Factors That Affect the Design of Clean Coal Technologies – Phase II: Final Report

Synfuel Park Location Study

by
Paul V. Preckel, Principal Investigator and
Zuwei Yu, Co-PI & Senior Analyst
State Utility Forecasting Group (SUFG)
September 6, 2007
Phase 2 Project Team

PURDUE:

• Paul V. Preckel, PI (formerly Ron Rardin)
• Zuwei Yu, Co-PI
• Jesse Oberbeck, GRA
• Akiner Tuzuner, GRA
• Sisi Guo, GRA
• Sika Dofonsu, GRA
Phase 2 Project Team (cont’d.)

INDIANA UNIVERSITY

• John A. Rupp
• Fritz H. Hieb
• Denver Harper
• Agnieszka Drobnia

• Plus numerous others providing advice and information in support of the project including:
STATE UTILITY FORECASTING GROUP

- Mr. Rich Cooper, Director, Port of Indiana
- Mr. Kent Curry, Director of Regulatory Affair, AEP
- Mr. Daren Eliason, Dakota Gasification Company
- Mr. Kent Holcomb, the Francisco Mine, Indiana
- Mr. Renus Kelfkens, Sasol North America
- Dr. Thomas Lynch, Chief Engineer, Wabash IGCC Plant
- Mr. Mark Newlin, General Manager of Regulatory Affair, Duke Energy Indiana
- Mr. Mike Rampley, Sr. Vice President, Hoosier Energy
- Dr. Mike Reed, System Analyst, NETL/DOE
- Mr. Mark Sabree, Business Manager, the Black Beauty Mine, Peabody, Indiana
- Mr. Phil Wilzbacher, Director, Port of Indiana Mount Vernon
- and many others too numerous to list.
Phase II Vision

• Investigate the feasibility of one or more Synfuel Parks in the state using gasified Indiana coal to produce
  – Any or all of Fischer-Tropsch (FT) Diesel, Jet Fuel, Electricity, Synthetic Natural Gas, and related chemicals
• Having conforming air & water emissions and expectation of sequestering CO$_2$
Concepts & Options

Indiana Mines → Coal → Gasifier & Purification

CO₂ → Syngas

Coal → Gasifier & Purification

Gasifier & Purification → CO₂ → Syngas

Syngas → Meth → SNG

Syngas → Oth → Chem

Syngas → CCG

Electricity

FT Synth. → Liquids

FT Synth. → FT Diesel

FT Synth. → Naphtha

FT Synth. → Kerosene (Jet Fuel)

En Oil Recov

Aquifer Sequ

Cl Bed Meth

En Sh Gas
Site Selection Criteria

- Coal access
- Sequestration access
- Land availability
- Transportation (rail, highway, water way)
- Transmission lines
- Gas pipelines
- Water availability
- Waste disposal, environment
- Labor force
- Economic development
Specific Sites Evaluated

- Breed/Fairbanks
- Crane – Glendora (near Sullivan)
- Crane (Main)
- Merom
- Minnehaha
- Francisco
- Mt. Vernon (CountryMark and Port of IN)
Site Locations

States and Provinces
- In Service
- Proposed

Electric Substations
- Electric Transmission Lines
  - Voltage Class kV
  - Under 100
  - 100-161
  - 230-287
  - 345
  - 500
  - 735 and Above
  - DC Line

Natural Gas Pipelines
- In Service
- Proposed

Rivers By Type
- Rivers
- Streams/Tributaries
Coal Availability

- Original resources: 59.5 Billion Tons
- Remaining resources: 56.7 Billion Tons
- Restricted resources: 39.2 Billion Tons

Coal Availability:
- Coal available for surface mining (2.1)
- Coal available for underground mining (16.8)
- Coal restricted by technological factors
- Coal restricted by land-use
- Coal mined out and lost in mining (2.8)

Source: Mestaier, IGS, 2007

* Some resources are available for both surface & underground mining.

