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A Feasibility Study for the Construction of a Fischer-Tropsch Liquid Fuels Production Plant with Power Co-Production at NSA Crane (Naval Support Activity Crane)

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This feasibility assessment, coordinated through the Center for Coal Technology Research (CCTR, Energy Center at Discovery Park, Purdue University) has been a joint project including experts from the State Utility Forecasting Group (SUFG, Energy Center at Discovery Park, Purdue University), and the Indiana Geological Survey (IGS, Indiana University). The complete list of team members is shown on the cover page. This short six-week feasibility study, forms part of a larger Clean Coal Technology (CCT) project supported by the CCTR, started April 12, 2007. Mr. George Mankowski, Sr. GIS Analyst of LJT & Associates, Inc., Mr. Brent Storey, NSA Crane's Energy Director, and Ms. Christine Freeman, from NSA Crane's Environmental Management team, have actively provided essential data related to NSA Crane. Their assistance has facilitated this research substantially. Funding to produce this feasibility study was provided by Crane Technology Inc. (CTI, Crane) through a grant from the U.S. Department of Labor, and the Indiana Office of Energy and Defense Development (OEDD, Indianapolis). Purdue's Energy Center at Discovery Park and the Center for Coal Technology Research (CCTR) value this constructive, collaborative partnership with CTI and OEDD.

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Executive Summary

This preliminary feasibility assessment focuses on ten criteria specified by Crane Technology Incorporated (CTI) to determine whether to proceed with a more in-depth study of the construction of a Fischer-Tropsch (FT) transportation fuel production facility with an approximate capacity of 10,000 barrels of FT liquids per day. Our goal was to identify any clear indications that such a plant could *not* be sited at Naval Support Activity Crane (NSA Crane).

This study indicates there are generally good technical grounds to consider construction of a FT facility at Crane and that an in-depth technical and financial evaluation is not contra-indicated by any insurmountable problems.

Reasons for this conclusion are as follows.

- Proven reserves of coal are within easy transportation range of the Crane site. Natural gas, once plentiful in the state of Indiana, is now supplied primarily from the Gulf region. Pipelines supplying Indiana homes and business are all within easy access to the Crane site.
- CO_2 sequestration potential remains a large issue for all fossil fuel development. CO_2 needs to be viewed as a potential energy development resource rather than as an environmental hazard. CO_2 could be used to produce additional energy via advanced coal bed methane or oil shale methane production.
- Land/real estate requirements are estimated to be approximately 120 acres of land with no more than 75 acres needed at any one site for fuel production and materials handling. Crane has more than adequate land for these facilities and has adequate topography for the estimated less than 1,000 acres that will be needed for waste landfill.
- Transportation infrastructure appears to be sufficient to meet the needs of a FT plant of the proposed size. Rail lines are adequate for import of coal and export of final products. Crane is served by class 1 rail lines and has within its borders excellent rail mobility. The rail system allows for movements of raw materials into the facility and the movement of product out.
- Transmission lines and power availability appear to be adequate since the site is connected to the grid through 2 substations: one owned by Duke Energy/Indiana the other by Hoosier Energy System. Crane also has access to a 345kv line that passes through the site. Crane is also close to Duke Energy's proposed 625MW IGCC plant at Edwardsport
- Gas pipelines transverse or are within relatively close proximity of the Crane facility. Oil pipelines are not in close proximity, but they are not an essential resource. In the future, it may prove advantageous to build a pipeline for exporting the final product, but for the proposed scale of operations, it is not necessary.
- Water requirements and resources are a major concern for the development of coal derived (as well as biomass-based) synthetic fuels. The coal to liquid process

requires approximately 15 barrels of water per barrel of final product. The volume is large but does not pose an insurmountable problem. On-site sources are likely not sufficient to sustain the plant, but adequate resources are available from the East Fork of the White River only 2 miles to the south of Crane.

- Waste disposal and environmental issues are a direct reflection of the technology chosen for the process. In general, the waste stream will consist of sour water from the treatment plant. Crane already has a history of environmental compliance and the ability to work with the State of Indiana to develop the needed procedures.
- Labor force requirements for the production of the fuel once the plant is built will be relatively small, less than 150 people. The range of labor needs is well within those already on site at Crane. However, training programs will be a key to the success of the operation. Education and training will be addressed by Purdue University, surrounding institutes of higher education and Ivy Tech State College. There will be a need for more coal miners than there will be for CTL workers. There will be a need for 160 coal miners if the entire capacity of the facility is to be met with coal from Indiana mines.
- Economic impact of this plant comes in the form of the value of the coal produced and the value added via the products produced. The value of the coal produced (2 million tons per year) and the ancillary jobs created would be about $120 million annually. The transportation fuel and the naphtha, plus elemental sulfur and electricity come to about $80 per barrel of product, or $266 million per year, for a value added amount of $146 million per year.

No significant problem area was identified that would make further pursuit of this project unjustified. There are challenges but no insurmountable problems.

I. Introduction

The Center for Coal Technology Research (CCTR) and the State Utility Forecasting Group (SUFG) at Purdue University, together with the Indiana Geology Survey (IGS) at Indiana University, have contracted with Crane Technology Inc. (CTI) to conduct a preliminary feasibility study to determine whether it would be possible to build a Fischer-Tropsch (FT) plant for producing synthetic fuels at the Naval Support Activity Crane (NSA Crane or simply Crane). Crane is located in Martin County, in southwestern Indiana, as indicated in Figure I.1. (An additional site was identified in Sullivan County at a late stage of development of this report. The advantages and drawbacks of that site are addressed in section XII). The plant will co-produce diesel, jet fuel and naphtha, as well as electrical power, and use coal as its primary feedstock.

The FT process (Fischer-Tropsch process) was developed by the two German scientists Franz Fischer and Hans Tropsch in 1923. The process is an indirect coal liquefaction (ICL) process. ICL, including the FT process, is a mature technology. In the past, commercialization of the ICL technology was not widespread, for the simple reason that oil prices did not remain high enough for long periods of time. However, due to the high crude oil prices of the past few years and concerns about energy security, many countries have been considering the development of ICL plants for producing synthetic fuels. The current leader in plant construction and development is China, with a few large commercial projects under development, and many more at the planning stage.

ICL and the FT process have been developed and used successfully for some time. At the end of World War II Germany was operating nine indirect and 18 direct coal liquefaction plants. Direct coal liquefaction, or DCL, plants involve a somewhat different technology from ICL, but have the same ultimate goal to create liquid fuels from coal. These plants supplied Germany with almost four million tons of fuel per year (both diesel and gasoline) [1].

Since the early 1950s, South Africa has been the world leader in production of ICL liquids, with three large commercial plants. The Sasol Company is the major force in ICL research, development, and operation. They have achieved substantial improvements over the original FT synthesis process, including the use of iron-based catalysts, the high temperature FT (HTFT) fluidized circulating bed technology, and the Sasol Advanced Synthol (SAS) technology. The fuels, which have been the primary products, meet up to 60% of South Africa's oil demand. The plants also yield a substantial amount of various chemical feedstocks (see [1] and Figure I.2).

The U.S. has conducted significant research in the ICL area with sponsorship from both industry and government. ExxonMobil, Rentech and Syntroleum have independently developed ICL processes. One commercial plant using ICL technology, the Eastman Kingsport methanol plant, has been operating successfully for the past 10 years, with co-sponsorship from the U.S. Department of Energy (DOE).

Figure I.1. NSA Crane and Its Surrounding Area within a 25 Mile Radius

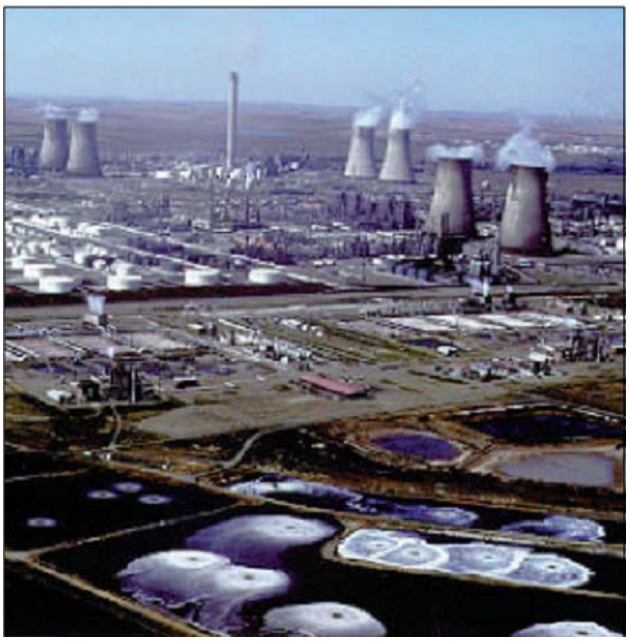

Figure I.2. The Sasol Secunda Synfuel Plant, South Africa [1]

This report makes an initial assessment of the feasibility of locating a FT plant at Crane, specifically addressing the following criteria agreed upon with CTI personnel (see Appendix I):

- Coal availability
- CO_2 sequestration potential
- Land/real estate requirements
- Transportation infrastructure
- Transmission lines and power availability
- Gas and oil pipelines
- Water requirements and resources
- Waste disposal and environmental issues
- Labor force/availability
- Economic impact

Our major conclusions are as follows:

(1) coal, natural gas, water, and geological sequestration resources are available at Crane to operate a FT plant with co-production of power;

(2) power and gas transmission lines are available and should be able to handle the added load required during construction;

(3) there are challenges associated with transportation of the large mechanical components needed for the construction of the facility and with disposal of water. However, it should be possible to overcome these challenges through careful selection of technologies and design choices; and

(4) a facility located at Crane will enable Indiana to be a major component to the training and education of future advanced energy personnel.

Thus, our primary conclusion is that adequate natural and human resources are located at or near Crane to build a FT plant generating a modest net amount of electrical power.

II. Coal Availability

Recent IGS assessments of Indiana's coal resources indicate that the state has over 17.6 billion tons of coal available for recovery by both surface and underground mining (Table II.1). These coal resources are located in the southwestern part of the state, as indicated in Figure II.1. Mineable blocks of varying thicknesses and qualities are located at a variety of locations within twenty-five miles of Crane. While estimates vary, a 10,000 barrel per day FT plant with modest power co-production should use about 42 million tons of coal over its 20 year expected life.

County	Mining Type	DANVILLE Coal Bed	SPRINGFIELD Coal Bed	D + S
Daviess	Surface	0.00	16.59	16.59
	Underground	-	0.00	0.00
Gibson	Surface	43.91	95.53	139.44
	Underground	36.35	**1,930.91**	**1,967.26**
Greene	Surface	0.69	70.17	70.86
	Underground	-	5.68	5.68
Knox	Surface	51.63	55.49	107.12
	Underground	228.35	**1,072.42**	**1,300.77**
Pike	Surface	9.75	160.68	170.43
	Underground	0.00	175.11	175.11
Posey	Surface	0.00	-	0.00
	Underground	0.00	**1,527.61**	**1,527.61**
Sullivan	Surface	78.95	72.64	151.59
	Underground	108.11	741.72	849.83
Vanderburgh	Surface	0.07	0.00	0.07
	Underground	0.00	516.07	516.07
Vermillion	Surface	12.03	5.23	17.26
	Underground	11.70	21.12	32.82
Vigo	Surface	98.75	48.30	147.05
	Underground	137.82	335.26	473.08
Warwick	Surface	53.97	295.48	349.45
	Underground	0.00	608.78	608.78
TOTAL	**Surface**	**349.75**	**820.11**	**1,169.86**
	Underground	**522.32**	**6,934.68**	**7,457.00**

Table II.1. Coal Resources (in million tons) Available from the Two Major Coal Seams (Springfield and Danville) in Indiana by County (Mastalerz, et al., 2004)

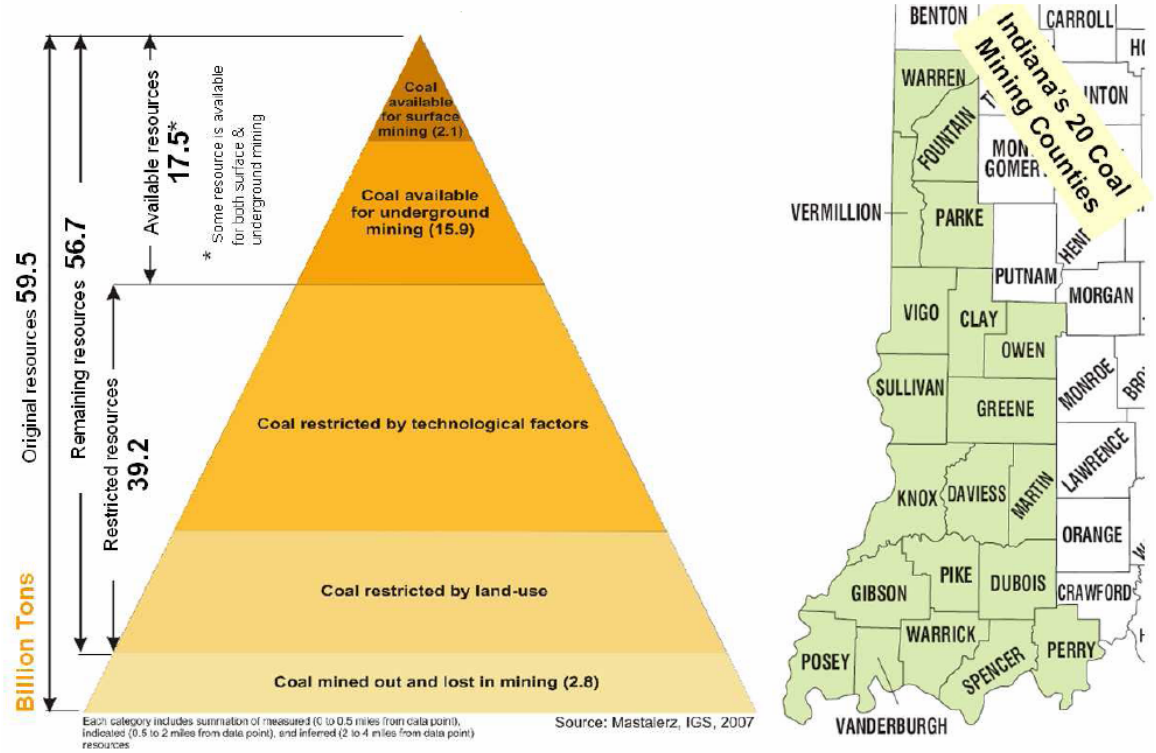

Figure II.1. Coal Reserves in Indiana (Source: IGS 2007)

Indiana's coal supply is therefore sufficient to supply a FT plant at Crane as long as the FT capacity is not too large and the power co-production capacity is limited. The specific qualities and characteristics of the state's coals will need to be assessed in more detail relative to the specific needs of the project. Some coals have more advantageous properties for reaction in a gasification system than others; therefore, additional work must be completed to optimize the choice of specific coals [2A].

III. Carbon Dioxide Sequestration

Coal produces a large amount of CO_2 when it is converted to heat energy, and a FT plant of the type proposed for Crane uses a great deal of coal. One potential way to mitigate the problem of CO_2 emission is to capture and store (sequester) the CO_2 in geological formations including saline reservoirs, unmineable coal beds (enhanced coal bed methane), and underground oil and gas reservoirs (enhanced oil recovery and enhanced shale gas production). Southwestern Indiana, much of Illinois, and Western Kentucky all have geological features that indicate potential for CO_2 sequestration.

As part of the results of the Phase I investigation of the DOE-funded Midwestern Geological Sequestration Consortium, the potential of geological strata located in the deep subsurface of southwestern Indiana for use in CO_2 sequestration has recently been evaluated by the IGS (Finley and others, 2006). Additionally, the possibility of using injected CO_2 to assist in the recovery of petroleum using enhanced oil recovery (EOR), enhanced coal bed methane (ECBM), and enhanced shale gas production (ESGP) techniques has been evaluated. Table III.1 shows estimates of CO_2 sequestration potential and the potential for the value-added production of oil and gas using ECBM and EOR technologies.

