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Quarterly Progress Report

Quarterly Report
April 1 - June 30, 1998

By:
David Gray
Glen Tomlinson

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For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
MITRETEK
7525 Colshire Drive
McLean, Virginia 22102

Disclaimer

Section 1: Introduction and Background

The Federal Energy Technology Center (FETC) at Pittsburgh contracted with the MITRE Corporation to perform Research Guidance Studies that will assist the Center and other relevant offices in the Department of Energy in evaluating and prioritizing research in the areas of coal and natural gas conversion. MITRE was reorganized in December 1995, which resulted in the formation of Mitretek Systems Inc. Mitretek has been performing this work on MITRE's behalf awaiting completion of contract novation to Mitretek. The contract was novated in February 1998 to Mitretek Systems.

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.

During the prior reporting period (January to March 1998), 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 an effort within Fossil Energy to integrate 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. 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.

Section 2 Project Activity Summary

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

During this quarter, work was performed in two areas of Task 1. In the first of these, an analysis of the potential employment generated as a result of deployment of a synfuels from coal industry was conducted. In the second study under task 1, Mitretek investigated the potential impact of alternative liquid fuel sources on the world oil price (WOP). This study is part of a larger study to develop a strategic plan for the Coal Fuels program. As part of this strategic plan, a convincing and credible rationale has to be developed that clearly shows the necessity of a program whose goal is to provide alternative transportation fuels from domestic coal resources.

Summarizing the results of the employment potential analysis, Figure 1 shows a ramp-up profile for the deployment of synthetic fuels plants. It is assumed that deployment results by first constructing three pioneer plants each of 10,000 BPD capacity. The first pioneer plant comes on-line in 2006 followed by the second in 2007 and the third in 2008. The first entrance plant of 20,000 BPD starts operation in 2009, followed by a second entrance plant of 20,000 BPD in 2010. Deployment of commercial plants follow with five (5) 50,000 BPD plants coming on-line in the consecutive years from 2011 to 2015. In 2016 a commercial plant of 80,000 BPD begins operation followed by 6 larger

100,000 BPD plants coming on-line from 2017 to 2020. The total production of synthetics from these 17 plants is 1 million BPD by 2020.

Figure 2 shows a summary of the employment resulting from this ramp-up of synthetic plants. Four employment categories are shown. Total employment is the sum of total construction, total operation, and total mining. "Total" means the sum of the direct and indirect labor that make up the category. Direct labor is defined as those jobs created directly as a result of the activity. In construction and operation, for example, it refers to those jobs directly related to the construction and operation of the plants. In mining, it refers to jobs resulting directly from the production of the coal through mining operations. Indirect jobs are those created by a ripple effect or a multiplier effect through the rest of the economy as a result of this direct employment.

Considering the **construction** labor category. This analysis uses the Bechtel baseline study[1] to determine the construction labor man-hours per million dollars of plant capital investment. For an Nth plant, 9,650 man-hours per million dollars of investment is used based on the direct and sub-contractor capital costs used in the Bechtel study. Assuming $40,000 per daily barrel for the capital investment of the synthetics plants, construction labor peaks at about 43,000 in 2017. Indirect construction labor was estimated from an Input-Output analysis conducted by E.A. Muellar in 1993.[2] Using the Muellar ratio of 1.549, indirect employment resulting from the direct labor in construction peaks at 66,400 in 2017. Total direct and indirect employment as a result of this construction activity will peak in 2017 at about 109,000 jobs.

A similar analyses can be performed for the operating labor category. In the Bechtel baseline design report[1], direct operating labor was estimated to be 1200 people for a nominal 70,000 BPD plant. This is equivalent to 850 jobs for a 50,000 BPD plant, and smaller plants are prorated based on output. Using this assumption, direct operating labor would build up to a level maximum of 17,000 jobs by 2020. Indirect operating labor was calculated from the Muellar report using an indirect to direct ratio of 3.045. Indirect operating labor will also rise to a level maximum by 2020 of 51,700 jobs, for a total operating labor force of 68,700 jobs.

Employment in coal mining was estimated by assuming an average current productivity of 0.2 man-hours per ton of coal mined[3]. With this assumption, direct mining jobs steadily rise to a level maximum of 14,600 jobs by 2020. The ratio of indirect to direct mining jobs was assumed to be 11 times, based on a report by Rose and Frias of Penn State University[4]. Indirect mining jobs increase to a level of 161,000 by 2020. Total mining jobs peak in 2020 to 176,000 in 2020. A summary of these labor categories by year is shown in Table 1.

Deployment of a synthetics industry that produces 1 million BPD of fuels would therefore result in the creation of jobs equal to the sum of total construction, operating, and mining. This total at the peak of construction would be more than 305,000 jobs in

2018, leveling off to a total of 245,000 jobs by 2021 when plant construction is completed.

Summarizing the preliminary results of the study to assess the potential impact of an alternative fuels supply on the WOP, the elasticity of the WOP to petroleum supply was analyzed from data in the Energy Information Administration Annual Energy Outlook (EIA AEO '98). Table 2 shows EIA projections of world oil production in million barrels per day (MMBPD) and WOP in $ per barrel. Figure 3 shows the elasticity plot of supply versus WOP based on this data for the year 2015. The additional availability of 1 million BPD of oil effects the WOP by $1.12 per barrel. Similarly, a deficit of 1 million BPD increases the WOP by $1.12 per barrel. This supply/demand elasticity determines the WOP. Currently with supply of oil exceeding world demand by over 2 MMBPD, the WOP is at a very low level. When this excess supply surplus is mopped up by demand in the future, the WOP will strengthen and increase.

This elasticity relationship allows us to estimate the impact of supplying a synthetic or alternative supply of liquid fuels from the liquefaction of coal. Assuming the ramp-up of synthetics production as shown in Figure 1, we can calculate the oil cost savings to the consumer that results from this production of synthetics. This is shown in Figure 4. The cumulative oil cost savings is shown as increasing from essentially zero in the year 2010 where synthetics production is just starting to over $40 billion by the year 2020. This oil cost savings is the result of the lowering of the WOP by supplying synthetics to the market over this period. However, synthetics are never competitive with the WOP in this reference EIA scenario until after 2020 (see Table 2). Therefore a subsidy must be given to the synthetics producers so that they can produce them competitively. In this analysis, it is assumed that the cost of production for the synthetics is $27 per barrel and the subsidy is the difference between the WOP and $27 per barrel. The cumulative subsidy by 2020 is about $10 billion. Therefore the net gain to the consumers, as a result of supplying synthetics and suppressing the WOP, amounts to a positive gain of over $30 billion. This is true for even the low EIA oil price scenario. This is shown in Figure 5 where the net gains to the consumer are plotted for all three EIA WOP scenarios.

This analysis is being continued as part of the rationale and strategy document being prepared for the Coal-Fuels program.

2.2) Task 4: Advanced Power Systems, Integrated Gasification Combined Cycle:

During this quarter, work was performed in three areas of task 4. These areas were: continuation of the analysis of the IGCC baseline case and improvement options, preparation of a briefing on the benefits of coproduction of power and fuels using IGCC facilities, and development of a work outline for the IGCC market penetration study.

We have carefully reviewed the configurations described in the April 1998 report entitled *Texaco Gasifier IGCC Base Cases* (PED-IGC-98-001) and compared them to our own simulations of similar cases as shown in Table 3 . The results of the Texaco Radiant

Heat Recovery configuration (Case 2) and Radiant Heat Recovery and Hot Gas Cleanup (Case 3) are virtually identical to our own analysis of these configurations. Our results for the Case 2 analysis were presented in our last quarterly before the EGG results were available to us. We thus conclude that our process simulations are more than adequate for evaluation and optimizations of advanced technologies, cycle innovations, R&D goals, etc. Our estimates of construction costs are similar to the EEG analysis, but there are still differences in the manner in which the components are grouped for cost analysis.

The main problem remaining is arriving at an appropriate standard for determining the cost of power. The EEG report computes levelized costs using guidelines recommended by EPRI in 1984. Levelized costs are intimately associated with a regulated price structure, and are less useful in the coming deregulated environment. As a part of our market study, we are currently working with CONSOL and power producers to gain an understanding of the type of analysis and financial assumptions potential buyers of IGCC system would find most useful. This effort will be carefully coordinated with FETC as it evolves.

A briefing was prepared for the IGCC program manager for presentation at the Tennessee Valley Authority (TVA). A copy of the briefing slides is appended (see Appendix 1).

Mitretek is conducting an IGCC market penetration study for the IGCC program. The overall objective of this study is to provide the necessary information, rationale, and framework so that the client can develop a strategic and defensible marketing plan for commercial deployment of IGCC technologies in the U.S. and overseas. Specifically this study will attempt to estimate the market potential of IGCC between now and the year 2020 in power generation, coproduct applications, and niche markets.

