

# **FINAL PROGRESS REPORT**

**THROUGH SEPTEMBER 2000**

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**DATE:** OCTOBER 2000

**CONTRACT NUMBER:** Research Guidance Studies (DE-AC22-95PC95054)

(This Report does not contain proprietary or patentable information)

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## **ABSTRACT**

This represents the final report of the current contract. The major accomplishments achieved during the execution of this contract fulfilled the deliverables requirements of the contract. Overall the major accomplishments by Task area are summarized below. In Task area 1, Coal Fuels area, the major accomplishments were the preparation of the comprehensive Multi Year Program Plan (MYPP) for the Ultra-Clean Transportation Fuels Initiative (UCTFI) team, updating the complex coal fuels production models from coal including the development of a comprehensive coproduction model. In addition work accomplished included an exhaustive analysis of direct coal liquefaction and coprocessing of coals and heavy oils. Also completed was a comprehensive study on the benefits to the nation of an ultra clean fuels from coal program.

In Task 4 several accomplishments were made. These included modification of the complex gasification models to include capabilities for analysis of petroleum coke gasification in refineries and for the production of hydrogen with and without carbon dioxide sequestration, development of a sound methodology and results to analyze the potential for market penetration of IGCC in several NERC reliability regions of the U.S. and completion and documentation of several studies on coproduction of power and ultra clean fuels.

The major accomplishments in Task 5 included analysis of the options to optimize the value of Alaska North Slope (ANS) natural gas, evaluation of the impact of ceramic membranes on the GTL process, and analysis of the real value of the GTL product.

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## **INTRODUCTION**

The overall objectives of this contract are to provide support to DOE in the following areas: (1) technical and economic analyses of current and future coal-based energy conversion technologies and other similar emerging technologies such as coal-waste coprocessing, natural gas conversion, and biomass conversion technologies for the production of fuels, chemicals and electric power, (2) monitor progress in these technologies with respect to technical, economic, and environmental impact (including climate change), (3) conduct specific and generic project economic and technical feasibility studies based on these technologies, (4) identify long-range R&D areas that have the greatest potential for process improvements, and (5) investigate optimum configurations and associated costs for production of high quality energy products via refining and their performance in end-use applications.

Mitretek has been performing work to achieve several of these above objectives for DOE since 1980. As a result Mitretek has developed specialized and unique databases and spreadsheet simulation models that are quickly and reliably used to evaluate new and emerging fossil energy technologies. More recently, Mitretek has worked closely with other DOE contractors to screen process alternatives and provide preliminary data and information required to set the basis for doing more detailed process studies using commercial process development techniques and software such as Linear Programming (LP) and Aspen Plus. Such preliminary screening saves significant time and money in accomplishing the subsequent, more expensive, detailed process studies. The Mitretek databases and spreadsheet models are continuously checked and updated, as required, with results obtained from the detailed process studies to maintain the validity of the spreadsheet models. In addition to simulating direct and indirect liquefaction systems, these models also include detailed refinery models based on bench-scale upgrading data of coal derived liquid fuels to specification transportation fuels. In addition to the simulation models of actual conversion system configurations, Mitretek is able to simulate innovative process configurations for coal and gas conversion to fuels, power, and chemicals.

To supplement these system models and to provide a context to investigate expected energy use scenarios when alternate coal and natural gas based fuels will be needed, Mitretek's staff has also developed world and country by country energy supply and demand models, including resource limitation considerations. The work to be performed in the current contract will be accomplished by using the existing models where appropriate and by extending and modifying the system models where necessary.

The format for this final contract report gives a brief overview of the overall accomplishments achieved during execution of this contract including a list of reports, presentations, and papers.

## **EXECUTIVE SUMMARY**

In this represents the final report of the current contract, the major accomplishments achieved during the execution of this contract are briefly described. In Task area 1, Coal Fuels area, the major accomplishments were the preparation of the comprehensive Multi Year Program Plan (MYPP) for the Ultra-Clean Transportation Fuels Initiative (UCTFI) team, updating the complex coal fuels production models from coal including the development of a comprehensive coproduction model. In addition work accomplished included an exhaustive analysis of direct coal liquefaction and coprocessing of coals and heavy oils. Also analysis of coal/waste coprocessing and coal solvent extraction were undertaken. Also completed was a comprehensive study on the benefits to the nation of an ultra clean fuels from coal program.

In Task 4 several accomplishments were made. These included modification of the complex gasification models to include capabilities for analysis of petroleum coke gasification in refineries and for the production of hydrogen with and without carbon dioxide sequestration, development of a sound methodology and results to analyze the potential for market penetration of IGCC in several NERC reliability regions of the U.S. and completion and documentation of several studies on coproduction of power and ultra clean fuels.