Given the substantial coal resources available and growing experience with coal gasification, other power plants may also be located in the region in the future. Possibly, these plants could also be designed to capture CO_2 for sequestration and could share with a FT plant at Crane the same network of pipelines gathering CO_2. Thus, one might see a coordinated effort for sequestering the captured CO_2.

For this feasibility study, we evaluated a buffer area with a 25 mile radius centered on Crane for sequestration, enhanced petroleum recovery and shale, and coal bed methane production potential. Within this area, two deep saline aquifers, a set of mature oil fields, and a shale gas field were assessed for their ability to sequester the CO_2 produced by the proposed FT facility. These reservoirs or “sinks” were then quantitatively analyzed to produce a set of maps and tables that display their potential.

The deep saline aquifers have the greatest potential storage within the 25 mile area surrounding Crane. However, by expanding the potential area of interest, perhaps through the combining of this project with other power plant projects involving capture and sequestration of CO_2, other potential storage options could exist.

Reservoirs	CO2 Storage	Methane Recovery	Enhanced Oil/Gas Recovery

Saline Reservoirs	CO2 Storage Capacity (MMt)
Mt. Simon Sandstone	15,355
St. Peter Sandstone	210
Total	15,565

Oil & Gas	CO2 Storage Capacity (MMt)	EOR (standard barrels)
Petroleum Fields	0.67	3,828,039

Coal Seams	CBM (MMscf)
Hymera	4.2
Seelyville	0.4
Springfield	0.9
Survant	0.5
Colchester	2.9
Danville	1.9
Herrin	3.8
Total	14.6

Shale	CO2 Storage Capacity (MMt)	Shale Gas (MMscf)	Enhanced Shale Gas (MMscf)
New Albany Shale	572	10,004	1,500

Table III.1. Summary of CO_2 Sequestration Potential within a 25 Mile Radius of Crane

Table III.1 summarizes the potential capacities of these various types of reservoirs as well as the volumes of oil and gas that could be produced as the result of injection of CO_2. Figure III.1 maps illustrate the potential capacities of the Mount Simon and St. Peter sandstones associated with the deep saline aquifers surrounding Crane. Details of the distribution of the oil fields located to the west and north of Crane, their sequestration and EOR capabilities, and the potential of the New Albany Shale (an organic-rich gas shale), to sequester CO_2 and produce gas as a result of CO_2 injection are available from IGS studies. Further study of the data for these options can be made if considered viable considering the much greater aquifer potential. The coal seams in the buffer area are too

shallow for sequestration. The amount of coal-bed methane that could be potentially recovered is included in the calculations. However, this amount is small and the coal seams only reach the western fringes of the buffer area around Crane.

A comparison of the three sequestration options (saline aquifers, gas shale and mature oil fields) shows that there are significant volumes of pore space that are conceptually available for use to sequester carbon dioxide. The deep saline aquifers have the greatest potential storage within the 25 mile area surrounding Crane, followed by the New Albany Shale, and lastly nearby oil fields. These capacities are calculated to be 15.5 billion tonnes, 0.572 billion tonnes, and 0.67 million tonnes for each of these types of reservoirs, respectively. However, by expanding the potential area of interest, perhaps through the combining of this project with other power plant projects involving capture and sequestration of CO_2, other potential storage options could exist that could possibly expand this overall capacity. For the purposes of this initial feasibility assessment, the conclusion is that there is significant geological storage capacity for injected carbon dioxide under Crane and in the surrounding area.

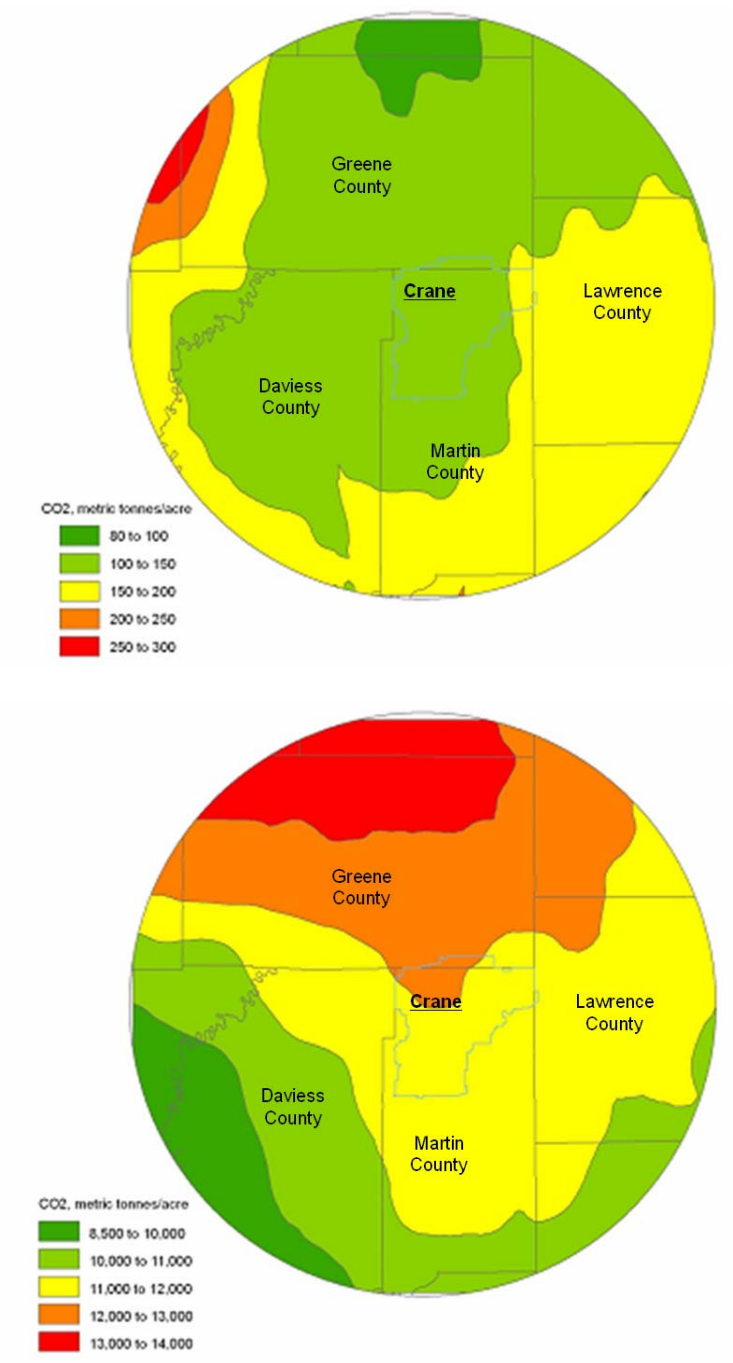

Figure III.1. Potential Saline Aquifer Sequestration within a 25 Mile Radius of NSA Crane (Top: St. Peter sandstone; Bottom: Mt. Simon sandstone)

IV. Land/Real Estate Requirements

An FT plant with power co-production is a large facility requiring substantial land, not only for the various components of the plant, but also for coal storage and handling, for water cooling and treatment, and for disposal of solid wastes (mostly slag and ash). Precise land requirements depend on the details of the plant design, such as the facilities chosen, the product mix, including the amount of power co-production, the cooling system, etc. In general, the land requirements also depend on the capacity of the plant. These requirements can be placed into four categories: (a) the main FT plant, (b) coal storage, (c) slag/ash disposal and perhaps (d) a cooling pond.

IV.1 Main plant

The layout for the planned Gilberton, Pennsylvania, FT plant is a helpful template for estimating the Crane land requirements. The layout was developed by a consortium called WMPI, with financial backing and management support from DOE. Coal culm (low energy waste coal that nationally has about 60% of the Btu content of normal levels) is to be used as their feedstock, and the product mix is about 3,700 barrels per day (B/D) of FT diesel, 1,300 B/D of naphtha, and co-produced power with a net export capacity of 41 MW [2]. The plant's gross power capacity will be greater than 100 MW. The FT plant will be near a strip mine and an old power plant, as indicated in Figure IV.1. The FT and co-production power will be located in the main plant, with a detailed footprint shown in Figure IV.2. The main plant will use Shell gasifiers, two Sasol slurry FT reactors, the Chevron iso-hydrocracking technology, a gas turbine generator and a steam power generator, plus other supporting facilities. All in all, the main plant will occupy about 75 acres of land [2B].

Note that the Gilberton FT plant will use coal culm as the primary feedstock and this will need to be washed and treated prior to gasification, which may require more land than when regular bituminous coal is used as feedstock. We estimate that if a FT plant is constructed at Crane using bituminous coal as feedstock, and with a capacity of 10,000 B/D of FT fuels plus a small net power export of about 50 MW, the main plant will occupy 120-130 acres depending upon whether CO_2 capture is required or not. (We focus on a plant with a relatively small power export capacity due to the limited water availability at Crane (see section VIII on water availability.) This number is calculated by assuming that the area for coal culm wash and treatment is not needed at Crane, and that space for temporary facilities during construction should not be considered part of the long-term land requirement. After one deducts these two parcels of land, the remaining land for the main plant is no more than 60 acres. Assuming that the main part of a 10,000 B/D FT plant requires twice the area of a 5,000 B/D plant, we conclude that about 120 acres of land are required.

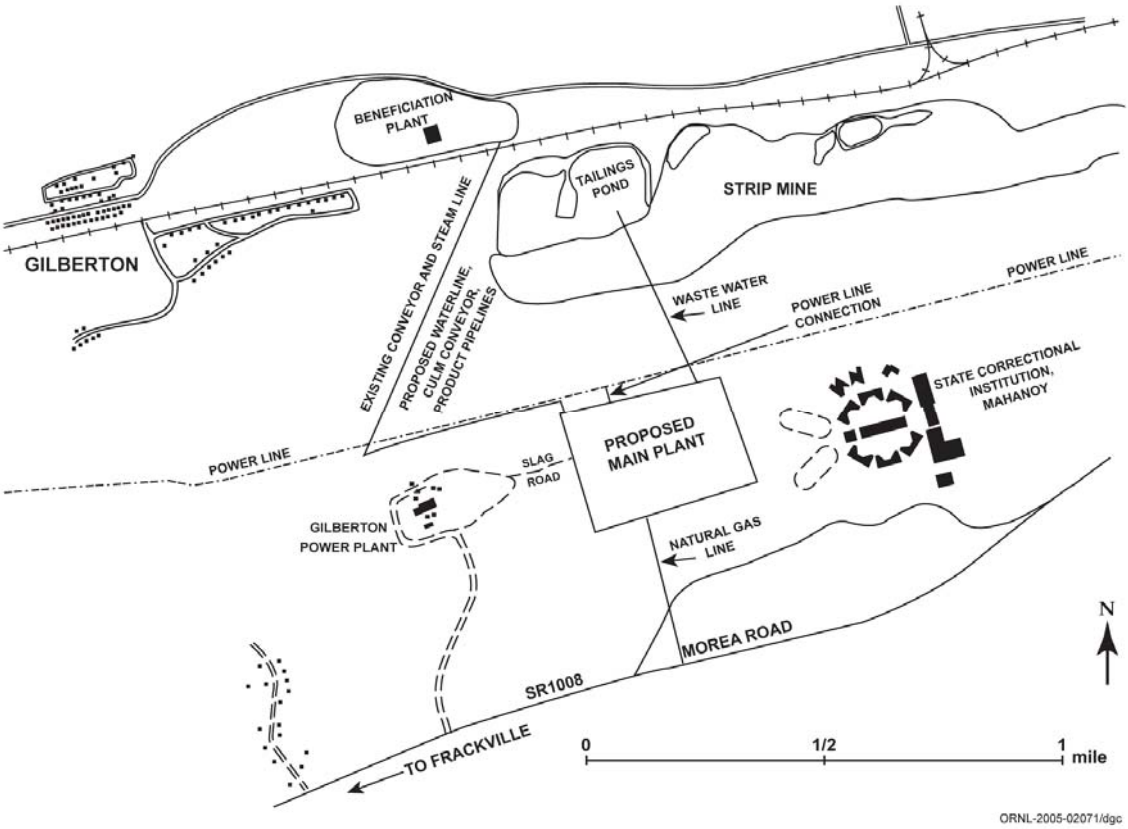

Figure IV.1. Site Layout of the Gilberton FT Plant [2]

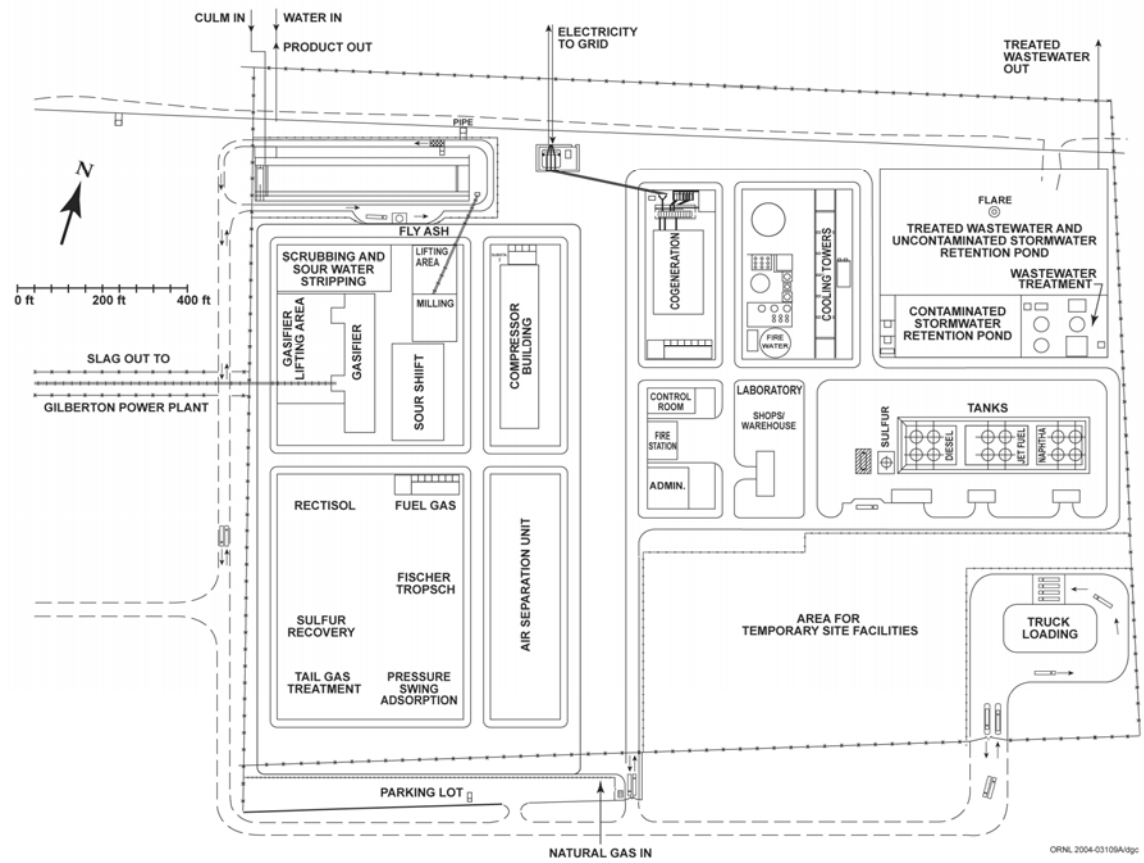

Figure IV.2. Footprint of the Gilberton FT Main Plant

Crane has approximately 63,000 acres of land. Even though the land is generally hilly, it does have some flat areas. One such area is the old ammunition production plant, which is about 100 acres, with relatively flat surrounding areas. With some land preparation and leveling, other flat areas inside Crane could also be considered for constructing the FT plant.