In order to more produce a more credible market study, it was decided to undertake this study with direct participation with industrial companies involved in projections of the future of coal-based technologies. To this end, Mitretek, with agreement from DOE, prepared to subcontract the coal company CONSOL to assist in this study. CONSOL has already been involved in similar market assessment studies with the Coal Utilization Research Council (CURC). Also, to obtain input from companies directly working in the gasification arena, Mitretek joined the Gasification Technologies Council (GTC). We believe that a strong endorsement from industry is critical to developing a credible market analysis for IGCC technology.

The outline for the IGCC market penetration study is appended in Appendix 2.

2.3) Task 5: Gas-to-Liquids Technology Assessment:

During this quarter, DOE initiated a product team to investigate the potential for a greater degree of integration between the activities in the Coal-Fuels and Gas-to-Liquids (GTL) programs. Mitretek was part of this product team and attended several meetings in

which a strategic planning approach to this integration was developed. The summary of the strategic planning meetings is given in Appendix 3.

The technical configurational analyses of GTL plants using both oxygen and air blown reforming has been started. Several configurations are currently being analyzed in order to optimize the technical and economic performance. The results of these analyses and of configurations utilizing the Ion Transport Membrane (ITM) system will be reported in the next quarterly progress report.

Meetings and other activities:

April 14/15: Energy Frontiers International (EFI) meeting on Climate Change, Washington DC
April 22: Meeting at DOE HQ on Level II briefing of Coal-Fuels/IGCC program
April 28-31: 6th Clean Coal Technology Conference, Reno, Nevada
May 4: Meeting with IGCC product team FETC, Pittsburgh to discuss IGCC market penetration study
May 5: Meeting with CONSOL, Pittsburgh to discuss potential subcontract on market penetration study
May11/12: Meetings with David Scott of the International Energy Agency (IEA) to discuss their draft report entitled " Competitiveness of future coal-fired units in different countries" authored by David Scott and Per-Axel Nilsson. This meeting was arranged by the GTC.
June 10: Meeting of the Energy Efficiency Forum, Washington DC on Energy Efficiency and Climate Change. A summary of this meeting is provided in Appendix 4.
June 24/25: Meetings at FETC Pittsburgh to develop Coal-Fuels/GTL strategy. (see Appendix 3)

References:

1) Direct Coal Liquefaction Baseline Design and System Analysis. Final report on Baseline and Improved Baseline, Volume IV, Capital Cost and Economics for Baseline. Report prepared for the U.S. DOE by Bechtel and Amoco under contract DEAC22-90PC89857, March 1993.
2) The Analysis of Scenario Options for the Development of U.S. Coal Derived Fuels Production Capability. Report prepared for the U.S. DOE by E.A. Muellar Associates under contract DE-AC01-A8FE61661, 1993.
3) Personal communication with Dr. Francis Burke, Vice President of Research and Development, CONSOL, Pittsburgh, June 1998.
4) Rose, Adam, and Oscar Frias, The Impact of Coal on the U.S. Economy, report prepared for the National Coal Association, April 1994.

TABLES

TABLE 1: EMPLOYMENT BY LABOR CATEGORY

YEAR	2005	2010	2015	2020	2025
DIRECT CONSTRUCTION	1,072	4,289	10,722	21,444	0
INDIRECT CONSTRUCTION	1661	6,644	16,608	33,217	0
DIRECT OPERATION		1,190	5,440	17,000	17,000
INDIRECT OPERATION		3,624	16,565	51,765	51,765
DIRECT MINING		1,027	4,693	14,667	14,667
INDIRECT MINING		11,297	51,623	161,337	161,337
TOTAL	2,733	28,070	105,651	299,430	244,769

TABLE 2
WORLD OIL PRODUCTION
EIA PROJECTIONS

			2010			
	REF(IEO)	REF(AEO)	HIGH(IEO)	HIGH(AEO)	LOW(IEO)	LOW(AEO)
OPEC	**40.60**	48.19	**35.30**	42.96	**48.80**	56.29
NON-OPEC	**54.90**	48.40	**56.70**	49.97	**52.50**	46.10
WORLD	**95.50**	96.59	**92.00**	92.93	**101.30**	102.39
WOP$/BBL	**20.81**	20.81	**26.97**	26.87	**14.44**	14.44
			2015			
	REF(IEO)	REF(AEO)	HIGH(IEO)	HIGH(AEO)	LOW(IEO)	LOW(AEO)
OPEC	**49.90**	56.40	**42.60**	49.12	**60.30**	66.60
NON-OPEC	**55.20**	49.51	**57.60**	51.80	**52.50**	46.99
WORLD	**105.10**	105.91	**100.20**	100.92	**112.80**	113.59
WOP$/BBL	**21.48**	21.48	**28.59**	28.59	**14.42**	14.43
			2020			
OPEC	**60.50**	65.98	**52.50**	58.08	**73.00**	78.32
NON-OPEC	**55.40**	50.36	**57.80**	52.58	**52.50**	47.65
WORLD	**115.90**	116.34	**110.30**	110.66	**125.50**	125.97
WOP$/BBL	**22.32**	22.32	**28.71**	28.71	**14.43**	14.43

Table 3: Comparison of Mitretek and EG&G Simulation Results

Configuration	Texaco Quench		Case 2 Texaco RHR		Case 3 TexRHR, HGC	
Analysis	EGG	Mitretek	EGG	Mitretek	EGG	Mitretek
Coal. Tons/day Dry	3,010	3,010	2,951	3,010	2,740	2,741
Gasifier Efficiency		75.45%		75.42%		75.21%
Gas Turb Power,MW	272.7	272.8	272.5	272.7	271.2	277.2
Steam Power MW	155.9	155.8	192.4	191.8	184.9	175.1
System Power Req	45.9	45.0	54.5	45.9	49.2	45.8
Net Power, MW	382.7	383.6	410.4	418.6	406.9	406.5
System Effic. HHV	39.60%	39.6%	43.40%	43.39%	46.30%	46.26%

