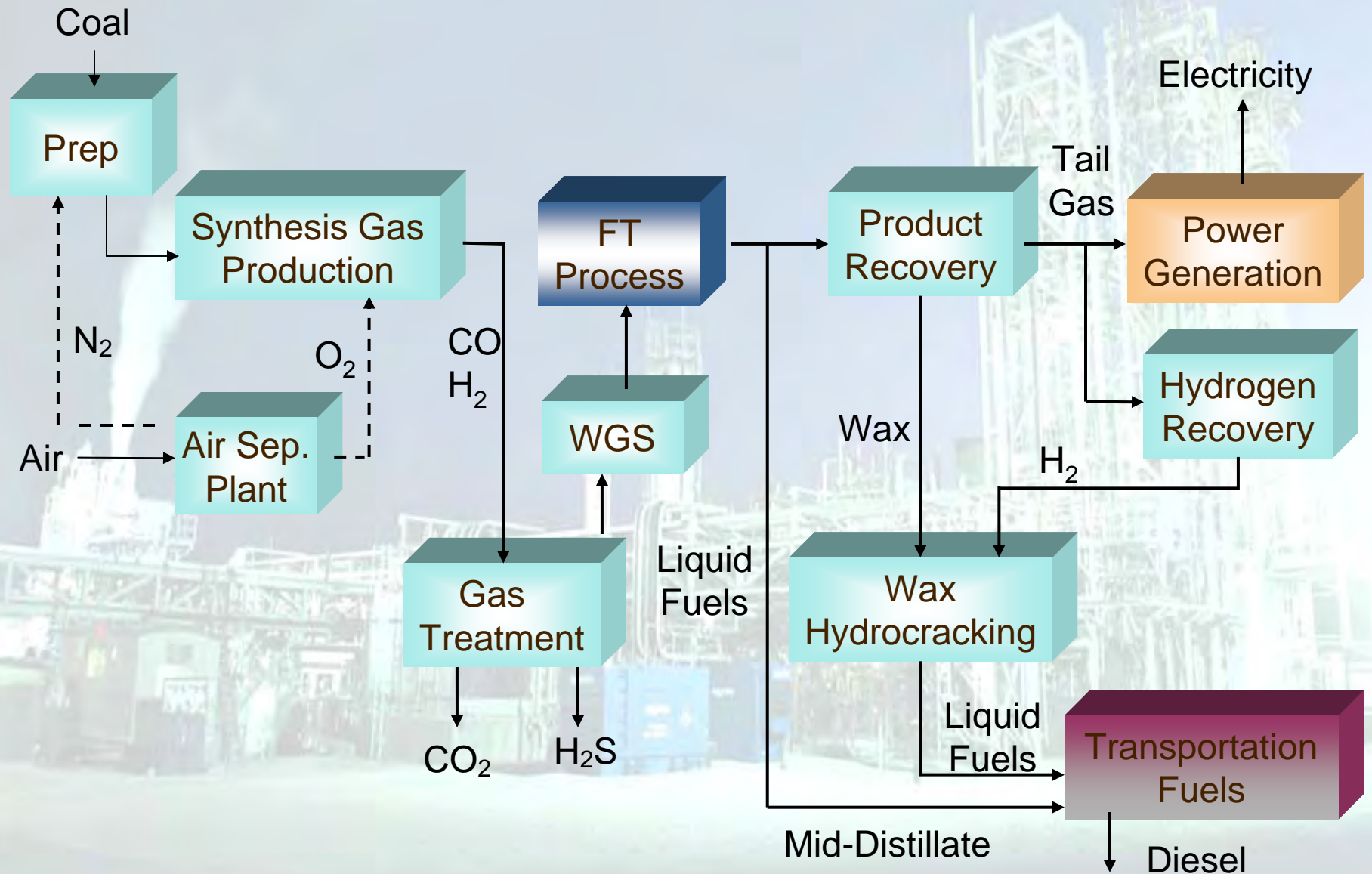
- ▶ Wide range of high-value hydrocarbons + energy
- ▶ Diesel fuel with low sulfur (<5ppm), high cetane index, low aromatics, and less particulates, NO<sub>x</sub> and SO<sub>2</sub> when combusted compared to conventional diesel fuels
  - Can meet any current or near-future diesel specifications
  - Can likely be burned in any diesel engine
  - Can be a 'neat' fuel or blended with petroleum stocks
- ▶ Totally domestic product