IV.2 Coal storage and handling

Coal storage and handling may require another 20 acres or so, depending on the target coal reserve for the plant.

IV.3 Landfill

Slag/ash disposal will require additional land. However, waste disposal does not require flat land. In fact, valleys may be better sites for slag/ash disposal since they can enclose

more than flat land. An FT plant of about 10,000 B/D plus about 50 MW of net power export would use about 6,000 tons per day of bituminous coal with an ash content of about 13-15%. This means that daily production of slag/ash would be no more than 1,200 tons, assuming about 3% of the carbon in the coal ends up in the slag. If the plant's life is 25 years and the availability of the plant is assumed to be 90%, the total slag/ash generated will be around 10 million tons. Assuming that one acre of flat land can hold about 10 thousand tons of slag/ash (about two tons per square yard), the FT plant will require no more than 1,000 acres for landfill, assuming the slag is not sold or given away. Landfill area will be significantly less than 1,000 acres if valleys are used. These estimates are preliminary since the actual geographical form of the land will make a large difference in its holding capacity for the slag/ash. No matter how much land is required, however, it can ultimately be restored and used for other purposes because the slag/ash underneath is inert. The landfill area required could be approximately 1% of the total Crane area.

IV.4 Cooling pond

The combined FT and power plant may need a tailing pond to further cool water blowdown, especially if some hot water blowdown cannot be fed into one of the cooling towers. The cooling pond issue will be discussed further in the section on waste disposal and environmental issues (see section IX.1).

V. Transportation Infrastructure (Rail, Roads, and Waterways)

Three processes require use of the transportation infrastructure: (1) shipment of large components of the FT plant (mainly the gasifier(s) and FT reactors) during construction, (2) the transportation of coal to Crane, and (3) the distribution of finished products. These issues are discussed separately below.

V.1 Shipment of large pieces of equipment to Crane

Gasifiers and especially FT reactors are quite heavy and large. A gasifier may weigh 200 to 300 tons. A Sasol FT synthesis reactor with a capacity of 20,000 B/D can weigh over 2,000 tons and have a diameter of about 33 feet and a height of over 180 feet [3] (see Figure V.1). Fortunately, gasifiers and FT reactors can be manufactured in various sizes according to customers' requirements. According to Sasol [4], a Sasol low temperature FT reactor with a capacity of 17,000 B/D weighs approximately 2,200 tons, and for shipping purposes, its diameter is 10 meters with a length of 60 meters. Therefore, a FT reactor with a capacity of about 2,500 B/D could weigh less than 500 tons (2,200/6 = 367 tons), and its diameter could be less than 5 meters and its height less than 20 meters (1 meter = 3.28 feet).

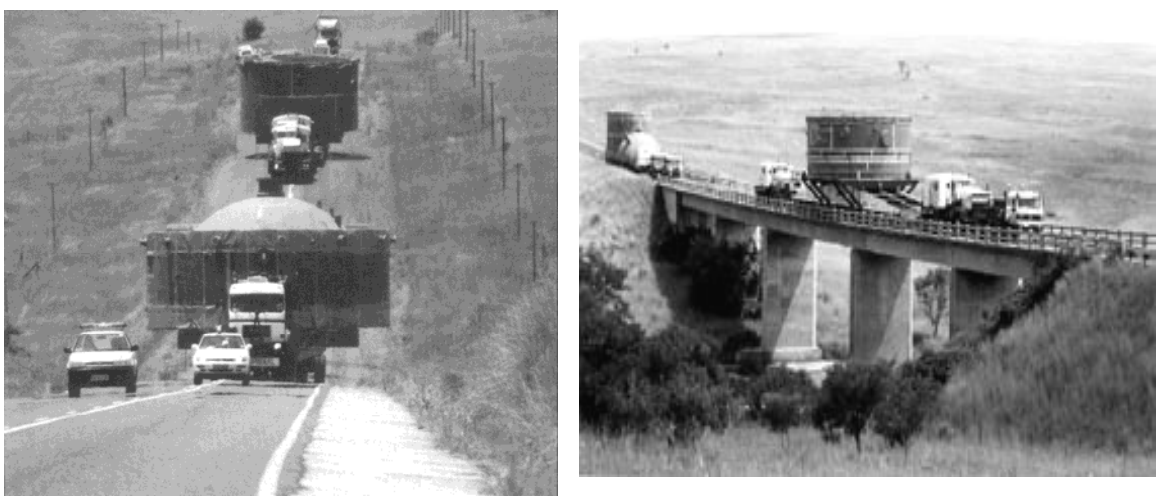

Figure V.1. Transportation of Very Large Size FT Reactors (Source: Sasol)

Crane has experience of moving large equipment. A very large reactor vessel from the Tennessee Valley Authority Yellow Creek Power Plant was transported to Crane in 1989. The load weighed around 500 tons, with an outside diameter of just over 19 feet and an overall length of just under 40 feet. It was first transported via barge to Jeffersonville, Indiana, then via train, and finally on a specially constructed short-haul road via a 48-wheeler flatbed truck. Jeffboat, L.L.C. handled the unloading of the equipment. Jeffboat,

which is located in Jeffersonville, Indiana (on the Ohio River), is the largest single-site inland shipbuilding and repair facility in the U.S. In addition to building tanker and hopper barges, Jeffboat also operates a loading dock in the Jeffersonville/New Albany area. A number of overpasses have been built over the rail line from Jeffersonville to Bedford and Crane since 1989, and the costs and benefits of different sized reactors and arrangements for shipment need to be assessed to determine the best strategy for shipping future components to Crane. The relevant sections of rail track appear to be owned by the Indiana Railroad but a definitive opinion regarding feasibility of shipping a FT reactor would depend upon the precise specification of the dimensions and weight of the reactor.

Sasol, which has also contracted with Korean and Japanese firms, is one of the few manufacturers of FT reactors in operation. If Sasol FT reactors are chosen, they could be barged up the Mississippi and Ohio Rivers to Jeffboat. If U.S. technology is used for the FT plant, the equipment could possibly be manufactured in the U.S. and transported via the rail system.

Indiana government regulations allow 11.25 tons per axle in highway transportation [5]. The maximum load on a truck is limited to no more than 63.7 tons by the Federal Motor Carrier Safety Administration, which may make highway transportation infeasible. However, railroad tracks connect Crane to Jeffersonville. According to [6], up to 850 tons can be loaded onto a Schnabel car – a specialized type of railroad freight car. Schnabel cars are designed to carry heavy and oversized loads in such a way that the load itself makes up part of the car.

The largest Schnabel car in operation, owned by ABB, carries the road number CEBX 800, and is used in North America. It can carry loads up to 113 ft 4 in (34.5 m) long. For comparison, a conventional boxcar currently operating on North American railroads measures 50 to 89 ft (15.2 to 27.1 m) long and has a capacity of 70 to 105 tons. (Also see Wikipedia and Table V.1.)

Capacity	1,779,260 lbs.
Light Weight	740,890 lbs.
Load Limit	1,779,260 lbs.
Number of axles (33” wheels)	36
Empty Car Length	231’ 8”
Maximum Loaded Length	345’ 0”
Maximum Vertical Load Shifting Ability	44”
Maximum Horizontal Load Shifting Ability (either side of car center line)	40”

Table V.1. Specification of Schnabel Car CEBX 800 (Source: [6])

In short, it appears feasible to transport smaller pieces of equipment to Crane without major enhancements to the transportation system. However, feasibility of rail shipment from Jeffersonville to Crane needs further assessment which will depend upon the precise sizes of the gasifier and FT reactors. One solution is to design these components to be small enough to be shipped via rail. However, because the efficiency of the FT process is scale sensitive, there will be a loss in conversion efficiency and probably higher operating costs.

V.2 Transportation of coal to Crane

The Indiana coal mines are scattered across the southwestern part of the state. Coal from these mines can be transported to Crane via rail, roads, or both. Some mines are only 20-30 miles from Crane, as indicated in Figures V.2 and V.3. Notice that Crane is in Martin County, and some coal mines, like the Cannelburg and Lewis pits in Pike County, are very close to Crane – about 10-20 miles away.

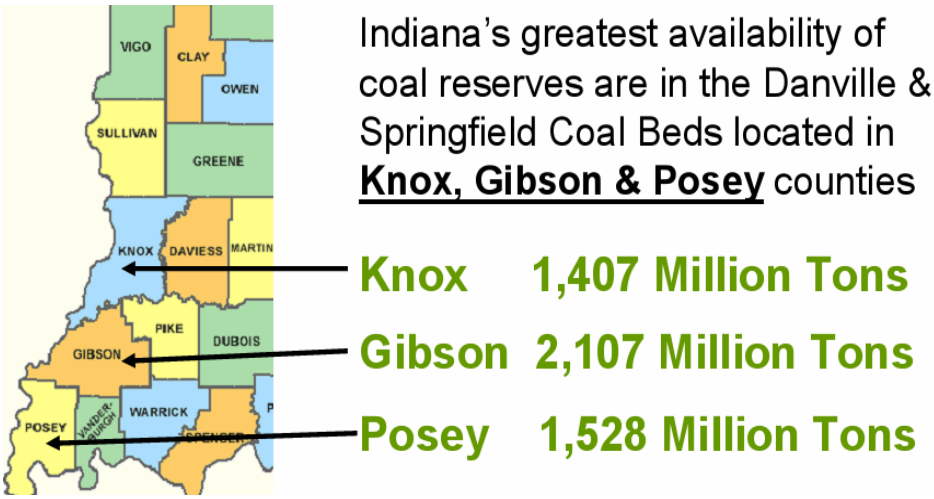

Figure V.2. Coal Sources around Crane (Source: CCTR/IGS)

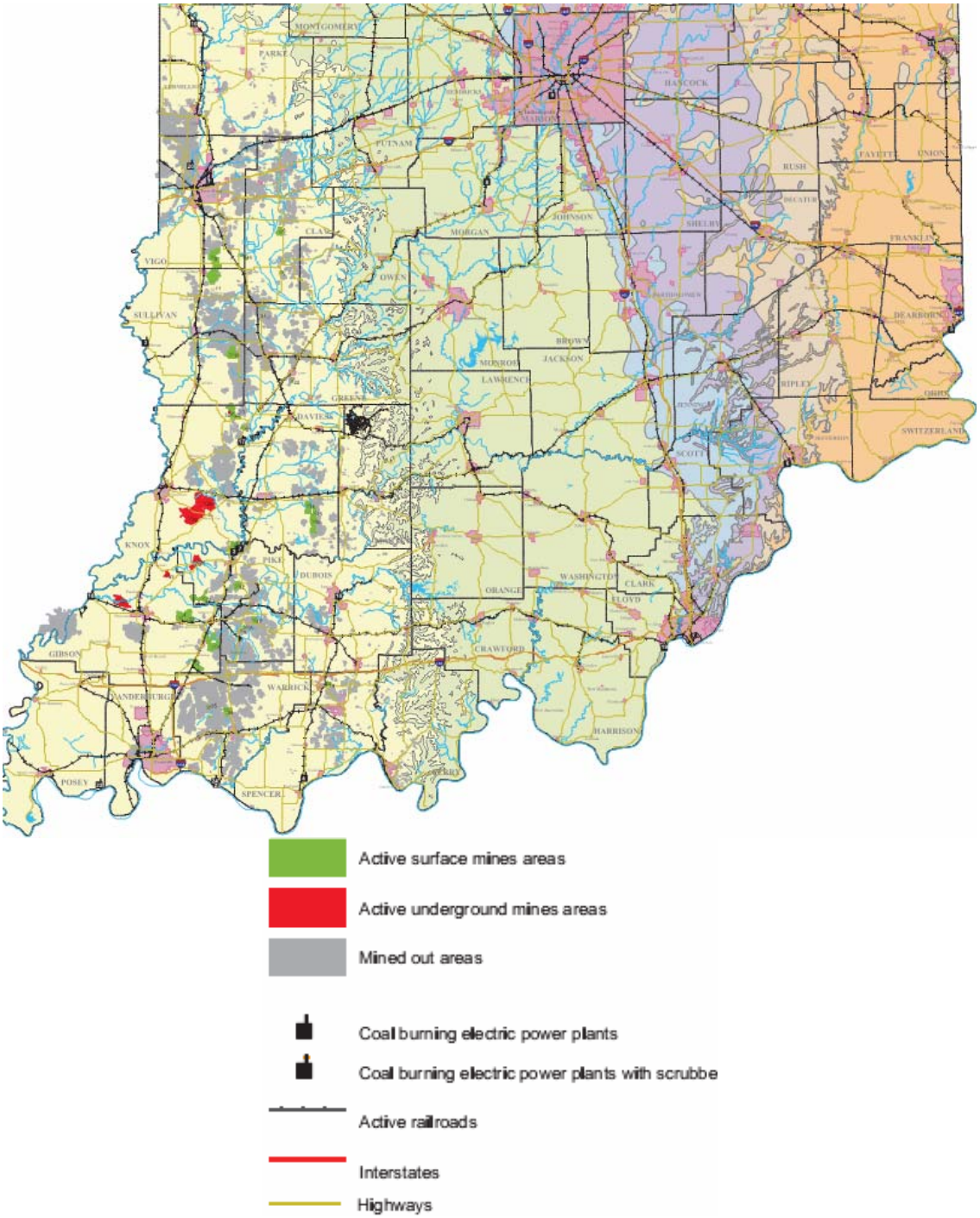

Figure V.3. Crane (Large Black Dot) and Surrounding Coal Mines (Source: IGS)

V.3 Transportation of finished products

Primary finished products are likely to be FT diesel or military jet fuels, plus naphtha. Sulfur is a byproduct that can be sold or given away for use in fertilizer production. These products can be shipped via rail. Crane is connected via the CSX system, and the Crane rail system also has a direct connection to Jeffersonville on the Ohio River, as discussed in section V.1 of this report. State highways can also be used for small quantities of product shipment.

In general, however, waterways are the most cost-effective mode of product shipment. Finished products can also be shipped from a port in Southern Indiana via the Ohio River to waterways in the South, the Midwest and the East, as indicated in Figure V.4.

Figure V.4. The U.S. Inland Waterways (Source: R. Butler, Gulf Intracoastal Canal Association. Available at: http://www.gicaonline.com/media/tools/gica040312.pdf)

VI. Electricity Transmission Lines and Available Power

Crane is connected to the power grid through two substations, one owned by the Hoosier Energy System, the other by the Duke Energy Indiana System (formerly PSI). Currently, Crane is a net power importer with a peak demand around 28 MW. If the FT plant is constructed at Crane, a small increase in power use is expected. However, according to our estimates, the power increase can be handled by the two substations. Transmission capacity is also sufficient for a small increase in power use at Crane. There are three 345kV transmission lines passing over Crane, as indicated in Figure VI.1, as well as three 138kV lines.

If a FT plant is constructed at Crane that exports about 50 MW of net power to the grid, the power flow will remain modest even though its direction will be reversed. The two power substations can handle the power export if the transformers can be adapted to feed the power to the grid. Alternatively, the transformers can be replaced.

A detailed connectivity study should be conducted to determine what network enhancements would be needed and to identify any adverse impacts on the power grid. There are two power plants with a total capacity of 2,107 MW within 25 miles of Crane (IPL's Petersburg 1,873 MW, and Hoosier Energy's Ratts 234 MW). There is also the Duke Energy's proposed IGCC Edwardsport 625 MW which is 22 miles away.

