PROJECT TITLE: MITRE Corporation Study on Feasibility of the Hybrid Coal Liquefaction Concept at Great Plains

ORGANIZATION: Dakota Gasification Company

INVESTIGATORS: Donald C. Pollock
Dakota Gasification Company

David Gray
The MITRE Corporation

DATE OF SUBMISSION: April 1, 1991

AMOUNT OF REQUEST: $60,000

1. SUMMARY

In addition to producing synthetic natural gas from lignite, liquid transportation fuels such as gasoline and diesel can be produced from lignite by coal liquefaction processes. Direct liquefaction processes break down the large coal molecules into smaller molecules in the presence of hydrogen, hydrogen rich coal-derived oil and a catalyst. Indirect liquefaction processes first gasify the coal to produce synthesis gas (CO and H_2) and then synthesize liquid fuels by means of a catalytic process. The liquid fuels produced have distinct properties unique to each liquefaction process with one common denominator, namely, very low sulfur and nitrogen contents.

Hydrocarbon Research, Inc. has asked Dakota Gasification Company (DGC) to participate in a proposal to the Department of Energy (DOE) for the Clean Coal Technology Round IV Program to produce petroleum products from coal through the process of direct liquefaction. SASOL, which produces a large portion of South Africa's requirements for petroleum products from their SYNTHOL technology, has recently completed a preliminary study on the merits of producing liquid fuels from our synthesis gas at Great Plains. The plant at Beulah could conceivably demonstrate both of these technologies to where its entire output would be oil products.

The MITRE Corporation, a Washington, D.C. based consulting firm, has completed a generic based on combining direct and indirect liquefaction technologies into a "hybrid plant." This study showed that there are real synergies achieved by co-siting each of these technologies at a common site, e.g., cost savings and energy efficiencies are realized. An added benefit is that the blending of the products from each technology produces products which are environmentally desirable--fuels that have the properties of reformulated gasoline as well as very low sulfur diesel fuel. The Department of Energy's technical staff has shown considerable interest in this concept.

Conversion of the Great Plains plant to produce liquid fuels instead of SNG could conceivably produce 30,000 barrels per day of oil and consume an additional three million tons of lignite annually.

DGC proposes that a site specific study be performed. This would entail a simulation or computer modelled study specifically based on Great Plains site parameters. We propose that The MITRE Corporation perform this study by virtue of their having completed a similar generic study for the hybrid plant concept.

The study would begin upon project approval and take about three months to complete. The results of the study would be issued in a report with a follow-up meeting to discuss the results of the study.

The total cost of this project is estimated by MITRE to be about $120,000. This includes six man months of consultant time, trip allowance, computer time, clerical help and overhead. The ND Industrial Commission is requested to provide funding in the amount of $60,000.

The major participants in this study will be DGC, who will manage the project, and MITRE Corporation, who will perform the study and write the final report.

2. OBJECTIVES

The objective of this project will be to perform a site-specific study of the hybrid coal liquefaction plant (i.e., the combination of both direct and indirect coal liquefaction processes at the same location). Study parameters would be specific to the Great Plains site. The study would determine the capital cost for conversion to the hybrid plant as well as the required selling price of products to ensure a reasonable degree of profitability.

We believe that conversion of the Great Plains plant to liquid fuels instead of SNG could ensure the long-term viability of the project. Projections of natural gas prices are predicted to remain low and flat for some time to come. The selling price of liquids on the other hand has a greater chance of sustaining a price level sufficient for the project to maintain profitability.

3. BACKGROUND

The objective of this study is to analyze a proposed hybrid direct/indirect liquefaction plant to be sited at the Great Plains gasification facility in Beulah, North Dakota. The hybrid plant will use Lurgi dry-ash gasification and Rectisol gas cleaning technology in place at Great Plains to produce clean synthesis gas suitable for processing in a SASOL Fixed Fluid Bed (FFB) Fischer-Tropsch (F-T) synthesis reactor. The synthesis gas will be processed once-through (or with minimum recycle to be determined by analysis) in the FFB reactor to produce raw F-T products ranging from methane to about C_{20} hydrocarbons. The FFB tail gases will be processed to separate sufficient hydrogen to be used as make up hydrogen for the direct coal liquefaction section of this hybrid plant. The direct coal liquefaction section will use Hydrocarbon Research, Inc.'s (HRI) Catalytic Two-State Liquefaction (CTSL) process to convert Beulah lignite and Lurgi gasification tar oil to distillate. The Lurgi tar oil will be used as part of the coal-derived recycle solvent. The products from this hybrid facility will be F-T naphtha and distillate, CTSL naphtha and distillate, Lurgi coal gasification naphtha and substitute natural gas (SNG).