FIGURES

Figure 1: Synthetics Ramp-up to 1 Million BPD by 2020

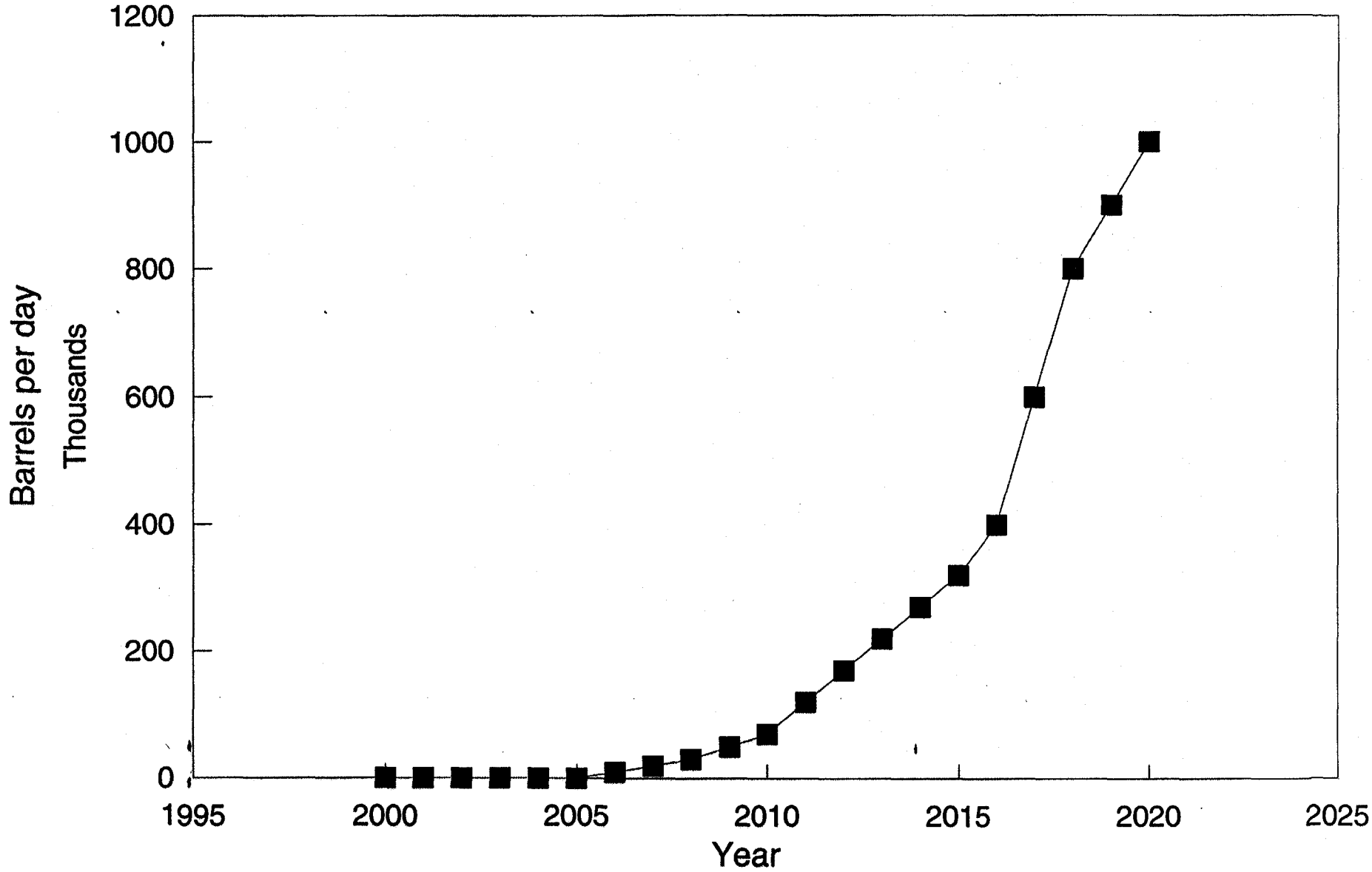
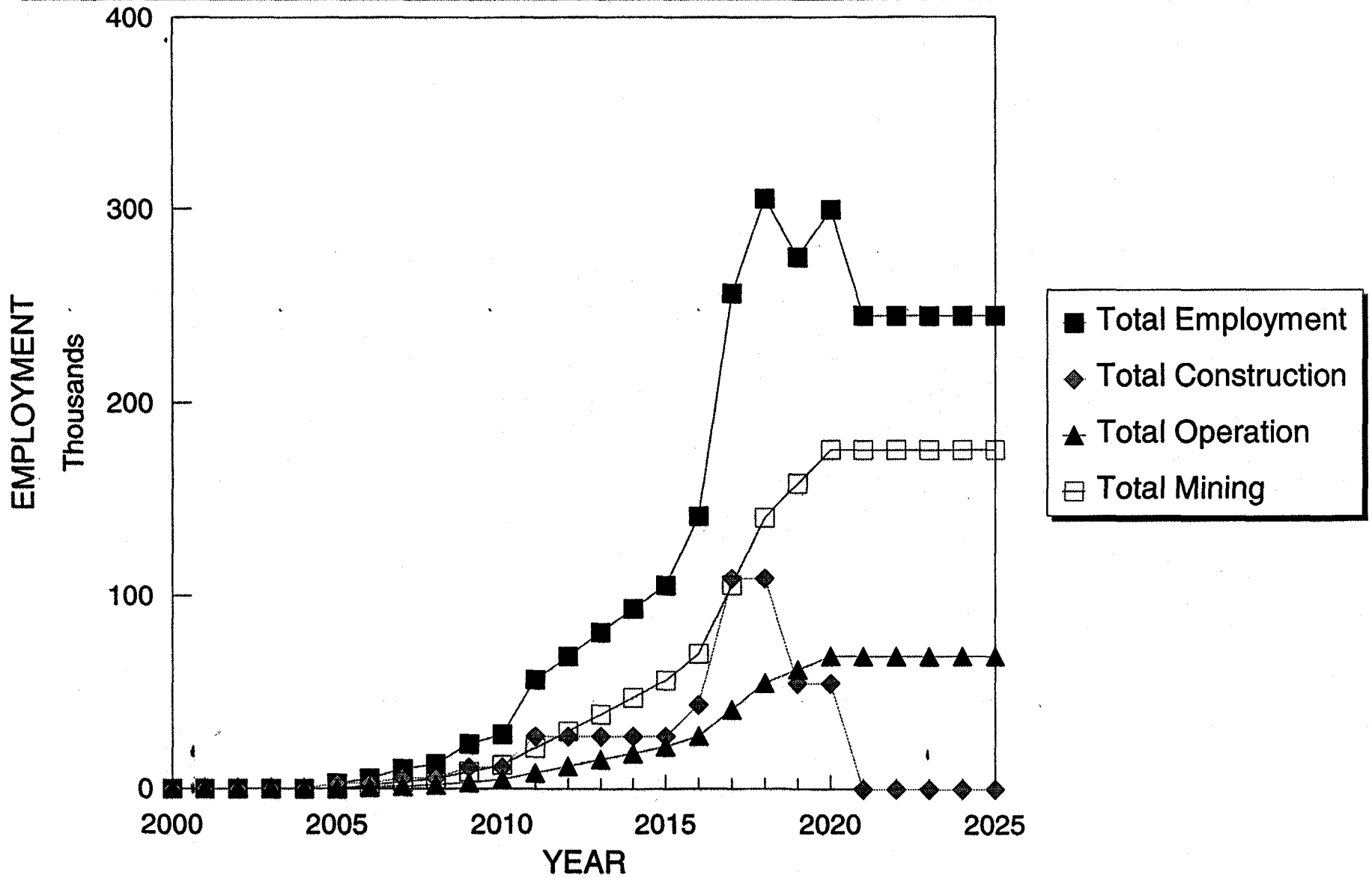