The major accomplishments in Task 5 included analysis of the options to optimize the value of Alaska North Slope (ANS) natural gas, evaluation of the impact of ceramic membranes on the GTL process, and analysis of the real value of the GTL product.

## **RESULTS AND DISCUSSION**

The following is a list of the major reports, presentations, and papers generated as a result of the execution of this contract.

### **REPORTS, PAPERS AND PRESENTATIONS GENERATED UNDER CONTRACT NUMBER DE-AC22-95PC95054**

#### **Reports:**

(The reports cited here are in addition to the Quarterly Progress Reports required under the deliverables in the contract)

Waste/Coal Coprocessing: A Preliminary Feasibility Study  
Mitre report for US DOE 1995

Evaluation of the West Virginia University (WVU) Coal Extraction Process  
Mitre Report for US DOE 1996

Advanced Waste/Coal Coprocessing: The Concept of Integrating a Waste/Coal Coprocessing Plant with an Existing Refinery, Mitre Report 1996

Opportunities for Early Commercial Deployment of Coal-Derived Transportation Fuels: Configurations and Economics  
Mitretek report for DOE 1996

Rationale and Proposed Strategy for Commercial Deployment of Coal-Derived Transportation Fuels  
Mitretek Report for DOE 1996

Fischer-Tropsch Fuels from Coal and Natural Gas: Carbon Emissions Implications  
Mitretek Report for DOE Aug 1997

Coal/Oil Coprocessing: Integration Opportunities with Existing Petroleum Refineries  
Mitretek Report for DOE Oct 1997

The Importance of Deploying Clean Coal Technology in China  
Mitretek report prepared for US DOE, July 1998.

Preliminary Techno-Economic Analysis of Oxygen, Air, and Ionic Transport Membrane Gas-to-Liquids Systems  
Mitretek Report prepared for U.S. DOE, Jan 1999.

IGCC Market Penetration Study: Northeast US Region  
Mitretek/Consol Final report for DOE March 1999

Ultra-Clean Transportation Fuels for the 21<sup>st</sup> Century  
The Ultra-Clean transportation Fuels Initiative: A Strategic Plan  
Mitretek Report for Fossil Energy, December 1999.

Coproduction: An Update  
Report February 2000

Market potential of Gasification in the U.S. Refining Industry  
Report March 2000

### **Papers and Presentations:**

September 2000: Attendance at the Pittsburgh Coal Conference. Presentation of two papers entitled “Coproduction of Electric Power and High Quality Transportation Fuels in One Facility” and “Potential of Gasification in the U.S. Refining Industry”.

October 1999: Presentation of the paper at the International Pittsburgh Coal Conference entitled “ Market Potential for IGCC for Domestic Power production”.

October 1999: presentation of a paper entitled “ Gas-to-Liquids: Costs, Demand, and Product Value”.

March 2000: Presented a paper at the 25<sup>th</sup> International Technical Conference on Coal Utilization and Fuel Systems in Clearwater, Florida entitled “Potential Market Penetration of IGCC in the North East United States”.

*GTL: Technology, Economics, Risks, and Potential as a Source of Future Clean Transportation Fuels*

Paper prepared for presentation at the 2000 Annual Association of Petroleum Geologists Meeting, New Orleans, April 2000

April 2000: Attendance at the “Gasification for the Future “ Conference held at Noordwijk, The Netherlands, and presentation of a paper entitled “Coproduction of Electric Power and High Quality Transportation Fuels in One Facility”.

April 2000: Presented a paper at the American Association of Petroleum Geologists Annual Meeting held in New Orleans entitled “ GTL: Technology, Economics, Risks, and Potential as a Source of Future Clean Transportation Fuels”.

April 2000: Presentation of paper entitled “ Market Potential of Gasification in the U.S. Refining Industry” at the Gasification technologies Council Spring Meeting in Williamsburg, Virginia.

