

QUARTERLY PROGRESS REPORT

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ABSTRACT

During this quarter, in task area 1, work was performed on three separate areas of activity. These were 1) review of the proposed and final EPA Tier 2 regulations, 2) assistance in preparation of an ultra-clean transportation fuels report for the deputy assistant secretary for Fossil Energy, 3) preparation of a detailed trip report from attending the Clean Fuels 2000 conference in San Diego. In task area 4, three activities were undertaken: an update of coproduction, an analysis of the potential for gasification of petroleum coke in U.S. refineries, and preparation and presentation of a paper at the Coal Utilization and Fuel Systems conference in Clearwater. In task area 5, a presentation was prepared for the American Association of Petroleum Geologists (AAPG) Annual Convention to be held in New Orleans in April. This presentation was an overview of GTL technology including the current costs and product values. In addition the potential risks of the technology were addressed and the potential contribution of GTL products to the future world fuel market was discussed.

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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 contract was modified to include two additional tasks. These were: Task 4 entitled "Advanced Power Systems, Integrated Gasification Combined Cycle (IGCC)", and Task 5 entitled "Gas-to Liquids (GTL) Technology Assessment".

The format for this quarterly describes the activities for this period by task as far as is possible, but there is considerable overlap and integration among the three programs of coal fuels, IGCC, and GTL. This integration is perfectly logical because of the overlap of several of the enabling technologies within the three programs. For example, advanced synthesis gas preparation is the common element in all three programs. In coal fuels and IGCC, the feed is coal, in the GTL program the feed is natural gas. Also, advanced synthesis gas conversion is common to the coal fuels and GTL programs. Coproduction of ultra-clean transportation fuels and electric power is another area of integration between the coal fuels and the IGCC programs. In those instances where the activities describe these integrated program efforts, the activity write up is found in either one of the integrated task areas.

EXECUTIVE SUMMARY

Under Task 1 the major activities during this quarter were as follows. These were 1) review of the proposed and final EPA Tier 2 regulations, 2) assistance in preparation of an ultra-clean transportation fuels report for the deputy assistant secretary for Fossil Energy, 3) preparation of a detailed trip report from attending the Clean Fuels 2000 conference in San Diego. The effort concentrated on summarizing the overall Tier 2 regulations and assistance in the preparation of the writing of the Multi Year Program Plan (MYPP) for the Ultra-Clean Transportation Fuels Initiative (UCTFI) team. The purpose of this MYPP is to guide the UCTFI program and to act as an outreach document to explain the scope of the program to both industry and to other government offices.

Under task area **4**, three activities were undertaken. These were an update of coproduction, an analysis of the potential for gasification of petroleum coke in U.S. refineries, and preparation and presentation of a paper at the Coal Utilization and Fuel Systems conference in Clearwater. A study to assess the potential of using petroleum coke in U.S. refineries as a feed to produce a variety of products including hydrogen, electric power, and F-T fuels is being conducted for NETL. Preliminary results indicate that pet coke would be an ideal feedstock for hydrogen production, especially if natural gas prices are \$3/MMBtu or higher.

For Task 5, a presentation was prepared for the American Association of Petroleum Geologists (AAPG) Annual Convention to be held in New Orleans in April. This presentation was an overview of GTL technology including the current costs and a methodology to estimate the value of the GTL products.

RESULTS AND DISCUSSION

2.1) Task 1: Research Guidance Studies-Coal-Derived Fuels, Overview of Technical Activities:

During this quarter, work was performed on three separate areas of activity. These were 1) review of the proposed and final EPA Tier 2 regulations, 2) assistance in preparation of an ultra-clean transportation fuels report for the deputy assistant secretary for Fossil Energy, 3) preparation of a detailed trip report from attending the Clean Fuels 2000 conference in San Diego.

DOE requested that a review of the EPA Tier 2 regulations be undertaken to clarify the differences between the Notice of Proposed Rulemaking (NPRM) of 13 May 1999 and Notice of Final Rulemaking (NFRM) 21 December 1999. Both the NPRM and the NFRM documents were reviewed and summarized and the differences between the two were highlighted. An overview summary of this report is appended.

Mitretek assisted in the preparation of a draft document describing the Ultra-Clean Transportation Fuels Program. This document was requested by the Deputy Assistant Secretary of FE and was required to follow a strict format. Mitretek worked with a team from DOE and ANL to complete this draft document.