Figure 2: EMPLOYMENT GENERATED AS A RESULT OF SYNFUELS INDUSTRY
1 MILLION BARRELS PER DAY BY 2020



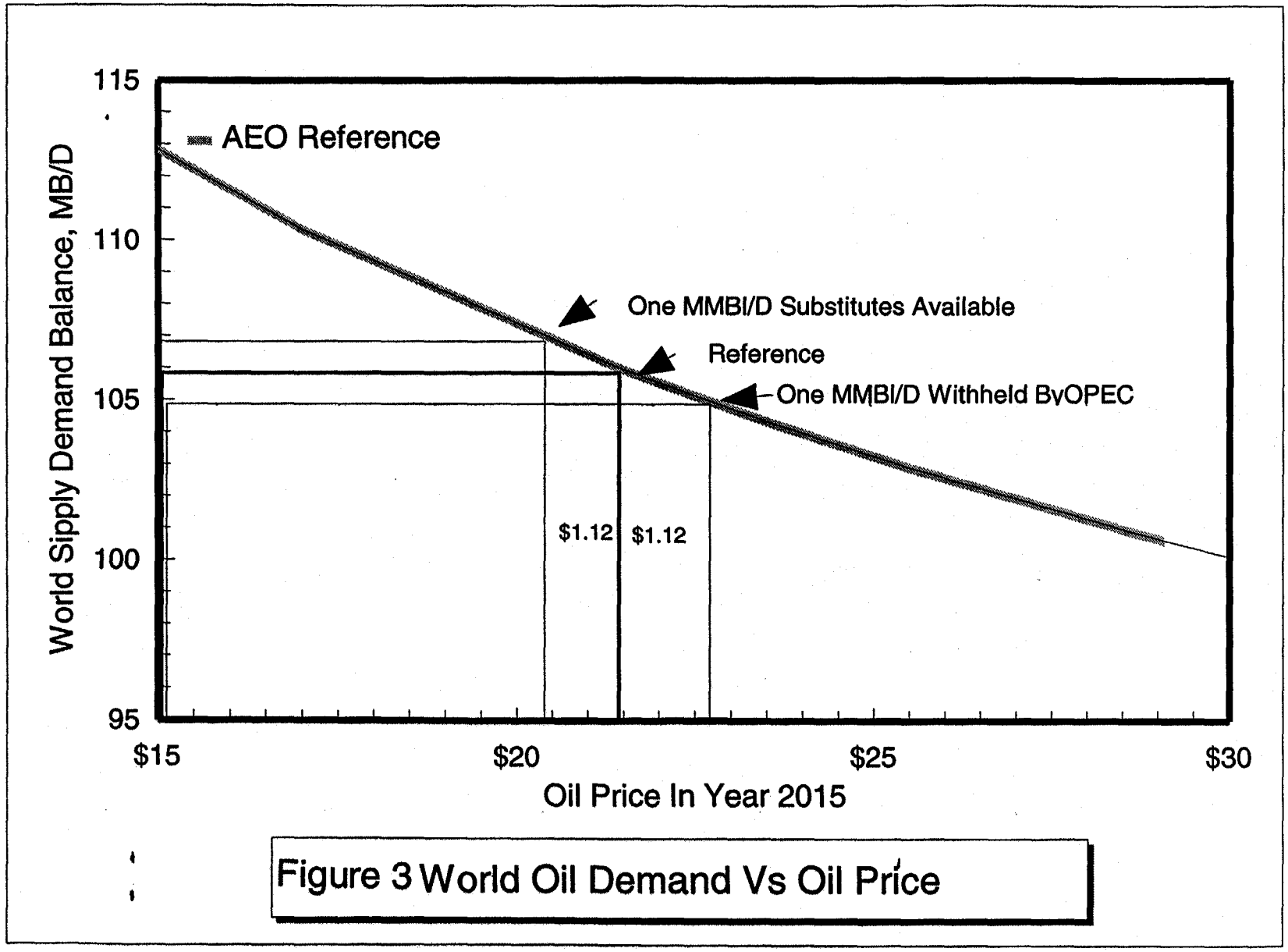


Figure 3 World Oil Demand Vs Oil Price

Figure 4: Synthetics Program Cost/Benefit
EIA Reference WOP

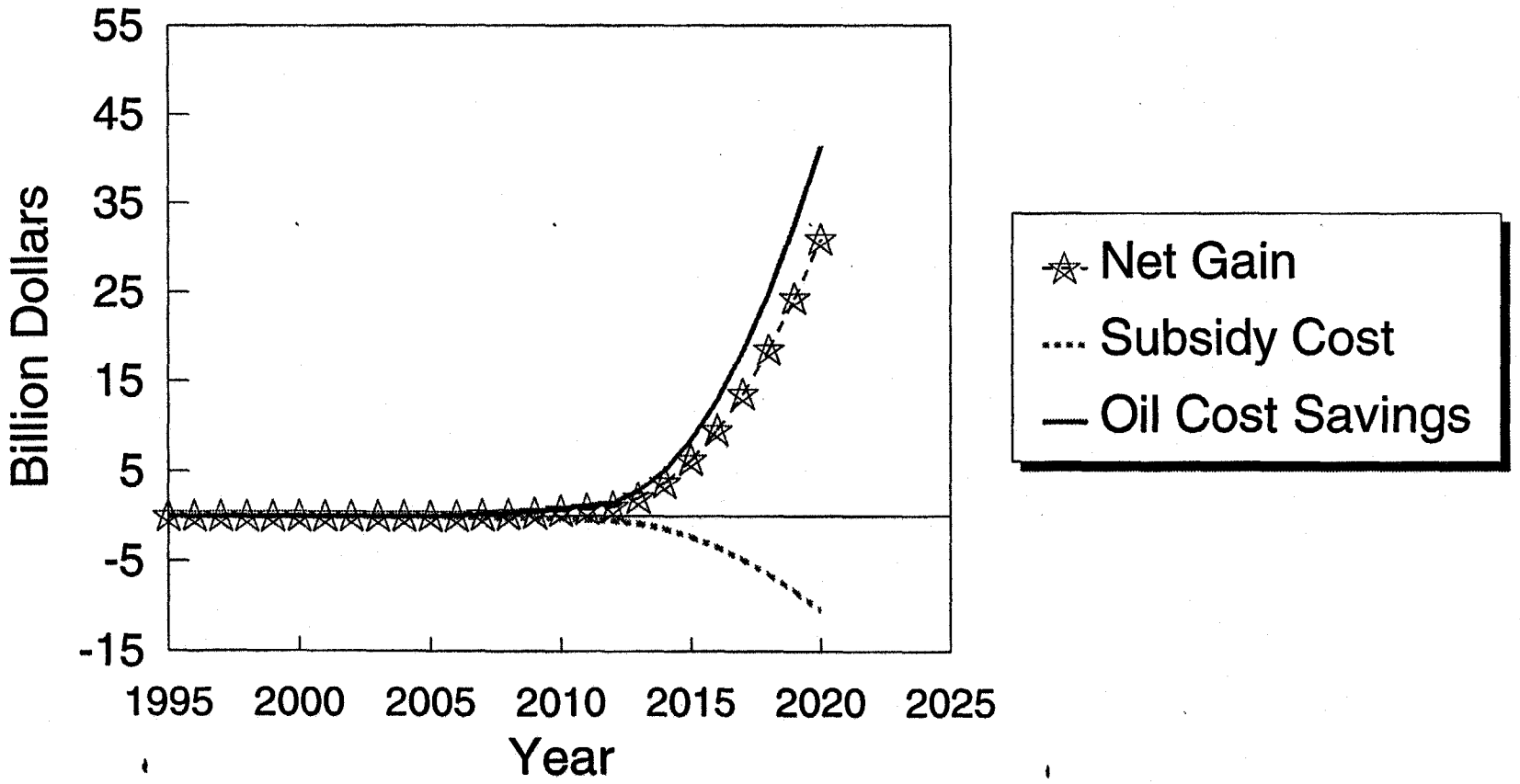
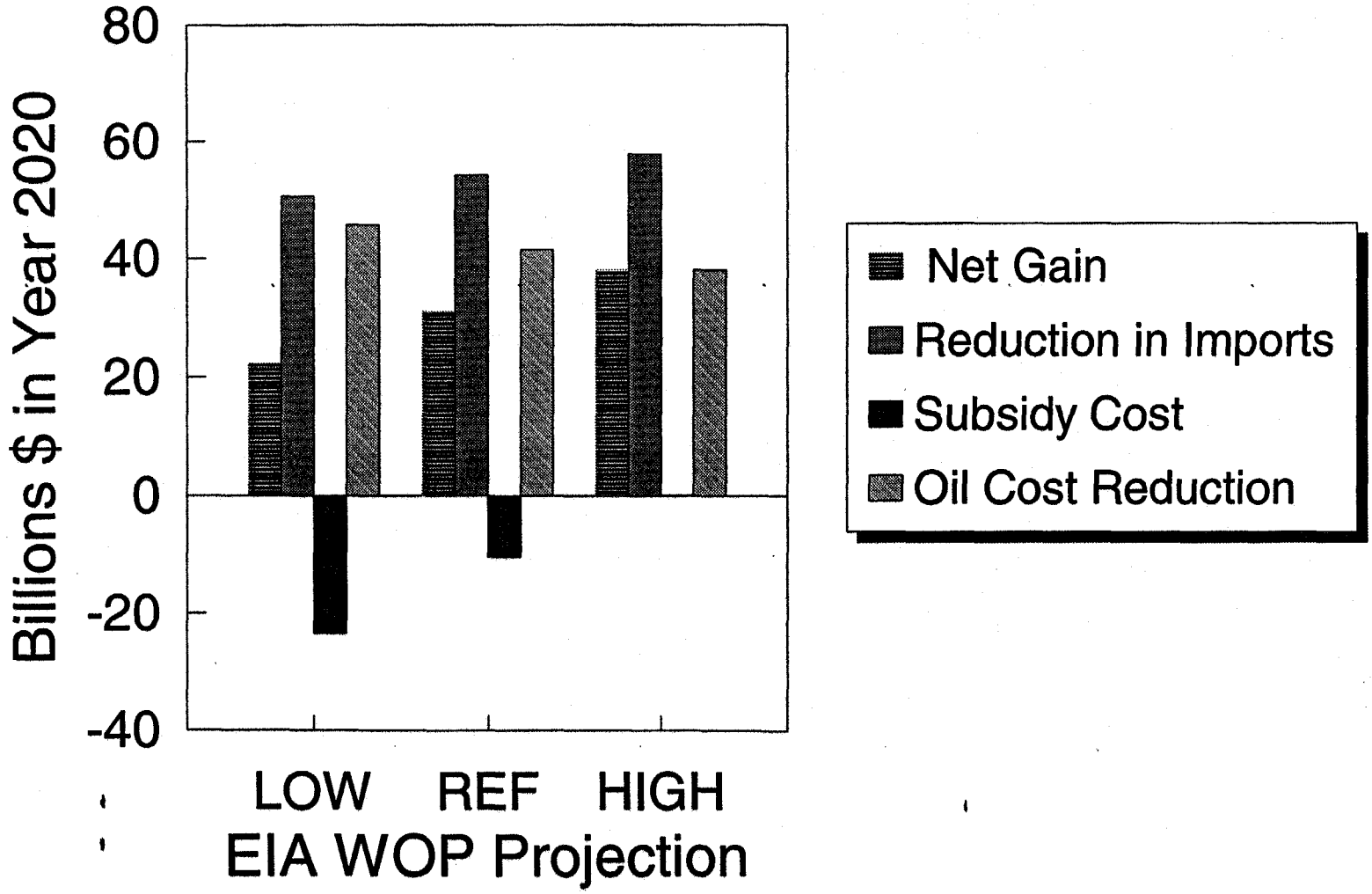
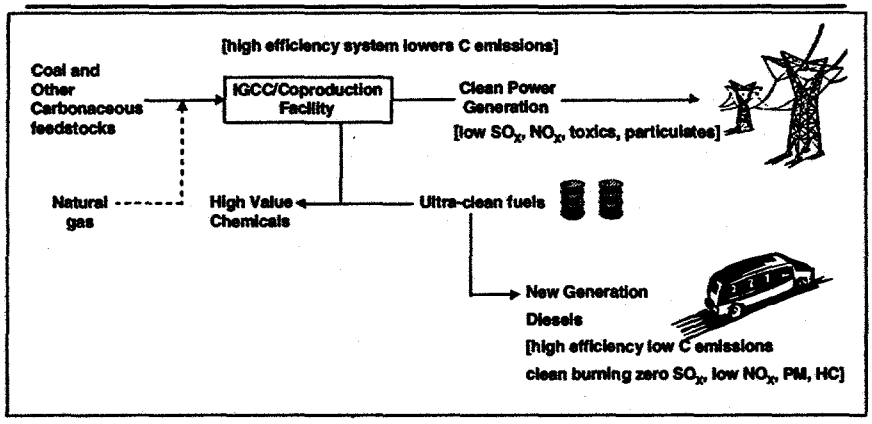