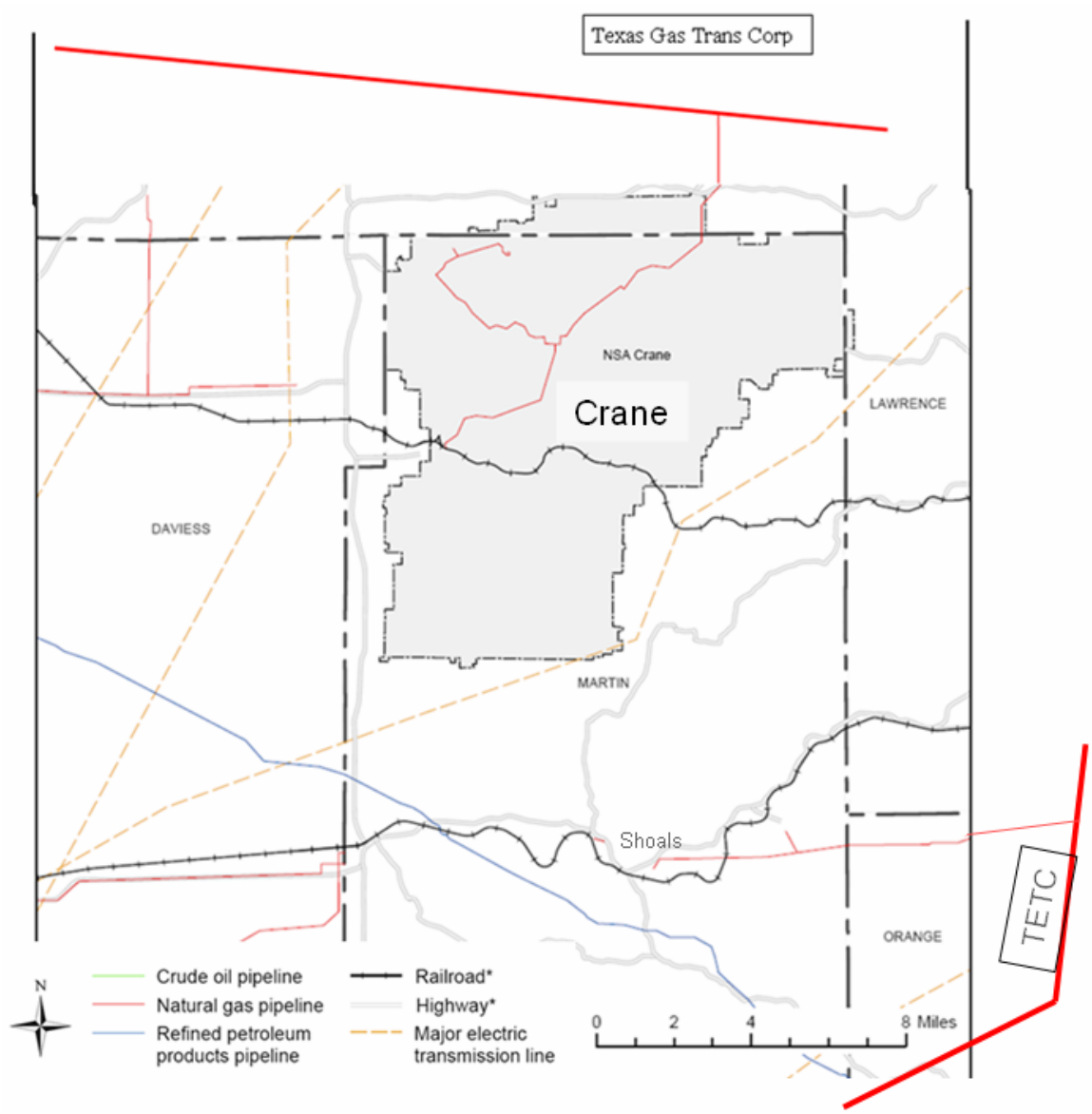

Figure VI.1. Major Transmission and Pipelines around Crane (Source: IGS)

VII. Gas and Oil Pipelines

Crane is connected to the natural gas system through the 16-inch pipeline owned by the Texas Gas Trans Corp., as was shown in Figure VI.1. A natural gas citygate controls gas flow at Crane, with the current loading about 30%. We estimate that the current pipeline connecting to this pipeline will be sufficient for the increased gas demand at Crane due to the construction of the FT plant. There is also the TETC pipeline south of Crane.

As estimated in [2], the Gilberton FT and power plant will need about 17 million Btu per hour of natural gas. Assuming approximately the same level of use at Crane, a 10,000 B/D plant will need around 30 million Btu of natural gas per hour. If the small pipeline connecting the Texas Gas Trans Corp. pipeline is insufficient to handle this extra gas load, it can be expanded to increase the gas flow rate. This expansion should not be a problem since the distance from Crane to the Texas Gas Trans Corp. pipeline is only about 6 miles. This assumes that there will be no gas exports from the Crane FT plant. One of the potential products of this type of plant is substitute natural gas, or SNG, which could be exported to the natural gas system. The configuration examined here does not include export of SNG. If SNG export were to be considered, the natural gas line capacity would need to be re-examined with this in mind.

There is no oil pipeline near Crane, but oil is not required for the FT plant. There are however refined fuels pipelines nearby. The FT diesel and jet fuel can be transported via rail to many parts of the country; so oil pipelines are not required for the potential FT fuel plant at Crane. Pipelines can of course be constructed for the distribution of the FT fuels if this proves to be a more economical way of distribution.

VIII. Water Requirements and Resources

Producing one barrel of FT fuels requires about 15 barrels of raw water if power co-production is included, depending on the design and choice of the facilities and the type of coal. There is insufficient water on the Crane site itself for a large capacity FT plant. However, the East and West Forks of the White River are close by, and both appear to have sufficient water to support the project. Some water could also be drawn from the West Boggs Lake near the southwest corner of Crane.

VIII.1 Water requirements

Water requirements depend on the facilities used and the capacity of the FT and power plants. According to [2], the Gilberton FT and power plant will consume about 28.4 barrels of raw water per barrel of FT liquid fuels (this figure includes the water required to produce the planned 41 MW net power export). While this number is substantially higher than our estimate of 15 barrels per barrel of FT fuels, the Gilberton plant uses coal culm as the feedstock, which requires much more water than regular bituminous coal. Generally, a FT plant with a small power co-production needs about 14.5 barrels of raw water per barrel of FT liquid fuels produced [7]. According to a Rentech study, less water use is possible through water conservation and more efficient design [8]. In fact, dry cooling systems could be used, which would reduce raw water use significantly.

In short, we believe about 15 barrels of raw water per barrel of FT liquids will be sufficient.

VIII.2 Water resources

a) Lake Greenwood

There are several sources of raw water in and around Crane. First of all, some water can be drawn from Lake Greenwood, especially during rainy seasons. The lake has an area of 812 acres, with an average depth of about 15 feet. The total water volume is over 3 billion gallons. However, the lake provides water for various processes at Crane and may not be able to provide all of the water requirements for the large FT plant with co-production of power because the average annual inflow of water is limited.

b) The East Fork of the White River

The East Fork of the White River is about 2 miles southeast of Crane. The monitoring station closest to Crane is near Shoals. The locations of the river and the Shoals monitoring station are shown in Figure VIII.1.

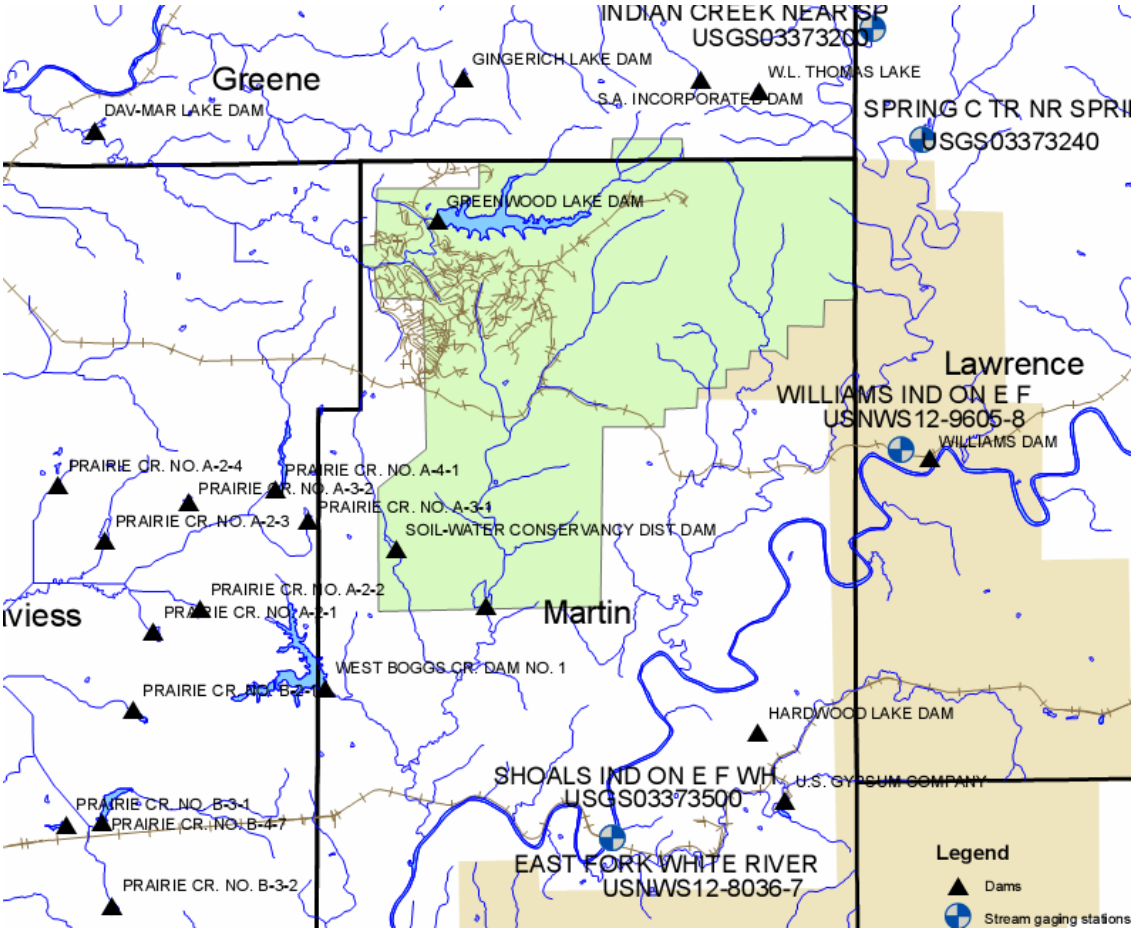

Figure VIII.1. Water Resources around Crane (IGS map)

At Shoals, the mean stream flow rates are greater than 5,000 cfs (cubic feet per second) for about half of the year (indicated in Figure VIII.2). On average, September tends to have the least flow, with a lowest mean daily flow rate of about 1,280 cfs. The daily mean flows of the East Fork at Shoals for the last 40 years (USGS 40 year data from 1966 to 2006) are shown in Figure VIII.3.

The percentage of water withdrawn from the river offers a helpful measure for understanding the water usage of the potential FT plant at Crane. The average stream flow rate of the East Fork at Shoals, 5,000 cfs, equals about 865 barrels per second or about 74,736,000 B/D (865 barrels/sec*3,600 sec/hr*24 hrs/day). Given that one barrel of FT liquid fuels requires about 15 barrels of raw water, the potential percentage of water withdrawal from the river is tabulated in Table VIII.1 as a function of the FT capacity and power. From Table VIII.1, we can see that water withdrawal from the East Fork is very limited, ranging from 0.1 to 0.3%.

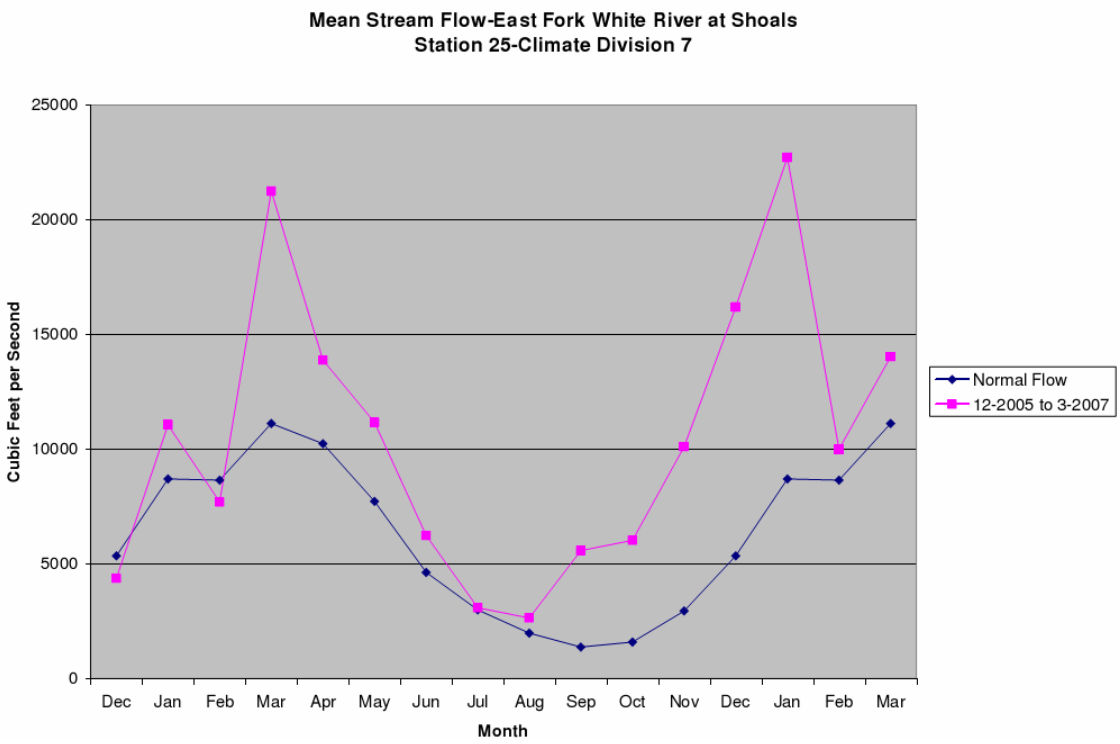

Figure VIII.2. Stream Flow of the East Fork River at Shoals (Source: Division of Water, Department of Natural Resources of Indiana)

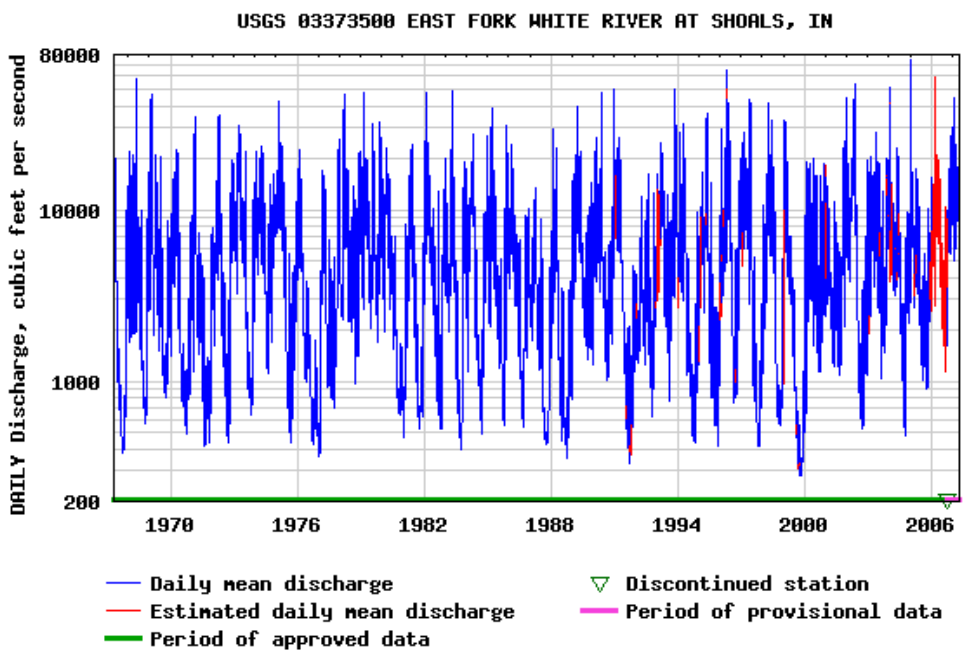

Figure VIII.3. Daily Mean Stream Flow of the East Fork at Shoals from 1967 to 2007 (Source: USGS)

	5,000 B/D FT 41 MW export	10,000 B/D FT 82 MW export	15,000 B/D FT 123 MW export
Average flow 5,000 cfs	0.1%	0.2%	0.3%
Low flow 1,280 cfs	0.39%	0.78%	1.17%

Table VIII.1. Percentage Water Withdrawal from East Fork near Shoals

The West Fork of the White River, a few miles to the northwest of Crane, also has significant amounts of water that could be used if needed (see the discussion in the next section).

c) The West Fork of the White River

The West Fork of the White River is about 6 miles to the northwest of Crane. Flow rates in this fork of the river vary less throughout the year than in the East Fork, especially in the section near Crane. Table VIII.2 shows the mean flow rates at Newberry for a period of 40 years. We can see that even the lowest mean daily flow rate in September is greater than 1,950 cfs, and the higher mean daily flow rates are nearly 10,000 cfs.