Mitretek personnel attended the Clean Fuels 2000 conference in San Diego on February 8-9. This conference included topics on low sulfur fuels production, future new fuels regulations, engine performance on new fuels, economics, exhaust aftertreatment systems, the effect of the MTBE ban, and alternative fuels. Because of the importance and relevance of these topics to the Task 1 work program in ultra-clean fuels, a detailed trip report was compiled to disseminate the salient information from this meeting to DOE.

2.2) Task 4: Gasification Technologies:

During this quarter, three activities were undertaken in this Task area: an update of coproduction, an analysis of the potential for gasification of petroleum coke in U.S. refineries, and preparation and presentation of a paper at the Coal Utilization and Fuel Systems conference in Clearwater.

The U.S. Department of Energy and Mitretek Systems have investigated the concept of producing both electric power and ultra-clean liquid transportation fuels at a single Integrated Gasification Combined Cycle (IGCC) facility in prior studies. This coproduction concept, as analyzed in conceptual simulation studies to date, essentially consists of placing a slurry-phase Fischer-Tropsch (F-T) reactor between the coal gasification section and the combined cycle block of an IGCC facility. In these prior studies of this concept, it has been shown that there are several performance and

economic advantages compared to a simple IGCC facility that produces only electric power.

Since Mitretek's original conceptual analyses of these coproduction plants, Parsons has produced a comprehensive report for the U.S. DOE that documents the expected performance and economics of several coal-fired systems including IGCC. DOE requested that Mitretek update its prior coproduction analyses to be consistent with the Parsons performance and cost data for advanced IGCC facilities. Two coproduction configurations have been investigated in this updated study. In the first, both coal and natural gas are used as feedstocks to produce both electric power and F-T liquid fuels (the CoCo concept). This configuration is referred to as a coproduction/cofeed facility or CoCo. In the second, only coal is the feedstock, and coal-derived synthesis gas is used both for production of F-T liquid fuels and for production of power. The report currently under preparation documents this update and includes analyses of both the coal-only and CoCo coproduction configurations. Details of the report will be given in the next QPR.

The highlights of the results of this updated study were used as the basis for the presentation at the Gasification for the Future Conference to be held in Noordwijk, The Netherlands in April.

The National Energy Technology Laboratory (NETL) requested that Mitretek undertake a study to assess the potential of using petroleum coke in U.S. refineries as a feed to produce a variety of products including hydrogen, electric power, and F-T fuels. The approach taken was to identify those U.S. refineries that currently produce enough coke to warrant gasification facilities. Assumptions were then made to estimate the likely petroleum coke situation in 2010. This year was chosen to allow sufficient time for construction of coke gasification facilities and because, by that time, it is expected that refineries will be required to produce fuels with sulfur contents of below 30 ppm. Then a macroscopic approach was used to estimate the economic impact of large-scale coke gasification in all U.S. refineries having over 1000 tons per day of coke production. Several scenarios were investigated including production of combinations of hydrogen, power, and F-T liquids. This approach identified the preferred product combinations in terms of those yielding the shortest payback periods. The final approach in this analysis was to analyze coke utilization at the single plant level in one refinery. Again several product combinations were investigated and the plant return on equity was estimated for each of the combinations. The results of this analysis are currently being documented in a report. Details of this will be given in the next QPR

A presentation to the 25th International Technical Conference on Coal Utilization and Fuel Systems held in Clearwater, Florida, March 6-9, 2000 was prepared.

2.3) Task 5: Gas to Liquids Technologies:

During this quarter, a presentation was prepared for the American Association of Petroleum Geologists (AAPG) Annual Convention to be held in New Orleans in April. This presentation was an overview of GTL technology including the current costs and

product values. In addition the potential risks of the technology were addressed and the potential contribution of GTL products to the future world fuel market was discussed.

CONCLUSIONS

The major conclusions from the work performed during this quarter relate to the potential for coproduction of clean fuels and power and the use of petroleum coke gasification in the U.S. refining industry for producing hydrogen, power, and ultra clean liquid fuels as blending stocks. In addition, a detailed review of the proposed and final EPA Tier 2 regulations was prepared and preparation of an ultra-clean transportation fuels report for the deputy assistant secretary for Fossil Energy was continued. This Multi Year Program Plan (MYPP) for the Ultra-Clean Transportation Fuels Initiative (UCTFI) team is designed to guide the UCTFI program and to act as an outreach document to explain the scope of the program to both industry and to other government offices.