Fig 5: Program Cost/Benefit vs. WOP

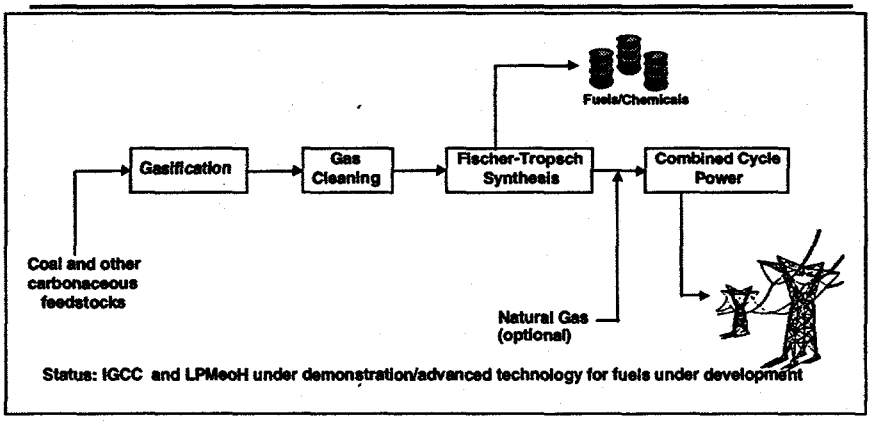


APPENDIX 1

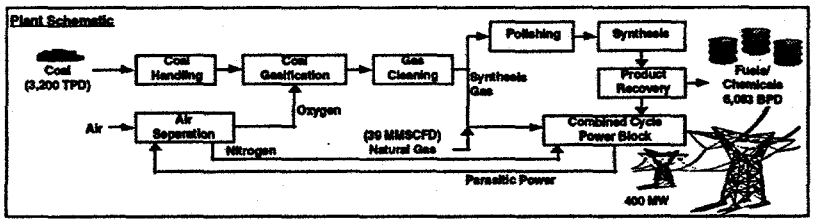
Coproduction Integrated into a Power/Fuels/End-Use System is an option



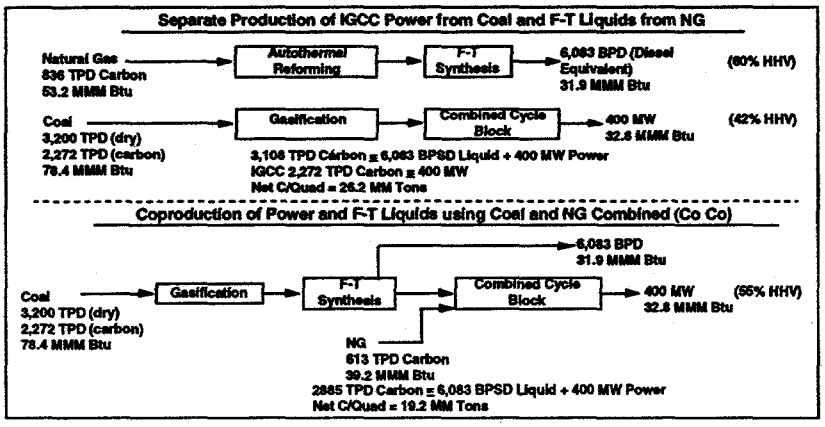
Coproduction Cofeed Concept Schematic (Co Co)



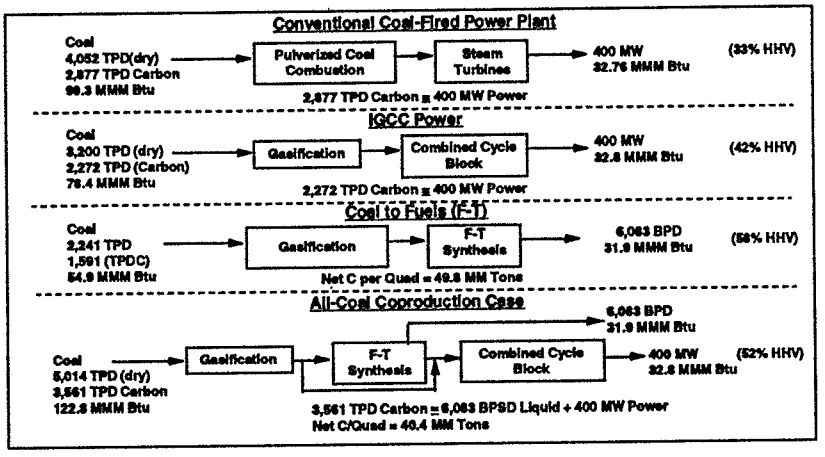
Coproduction Cofeed (Co Co) Configuration



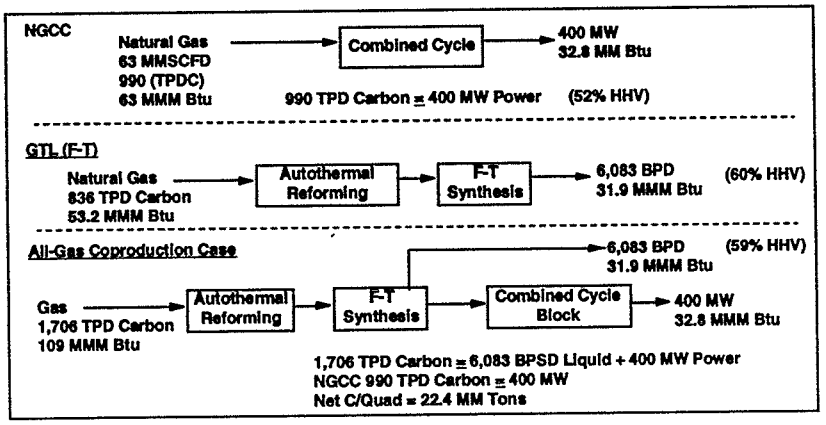
Separate Production vs. Coproduction of F-T Liquids and Power



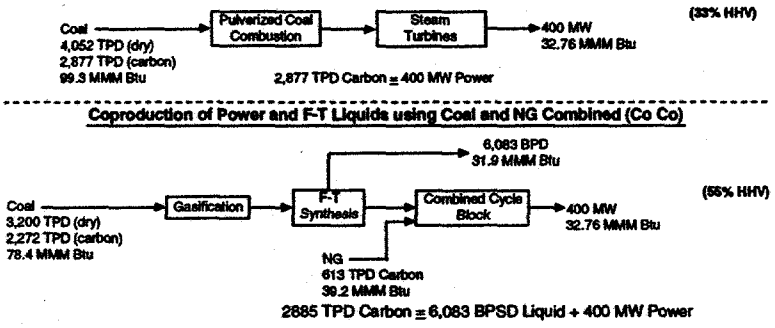
Coal-Based Energy Conversion Systems



Natural Gas-Based Energy Conversion Systems

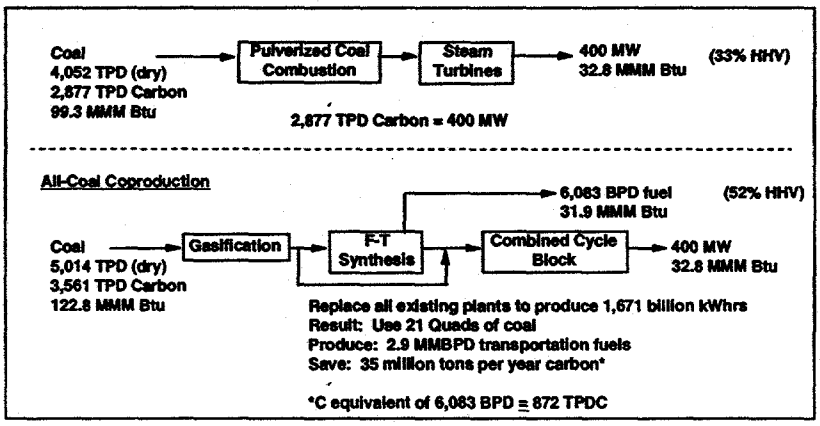


National Implications of Deployment of This Technology



Replace–**All existing plants to produce 1,671 Billion kWhrs**
Result–**Use 14 Quads Coal/7 Quads Natural Gas**
Produce–**2.9 MMBPD Transportation Fuels**
Save–**150 Million tons per year Carbon**

National Implications of Deployment of this Technology



Coproduction: Environmental/Energy Security Benefits

- Replacement of one 400 MW PC plant with coproduction (NG option) would reduce carbon emissions by 350,000 tons every year
- Replacement of all U.S. PC plants with coproduction (NG option) would reduce carbon emissions by 150 million tons every year (30% of expected carbon emissions increase by 2020) and coproduce 2.9 MMBPD of transportation fuels
- High quality F-T fuels from coproduction significantly reduce CO, HC, PM, and NO_x and eliminate SO_x
- F-T diesel could meet expected 2004 fuel emissions regulations
- Coproduced IGCC power is generated with minimal environmental impact

Coproduction: Economic Benefits

- Return on Equity comparisons
  IGCC ($1500/kW) ~1%
  NGCC ($580/kW) ~15%
  CoCo ($1500/kW) ~8.5%
  Coal Copro ($1500/kW) ~5.5%
  CoCo ($1200/kW) ~15%
- For current $1500/kW IGCC technology CoCo can realize 15% RoE by selling power @27 mills/kWh and fuels @~$28/bbl (19 cents/ gallon incentive)
- For $1200/kW IGCC technology CoCo can realize 15% RoE by selling power @25 mills/kWh and fuel @~$20/bbl (no incentive necessary)

APPENDIX 2

OUTLINE FOR THE IGCC MARKET PENETRATION STUDY

Client:

The client for this study is the Department of Energy (DOE) Office of Coal Power Systems, Integrated Gasification Combined Cycle (IGCC) Product Team.
DOE overall study coordinator Gary Stiegel, FETC. (Tel 412 892 4499)
DOE IGCC Product Team coordinators: Julianne Klara (Tel 412 892 6289) and Diane Madden (Tel 412 892 5931). The Contracting Officers Representative (COR) for this project is Mike Baird (Tel 412 892 4472).