FT reactor

Source: University of Michigan

# 'Simplified' CTL/FT Process for Diesel Fuel



# CTL/FT Process Providers

- ▶ There is no large scale one-stop-shops in the U.S. for a CTL plant using the FT process
- ▶ The U.S.-based CTL/FT industry is small, but with growth plans.
- ▶ Commercial worldwide providers of FT processes are:
  - Sasol Ltd, South Africa ([www.sasol.com](http://www.sasol.com))
  - Syntroleum Corporation, Tulsa, OK ([www.syntroleum.com](http://www.syntroleum.com))
  - Rentech, Denver, CO ([www.rentech.com](http://www.rentech.com))
  - Headwaters Technology Innovation Group, Inc., Lawrenceville, NJ ([www.htigrp.com](http://www.htigrp.com))
- ▶ Other providers with FT processes or turnkey consortiums may emerge if the industry becomes viable.



Sasol I

# Why U.S. Interest in Coal-to-Liquids?

- ▶ Steep increases and unpredictable spikes in crude oil and natural gas prices.
- ▶ A decline in domestic oil and natural gas production in those economies with high and increasing energy demands (particularly the U.S., China, India).
- ▶ Limitation in current domestic petroleum refining capacity and ability to site and build new refineries.
- ▶ Unstable political situation in the oil- and gas-rich Middle East.
- ▶ New technology developments in “clean coal” technologies including CTL and coal combustion.

And, most importantly.....



Source: Sasol Ltd.

# We Have a Large Supply of Coal!

- ▶ ~52% of today's electricity is generated by coal.
- ▶ U.S. coal reserves are equivalent to four times the oil of Saudi Arabia, 1.3 times the oil of OPEC and equal to all the world's proved oil reserves.
  - ~500,000 million short tons demonstrated base
  - ~267,000 million short tons recoverable
- ▶ U.S. coal production in 2004 totaled 1,112.1 million short tons and was divided among the regions as follows:
  - Appalachian: 389.9 million short tons
  - Western: 575.2 million short tons
  - Interior: 146.0 million short tons
- ▶ A mature CTL industry (by 2035) producing 2 to 3 million bpd of transportation fuels would require 2.5 to 4 million tons of coal/day or ~8% to 12% increase in production of today's mining in the Powder River Basin.