If the water from the West Fork were to be used, the percentage of water withdrawn from the river would be less than the percentage withdrawn from the East Fork. This is especially true during the dryer season from September to November.

In short, there are significant water resources near Crane to support a sizable FT plant. No more than 2% of the water would be withdrawn from either the East Fork or the West Fork of the White River even in the low flow season, provided that the FT plant size is no more than 20,000 B/D and the co-produced power is no greater than 120 MW.

00060, Discharge, cubic feet per second,												
Day of month	Mean of daily mean values for each day for 39 - 40 years of record in, cfs (Calculation Period 1966-10-01 -> 2006-09-30) Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8,420	8,660	8,550	9,610	7,790	6,860	3,730	3,560	2,720	2,060	1,620	5,940
2	9,070	9,530	8,060	9,740	8,240	6,520	3,660	3,630	3,110	2,010	1,990	5,730
3	8,870	9,540	7,770	9,720	8,100	6,250	3,650	3,460	3,000	2,160	2,570	5,480
4	8,630	9,060	7,840	9,220	7,620	5,820	3,700	3,160	3,010	2,030	2,720	5,440
5	8,670	8,960	8,410	8,950	7,340	5,470	3,790	2,910	3,140	2,280	2,720	5,290
6	8,820	8,570	8,790	8,740	7,050	5,500	3,680	2,850	3,290	2,500	2,680	5,110
7	8,760	8,060	8,820	8,660	7,310	5,610	3,740	2,870	3,020	2,510	2,490	4,910
8	8,600	7,640	8,860	8,990	7,530	5,640	3,780	2,910	2,620	2,550	2,450	4,800
9	7,950	7,000	8,630	9,310	7,340	5,840	3,700	2,590	2,130	2,380	2,410	4,640
10	7,000	6,630	8,730	9,280	7,170	5,450	3,760	2,440	1,970	2,190	2,420	4,430
11	6,200	6,410	8,650	8,940	7,370	5,020	3,770	2,300	2,070	2,000	2,580	4,320
12	5,670	6,320	8,860	8,740	7,310	4,550	3,730	2,150	2,250	1,940	2,960	4,500
13	5,400	6,120	9,230	8,980	7,630	4,830	4,100	2,180	2,350	2,070	3,120	4,560
14	5,610	5,830	9,660	9,170	8,000	5,190	4,250	2,150	2,180	2,240	3,350	5,230
15	5,790	5,750	9,820	9,160	8,250	5,080	4,420	2,100	2,030	2,300	4,110	5,920
16	5,660	6,020	10,000	9,170	8,800	5,120	4,330	2,060	1,980	2,340	5,090	6,350
17	5,440	6,440	10,000	9,210	8,890	5,250	4,170	2,150	1,960	2,420	6,140	6,570
18	5,830	6,810	9,810	9,050	8,650	5,720	3,900	2,260	2,010	2,370	6,740	6,450
19	6,050	7,170	9,490	8,750	8,310	5,850	3,510	2,350	2,160	2,410	6,250	6,050

http://waterdata.usgs.gov/nwis/dvstat?referred_module=sw&... compression=file&submitted_form=parameter_selection_list (1 of 2)5/2/2007 9:44:10 AM

Table VIII.2. Daily Stream Flow Rates of West Fork at Newberry (Source: USGS).

d) The West Boggs Lake

The West Boggs Lake is about 2 miles southwest of Crane, as indicated in Figure VIII.1. According to [20], the total water volume is over 2.5 billion gallons, which could provide some portion of the water requirements of the FT plant. Wells by this lake and along the East and West Forks of the White River could also be developed to provide additional water for the FT plant.

In the plant design phase, engineers will need to find a low-cost, sustainable means for providing water to the FT plant. This report, however, finds that sufficient water resources appear to be available for the proposed size of FT plant with power co-production at Crane.

VIII.3 Water use regulations

According to the Division of Water of the Indiana Department of Natural Resources (DNR), there are no restrictions on water withdrawal from the East Fork of the White River, except that the withdrawal must be registered with the DNR if it exceeds 100,000 gallons per day [9]. The DNR also requires that it be notified of the amount of water withdrawn per year.

The East and West Forks of the White River may be considered navigable waters, at least for small craft; therefore, permits for water withdrawal may be required if large quantities are involved. Indiana Riparian rights (or water rights) apply to the White River, meaning that landowners downstream can complain about water use upstream (See the following link for more details:
http://www.state.in.us/nrc_dnr/lakemichigan/watquan/watquanb.html.)

IX. Waste Disposal and Environmental Issues

An FT plant produces three categories of waste: (1) waste water, (2) air emissions and (3) solids. Their disposal and the associated environmental issues are discussed separately below. It should be noted that the precise composition of the wastes from a FT plant with power co-production is not known. However, environmental permitting is "fast-tracked" at NSA Crane under the provisions of the Military Base Protection Act (MBPA) passed by the 2005 Indiana General Assembly. The MBPA provides for first priority by the Indiana Department of Environmental Management (IDEM) for any IDEM permitting in support of operations at NSA Crane.

IX.1 Waste water

Waste water could be classified as a plant effluent. Water blowdown from the cooling towers and boilers(s) is relatively clean, and provided that the blowdown temperature meets the standards set by IDEM, it can be released into streams either directly or after minor treatment.

However, sour water from the FT plant will have to be treated in a sour water treatment plant. Sour water may be blown down from the gasification island, the syngas wash/quench, and/or the humidifier before the gas turbine. Sulfur and other pollutants in the waste water can be removed, and the percentage of removal depends on the characteristics of the waste water treatment plant.

According to [2], the Gilberton FT plant will have a total effluent of about 1,867 gallons per minute, about 47% of which are from cooling tower blowdown (see Table IX.1). The same size FT plant at Crane may have a smaller total effluent because there may be no mine pool water treatment purges if regular bituminous coal is used (because there is no need to wash the coal as must be done at the planned Gilberton FT plant).

Plant and processes		Cooling tower		Total rate (gpm)
Source or fate	Rate (gpm)	Source or fate	Rate (gpm)	
Water supplied (from mine pool)				
Pumped for process supply	1,032	Pumped for cooling tower supply	2,744	
Supplied to coal beneficiation plant	386			
Total	1,418		2,744	4,162
Consumption and losses				
Boiler feedwater deaerator vent	1	Evaporation and drift loss	1,757	
Gas turbine steam injection	161			
Net process consumption and losses	372			
Subtotal	534		1,757	2,291
Effluent discharged to tailings pond				
Mine pool water treatment purges	381	Water treatment purge	110	
Demineralizer regeneration wastes	9	**Cooling tower blowdown**	877	
Stripped sour water	28			
F-T wastewater	124			
Rectisol purge water	36			
Gasifier water purge	106			
Polisher regeneration wastewater	6			
Recovery condensate purge	109			
Boiler blowdown	43			
In-plant wash water and floor water	38			
Subtotal	880		987	1,867
Effluent discharged to septic system				
Domestic sewage	4			4
Total consumption, losses, and wastewater	1,418		2,744	4,162

Table IX.1. Water Balance in the Gilberton FT Plant (Source: DOE [2])

A pond or pool may need to be dug for effluent cooling if the combined temperature cannot meet the standards set by IDEM. This pond or pool can also be used for storm drainage.

There is no experience in the U.S. with the quality of waste water from a FT plant. However, in an earlier study [10], we found that waste water from the Wabash IGCC (integrated gasification combined cycle) power plant meets state and federal specifications (see Table IX.2). This indicates that a FT plant at Crane can be designed to meet regulators' standards.

PARAMETER/ CONSTITUENT	UNIT	PERMIT LEVEL MONTHLY AVERAGE	PERMIT LEVEL DAILY MAXIMUM	1997 MONTHLY AVERAGE	1998 MONTHLY AVERAGE	1999 MONTHLY AVERAGE
Ammonia (as Nitrogen)	mg/l	27.14	54.29	3.93	6.56	8.8
Arsenic	mg/l	0.018	0.043	0.0077	0.0199[a]	<0.01
Cadmium	mg/l	0.010	0.025	<0.0038	<0.008	<0.01
Chromium	mg/l	3.47	8.07	<0.006	<0.0108	<0.0167
Hexavalent Chromium	mg/l	0.014	0.032	<0.01	<0.0120	<0.01
Copper	mg/l	0.040	0.093	<0.01	<0.0145	0.0185
Cyanide	mg/l	0.019	0.044	0.107[a]	0.2798[a]	0.1438[a]
Lead	mg/l	0.260	0.606	<0.08	<0.08	<0.08
Mercury	mg/l	0.0005	0.001	<0.005	<0.0005	<0.0006
Nickel	mg/l	2.91	6.78	<0.02	<0.0236	<0.1140
Selenium	mg/l	0.017	0.040	0.0714[a]	0.230[a]	0.1380[a]
Zinc	mg/l	0.241	0.560	0.05	0.0414	0.1363
pH	mg/l	6.0 to 9.0	6.0 to 9.0	7.99	8.4	7.5

[a] Originally out of permit compliance, but later corrected

Table IX.2. Wabash River Process Wastewater Discharge (Source: Rardin, et al. [10]).

IX.2 Air emissions

Currently, there is only one operating CTL-FT plant in the world, the Sasol Secunda Plant in South Africa. The Great Plains Synfuel Plant in North Dakota mainly produces SNG (substitute natural gas), with liquids being produced only as byproducts (Figure IX.1). Since the composition of the emissions from the Secunda Plant have not been made public, the likely air emissions from a U.S. FT plant are not precisely known. However, if the FT plant includes co-production of power with an integrated gas turbine combined cycle generator, air emissions can be estimated based on current IGCC performance, plus some allowance for the FT unit. While the initial assessment reported below does not identify any insurmountable problems in terms of air emissions, careful attention should be paid to this issue in the in-depth technical assessment.

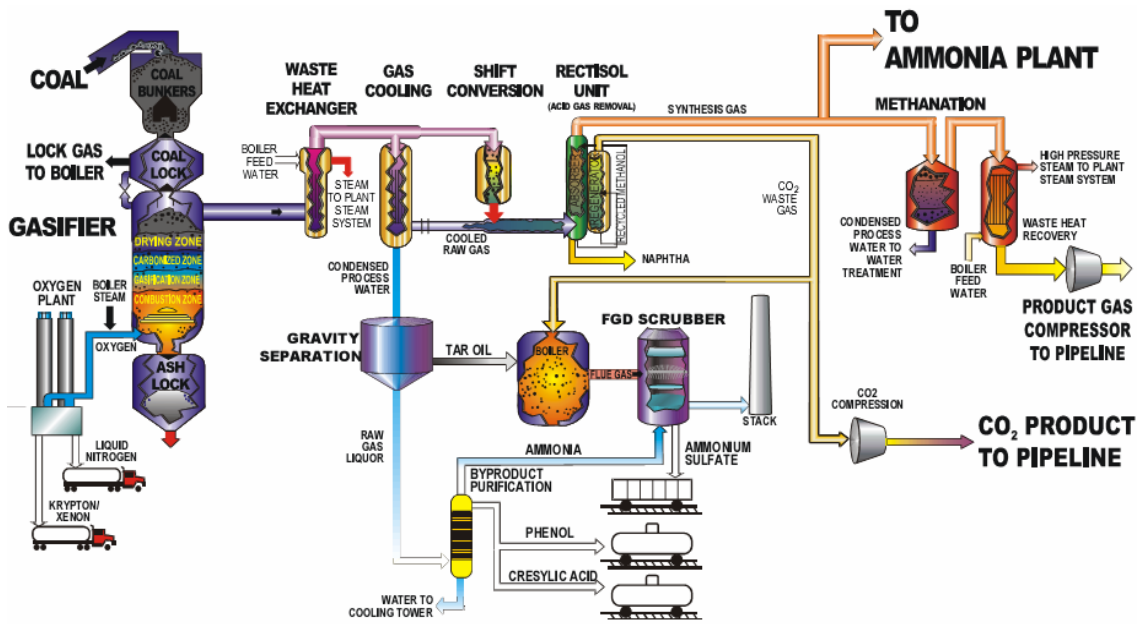

Figure IX.1. Simplified Flow Diagram of the Great Plains Synfuel Plant (Source: Office of Fossil Fuels, DOE, and [14])

a) Current and proposed IGCC air emissions

In an earlier study [11], we summarized the air emissions from some IGCC power plants, listed in Table IX.3 below. Note that the Wabash, TECO, and Pinon Pine IGCC power plants are demonstration plants that have been in commercial operation for the last few years. Others are either proposed or under development. IGCC plants such as the one proposed by Duke Energy Indiana for Edwardsport are expected to have air emission performance similar to the Mesaba plant (Figure IX.2).

Plant	SO2	Nox	Carbon monoxide	Volatile Organic Compounds	Hg
Wabash IGCC	99% or < 0.1 lb/mmBtu	<25 ppmv or 0.15lb/mmBtu or 1.09lb/MWh	0.05 lb/10^6, well below industry standards	n/a	n/a
Wabash-I	Similar to the above	Similar to the above	Similar to above	n/a	n/a
TECO Polk IGCC	>99% or 29lb/hr	15 ppmv or Average 0.7lb/MWh	n/a	< design limit	n/a
Sierra Pacific Pinon Pine IGCC	>95%	50% less conventional coal plants	20% less conventional coal plants	n/a	n/a
EKPC-Kentucky	0.032 lb/mmBtu	0.072 lb/mmBtu	0.032 lb/mmBtu	0.0044 lb/mmBtu	0.08 mg/dscf (EPA data)
Mesaba – Hoyt Lakes	0.022lb /mmBtu	0.058lb /mmBtu	0.03lb /mmBtu	0.002lb /mmBtu	4.3E-6 lb /mmBtu

Table IX.3. Environmental Performance of the U.S. IGCC Power Plants (Source: [11])

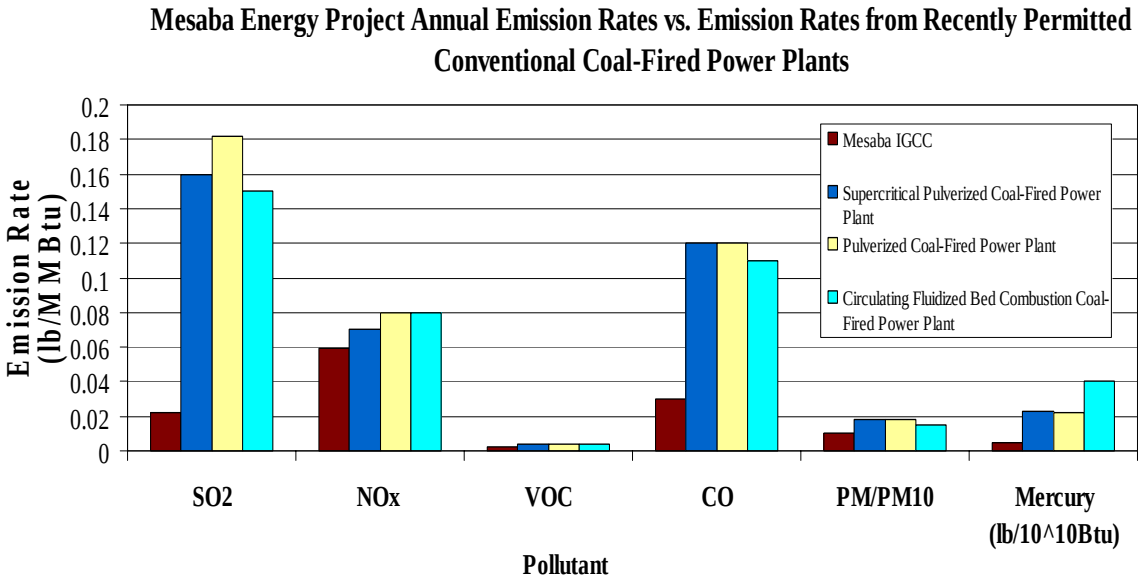

Figure IX.2. Comparison of IGCC and Other Power Plants (Source: Mike Wadley of Mesaba)

Note that the mercury (Hg) emission level from an IGCC is in the range of 5-10% of the mercury contained in the coal that fuels the plant [12]. This emission level actually outperforms IDEM's requirement of 30% or less [13].