Period of Performance:

June 1998 to December 1998.

Objective:

The overall objective of this study is to provide the necessary information, rationale, and framework so that the client can develop a strategic and defensible marketing plan for commercial deployment of IGCC technologies in the U.S. and overseas. Specifically this study will attempt to estimate the market potential of IGCC between now and the year 2020 in power generation, coproduct applications, and niche markets.

Work Plan:

1) Free Market (non-policy) scenarios:

The Energy Information Administration (EIA) Annual Energy Outlook (AEO)'98 reference case will be used as the baseline with respect to forecasts of national and regional power demand in the U.S. between now and 2020. (Regional demand forecasts are available in the supplement tables of the AEO report). This EIA baseline specifies power demand, feedstock costs, power price, etc. Under this baseline scenario 403 GW of total generating capacity will be required by 2020, of which 278 results from increased demand and 125 results from retirement of nuclear and older coal-fired plants. Under the assumptions of this baseline scenario, there is **no** market penetration of *advanced* coal power generating capacity.

Using this baseline to determine power demand and the cost of electricity as the benchmark, a regional comparison will be made to determine the cost competitiveness of natural gas combined cycle (GCC) and advanced coal plants like Integrated Coal Gasification Combined Cycle (IGCC) for power generation. For a fixed set of financing

assumptions, compatible with anticipated power industry project evaluation criteria in a deregulated market (determined by input from industry, results of the Energetics study, and DOE), the impact of feedstock cost (natural gas and coal), capital investment (technology and location-adjusted), capacity factor, and performance (efficiency) on the relative economics of GCC versus advanced coal plants for power generation will be analyzed. This analysis will result in determination of target parameters for advanced coal competitiveness.

This analysis will then be extended to illustrate the impact of economic dispatch of advanced coal-fired (power generation/coproduction) systems and GCC for a single typical utility system. This dispatch analysis will consider the operating cost and availability of new and existing units.

The impact of coproduction (systems producing fuels/chemicals in addition to power) and coproduction/cofeed systems that use coal and gas to produce multiple products will also be analyzed. Repowering of existing plants will also be considered as a possible factor to reduce costs and facilitate deployment.

The baseline advanced coal IGCC system to be used in this analysis has been developed by Mitretek and modified to be consistent with the baseline developed by EG&G for DOE. This baseline uses a Texaco quench gasification system with conventional gas cleaning, a Westinghouse W501G gas turbine, and a sophisticated steam cycle to produce about 400 MW net power. System performance improvements and cost reductions to this baseline will be assumed and justified in this analysis. It is proposed that a performance/cost estimate for a bituminous (Pittsburgh Seam) and a subbituminous (PRB) coal be developed to account for eastern and western U.S. markets.

2) Policy-induced scenarios:

In the reference EIA forecast for power generation between now and 2020, total domestic electricity demand increases by 39 percent from 3191 billion kWhrs to 4459 BkWhrs. During this period, nuclear generation declines by 43 percent and renewables generation remains essentially unchanged. Therefore the increased demand must be satisfied by using natural gas and coal. Although natural gas use for power generation increases 380 percent (from 3 to 10 quads) by 2020, coal utilization must still increase 29 percent (from 18.4 to 23 quads). By 2020, coal is still providing over 50 percent of domestic electricity generation. Clearly, then, both coal and natural gas will be needed to provide this power.

However, it may be necessary to implement policies that will induce deployment of advanced coal technologies rather than conventional coal-fired plants or the increased utilization of existing coal-fired power plants. The following policy inducements will be considered in this analysis. 1) Financial incentives given to reward investors for deploying highly efficient coal-based systems. The financial incentives to be considered include investment tax credits, accelerated depreciation and subsidies (excise tax exemption) for coproduced fuels or chemicals. 2) Environmental incentives including the imposition of a

carbon tax on fuels and more stringent regulations on NOx etc. In this analysis, different levels of carbon tax would be investigated to assess the impact of this on the relative deployment of technologies. Stricter environmental regulations which severely penalize emissions (for example NOx, particulates) would also be investigated. 3) A restriction on the amount of natural gas available for new power generation. In this analysis, the available natural gas for power would be constrained to be 10 quads (EIA projection in reference case by 2020) and the impact of this on deployment of advanced coal technologies for the various assumptions of costs and performance will be examined. This analysis would, therefore, provide a relative cost per carbon saved for the various forcing mechanisms.

3) IGCC versus other advanced coal technologies:

Review potentially competing advanced coal-based technologies including advanced PC, PCFB etc. for a representative region and identify those characteristics that could favor IGCC. These would include flexibility of IGCC with respect to coproduction configurations, ability to meet or exceed future, more stringent environmental regulations, applicability to Vision 21 configurations, etc. Strengths and weaknesses of IGCC systems will be identified.

4) Niche market and overseas deployment opportunities for gasification technologies:

Review and summarize current worldwide activities using gasification technologies in other industries (most particularly in refining) for a variety of feedstocks and for various products. Emphasis on flexibility of gasification with respect to feedstock and products, and how experience gained in these applications feed back to improving performance and reducing costs in power applications. Analyze opportunities that could exist for IGCC deployment overseas in developing and developed countries, including the impact of incentives such as the clean development mechanism (CDM).

Study working team:

It is proposed to incorporate significant input from industry in performing this study to improve overall credibility and to provide feedback from stakeholders. Mitretek intends to subcontract with CONSOL to help in this work and has joined the Gasification Technologies Council (GTC) to obtain input from GTC member companies.

APPENDIX 3

UPDATE OF SUMMARY OF COAL-FUELS/GTL STRATEGIC PLANNING SESSION
24/25 JUNE 1998, FETC PITTSBURGH
REVISED 9 JULY, DOE HQ

Attendees:
The attendees at the 24/25 June meting were:
Ralph Avellanet, Dan Driscoll, David Gray, John Hackworth, Greg Kawalkin, John Marano, Ed Schmetz, John Shen, Brad Tomer, Venkat Venkataraman, John Winslow.
This Strategic Planning Summary was revised at the DOE HQ meeting on 9 July, at that meeting the following were in attendance: Ralph Avellanet, David Gray, John Hackworth, Greg Kawalkin, Ed Schmetz, and Brad Tomer.

Goal:

Develop a framework for a comprehensive, credible strategy and implementation plan to justify a joint "coal-fuels/GTL" program within DOE for production of ultra-clean transportation fuels. This strategy will then be used to justify the program to DOE management, and for use in preparing an outreach strategy for outside stakeholders.

Why do we need this new strategy?

Because the current rationale and strategy has apparently failed to justify a need for the coal-fuels program with senior DOE management and potential stakeholders. There is a lack of constituency for this program and without a constituency it becomes increasingly difficult to maintain even the current modest budget.

Overall Approach:

The overall approach to this new strategy is to integrate the strategies of the Coal/Fuels and GTL programs within Fossil Energy. This integrated approach will lead to synergies and research efficiencies by recognizing the natural overlap between many aspects of the GTL and Coal/Fuels programs. Rather than base the programs on specific feedstocks like coal and natural gas, it is proposed to emphasize feedstock flexibility to produce common products. These common products are ultra-clean transportation fuels like F-T liquids and DME derivatives that fit the existing transportation infrastructure for refining, distribution and end-use and can meet future 2004 specifications for fuels. Strategic chemicals can also be produced if desired. As part of this overall strategy it is proposed to keep the existing alliance with IGCC intact so that an integrated system can be envisaged comprising coproduction of multiple products (fuels, chemicals, high value solid products,

and electric power) from multiple feeds like coal, natural gas, biomass, refinery wastes and residuals, MSW etc. This vision is ultimately consistent with the DOE Vision '21 concept.