Photos by Chuck Donaldson

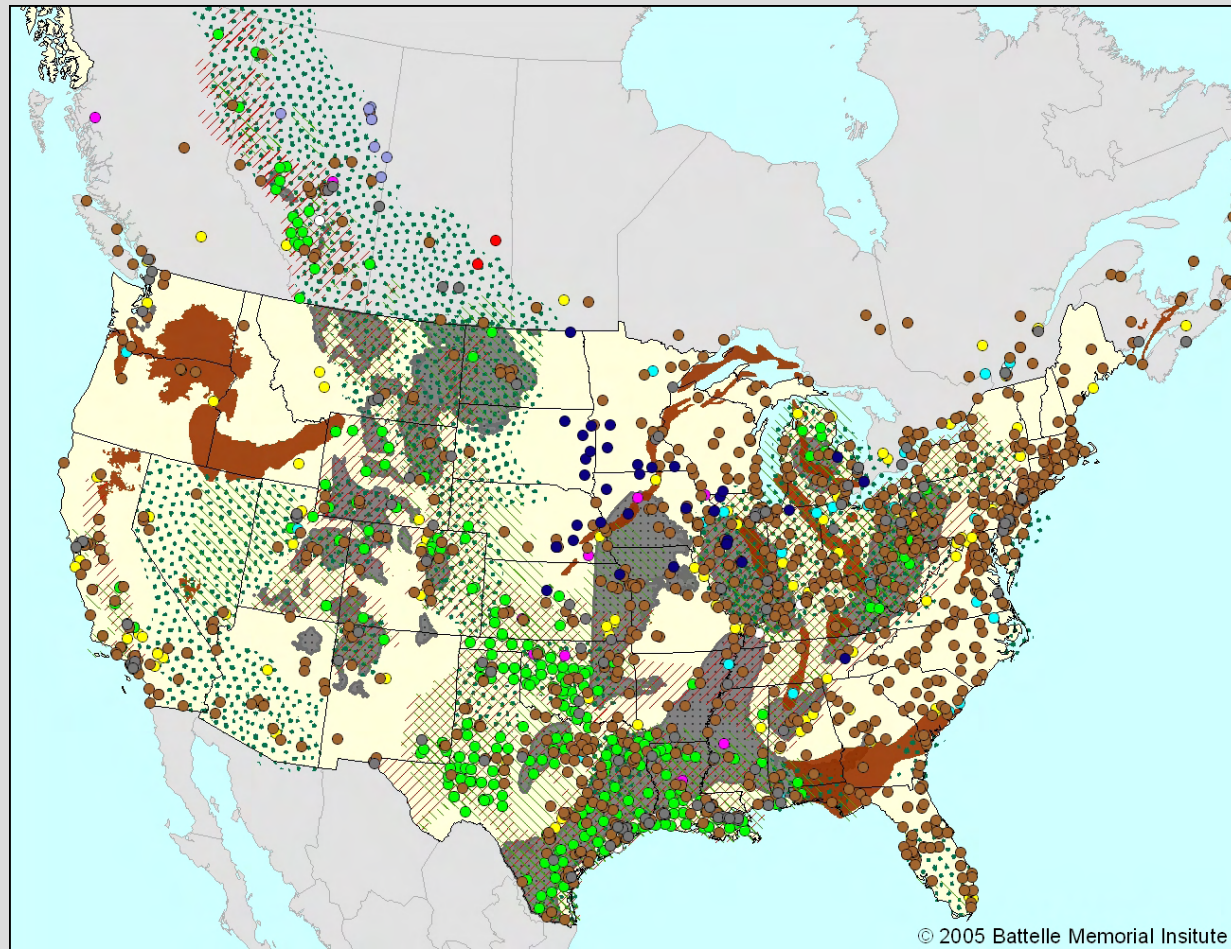
# FT Process Benefits

- ▶ The process yields a wide spectrum of hydrocarbons and oxygenated compounds. These include:
  - Light hydrocarbons (methane/ethane)
  - Liquid propane gas (LPG)
  - Naphtha/gasoline
  - Mid distillates/diesel fuel
  - Waxes
  - Hydrogen
- ▶ Product and distribution is affected by gas composition/temperature and catalyst (iron or cobalt).
- ▶ ‘Polygeneration’ option with production of fuels, fertilizer, hydrogen and electricity.
- ▶ Process lends itself to lower overall emissions and relatively easy capture and treatment of criteria pollutants as well as sequestration-ready CO<sub>2</sub>

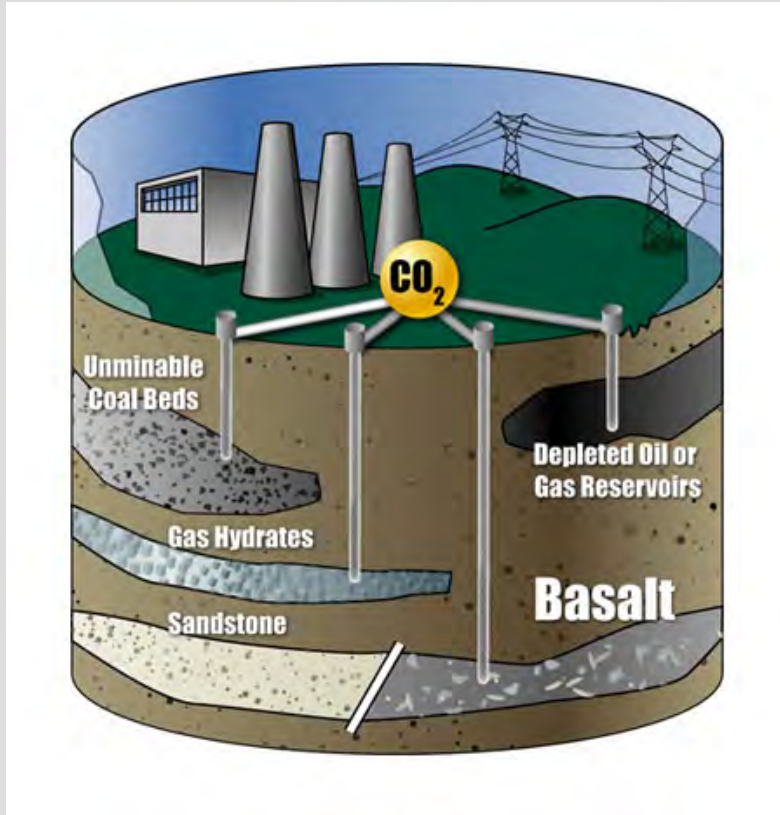
# Environmental Benefits of CTL vs. Coal Combustion