In general, coal gasification based technologies are superior in air emission performance to pulverized coal (PC) technologies. However, new power plants, even those based on the supercritical pulverized coal (SCPC) and ultra SCPC technologies, can also have excellent air emission performance (see Figure IX.2 and [13]).

b) CO_2 Capture in IGCC and FT

Greenhouse gases such as CO_2 may be regulated by the U.S. Government in the future. Fortunately, Synfuel and IGCC power plants with coal gasification can capture CO_2 because they use existing technologies such as the two-stage Rectisol, and because the syngas stream is under high pressure with concentrated CO_2 content. According to [13], Rectisol can capture 90-95% of the CO_2 in the syngas stream. One commercial project capturing CO_2 from syngas production is the Great Plains Synfuel Plant in North Dakota, where CO_2 is captured and transported via a 200-mile pipeline to the Weyburn oil field in Saskatchewan, Canada [14] (see Figure IX.3). According to [14], the Rectisol unit at the Great Plains Synfuels Plant already produces a 95% pure CO_2 stream just due to the nature of the process. It is also "bone-dry," with a dew point of -100º F, because of the cold methanol absorption and regeneration processes used to remove the CO_2 from the product gas stream.

CO_2 from the FT vapor stream can be captured by an absorption tower with the amine acid gas removal process. The CO_2 can be regenerated from the amine-based solvent, and then compressed for pipeline transportation.

As reported by the IGS (see section III), there is potential for sequestration in the deep subsurface of Indiana, including injection into saline aquifers, as well as potential for use in enhanced oil recovery by CO_2 flooding, enhanced coal bed methane production, and enhanced shale gas production. There is another commercial CO_2 removal project in the U.S. of smaller scale – the ammonia plant in Coffeyville, Kansas, owned by Farmland Industries (see Figure IX.4). At this facility, petcoke, which has much higher sulfur content than bituminous coal, is the primary feedstock. The Selexol process is used for sulfur and CO_2 removal instead of a Rectisol unit as in the case of the Great Plains Synfuels Plant. The separated CO_2 is partially used for the manufacture of fertilizer, with the excess vented to the atmosphere. These plants demonstrate that CO_2 removal technologies are commercially viable.

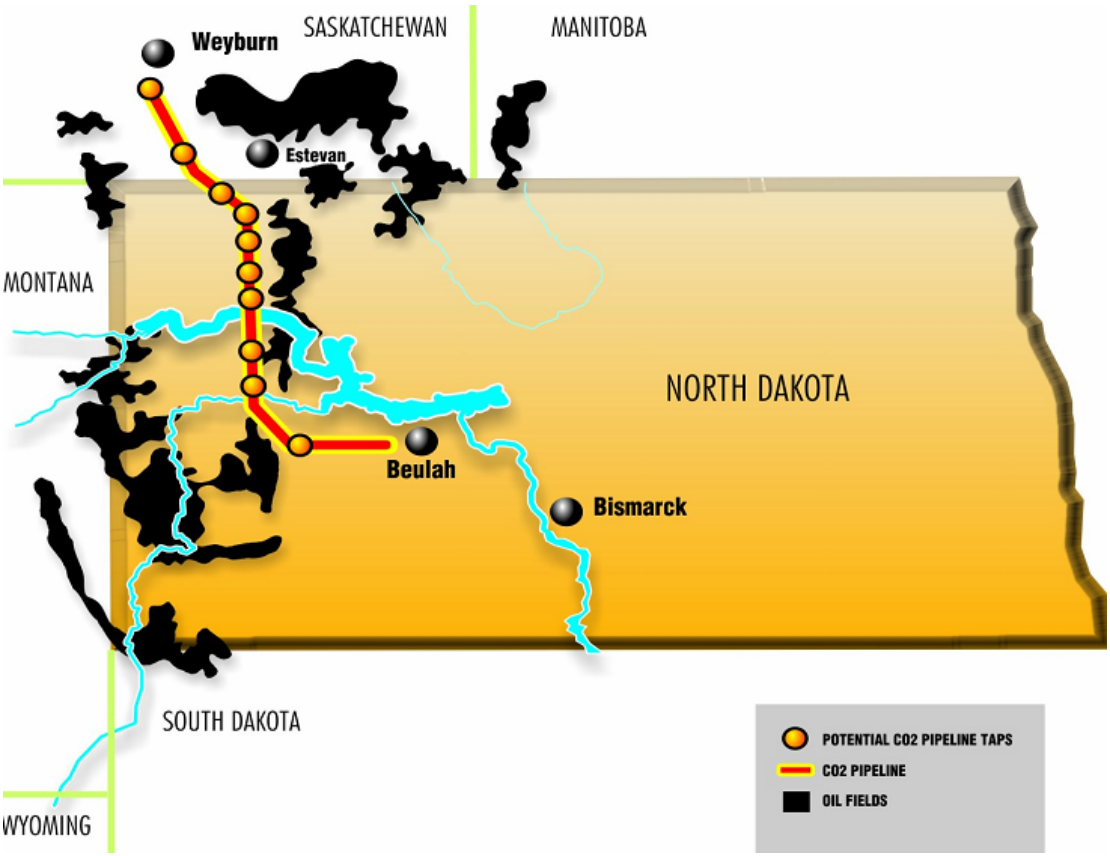

Figure IX.3. Topology of the Enhanced Oil Recovery Using CO_2 from the Great Plains Synfuels Plant near Beulah, North Dakota (Source: [14])

Figure IX.4. The Coffeyville Ammonia Plant with CO_2 Capture (Source: [15])

c) Air emissions from the FT section

Sulfur, nitrogen oxides (NOX), mercury (Hg), and particulate matter (PM) are removed from syngas before it is fed to the FT plant; so, these emissions do not present problems in the downstream FT process. Traces of methane, which could be regarded as a greenhouse gas, may be released from the FT process in addition to the methane traces in the syngas. We do not know how much methane would be released from the FT plant, and further studies would be needed to assess this issue. However, we do not think it will be a serious problem, because the tail gas from the FT plant can be fed to the gas turbine in order to burn the methane.

In general, we are not aware of any problems in obtaining permits for a FT plant with co-production of power due to air emissions. A draft study was performed for the planned Gilberton FT plant in Pennsylvania, where the environmental issues with the plant were assessed by the local authority and the U.S. Environmental Protection Agency [2]. The general conclusion was that there would be no serious problems with air emissions.

IX.3 Solid wastes

a) Slag

The primary solid waste is slag from coal gasification when very high temperature, high pressure gasifiers are used. In this case, ash is minimal. In 2003, EPA issued a regulatory document on the New Source Performance Standards (NSPS), in which Subpart Da sets Standards of Performance for Electric Utility Steam Generating Units (OMB Control Number 2060-0023, EPA ICR No. 1053.07). In this document, slag from coal gasification is covered as a "mineral processing waste" if coal feed is greater than 50% of the feedstock [16]. This classification means that permission to dispose of slag as landfill is not too difficult to obtain. Slag is inert, and the landfill can be beautified and used for other purposes. In Crane's case, if slag is deposited in valleys, level areas can be created after landfill.

In addition, slag can be sold or given away for making cement, asphalt fillers and roofing shingles, as well as for building sports fields and roads. Thus, some extra revenue could be generated by selling the slag byproduct.

b) Sulfur

Using current technologies, more than 99% of the sulfur in coal can be recovered in the FT and power plants. If 6,000 tons of coal, with a sulfur content of 3%, are used each day, approximately 180 tons of pure sulfur would be produced. Sulfur is recovered from a Scott/Clause system, and can be sold for fertilizer production and industrial processes.

c) Carbon beds

Carbon beds can contain significant concentrations of mercury and are hazardous. They will need to be disposed of by a professional waste management firm.

IX.4 Sludge and oil

Iron sludge, wastewater sludge, spent catalyst sludge, oil and other organic compounds will need to be separated and removed. Oil/water separators, air flotation units, and biological reactors can be used for this purpose. This type of water treatment process neutralizes the water to a pH of 7, as reported by [2]. Oil recovered by an oil/water separator would be directed to a used oil storage tank and ultimately removed by a contractor for recycling and/or disposal.

X. Labor Force Requirement and Availability

The National Energy Technology Lab (NETL) estimates that a 50,000 B/D facility requires 144 direct operations people. Increases in the capacity of a coal to liquids facility do not correspond with an equal increase in employees needed; thus the manpower savings in scaling down from 50,000 B/D to 10,000 is far less than a factor of 5. Thus, for the purpose of this study, CCTR will assume that 144 people, including administrative personnel, are necessary to operate the Crane 10,000 barrel per day Coal to Liquids facility. The level of expertise and training will be varied but, as described below, it will not be beyond the level of education and training that already exists at Crane.

X.1 The educational and training component of clean coal technology

The exploitation of the West Texas and Gulf oil and gas fields has resulted in an explosion of "oil patch" vocational and higher education programs in that region over the last 50 years. As coal and biomass (conversion of biomass to liquid fuels via gasification involves many of the same processes as coal gasification), rather than imported oil and gas, become the fuels of choice, we envision the same occurring with coal and the Illinois basin becoming the national center of the emerging synfuels industry.

None of this can happen, however, without a trained workforce ready to meet the demands of this emerging industry. To put the problem in perspective, just the mining of the coal required to support a Coal to Liquids Plant will require about 150 new miners. The coal conversion processes require a higher level of skills. Coal gasification plants and Fischer-Tropsch units, the two technologies that set Coal to Liquids Technology apart from conventional plants, are massive chemical plants, thus requiring a more sophisticated work force than ordinary power plants. The same is true for the downstream processes that gather, condense and transport CO_2. Thus, the training task is a formidable one.

However, the challenge is one that Indiana is ready to meet. The region is primed to become an educational and training center and to create programs in Coal Conversion Technology, producing individuals who will run clean coal technology and other such plants as they are introduced into the region and the nation. Sustainability is very important insofar as the ultimate goal of clean coal technology is to build a facility that can be replicated throughout the U.S. Multiple sites mean an increased demand for a new type of energy operations professionals.

X.2 Educational infrastructure

The question of training and education for clean coal technologies has been addressed by Indiana and the CCTR. As a partner with the State of Illinois in the FutureGen proposal, Indiana has assembled an education component based on the fact that the largest and

longest operating coal gasification facility in the U.S. is located in Terre Haute, Indiana. CCTR is also working with the Coal Fuel Alliance, which was created for the Energy Act of 2005, to promote coal conversion activities by establishing the education component and the long term use of coal derived fuels.

Fortunately, the region has in place an educational infrastructure which can be expanded to meet this challenge. Vincennes University already provides mine worker training and safety programs, and academic programs in coal conversion exist at Southern Illinois University and the University of Kentucky. Resources of the Purdue University Energy Center include the Coal Transformation Lab, the Coal Fuel Alliance and the CCTR. These institutions combined have the capability and the resources to aid in the advanced training and future research needed to support this project as well as other advanced coal conversion projects. Vincennes University, Indiana State University, the University of Evansville, Indiana University Southwest, Purdue University and Rose-Hulman Institute, will work together to develop a curriculum in consultation with State Higher Education Commissions. The Illinois basin states, Kentucky, Illinois, and Indiana, will lay the groundwork now for creating a regional program in Coal Conversion Technology through the Coal Fuel Alliance (CFA). The CFA will prepare workers for the opportunities that will be created as the region takes the lead in clean coal technology commercialization with projects such as FutureGen, Duke-Edwardsport IGCC, Indiana Gasification LLC, and Crane FT Plant.

Indiana's Center for Coal Technology Research will host workshops for the educational institutions and the Wabash Gasification facility for the purposes of establishing the education needs of Clean Coal Technology and to muster the available resources to meet those needs. This meeting will be coordinated with the Indiana Higher Education Commission for the purpose of certifying any new programs for technicians and professionals wanting to work in the newly established industry.

The Crane region already has a major research university and has relatively easy access to a number of state and private universities. Indiana University (IU)-Bloomington, IUPUI, Purdue University, Rose-Hulman Institute of Technology, Vincennes University, IVY Tech State College, and Indiana State University have substantial programs in science, engineering, medicine, electronics, etc. that serve the region.

Crane itself has a long history of working closely with academic partners. The region's two technology parks have already formed partnerships with IU-Bloomington, Purdue University, and Rose-Hulman.

X.3 Training opportunities

Another cornerstone of this infrastructure is the Wabash IGCC plant. Owned by Global Energy and Wabash Valley Power Association, it is the largest commercially operating coal gasification plant in the United States. The opportunity for the Clean Coal Technology operators to be trained at the Wabash facility in preparation for a Coal to Liquid plant and the other plants that will follow is a truly unique advantage of this project.

XI. Economic Impact at NSA Crane

> *"NSA Crane, one of the most diverse and largest Technical Centers, exemplifies a "first-responder" activity. Its value statement, Harnessing the Power of Technology for the Warfighter, drives everything this vital Navy Technical Center does. Whether addressing new requirements, improving existing capabilities, or maintaining operational readiness of older equipment, NSA Crane marshals its diverse engineering, technical and industrial resources to serve the user."*
>
> --David M. Reece
> Crane Division, Naval Surface Warfare Center

The economic impacts of this project for this region of Indiana could be quite large. The area is depressed with relatively high unemployment and low labor force skill levels. The proposed project would create a large number of high-skills, high-paying jobs in the area. When combined with an economic multiplier effect, the result will be a substantial economic development thrust.

XI.1 Crane regional statistical profile

Below is a brief demographic and economic profile of the six counties – Daviess, Greene, Lawrence, Martin, Monroe, and Orange – which comprise the Crane region's economy.

Some general characteristics of the region as a whole include the following:

- The six counties have a combined land area of 2,551 square miles
- The population density per square mile is 102.7
- Bloomington is the region's largest city with a population of 69,017 (2005)
- Bedford is the region's second largest city with a population of 13,768 (2000)

a) Education

Aside from Monroe County, which is home to Indiana University, the largest university in the state, education levels in the region lag well behind the Indiana average. In most of the counties, the percentage of adults with a bachelor's degree is around half the state average. These five counties also trail the state average in terms of high school graduation levels, although the disparity is not quite as pronounced.

Educational attainment is therefore a potential problem area for moving the Crane region into a 21st century economy. For example, in three counties, at least 25% of adults lack a high school diploma. A training program is needed to permit the employment of these populations in the ancillary jobs created as a result of this project. After identifying these jobs and their skill sets, a plan will be developed to meet the training needs.