Other fuel and non-fuel products such as solid fuels and carbon products (possibly heavy and extra heavy oils) and low quality natural gas upgrading will be included at a later date to provide a comprehensive fuels strategy.

Background:

Prior strategies are already in existence within both the Coal/Fuels and GTL programs, and a list of existing documentation was compiled and listed here.

"Coal Liquids: Clean Transportation Fuels of the Future," May 1995, USDOE PETC.
"Rationale and Proposed Strategy for Commercial Deployment of Coal-Derived Transportation Fuels," David Gray and Glenn Tomlinson, June 1996, Mitretek, MP96W0000209.
"Coal Liquefaction Product Plan," December 1997, FETC.
US DOE Fossil Energy Strategic Plan, March 1998.
US DOE Strategic Plan, March 1998.
"Coal/Oil Coprocessing: Integration Opportunities with Existing Petroleum Refineries." Oct 97, Mitretek.
"Fischer-Tropsch Fuels from Coal and Natural Gas, Carbon Emissions Implications," Mitretek, August 1997.
US DOE FE multi-year program plan for coal.
US DOE FE multi-year program plan for gas.
"Natural Gas Processing and Utilization Product Plan," Dec 97, FETC.
Two page defense materials for coal and gas prepared June 1998 for ASFE program defense.
Pioneer Plant Presentation, June 1998.

"Economics of Alaska North Slope Gas Utilization Options", INEL-96/0322 April 1996
"Economic Evaluation and Market Analysis for Natural Gas Utilization," Hackworth et al, April 1995
Multiyear Program Plan Natural Gas, prepared by FE, ER, EE, and EIA, Dec 1997
Oil and Gas R&D Program, Office of Natural Gas and Petroleum Technologies, March 1997

The **key differences** in the **approach** between this new strategy and prior strategies are:

- emphasis on product end-market orientation rather than specific feedstock
- emphasis on the benefits to be derived from the integration of the Coal/Fuels and GTL program strategies
- emphasize partnerships with EE and other offices within DOE

The **key differences** in **priorities** between past strategies and this current one are: (in order of importance by a majority opinion):

- **regional environmental** benefits of the products are to be emphasized
- **economic** benefits (employment, balance of payments, benefits to country and consumer) are issues to be stressed
- impact of **global climate change** to be more thoroughly addressed in this strategy compared to prior versions
- **energy security** aspects of the program rationale (preparing for eventual oil shortfalls, reducing dependence on foreign oil) are considered to be a secondary rationale for the program (although some team members felt that this was still an important driver for the program and is used by other groups within DOE for program justification.)

Product Planning Process:

To attempt to answer the question "where are we?" **a situation analysis** was conducted. First, the internal situation was examined by addressing the following issues:

Internal Situation:

- mandates
- technology options
- stakeholder analysis
- how well is current strategy working?

With respect to **mandates**, there was uncertainty.

Technology options

Technologies being developed or improved as a result of the current program. These included: slurry bubble column reactor (SBCR) development, Catalytic Two-Stage Liquefaction (CTSL), catalyst development, coproduction, advanced syngas preparation (Ionic Transport Membrane etc.), LNG, simulation and life cycle analysis, end-use product testing, biomemetic /computational chemistry, molecular and hydrodynamic modeling.

Potential Stakeholder identification:

potential stakeholders included: State of Alaska, coal producers, oil companies, petroleum refiners, equipment/technology developers, engine manufacturers, petrochemical industry, independent power producers and utilities, the consuming public, state and local governments, Congress, the Administration. (A stakeholder analysis may have to be performed in the future.)

Is the current strategy working?

This was addressed by examining the mission for the two programs (Coal/Fuels and GTL) and then defining the problems with the current strategy.

The Coal/Fuels Program:

The overall mission is to ensure a future secure supply of transportation fuels by fostering development and deployment of clean fuels from coal to supplement petroleum. This is to be accomplished by partnering with industry via a pioneer plant strategy for deployment of the technologies at existing facilities. The rationale for the program is to be a national insurance policy against potential future oil shortfalls by providing an alternative to imported petroleum from domestic resources that could also cap future increases in the world oil price (WOP).

Problems with this current strategy:

- the future oil shortfall argument is not accepted by most decision makers. This is particularly the case at present with an oil glut and low prices. However, it should be noted that many other alternative fuel programs (in EE, for example) use the future shortfall argument and reduction in oil imports as justification.
- the major problem is lack of a constituency. Coal companies ought to be stakeholders but they only see coal as a feed for power plants. Oil companies have little interest in supporting a product that could compete with petroleum. If the WOP increases oil companies reap the profits.
- global climate concerns over increasing the use of coal for uses in addition to power production
- high cost of the proposed technologies that result in synthetics prices that are non-competitive with petroleum even to the end of the planning horizon
- EIA future scenarios that show continued low prices (and no supply problems) for energy until 2020
- potentially cheaper alternative technologies to coal-derived fuels like EOR, heavy oil and bitumen upgrading
- image problem with coal-derived synthetic fuels

The GTL program:

The mission is to foster development options (with industrial partnerships) for stranded natural-gas. Domestically, the Alaska North Slope (ANS) is the identified opportunity and possible off-shore and coal-bed methane sites.

Problems with this current strategy:

- since industry is actively developing and beginning to deploy GTL technology worldwide, there is the question of the appropriate role for government in this arena
- a relatively small number of domestic opportunities for GTL

External Situation:

- competing technologies/products
- economic situation
- drivers
- politics
- laws/regulations

- opportunities/threats

Competing technologies

these were identified as (no priority order): conventional petroleum refining, EOR, heavy oil and bitumen upgrading technologies, LNG, renewable technologies for hydrogen and ethanol, fuel cells for transportation

Competing products:

these were identified as: reformulated gasoline and diesel and all other alternative fuels (EV, MeOH, EtOH, CNG, LNG, hydrogen), and heavy oil, bitumens, oil sands as alternative feedstocks.

External driving forces:
(These are prevailing external factors, beyond our control, that by their existence have a potential impact on the program, either positive or negative)

- **Environmental:**
  -concerns over global warming may impact the use of coal and reduce NG flaring
  -local regional pollution issues may result in stricter regulations/specifications for fuels and emissions
- **Economic:**
  -continuing world oil demand growth will increase future world oil price (WOP) and impact US economy and the balance of payments (BOP) situation
- **Energy Security:**
  -continuing decline in domestic oil production and hence rising oil imports will make the US more dependent on foreign oil from essentially unstable regions of the world
  -energy is essential for maintaining the current standard of living and for sustaining continued economic growth.

The next step in the process was to identify what **factors are essential for the success of the program.**

The Key Success Factor Necessary to the Program:

- **stakeholder** (DOE, Congress, Administration, industry, consumers) **interest crucial**, this requires developing a strong, credible, defensible reason (rationale) for this program. If a convincing argument cannot be provided for the existence of this program, then the perception is that the program is not necessary.

The argument for the existence of the program is that it can address all of the **external driving** forces identified above.

The program addresses the **environmental** drivers by:

- allowing domestic coal and gas to be used in efficient ways to produce liquid fuels in addition to power with greatly reduced greenhouse gas emissions
- allowing remote natural gas that cannot be brought to market or that otherwise would be flared to be used to provide high quality liquid transportation fuels
- producing liquid transportation fuels, compatible with the existing infrastructure, that are environmentally superior to current petroleum-based fuels that will significantly reduce regional pollution resulting from transportation (this gives product a premium to help counter high cost of production)

The program addresses the **economic** drivers by:

- fostering R&D to reduce the technological and economic risk of technologies that produce synthetics so that they can be deployed by industry in a cost competitive manner (product can eventually be cost competitive with alternative options and petroleum)
- providing an alternative to petroleum from domestic resources that could cap (or influence) the WOP, reduce the US balance of payments and improve the US economy

The program addresses the **energy security** drivers by:

- providing an alternate source of liquid transportation fuels from domestic resources that is potentially equivalent to over 1.5 trillion barrels of oil (100 Prudhoe Bays)

What are the barriers/weaknesses/threats that impede the program?
(These have been combined into one category in this rewrite to prevent confusing repetition)

- lack of constituency (stakeholders)
- lack of internal DOE management support
- program rationale not convincing to potential stakeholders
- role of government disputed by industry (especially for the GTL program)
- lack of funding and competition with power program in DOE for funding
- global climate change (carbon emissions), concern over increased use of coal
- high cost of technologies for synthetics compared to other alternatives
- perception of continued plentiful and cheap supplies of oil and gas
- bad public perception of increased coal use and diesel fuels and engines
- uncertainty in future regulations for fuels/emissions
- limitations of natural gas resource
- option to use military to secure oil supplies

These are not prioritized.