Indiana's 20 Coal Mining Counties:
- Benton
- Carroll
- Cass
- Clay
- Clinton
- Decatur
- Dubois
- Elliott
- Floyd
- Fountain
- Gibson
- Harrison
- Henderson
- Jasper
- Jefferson
- Knox
- Lake
- Lee
- Madison
- Monroe
- Montgomery
- Parke
- Perry
- Martin
- Marshall
- Monroe
- Morgan
- Owen
- Parke
- Putnam
- Sullivan
- Vanderburgh
- Vermilion
- Warrick
- Warren
- Washington
- Wayne
- White
- Williams
- Wabash
Potential Sequestration Access

• Generally good opportunities in southwest Indiana
  – Saline aquifers
  – Enhanced coal bed methane (ECBM)
  – Enhanced oil recovery (EOR)
  – Enhanced shale gas (ESG)

• Details vary by site

• Centralized sequestration for multiple sites may be desirable
Land Availability

• Land required for a 10,000 b/d plant
  – About 120 acres for the plant, including water cooling and treatment
  – About 20 acres for coal handling
  – About 500-1,000 acres for slag/ash disposal
  – Total: 640-1,140 acres for 10,000 bbl/d

• There may be some economies of scale in land requirements, especially for large ops.
Supporting Infrastructure

- Transportation (rail, highway, waterway)
  - Construction phase (transport of large equipment)
  - Operation phase (coal in/products out)
- Transmission lines (in for construction/out for power export)
- Gas pipelines (in for construction/out for SNG)
Supporting Infrastructure
Water Needs

• Water requirements can be substantial
  – Roughly 15 bbl water/bbl FT liquids
  – 10,000 bbl/d = 150,000 bbl/d

• Use of air cooling or hybrid systems can substantially reduce these requirements

• There are economies of scale in water use
Waste Disposal/Environment

- Synfuel plants with CO$_2$ sequestration relatively benign environmentally
  - Waste water can be treated to remove pollutants
  - Air emissions (based on IGCC experience) superior to pulverized coal power plants
  - Solid wastes (slag and ash) inert and may be useful as construction materials
Labor Force

• NETL estimates 144 direct operations people for 50,000 bbl/d

• Administrative and support personnel likely add another 40-50 percent

• Scaling is probably not linear – smaller scale operations require more labor per bbl
Labor Force (cont’d.)

• Training will be an issue, but resources are available (Purdue, IU, Vincennes, Ivy Tech, ISU)

• Wabash Valley Power Association IGCC
Economic Development

• NETL estimates indicate gross revenues (including exported power) of about $80 per barrel of FT liquids – $750,000 per day even for a small plant (90% capacity factor)

• Indirect impact much larger through multiplier effect
Economic Development (cont’d.)

• Counties surrounding the sites
  – Have higher unemployment than the State average (except Daviess and Dubois)
  – Have lower per capita income than the State average (except Dubois, Posey, Vanderburg and Warrick)

• Need for economic development is substantial – potential contribution is large
Breed/Fairbanks

- Coal available nearby – 10-15 miles
- CO$_2$ sequestration potential substantial (SA, ESG, ECBM, EOR)
- Land available excellent – brown field site (9,000 acres)
- Infrastructure good – rail&highway access, electricity transmission lines available onsite, oil and gas pipelines close by
Breed/Fairbanks (cont’d.)

• Water resources available from Wabash – a 50,000 bbl/d plant = ~1% of stream flow

• Labor availability – close to Sullivan and Terre Haute

• Potential capacity – 50,000 bbl/d; 300 MW export; SNG possible
Crane – Glendora

- Coal available nearby – 3-10 miles
- CO$_2$ sequestration potential good (SA, ESG, ECBM, EOR)
- Land available – 750 acres on site (sufficient for FT plant, may not be enough for slag/ash – mined out strip mines nearby)
- Infrastructure is good with nearby access to transmission line, gas and oil pipelines, rail
Crane – Glendora

- Water may be a limiting factor – two lakes available: Glendora and Sullivan
- Labor available – close to Sullivan and Terre Haute
- Potential capacity – 20,000 bbl/d; 100 MW export; SNG not recommended
Crane – Main

• Coal available within 10-30 miles
• CO$_2$ sequestration potential good (SA, ESG, ECBM, EOR)
• Land available – 63,000 acres on site
• Infrastructure is good with onsite access to transmission line, gas pipeline and rail onsite; nearby access to oil pipeline and road
Crane – Main (cont’d.)