Talent is increasingly the most critical asset for economic growth in the 21st Century. Available workers with the right skill mix and an institutional framework that not only provides a pipeline of new right-skilled workers, but supports the skill upgrading and retraining of existing workers. This need has become a core requirement for business expansion and location.

b) Employment

In both 2005 and August 2006, the region's overall unemployment rate was slightly higher than Indiana's. More specifically, Lawrence and Orange Counties have the highest unemployment rates in the region. Daviess, Martin and Monroe Counties, which have the area's lowest unemployment rates, either match or are lower than the state average.

c) I-69 proposed extension

NSA Crane does not have immediate access to an interstate highway. In a state where many new employers have located near interstate exits, the region's lack of easy interstate access will be a consideration for prospective secondary businesses near the Crane facility.

However, for the past several years, the state of Indiana has been working on an initiative to extend Interstate 69 from Indianapolis to Evansville. This proposed extension would have a significant economic impact upon the Crane region, because the currently recommended route would have exits in Bloomington, in Greene County (about 2 miles northwest of Crane), and in Daviess County.

Governor Daniels recently announced that construction on the southern portion of the extended highway will begin in 2008. As a result, it is not clear if I-69 will be developed through the Crane region in time to affect the Coal to Liquids project. However, it is not necessary for I-69 to be built for the project to be successful. The primary transportation need for this project is railroad-based, and we have already noted that this infrastructure appears adequate for the needs of Crane and the new demands of this project.

XI.2 Crane's economic impact

NSA Crane is a major economic force in southwestern Indiana, with its total estimated economic impact approaching $1.5 billion. The multi-county area around the base shares a total annual benefit of $844.7 million. Much of this impact is generated by wages and purchases. The number of highly paid professionals and contract expenditures equals and even exceeds those of many of Indiana's large private enterprises.

The most notable economic impact delivered by Crane is employment. Crane is the twelfth largest single-site employer in Indiana and the second largest single-site employer

in the southwestern part of the state. Its wide range of professional and technical jobs provides comparatively high pay in an otherwise mostly rural area. Crane's on-site employment of approximately 4,780 workers is supported by an additional regional workforce of approximately 3,700 workers. This brings the total employment level of NSA Crane to about 8,500 jobs, approximately 7,400 of which are in Martin County and the contiguous counties of southwest Indiana.

Moreover, wages earned by NSA Crane workers are among the highest in Indiana. The average wage of workers at Crane is approximately twice the average wage in Martin County. The highly skilled and highly paid jobs offered through the Navy, defense contractors, and other operations at the base have enabled this region of Indiana to attract educated and talented professionals to communities that would otherwise have few scientific, engineering, and technology positions. Crane's impact is the greatest at the individual county level, where Crane's economic impact constitutes a large proportion of regional income.

Thus, from numbers of jobs supported, to wages and income, to commuting patterns, NSA Crane is the major force supporting key elements of the area economy. Crane is an economic engine of significant importance and on a par with the private sector industrial giants of the Hoosier state.

A 10,000 B/D coal to liquid plant will have a big impact "outside the fence" of Crane, creating new and desirable jobs and having significant economic multiplier effects. The major reason this facility can work at this site is because the infrastructure and capability to do the project is already in place. Production of 10,000 B/D of liquid fuel from coal requires about 5,000 tons of coal per day, or about 1.8 million tons of coal per year. There are an estimated 1.17 billion tons of coal within 100 square miles of Crane accessible from surface mining and another 7.46 billion tons available from underground mining. Thus, the resources to meet this demand of 1.8 million tons per year already exist through expanding existing mine production.

Mining this additional 1.8 million tons of coal per year will require about 150 new jobs in mining itself and about 760 secondary and ancillary jobs. The income from these jobs will be around $62 million annually. The overall economic impact of 1.8 million tons of coal is over $108 million annually and represents new money into the region. Establishment of a coal to liquids plant will allow Crane to maintain its role as the primary source of high paying jobs in an area of Indiana with the lowest income levels.

The coal will need to be moved by rail car. A rail car holds 131.5 tons of coal per unit, compared to 25 tons of coal capacity of an over the road truck. 5,000 tons of coal per day will require 38 rail cars per day (compared to 200 trucks) or one train a day. The rail line servicing the Crane complex is class 1 track owned by Indiana Rail Road.

The Indiana Rail Road (80% owned by CSX) owns that trackage exclusively. The trackage continues on with rights to Chicago (via Terre Haute) and Louisville (via

Bedford). Indiana Rail Road is the only company which operates that right-of-way. The route was rehabilitated years ago with new roadbed, wooden ties and welded rail. The route was originally part of the Chicago, Milwaukee, St. Paul & Pacific Railroad's Terre Haute Division: commonly known as "The Southeastern." This rail line is included in the CCTR report "A Prescriptive Analysis of the Indiana Coal Transportation Infrastructure," Tom Brady, Purdue North Central, which details among other things the opportunity for a Coal Corridor in Indiana [22].

XI.3 Regional economic impact

The 10,000 B/D facility will create products of value for direct use and for sale on the open market. The 10,000 B/D is the total amount of FT liquids – it is not all one fuel. A 10,000 B/D plant will produce 5,563.8 barrels of diesel equivalent military type fuel, and 4,434.6 barrels of naphtha, the feedstock for gasoline. The facility would also produce about 1,200 MWh of electricity for export and 180 tons of elemental sulfur on a daily basis.

The estimated value of the 10,000 B/D production is as follows:

5,563.8 barrels of diesel	@ $82.32/barrel	$458,012.02
4434.6 barrels of naphtha	@$63.00 /barrel	$279,379.80
1,200 MWh of electricity	@ $.06 / KWh	$ 72,000.00
180 tons of elemental sulfur	@ $10.00/ton	$ 1,800.00
Daily production value		$811,191.82

Average value per barrel of FT production	**$81.12**
Annual values based on 90% capacity (7,889 hours of operation)	**$266,659,031.03**

Source: [21]

XI.4 Crane economic development programs

Crane has a number of economic, educational, and environmental outreach programs. There are three important areas in which Crane has assisted businesses: the Technology Transfer Office, the Sale of Test Services program, and the Cooperative Research and Development Agreement (CRADA). In addition to these three government programs, Crane Technology Inc. (CTI) is a 501(C)3 non-profit economic development organization that is in place to leverage Crane for economic development in the region. CTI administers the Crane Technical Assistance Program under a CRADA with Crane and acts as a non-government representative on behalf of Crane's interests.

Since 1995, Crane has had a Technology Transfer Office to assist private firms. The Technology Transfer Program provides 32 hours of no-cost assistance in production or

manufacturing problem analysis. In addition, the Sale of Test Services program allows businesses to access Crane's testing facilities in material science, failure analysis, and acoustic sensors. Nearly 100 companies have made use of these services.

The CRADA program enables Crane to partner with businesses and can be used to expand and further develop emerging technologies. It will aid in attracting new companies to the area.

NSA Crane's primary mission is to serve the warfighter. CTI is in the process of establishing itself as a permanent intermediary between NSA Crane and some private sector clients. This intermediary would serve as both a marketing operation and represent private clients' interests in NSA Crane activities.

XI.5 Regional technology parks

Certified technology parks comprise one of the strongest economic development assets for regional development. In comparison to other areas of the state, South Central Indiana has been slow to create technology parks. However, with two parks now in place and a third one planned, the region has partners who can help carry out a sustained effort to diversify the economy. Certified by the state of Indiana, the two existing technology parks in the six-county area are West Gate at Crane and Bloomington's Inventure.

West Gate is in its start-up phase, with a building under construction and a multi-year building program in negotiation. Its mission is to build initially upon businesses that could profit from close proximity to NSA Crane. The park will be close to an exit on the proposed extension of I-69, which may begin construction in 2008.

West Gate is a joint venture among three counties: Daviess, Greene, and Martin. Daviess County has been the most aggressive by far, and has used future revenue to support a bond for initial development. West Gate should be a significant player in the diversification strategy. This technology park is an example of how local leadership in rural communities can use existing resources to build economic assets.

Although West Gate initially intends to grow by attracting clients that will work with NSA Crane, in the long-term this technology park has the potential to lead the region's diversification away from dependence upon Crane and DOD.

Inventure is another new technology park created by a joint venture between IU-Bloomington and the Bloomington-based SBDC, located at the Showers Research Park. It already has a client that is a spin-off from Crane. Although Inventure does not have the land that West Gate possesses, the Bloomington operation should serve as a likely location for businesses coming out of IU-Bloomington. Inventure is also a likely source for life sciences and information technology start-ups that have begun to develop in the Bloomington area. Inventure already has clients in these sectors.

Both West Gate and Inventure have close ties to universities: IU-Bloomington, IUPUI, Rose-Hulman, and Purdue University. A third technology park has been proposed. "East Gate" would be located in Lawrence County and have similar goals to that of West Gate. This confluence of regional technology parks will serve to support the economic development that will be fostered by the NSA Crane Coal to Liquids Project.

XI.6 Hoosier Homegrown Energy- Indiana's Strategic Energy Plan

The Hoosier Homegrown Energy Plan [18] commits Indiana to using new and emerging technologies to convert Indiana coal, corn, soy and other resources to energy, thus reducing Indiana's dependency upon imports. The spectrum of initiatives and projects includes coal gasification, biofuels and biomass, as well as other renewables such as wind and energy efficiency. The Crane Coal to Liquids project exemplifies the goal of this plan – use local resources to meet local, regional and national energy needs.

The plan outlines a role for major research universities and Crane to optimize the development of needed new technologies. Specifically, Indiana's 21st Century Research and Development Fund will be expanded, and a portion of the fund will be dedicated to energy technology development and commercialization. The vision statement of the plan [18] is "Grow Indiana jobs and incomes by producing more of the energy we need from our own natural resources while encouraging conservation and energy efficiency." The goals of the plan are as follows:

Goals of Indiana's Strategic Energy Plan

- Trade current energy imports for future economic growth
    - Importing energy exports future growth
    - New plants bring new jobs
    - Reduce energy dependency and increase reliability
- Produce electricity, natural gas and transportation fuels from clean coal and bioenergy
    - Build needed new power plants using clean coal technology
    - Make gas from coal versus importing natural gas
    - Unlock biomass and build on biofuels success

- Improve energy efficiency and infrastructure
    - Create new tools and incentives
    - Support flex- fuel fleets
    - Strengthen/expand energy infrastructure (including rail)

Source: [18]

The NSA Crane FT plant project is very much in line with the goals of Indiana's Strategic Energy Plan. Thus, it seems reasonable to expect that this project will receive encouragement and perhaps even limited support from the state.

XII. The NSA Crane Site near the City of Sullivan

A preliminary evaluation of the feasibility of locating a FT plant at the NSA Crane site near the City of Sullivan, in Sullivan County, Indiana was also performed. Because the research team was made aware of this secondary site later in the project, the analysis of the Sullivan County site is presented in this separate section. The site is indicated in Figure XII.1 by the region within the red lines. Lake Glendora is within the boundaries of the site, which has been used for weapon testing by Crane. About 1/5 of the site is covered by surface water. We will use "the Crane west site" or "the site" in the rest of section XII.

The analysis for the Crane west site is organized into the following sections: (1) land requirements, (2) water resources, (3) transportation of coal and (4) transportation of large equipment. The analysis in the other sections (I-XI) applies to the Crane west site as well, with only minor adjustments, and it will not be repeated in this section.

XII.1 Land requirements

As discussed in earlier sections of this report, the main FT plant of 10,000 B/D liquids may require about 120 acres of land. This is less than the total area of the Crane west site, which is about 750 acres. The mine pool at the northeast corner of the site may be used for storm water containment and as a cooling pond if needed. The site is surrounded by surface mine pools and ponds, which can be used for slag/ash disposal (see Figure XII.1). In short, land is plentiful for even a large FT plant on the Crane west site, and slag/ash disposal could be accommodated by the many strip mine pools in the area nearby.

XII.2 Water resources

Lake Glendora is inside the boundaries of the site and is very deep. Its deepest point is around 120 feet. It appears to be suitable for onsite water cooling. It may be able to provide some initial feed water to the FT plant for the first year or two. However, since the inflow to Lake Glendora is quite limited, it cannot be viewed as a long-term solution to the water requirement of a large FT plant at the site. Fortunately, there are some other water sources nearby. Lake Sullivan is one such source of water. Lake Sullivan was constructed in 1968 and has a surface area of 468 acres. Its average depth is about 10 feet, and the deepest area may be around 25 feet [19]. Therefore, the water volume is around 43,560x10x468 = 204 million cubic feet, or about 1.8 billion gallons. Even though there is no major river feeding the lake, the lake can still provide some raw water because of its sizable volume.

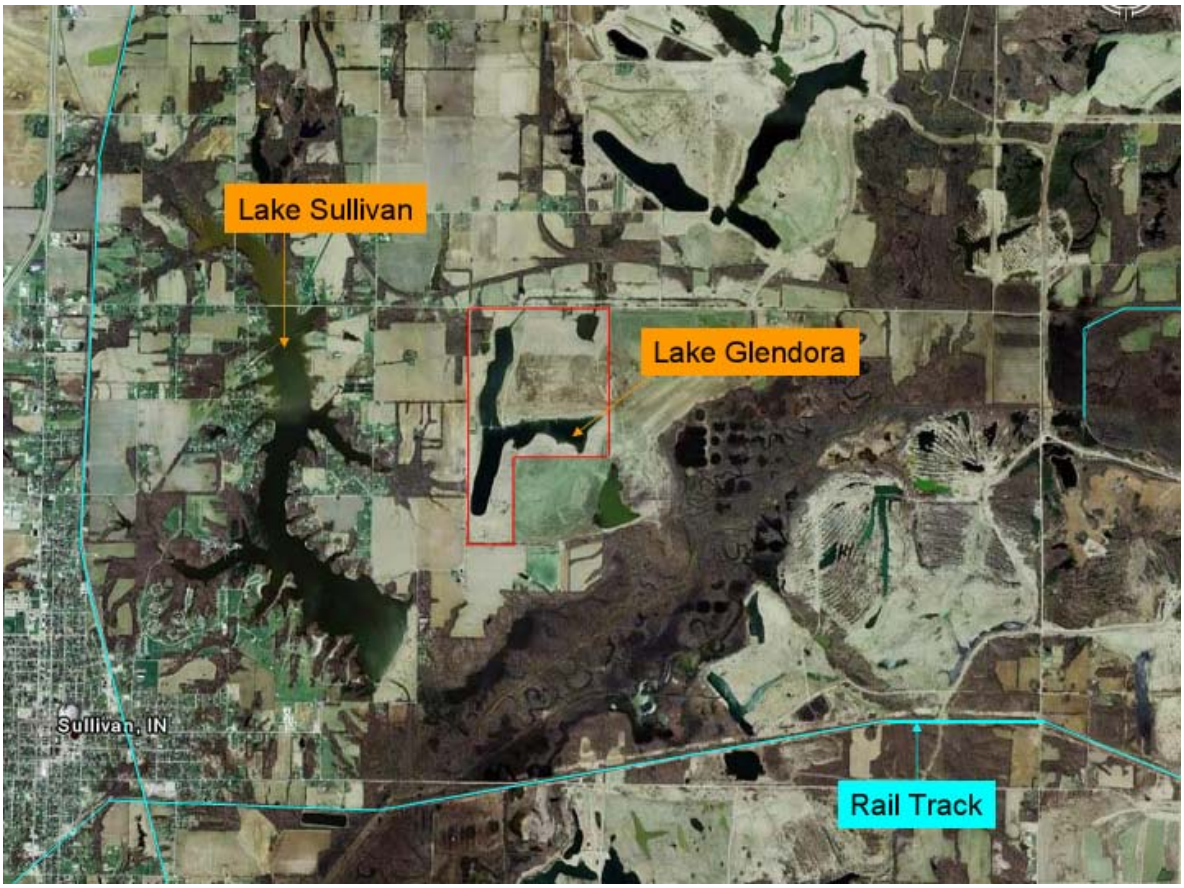

Figure XII.1. The Location of the CNSC Weapon Test Site in Sullivan (Courtesy of Google Maps, with legends added)

Underground water could also be considered as a source of water for the FT plant, with each well providing 10-50 gpm of fresh water (see http://www.in.gov/idem/, and Figure XII.2 from http://www.in.gov/dnr/water/ground_water/ground_water_avail/index.html). However, wells for drawing underground water around the site may have to be at least 50 feet deep, because the water levels vary considerably in the county, as indicated in Figure XII.3.