What are the strengths and opportunities that assist the program?
(Again, these are combined in this one category to eliminate repetition)

- program is developing flexible, versatile, high efficiency technologies that produce ultra-clean transportation fuels and other coproduced energy products from domestic resources, that are compatible with existing infrastructures, from multiple feedstocks with minimal environmental impact. This fits into the future Vision 21 concept.
- program addresses energy security concerns (reduces imports) by providing an alternative source of transportation fuels from domestic resources that is potentially equivalent to over 1.5 trillion barrels of oil (100 Prudhoe Bays)
- program addresses environmental concerns by producing high quality fuels from coal and natural gas with significant reductions in carbon emissions
- program allows remote natural gas that cannot be brought to market or that otherwise would be flared to be used to provide high quality liquid transportation fuels
- program produces liquid transportation fuels, compatible with the existing infrastructure, that are environmentally superior to current petroleum-based fuels that will significantly reduce regional pollution resulting from transportation
- program has partnerships with other DOE programs like EE, IGCC
- Alaska supports the GTL program because of ANS opportunity for GTL
- program helps US in global markets (competitiveness)
- program boosts US technological leadership
- program fosters waste utilization (petroleum coke etc.) as feedstocks
- program fosters opportunity for deployment of direct liquefaction in China
- program provides significant economic benefits resulting from creation of a domestic industry
- program fosters R&D to develop new and improved technologies (AFDU, ITM etc.) and to reduce the technological and economic risk of technologies that produce synthetics so that they can be deployed by industry in a cost competitive manner (product can eventually be cost competitive with alternative options and petroleum)
- program provides an alternative to petroleum from domestic resources that could cap (or influence) the WOP, reduce the US balance of payments and improve the US economy

These are not prioritized.

The next step in the planning process was to list the **Planning Assumptions** that form the base assumptions for the reminder of the program plan.

Planning Assumptions:

- fossil fuels remain an important energy source well into the next century
- global warming will continue to be an issue that must be addressed
- demand for ultra-clean transportation fuels will increase
- regional environmental regulations will become more stringent

- transportation sector continues to be a significant contributor to environmental problems
- domestic oil production continues to decline and oil imports continue to increase
- renewable energy is not a significant player between now and 2020
- a sufficient quantity of synthetics can influence the WOP
- synthetics can play a role in energy security
- large volumes of ANS gas available in 2010
- no single solution exists to the problem (this program will not solve all problems other programs are also needed)
- stakeholder participation crucial to program success
- negative public perception to coal and diesels continues to be prevalent
- appropriate government role in this program needs to be defined and agreed on by industry
- a significant number of key decision makers continue to believe in the continued unlimited availability of cheap oil and gas.

Mission Statement for the Advanced Fossil Energy Fuels Program:

The mission of the advanced fossil energy fuels program is to ensure a stable, affordable supply of energy for the U.S. by fostering, in partnership with industry, the development and deployment of a new generation of transportation fuels technologies from domestic fossil resources and wastes. These technologies will be capable of producing fuels:

1) that are compatible with the existing transportation system infrastructure
2) that, when used in advanced engine systems, will surpass future transportation fuel emissions requirements for reductions in hydrocarbons, nitrogen oxides, sulfur oxides, carbon monoxide, and particulates
3) that will enable the efficiency of the current vehicle fleet to be increased from 20 to 40 percent
4) that are cost competitive with petroleum and other alternative fuels.

The program will also provide cost competitive options for producing strategically important chemicals and advanced carbon products for lightweight vehicles and hydrogen storage from domestic coal and waste carbonaceous materials.

APPENDIX 4

ENERGY EFFICIENCY FORUM

ENERGY EFFICIENCY AND CLIMATE CHANGE: THE NATIONAL DEBATE

I attended the Energy Efficiency Forum at the National Press Club in Washington DC on Wednesday June 10. The subject of this year's forum sponsored by the United States Energy Association (USEA) was energy efficiency and climate change.

This was a real debate in that all sides of the issue; those totally opposed to the Kyoto Protocol (KP), those that were essentially neutral, and those totally for KP were represented. The most outspoken critics of KP included Jim Sensenbrenner (Chairman, Committee on Science, US House of Representatives) and Chuck Hagel (Senator from Nebraska) and cosponsor of the Byrd-Hagel motion. Those for the KP were Ambassador Eizenstat (Under Secretary for Business and Agricultural Affairs, Department of State) who was the prime US negotiator in Kyoto, Brian Atwood (Administrator US AID), and Hazel O'Leary (former Secretary of Energy).

Those opposed to KP:

Sensenbrenner holds the view that KP if ratified would be an unmitigated economic disaster for the US. He says KP is fatally flawed (because of non-participation by the developing countries who will be the greatest polluters in the near future) and cannot be salvaged. US industry would move operations and hence jobs to those developing countries who were not participants. Energy prices, and hence all goods and services, in the US would rise considerably and put the US at an unfair disadvantage in the global economy. The scientific basis on which KP is predicated is uncertain and does not justify the drastic actions and economic disruptions called for in KP. If KP was brought before the senate for ratification it would not pass. The administration knows this and hence will not bring it before the senate. Without ratification by the US, KP could not come into effect anyway. He suggested that the European Union (EU) and China teamed up against the US so that the EU got to maintain its "bubble" and China did not have to sign on to KP. The major loser if KP was ratified would be the US because the US really would have to reduce its GHGs by over 30 percent, and this cannot be done in the KP target timeframe without unacceptable social and economic disruption in the US.

Senator Hagel holds very similar views concerning KP as Sensenbrenner. He stated that he is not opposed to the objective of improving efficiencies and reducing pollutants but he is totally opposed to the command/control approach of the KP. All rational people (including US Senators) wanted to live in a clean, efficient world and leave this legacy to their children. He thinks the science is flawed and that models cannot predict future climate trends. These same modelers were predicting global cooling a few years ago. His

main concern is that KP would allow the developing world, especially China and India, to take no action to reduce their GHGs while the US and other OECD countries would have to disrupt their economies in order to comply. This would amount to a huge redistribution of wealth between rich and poor countries with the US being penalized for having the greatest economy in the world. It would also mean sacrificing US hegemony to the United Nations. Hagel believes that Eizenstat gave the store away in Kyoto by not sticking to the original terms of negotiation. The mood of the US senate towards KP is documented in the overwhelming bipartisan (95 senators signed on) support for the Byrd-Hagel motion that states that the US will not ratify KP unless developing countries sign on and it can be shown that there will be no significant economic harm to the US.

Those supporting KP:

Ambassador Eizenstat is obviously a staunch supporter of KP and was responsible for negotiating the terms of the US participation at Kyoto (7 percent below 1990 levels etc.). He strongly believes in the science behind KP and believes that the devastating impacts of global warming are irreversible. He stated that, if we fail to act now to curb these impacts, our children will blame us for essentially destroying our planet. He says that thousands of scientists and experts worldwide have massed sufficient evidence to support that facts that temperatures are rising, that there are more frequent catastrophic weather events, and that manmade emissions of GHGs are the culprit. He also believes that the KP provides for realistic reduction targets and timetables. Other benefits of complying with KP for the US include reducing imports of oil that would improve our trade balance and reduce our dependency on potentially unstable sources of supply. He sees KP as an insurance policy against future devastating climatic events. We can pay a smaller premium now to address the problem, or wait until later when climate change effects intensify causing us to pay a much larger premium in the future. He believes in enhancing our national energy security position by energy diversification. He is a supporter of increased use of nuclear power. He mentioned the Presidents climate initiatives and the $6 billion allocated for credits for improved technologies. (However, I believe that much of this money is tied to the tobacco bill that may not pass). He does not believe in taxes on fuels as an option to reduce consumption. He says that the administration will not submit KP to the senate until there is a chance for ratification.

Brian Atwood believes that efficiency in energy use should be the goal even if climate change were not a problem. He obviously supports the administration line on the KP. He believes wholeheartedly in the science behind global warming. that there will be serious climate effects in the future and we already there are more frequent tornadoes etc. He thinks it is a serious problem and connects El Nino to climate change and anthropogenic GHG emissions. He also thinks that developing countries must dramatically reduce environmental impact per unit of added prosperity as they race towards standard of living improvements.

Hazel O'Leary is supportive of KP and says the challenge is to muster more general support for complying with KP.

Energy Secretary Pena gave the luncheon address. His very upbeat message was that energy efficiency and technologies and solutions to global climate change are not only good for the world but they are also good for business.

Neutral to KP:

The other speakers did not generally address KP but were positive towards concepts for improving energy efficiency.

Cecil Underwood, Governor of West Virginia, described how his state of WV was working towards improving efficiency in the use of state coal and gas resources. He is bullish on natural gas vehicles, and he mentioned his Main Street and Industries of the Future programs.

Other speakers included: Thomas Rotticci from Bank of America (soon to be the largest US bank after its coming merger with Nations Bank), who stressed BoA's commitment to energy efficiency in its operations; Peter Coy from Business Week, and Richard Sandor from Environmental Financial Products, who thought that climate change was not a problem and could be readily solved using market based carbon trading solutions rather than command and control approaches.