Potential Market penetration of IGCC in the Northeast United States  
Paper prepared for presentation at the 25<sup>th</sup> International Technical Conference on Coal Utilization and fuel Systems, Florida, March 2000

Gas-to-Liquids: Costs, Demand, and Product Value  
Paper prepared for publication in Oil and Gas Journal  
February 2000

*Coproduction: An Option for Clean Energy Systems of the Future*  
Paper presented at the National Research Council Committee on R&D Opportunities for Advanced Fossil-Fueled Energy Complexes, June 1999

*Fischer-Tropsch Gas Conversion Process Fundamentals- A Technical Overview*  
Paper presented at the Society of Petroleum Engineers 69<sup>th</sup> Annual Western Regional Meeting, Anchorage, Alaska, May 1999

*Dispatch Considerations for IGCC and GCC Power Systems*  
Paper presented at the Gasification Technologies Council Spring Meeting, Washington DC, April 1999

*Hydroconversion of Coal to Liquid Transportation Fuels: Is This Still a Relevant Technology?* Paper presented at the US/Japan Joint technical Workshop, Rocky Gap, Maryland, March 1999.

*Coproducing Power and Liquid transportation Fuels from Domestic Resources using IGCC*, paper presented at the US/Japan Joint Technical Workshop Rocky Gap, Maryland, March 1999.

*Carbon Dioxide Emissions from Fischer-Tropsch Fuels*, paper presented at the Energy Frontiers International (EFI) Conference on Fuels and Engines, Tucson, Arizona, Jan 1999.

*Natural Gas to Ultra Clean Liquid Transportation Fuels*, paper presented at the SMI Gas-to- Liquids: Clean Fuels Strategy Conference, London UK, Nov 1998

*The Potential for Advanced Coal Conversion Processes in China*, paper presented at the Asia Pacific Economic Council (APEC) Meeting on Clean Fossil Energy, Okinawa, Japan, October 1998.

*Coproduction of Electric Power and Ultra-clean Transportation Fuels at the Polk Power Station*, scoping study prepared for DOE Oct 1998

*The Benefits of Coproducing Power and Fuels from IGCC Facilities*, paper presented at the Pittsburgh International Coal Conference, Sept 1998.

*Economic and Environmental Benefits of Coproducing Power and Fuels from Domestic Resources using IGCC*, Paper prepared for the proceedings of the Advanced Coal-Based Power and Environmental Systems '98 Conference, FETC, Morgantown July, 1998

*A Novel Configuration for Coproducing Transportation Fuels and Power from Coal and Natural Gas* paper presented at the 23<sup>rd</sup> International Technical Conference on Coal Utilization and Fuel Systems, Clearwater Florida, March 1998.

*A Primer on Indirect Liquefaction Technology*, paper presented at the 23<sup>rd</sup> International Technical Conference on Coal Utilization and Fuel Systems, Clearwater Florida, March 1998.

*Gas-to-Liquids: The Opportunities, Technologies, and Issues*, paper presented at the Gas-To-Liquids Processing Conference, San Antonio, Texas, March 1998.

*Integration Opportunities for Coal/Oil Coprocessing with Existing Petroleum Refineries*, paper presented at the Coal Liquefaction and Solid Fuels Contractors' Review Conference, Pittsburgh PA, Sept 1997.

*A Novel Configuration for Coproducing Fischer-Tropsch Fuels and Electric Power from Coal and Natural Gas*, paper presented at the Coal Liquefaction and Solid Fuels Contractors' Review Conference, Pittsburgh PA, Sept 1997.

*Opportunities for Early Commercial Deployment of Indirect Liquefaction*, presented at the American Chemical Society National meeting in San Francisco, Ca. April 1997.

*Economics and Incentives for a Direct Liquefaction Pioneer Plant*, paper presented at the US/Japan Joint Technical Workshop, State College, PA, Oct 1996.

*Incentives for the Commercialization of Direct Coal Liquefaction Technologies*, paper presented at the First Joint Power and Fuel Systems Contractors' Conference, Pittsburgh PA, July 1996.

*Incentives for the Commercialization of Indirect Coal Liquefaction Technologies*, presented at the First Joint Power and Fuel Systems Contractors' Conference, Pittsburgh PA, July 1996.

*Preliminary Techno-Economic Assessment of Coproduction/IGCC Merchant Facility*, briefing given to East Kentucky Power Company and State of Kentucky, January 1996.

Techno-economic assessment of Integrating a Waste/Coal Coprocessing Facility with an Existing Oil Refinery, *paper presented at the 9<sup>th</sup> Annual CFFLS Technical Meeting August 1995 Pipestem WV.*

## **CONCLUSIONS**

An overview of the major accomplishments and documentation resulting from execution of this contract has been provided in this final report. All the requirements were met and the contract has provided valuable support to NETL and DOE in the areas of coal fuels and chemicals, advanced power and gasification technologies, and gas-to-liquids technologies.

Details of the analysis undertaken and on the contents of these various reports, presentations, and papers can be found in the individual monthly progress reports and in the quarterly progress reports for this entire contract period.