• Water available from East and West Forks of the White River (East Fork is 2 mi from Crane) with adequate stream flow

• Labor available from Crane and communities in surrounding counties

• Potential capacity – 20-30,000 bbl/d; 150 MW export; SNG needs further evaluation
Merom

- Coal available within 10-15 miles
- CO$_2$ sequestration potential substantial (SA, ESG, ECBM, EOR)
- Land would need to be purchased
- Infrastructure is good with electricity transmission lines and rail onsite; oil and gas pipelines, and roads nearby
Merom (cont’d.)

• Water availability is excellent as this site is located on the Wabash (even a 50,000 bbl/d plant would only take ~1% of stream flow)
• Labor availability is good with Sullivan, Terre Haute and Vincennes nearby
• Potential capacity – 50,000 bbl/d; 300 MW export; SNG possible
Minnehaha

- Coal availability ideal (mine mouth site)
- CO$_2$ sequestration potential substantial (SA, ESG, ECBM, EOR)
- Land availability – strip mines in the area could be reclaimed
- Infrastructure is good with electricity transmission lines, rail, oil and gas pipelines, and roads nearby
Minnehaha (cont’d.)

- Water availability is limited – Lake Sullivan and Lake Glendora are reasonably close, or water could be piped from the Wabash (11 mi)
- Labor availability is good with proximity to Sullivan, Terre Haute and Vincennes
- Potential capacity – 10-20,000 bbl/d; 50-100 MW export; SNG not recommended
Francisco

- Coal availability ideal (mine mouth site)
- CO$_2$ sequestration potential excellent (ESG, SA, ECBM, EOR)
- Land availability is excellent: abandoned strip mines and agricultural land nearby
- Infrastructure is good with onsite rail access and electricity transmission lines, oil and gas pipelines, and roads nearby
Francisco (cont’d.)

- Water availability is limited – Patoka River might support 10,000-20,000 bbl/d
- Labor availability is good with proximity to Evansville
- Potential capacity – 20,000 bbl/d; 100 MW export; SNG not recommended
Mt. Vernon (SMC and CM)

- Coal availability is good – 30 miles to mines
- CO₂ sequestration potential excellent (ESG, SA, ECBM, EOR)
- Land availability is good with 150 acres at SMC and farm land available nearby
- Infrastructure is good with onsite access to rail, oil and gas pipelines, and limited electricity transmission capacity, and roads are available nearby
Mt. Vernon (cont’d.)

• Water availability – SMC on Ohio River; CM 1-2 miles from Ohio River
• Labor availability is good with a potential workforce from Mt. Vernon and surrounding communities
• Potential capacity
  – SMC 50-100,000 bbl/d; 3-600 MW export; SNG possible
  – CM 20-30,000 bbl/d; 100-150 MW export; SNG possible
Conclusions for CCT in IN

• There are many reasons to consider siting synfuel parks in Indiana
  – Coal resources available
  – Economic development needed in coal producing areas
  – Contributes to the energy security of the state and nation
Conclusions for CCT in IN (cont’d.)

• Several sites were evaluated and found to be feasible
• No site dominates all others, and not all relevant criteria were evaluated (e.g., ecosystem impacts)
• There will be challenges for every site, and each site has its own advantages
Next Steps for CCT in IN

- Location of plants using Clean Coal Technology for CTL has been the primary focus so far.
- Work to date has revealed that Fischer-Tropsch reaction creates challenges.
- Future work could consider the full spectrum of uses for gasified coal: CTL, SNG, Methanol, fertilizers, other chemicals, electricity.
Next Steps for CCT in IN (cont’d.)

• Need to prioritize development efforts
  – Estimate benefits and costs for alternative types of plants
  – Evaluate alternative sites relative to alternative primary products
Next Steps for CCT in IN (cont’d.)

- Electric power generation is an important part of the equation
  - More capacity needed
  - If re-power/expand based on SNG from CTG, where first?
- Understanding transmission and distribution network expansion needs critical (MISO)
Next Steps for CCT in IN (cont’d.)

- CO$_2$ will also play a critical role siting
  - Impending site selection for FutureGen
  - Potential for CO$_2$ legislation