The update of coproduction demonstrated the potential importance of this technological approach by reducing the cost of both electricity and power and increasing the overall plant efficiency. The analysis of the potential for gasification of petroleum coke in U.S. refineries also showed the importance of the DOE gasification program in helping to get these technologies deployed in a timely manner. Preliminary results indicate that pet coke would be an ideal feedstock for hydrogen production, especially if natural gas prices are \$3/MMBtu or higher. Coproduction is clearly a relevant technology and worthy of a continuing DOE funded R&D program.

In the GTL area, a presentation was prepared for the American Association of Petroleum Geologists (AAPG) Annual Convention to be held in New Orleans in April. This presentation was an overview of GTL technology including the current costs and a methodology to estimate the value of the GTL products.

MEETINGS AND OTHER ACTIVITIES:

February 8-9: Attendance at the Clean Fuels 2000 Conference in San Diego, CA.

March 7-9: Presented a paper at the 25th International Technical Conference on Coal Utilization and Fuel Systems in Clearwater, Florida entitled "Potential Market Penetration of IGCC in the North East United States".

APPENDIX

Environmental Protection Agency (EPA)

Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements

Overview of major differences between the Notice of Proposed Rulemaking (NPRM) of 13 May 1999 and Notice of Final Rulemaking (NFRM) 21 December 1999.

Summary:

The major differences between the NPRM and the NFRM can be summarized as follows:

- The final program is very similar to the proposed program in all major aspects, where adjustments have been made they have been done, according to EPA, in ways that improve the implementation without impairing the overall environmental benefits.
- The final rule includes provisions to regulate heavy-duty passenger vehicles primarily sports utility vehicles (SUVs) of less than 10,000 pounds GVWR (vehicle weight plus rated cargo capacity). These were not included in the NPRM. These heavier vehicles are called medium duty passenger vehicles (MDPVs).
- The final rule Tier 2 bin structure is different from the proposed rule. There are 8 bins instead of the 7 in the NPRM. Two additional bins will be available only during the interim program. There is also an additional bin for MDPVs. EPA believes the extra bins will help manufacturers comply with the 0.07 grams/mile NO_x standard. The two higher bins will provide extra flexibility during the phase in years and will terminate after the standards are fully in place leaving only the eight bins for the duration of the Tier 2 program. This final bin structure replaces the interim bins that were proposed in the NPRM.
- The phase-in schedule for the final Tier 2 standards for both the light duty vehicles (LDVs) and heavy light duty trucks (HLDTs) are the same as proposed in the NPRM. Interim vehicles will certify to the same bins as Tier 2 vehicles, since, in the final rule, EPA has merged the tables of bins originally in the NPRM for simplicity and added a few extra bins.
- To encourage introduction of cleaner vehicles EPA will allow manufacturers to weight LDVs certified to the lowest two bins more heavily when calculating their

fleet average NO_x emissions. Under this provision, which applies through 2005, manufacturers may apply a multiplier of 1.5 to vehicles certified in bin 2 and a multiplier of 2 for vehicles in bin 1.

- For sulfur control in gasoline overall the final program is similar to the proposed program. However, there are changes from the NPRM. EPA has changed the per gallon cap establishing a 300 ppm cap for 2004 and 2005 rather than the proposed cap of 180 ppm in 2005. The refinery average 30-ppm standard has been delayed one year and now goes into effect in 2005 rather than in 2004. EPA is encouraging early introduction of cleaner fuel (by 2000) into the marketplace through an early sulfur credit and allotment program. A geographic phase-in of standards has been allowed to permit refiners in certain parts of the country more flexibility in complying with the standards; and changes have been made to the sulfur baseline requirement and the credit trigger to help the functioning of the sulfur banking and trading program.
- EPA continues to be aware of the difficulties and challenges that diesel vehicles will have in complying with Tier 2 standards. Based on the responses received from the Advanced Notice of Proposed Rulemaking (ANPRM) issued in May 1999, EPA anticipates issuing a NPRM to reduce sulfur in diesel fuel in the spring of 2000 followed by a final rule in late 2000. The goal is to have low sulfur diesel fuel available that will allow diesel-powered vehicle to meet the Tier 2 standards within the final bin structure by the time Tier 2 standards are required by the entire fleet.
- The NFRM does mention the potential requirement for very low sulfur fuels (5 ppm or less) in the context of these fuels being needed for fuel cells in the future. Fuel cell technology is extremely sensitive to fuel sulfur poisoning. If fuel cells are to be a viable option and are to be fueled with liquid hydrocarbon fuels, then ultra low sulfur liquid fuels will be necessary sometime in the future.