- ▶ Far fewer air emissions, water use/discharge, less solid waste and smaller footprint than conventional refinery or coal combustion power plant.
- ▶ More efficient use of coal; can use over-burden/lower quality coal or other solid fuels (e.g., coke).
- ▶ Ability to produce clean liquid fuels (e.g., 'premium' diesel), hydrogen & other chemicals for multiple uses as well as electricity.
- ▶ Can be air & water 'neutral'. Water issues in the West are of critical concern in power plant siting.
- ▶ Carbon can be more readily captured with modest cost penalty and available for sequestration or other uses.

# GIS Database of CO<sub>2</sub> Sources and Potential Geologic Storage Reservoirs



# CO<sub>2</sub> Sequestration and Use Options



Source: PNNL

## Candidate CO<sub>2</sub> Trapping Mechanisms

- ▶ Physical trapping
- ▶ Hydrodynamic trapping
- ▶ Solubility trapping
- ▶ Mineral trapping

Different geologies have differing primary and secondary trapping mechanisms

## Other Beneficial Uses

- ▶ Enhanced oil recovery
- ▶ Coal-bed methane extraction

# Under What Conditions is CTL Viable?

- ▶ Oil remains at above \$45 to \$50/barrel (\$2005)
- ▶ Coal prices at less than \$20 to \$25/ton
- ▶ Viable processes and solid business case convincing to the investment community
- ▶ Reasonable cost of capital
- ▶ Short/streamlined permitting process
- ▶ High-value products compatible with current fuels
  - Would a premium be paid for premium products?
  - Are domestic-produced fuels worth a premium? If so, what is that premium?

# CTL Proposed or Announced Projects

Source: Sasol Ltd.



Transporting a FT  
Pressure Vessel

- ▶ Rentech partnerships: 57,000 bpd plant in Kentucky, 12,000 bpd in Medicine Bow WY (mine-mouth), 10,000 bpd plant in Mississippi, and a project in Colorado to convert former coal-to-methanol plant into CTL plant.
- ▶ Pennsylvania: consortium formed to purchase fuel and construct 10,000 bpd CTL plant in partnership with Sasol.
- ▶ West Virginia: state announcement in 2005 to build CTL plant.
- ▶ Montana: state announcement in 2005 to build CTL plant near PRB coal fields.
- ▶ Kentucky: Office of Energy Policy/Division of Energy announcement in 2006 to build CTL plant.
- ▶ China: multiple plants in partnership with Sasol and Headwaters. ~17 million bpd by 2020.
- ▶ Indonesia: 80,000 bpd CTL plant by 2008.
- ▶ India/Pakistan/Africa: multiple plants in partnership with Sasol

# Potential Impediments

- ▶ Lack of robust coal transportation infrastructure.
  - Limited and under-maintained rail.
  - Consolidated/limited carriers—particularly in the West.
  - Cost and permitting of new rail (~\$1M/mile over flat land).
- ▶ Lack of replacement tires for surface coal mining equipment (no joke!).
- ▶ Uncertainty of CTL process viability/business case by financial community.
- ▶ Premium cost of FT diesel; lack of out-take contract.
- ▶ Acceptance of FT diesel by engine manufacturers and potential need to blend with other fuels.

# CTL Will be a Key Element of the Nation's Liquid Fuels Portfolio

- ▶ Byrd Amendment to the 2006 DoD Authorization Bill calls for a national coal-to-liquid fuels production plan “.. to cut America's ties to foreign oil.”
  - Directs DoD to prepare a report to Congress on potential use of alternative fuels by DoD
- ▶ EPA Act 2005 sets out incentives for development of clean coal technologies including CTL
- ▶ 2006 State of the Union address announces the *Advanced Energy Initiative*
  - New fuel-production technologies “..to replace more than 75% of our oil imports from the Middle East by 2025.”