MITRE has developed a computerized simulation model of a conceptual commercial scale hybrid plant that uses Shell gasification technology to produce coal-derived synthesis gas, slurry-phase F-T synthesis to produce raw F-T products, and two-stage coal liquefaction to produce raw direct coal liquids. This hybrid plant configuration passes the synthesis gas once-through F-T reactors and recovers hydrogen for the direct liquefaction section of the facility. It is proposed to modify this MITRE hybrid plant model to analyze the site specific Great Plains hybrid concept.

4. GOALS

The goals of this project will be:

a. To gather the necessary data and information from Great Plains to modify the MITRE computer model of the hybrid direct and indirect liquefaction processes.

b. To perform the computer simulation of the hybrid plant based on Great Plains parameters and determine the volumes and qualities of the liquid products estimated from the model.

c. To determine the necessary refining requirements to produce specification transportation fuels.

d. Investigate alternative hybrid configurations to determine the configuration that has the potential to maximize return on investment.

e. To prepare a report documenting the results of the study.

5. METHODS

DGC has selected The MITRE Corporation to perform this study for reasons which are explained in Section 8, Qualifications of the Applicant. MITRE's proposed method of performing the work is as follows:

a. Obtain and review data from Great Plains and Lurgi on performance of Lurgi dry-ash gasifiers on Beulah lignite. Reduce data to a form suitable to input into the MITRE hybrid plant coal liquefaction simulation model. This Lurgi gasification section will replace the Shell gasification system currently in the model. The result of this operation will be to obtain the clean product gas composition and flow rate together with characteristics and flow rates of gasifier naphtha, phenols, tars and oils.

b. Obtain and review data from SASOL on operational performance of the FFB F-T reactor. Reduce data and input into F-T synthesis section of the MITRE model. This section will replace the slurry and SYNTHOL synthesis reactor systems currently in the model. The SASOL FFB performance data will allow MITRE to perform an analysis to determine a satisfactory balance between synthesis gas conversion (once-through or minimal recycle), F-T liquid product and tail gas hydrogen for CTSL requirement.

c. Obtain and review data from HRI on the operational performance of Beulah lignite and Lurgi tar oils in the CTSL process. Input data into the MITRE model and adjust kinetic parameters until simulation matches test data.

d. Data on characterization of the raw liquid product will be reviewed and potential refineries will be contacted to determine necessary refining requirements for marketable transportation fuel production.

e. Having modified the hybrid plant simulation model to conform to the site specific situation at Great Plains, MITRE will investigate alternative hybrid configurations to determine the configuration that has the potential to maximize return on investment.

f. Three trips to great Plains will be necessary. A kick-off meeting will review the overall work plan and methodology and all necessary data will be collected and reviewed for completeness. A project progress

review meeting will be held mid-way through the work, and a final meeting will be convened for MITRE to brief the client on the results of the study.

g. The methodology and results of the project will be documented in a brief, concise report.

6. TIMETABLE

DGC will conduct this study as soon as project approval is obtained. The study is expected to take about three months. Early completion of this study is desirable since it could affect the basis of design for the CCT-IV proposal on the CTSL project proposed by HRI and supported by DGC.

7. PERSONNEL

Mr. Donald C. Pollock, Project Development Manager, Dakota Gasification Company.

The program manager for DGC on this project will be Donald Pollock, DGC Project Development Manager. Mr. Pollock has over 37 years of widely varying industrial experience primarily in the petroleum refining and synthetic fuels industry. After graduating from the University of Wisconsin with a degree in Chemical Engineering, he was employed by Chevron in a variety of process engineering, process development and operation supervision positions. He joined ARCO where he held engineering supervision positions working on shale oil, coal mining surface facilities, underground coal gasification and in-situ uranium extraction. Mr. Pollock joined ANG in the early days of plant design and construction and served as the Technical Director of the Great Plains plant during start-up and subsequent operation. When DGC assumed ownership of the plant, he served as Byproduct Development Manager and was instrumental in the design and construction of the phenol and krypton-xenon projects. He currently is Project Development Manager. His wide experience in petroleum and synfuels projects qualifies him to oversee the proposed study.