According to our analysis, economical water resources within 5 miles of the site may be insufficient for a large FT plant with 50-100 MW of net power export if wet cooling towers are used. One way to resolve the problem is to have a smaller co-production of power since the power section uses a large portion of the water (as indicated in Table IX.1). The problem may also be solved by using a dry-cooling system, in which evaporation is minimized by separating cooling water from air. This design may reduce raw water use by 40% or even more. A large quantity of raw water can be piped in from the Wabash River area, which is about 10 miles to the west. This option would of course increase the cost of the facility.

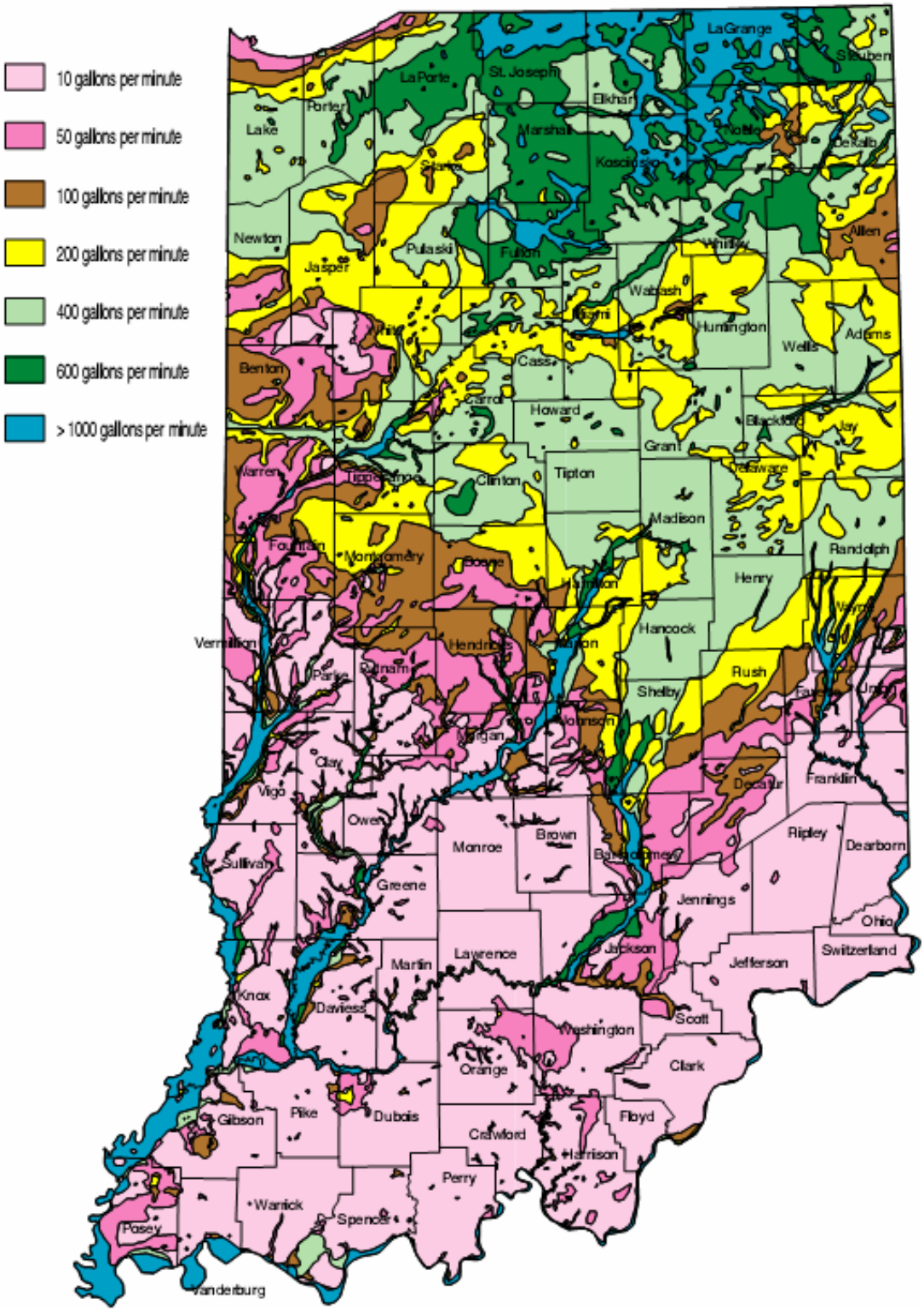

Figure XII.2. Indiana Underground Water Map (Source: IDEM)

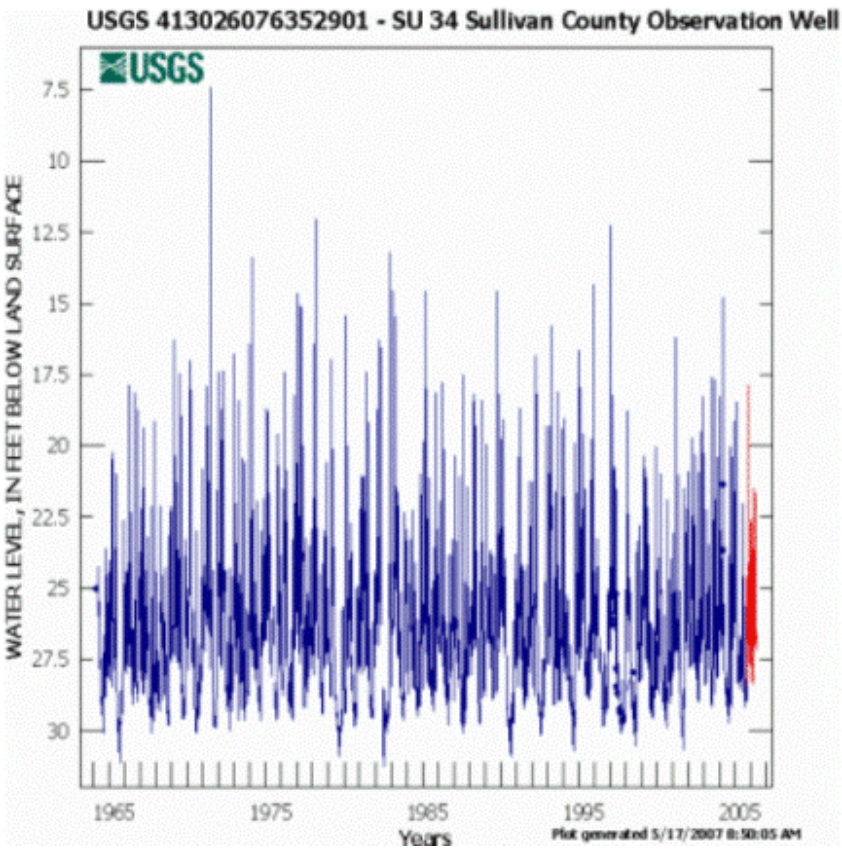

Figure XII.3. Sample Historical Underground Water Levels in Sullivan

	Highway	**Location**
1	West Lloyd Expy	In Evansville
2	West Delaware St.	Evansville
3	HWY 66	North of Evansville
4	Darmstadt Rd	North of Evansville
5	HWY64	South of Haubstadt
6	Old State Rd	North of Evansville
7	HWY41	Princeton
8	Parallel HWY41	Princeton
9	Brown St.	Princeton
10	HWY41	Vincennes
11	HWY41	Oaktown
12	HWY150	Oaktown

Table XII.1. Overpasses along the North-South CSX Track from Evansville to Sullivan, Indiana

XII.3 Transportation of coal

There are coal mines near the site, including the Kindill #3 Mine about 5 miles south of the site and the Hymera Mine and the Farmersburg South Pit 15-20 miles north of the site. The site is about 1.1 miles north of the CSX rail line, so coal from mines at greater distances could be delivered via the rail system.

XII.4 Transportation of large equipment

Because the site is near the CSX railway, the transportation of large equipment should be relatively easy. The very large FT reactors may be transported from Jeffboat to Bedford and then to the NSA Crane west site. This is an extension of the route that is suggested in section V.1, and thus needs further evaluation. Alternatively, FT facilities could be transported from Mt. Vernon or Evansville to the site via the North-South CSX rail tract. Again, further evaluation is needed.

Depending on routing, there may be as many as 12 overpasses from Evansville to Sullivan. Most of the overpasses are highway bridges along the North-South CSX rail track, as listed in Table XII.1. In addition, there is at least one overpass between Mt. Vernon and Evansville.

Since the site is about 1.1 miles north of the CSX rail line in order to ship large equipment to the site, it may be necessary to construct either a rail track or a heavy duty concrete road.

XII.5 Distribution of finished products

The site is close to both rail and highway systems, which facilitates the distribution of finished products. A substation in the city of Sullivan can be used for small scale power distribution. For larger power distributions, the substation and the transmission line system may need to be expanded. The site is also near a natural gas pipeline at the Sullivan city gate.

XII.6 Conclusions for alternate site

Land is plentiful at the NSA Crane west site for a large FT plant with co-production of power. Slag/ash disposal can be accommodated using abandoned strip mines near the site. In addition, there is good access to nearby coal mines to supply the primary feedstock of the plant. Water resources are limited within a few miles of the site. Hence, a large FT plant with sizable co-production of power may not be feasible without drawing water from longer distances, such as the Wabash River area about 10 miles to the west. Transportation of large facilities presents the same challenges for this secondary site as it

does for the primary NSA Crane site. For these reasons, the primary site at NSA Crane is viewed as being superior to the secondary, Sullivan County site.

XIII. Conclusions

The goal of this study was to identify whether there are any clear indications that a Coal to Liquids FT plant with electricity co-production could *not* be sited at NSA Crane. This study is not intended to be a comprehensive evaluation that identifies precisely how, and at what cost, such a plant can be built at Crane; rather, it is only a preliminary feasibility assessment.

Our bottom line conclusion is that there are no clear reasons why the plant can not be sited. On the contrary, a number of features make Crane an attractive location for the construction of such a facility. These are recapped below.

Coal supplies are available in abundance in the region around Crane. Through a combination of existing and new mines, sufficient coal resources can be obtained to support the plant over its 20-25 year useful life. While a modest amount of natural gas may be needed to run the plant, the existing pipeline infrastructure should be adequate to supply these needs.

The deep subsurface geological environment has significant potential to sequester the carbon dioxide produced by the plant. Saline aquifers, mature oil fields, and shale gas fields are all available either directly under the property or in close proximity to the west. Sequestration into coal beds and associated enhanced coal bed methane production is not possible in the immediate area due to the shallow nature of the seams on the site. Enhanced oil recovery (EOR) and enhanced gas recovery (EGR) offer significant potential for value-added production of energy resources via the injection of CO_2 into oil fields and in the gas shale.

Sufficient land for the various components of the plant, for coal inventory and handling, for water cooling and treatment, and for disposal of solid wastes (mostly slag and ash) appears to be available on-site. A more detailed study to identify their precise locations within the facility should be performed as this project moves into its next phase. Considerations in site selection should include terrain, distance to various elements of infrastructure (power grid, gas pipelines, water sources, etc.), proximity to landfill areas for slag and ash, economics of necessary infrastructure enhancements, etc.

The rail and road systems to and within Crane appear to be sufficient to support the operation of a CTL plant. It is expected that much of the coal will be brought in by rail, and many of the products of the plant can be sent out by rail or truck, depending upon the results of the economic analyses. The biggest remaining question is the feasibility of transporting the largest pieces of equipment – namely the FT reactors – to the plant site. In 1989, a similarly large and heavy piece of equipment was delivered via barge to Jeffboat in Jefferson, Indiana and then via rail to Crane. It may be possible to use this strategy to deliver the FT reactors. A more detailed analysis will be needed once the precise size and weight of the components of the CTL plant have been identified.

The configuration of CTL plant we focus on in this study produces electricity in excess of the plant's needs . The net export capacity of the plant would likely be on the order of 40-50 MW, and it appears that the grid should be able to absorb this level of export, perhaps with some moderate modifications. A more detailed power flow and stability analysis is beyond the scope of this report, but should be performed as this project moves forward.

While water supplies for cooling and the various processing stages of the CTL plant initially appeared to be a substantial challenge, the two nearby forks of the White River can provide sufficient water without great impacts on the river. More detailed engineering and economic analysis will be needed to determine the precise design of the cooling system and the water treatment systems, as well as the optimal sourcing of water for the project.

A secondary site in Sullivan County to the west of NSA Crane was also evaluated. However, the primary site appears to be superior due to the limited water availability at the western site and the proximity of the East and West Forks of the White River to the primary site.

No insurmountable problems were identified with respect to waste disposal or plant emissions. However, because no CTL plants are currently operating in the U.S. on a commercial scale, our knowledge of the exact composition of wastes and emissions is still imprecise. Nonetheless, environmental permitting is "fast-tracked" at NSA Crane under the provisions of the Military Base Protection Act (MBPA) passed by the 2005 Indiana General Assembly. The MBPA provides for first priority by the Indiana Department of Environmental Management (IDEM) for any IDEM permitting in support of operations at Crane.

The labor force requirements will be substantial. A significant expansion of the coal mining labor force will be needed. Of greater concern is the need for technicians and chemical engineers with the skills and knowledge to operate the CTL plant. However, substantial educational and training facilities are available in the region and the state. In addition, the IGCC plant operated by Global Energy and Wabash Valley Power Association is located in the area, and the gasifier at that plant could serve as an ideal training facility for a significant part of the CTL plant.

The economic impacts for this region of Indiana could be quite large. The area is depressed with relatively high unemployment and low skill levels in the labor force. The proposed project would create a large number of high-skill, high-paying jobs in the area. When combined with an economic multiplier effect, the result will be a substantial economic development thrust.

Thus, it appears that it would be feasible to locate a CTL plant at NSA Crane. Indeed, Crane seems a highly advantageous site because of the proximity of coal resources; excellent infrastructure, including rail, the power grid and pipelines for gas and refined products; available water access; available land within the facility; and available labor

resources. Of course, a full-blown engineering/economic study will be needed to determine the precise location, design, and operating characteristics to best meet the project goals. In the end, however, there does not appear to be any factor that would prohibit locating a CTL plant at Crane.

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Appendix 1 – Letter of Request for Study from CTI

Crane Technology Inc.

Applied technology for Indiana business

12 April 2007

Marty W. Irwin, Director
Center for Coal Technology Research
500 Central Drive, Room 270
West Lafayette IN 47907-2022

As a result of our meeting at Naval Support Activity Crane (NSA Crane) on 12 April, Crane Technology Inc. (CTI) requests the Center for Coal Technology Research (CCTR), in conjunction with the Indiana Geological Survey (IGS), conduct a feasibility study for siting of a coal to liquid (CTL) facility at NSA Crane.

Criteria for this feasibility study include but are not limited to:

1. Coal and natural gas availability
2. CO_2 sequestration potential
3. Land/real estate requirements
4. Transportation Infrastructure (rail, roads and waterways)
5. Electricity transmission lines and available power
6. Gas and oil pipelines
7. Water requirements and resources
8. Waste disposal/environmental issues
9. Labor force requirements/availability
10. Economic impact
11. Other issues

This study should be completed by 31 May if possible and shall be sufficiently detailed to support a go or no – go decision to continue with pursuing a CTL facility at NSA Crane.

Funding will be provided by CTI for this study and details will be addressed by separate correspondence.

Sincerely yours,

Jim Schonberger
President
Crane Technology, Inc