Dr. David Gray, Principal Engineer and Group Leader, Energy Systems Applications, The MITRE Corporation.

Since obtaining his Ph.D. in 1970 from the University of Southampton, United Kingdom, Dr. Gray has worked in the following energy related positions:

Research Associate to the Director of the Combustion Laboratory Fuel Science Section, Pennsylvania State University. Duties included research into the maximum utilization of coal as an energy source.

Principal Research Officer, Chemical Research Division, National Coal Research Institute of South Africa. Dr. Gray's duties included coordination of research into the production, chemical and physical characterization and upgrading of coal-derived liquids, fuels and petrochemicals. This work was done in close cooperation with SASOL.

Dr. Gray is presently Principal Engineer in the Energy, Resources and Environmental Division and Group Leader of the Energy Systems Applications

Group at The MITRE Corporation, Center for Civil Systems. His duties include the technological, engineering and economic assessments of energy conversion systems for the production of fuels from fossil and alternate energy sources.

Mr. Glen Tomlinson, Staff Engineer, Energy System Applications, The MITRE Corporation.

Mr. Tomlinson's work at MITRE has been principally in the area of establishing R&D requirements and assessing the potential of ongoing R&D in fossil energy. The effort requires detailed technical, economic and environmental performance analysis of the technology and/or facility being evaluated. He also has contributed to a wide range of MITRE study efforts requiring his detailed knowledge of the energy industry and specific knowledge of shale oil, tar sands and heavy oil reserves and processes for recovering the upgrading these types of fossil energy. Most recently, he has participated in studies to assess and recommend research and development related to the conversion of coal to clean specification fuels. Through these studies, Mr. Tomlinson has acquired an indepth knowledge of current and advanced technologies in coal gasification and direct and indirect coal liquefaction.

Mr. Tomlinson received an M.S. in Fluid Mechanics from Pensselaer Polytechnic Institute in 1959. He received a B.S. in Mechanical Engineering from the University of Texas in 1956. Prior to joining MITRE he worked as a private consultant, as Vice President of Sutron Corporation, Director of Energy Analysis Group for TetraTech, President of Hovermarine Corp., Rocketdyne, Convair Division of General Dynamics, and Pratt and Whitney Aircraft.

8. QUALIFICATIONS OF THE APPLICANTS

The MITRE Corporation has been selected by DGC to perform the proposed study of the hybrid coal liquefaction technology at Great Plains. MITRE has been active in the computer modelling of coal liquefaction and coal gasification processes for many years. As a consultant their primary source of funding has come from the Department of Energy. They are under direct contract from Sandia National Laboratories, and their work is supervised by the DOE's Pittsburgh Energy Technical Center. DOE's Fossil Energy Department Technical staff provide oversight and program direction:

Specific references pertaining to pertinent MITRE studies are:

a. Gray, D. and G.C. Tomlinson, *Assessing the Economic Impact of Two-Stage Liquefaction Process Improvements,* Sandia National Laboratories Contractor Report SAND87-7147, August 1988.

b. Gray, D. and G. Tomlinson, *Assessing the Economic Impact of Indirect Liquefaction Process Improvements - Volume I: Development of the Integrated Indirect Liquefaction Model and Baseline Case,* Sandia National Laboratories Contractor Report SAND89-7089, October 1990.

c. D. Gray, G.C. Tomlinson, and A. ElSawy, *The Hybrid Plant Concept: Combining Direct and Indirect Coal Liquefaction Processes,* Sandia

National Laboratories Contract No. 69-8416, Interim Report, Period of Performance: April 4, 1990 - May 31, 1991.

9. BUDGET

The total cost to perform the Hybrid Plant Study by HRI is $120,000.

Contributor	Amount
ND Industrial Commission	$ 60,000
DGC	$ 60,000
	$120,000

10. APPENDICES

None