EXECUTIVE SUMMARY

INTRODUCTION

The purpose of this study is to apply the methodologies developed in the Energy Conservation in Coal Conversion August, 1977 Progress Report - Contract No. EY77S024196 - to an energy efficient, near-term coal conversion process design, and to develop additional, general techniques for studying energy conservation and utilization in coal conversion processes.

The process selected for study was the Ralph M. Parsons Company of Pasadena, California "Oil/Gas Complex, Conceptual Design/Economic Analysis" as described in R & D Report No. 114 - Interim Report No. 4, published March, 1977, ERDA Contract No. E(49-18)-1975. This process was chosen because:

1) A primary design objective was energy efficiency, which resulted in a plant thermal efficiency of 77%.
2) We had access to most of the needed data.
3) This design is included in the Department of Energy's coal synthetic fuels demonstration plant accelerated program.

Inspite of the high overall thermal efficiency of this design, our studies reveal areas where significant amounts of energy may be conserved or utilized in a more cost effective manner.

I - Coal Conversion Process Selection

A number of processes were examined as candidates for this study. The Ralph M. Parsons Oil/Gas Complex was chosen because:

1) A primary emphasis was placed on maximizing the energy efficiency of the process.
2) This design is included in the Coal Synthetic Fuels Demonstration Plant Accelerated Program.
3) We had access to the design data.

II - Method for Computing the Optimum Economic Pipe Diameter for Newtonian Fluids

A closed form relation is presented for calculating the diameter of a pipe line which yields the minimum life-cycle cost for a wide range of parameters and operating conditions.

A central consideration in the derivation of the relation is that the optimum diameter should reflect the energy costs for overcoming friction losses.

Diameters from the method presented here are compared with a relation developed by DuPont Co. The mean absolute percent difference between the two methods is less than 19%, with the method outlined here yielding larger diameters than the DuPont relation.

III - Energy Conservation Potential in Heat Recovery Techniques - A Case Study

In this study, we looked at replacing certain heat exchangers with Organic Rankine Cycles. In each case, we determined the cost of generating power and then from this tabulation of capital investment for power generation, feasibility of replacement on a unit-by-unit basis was determined.

The results show that 18 heat exchangers reject sufficient heat to warrant ORC usage, with potential electric generation of 36 MW which is 17% of the 210 MW generated in the Oil/Gas Complex.

Cost estimates indicate the capital investment required to be approximately $1000/KW with a potential reduction to $300/KW for mass produced units.

IV - Alternate De-Ethanizer Refrigeration System to Conserve Energy - A Case Study

This study examines an alternate system to cool an ethane gas stream from the fractionator in Unit 18 of Parsons Oil/Gas Complex. This alternate will save 2.6 x 10^5 Btu/hr of energy or .25 short TPD of coal out of 36,000 TPD used in the Oil/Gas Complex, at an installed cost of $151,000 with an operation and maintenance cost of $7550/yr. Assuming a 20-year life, 9% interest rate on borrowed capital, and an electricity cost of $.025/KW-hr, the Life Cycle Cost (LCC) of the new system is $179,000 over a 20-year period. Using a Discounted Cash Flow Analysis the Return on Investment is 0%.

V - Feasibility Study of A Combined Combustion - Gasification Facility

This work examined the feasibility of mechanical deep cleaning of coal where the cleaned coal would be used for direct combustion and the rejected portion would be used in a coal gasification plant. To make this feasible, the reduced thermal efficiency from gasifying "dirty coal" must be offset by the reduced energy requirement for the flue gas desulfurization system.

Our study indicated, for the coal being considered for the Parsons Oil/Gas Complex - Illinois No. 6 - the energy saved by reduced flue gas desulfurization was approximately equal to the energy lost from gasifying the dirty coal. The methodology for this study is presented in such a way that other coals - particularly a high pyritic sulfur content - could be studied.

VI - High Pressure Steam Generation from Heat Recovery Boilers

This section develops a methodology for calculating and evaluating the increased work potential possible from high pressure steam generation in waste heat boilers. This methodology is applied to the Ralph M. Parsons' commercial concept of the Oil/Gas Complex. Implementation of the proposed scheme would result in an export power increase of 7.7 MW which is a 4% increase of the 210 MW generated in the complex at a cost of $2110/KW.

VII - Combined Cycle In-Plant Electrical Power Generation

A combined cycle power generation scheme for the Oil/Gas Complex was studied as an alternate to the steam turbine power generation system to see if energy can be saved in a cost effective way. The combined cycle generates an excess of 22.2 MW of electricity or a 10.6% increase of the 210 MW generated in the Oil/Gas Complex at a cost of $610/KW. If electricity is exported at $.025/KW-hr, a rate of return on the additional capital investment of 19% is realized. Using present state-of-the-art equipment, the combined cycle is a cost effective way to better utilize energy.

VIII - Direct Coal Fired Steam Generation in Lieu of Low Btu Gas

This section examined the feasibility of replacing the low Btu gas fired power generating system with a direct coal fired power generating system, in which 48,000 lb/hr of coal would be saved which is 1.6% of the total 36,000 TPD used in the Oil/Gas Complex. The difference in installed cost between the direct coal fired system and the gas fired power generation system is 36.4 million dollars. The rate of return on the additional capital cost for the coal-fired system is 8.21%. The life cycle cost is -4.4 million dollars over a 20-year life with capital borrowed at 9% interest.

IX - Alternate Acid Gas Removal Study

To reduce the reboiler steam required, we studied replacing the MEA (monoethanolamine) system proposed by the Ralph M. Parsons Co. with a DEA (diethanolamine) acid gas removal system. Steam consumption is reduced by 16,000 lbm/hr which is 1 % of the total steam generated in the Oil/Gas Complex or $317,000 per year. In addition, there is an annual savings of $88,000 for chemicals. The additional capital costs and operating expenses for the DEA system are negligible since the process plants are equivalent. It is therefore recommended that a DEA system replace the MEA system as Process Unit 17 of the Oil/Gas Complex.

X - The Thermodynamic Performance of Two Combined Cycle Power Plants Integrated with Two Coal Gasification Systems

Sections from a Ph.D. thesis present in summary, a thermodynamic treatment of four integrated coal gasification and combined power plants with the aim of studying the effects of component optimization, and emissions of NO_x and H_2S on cycle performance.

A combined cycle station efficiency of 36.67% results from the best plant configuration when allowable emmissions are met, and 10% of the electrical power generation is subtracted from the net work out. For a rankine cycle, the efficiency is 35%, when compared on an equal basis.

XI - Energy Conservation Potential in Shaft Power Generation and Distribution

A criteria for determining the most energy efficient horsepower break-point for using electric motors or steam turbines is developed and applied to the prime movers in the Ralph M. Parsons Co. Oil/Gas Complex. No significant amount of energy can be saved, since the electric motor turbine break-point established by Ralph M. Parsons Co. coincides with the criteria developed in this study.

XII - Basis for Fuel and Utility Costs

A common basis for fuel and utility costs is used throughout the sections in this study. FEA energy price projections for Region V (Michigan, Ohio, Indiana, Wisconsion, Minnesota, Illinois) and averaged prices from other sources are used.

XIII - Using Second Law Analysis to Pinpoint Inefficiencies in Coal Conversion Processes

A second law analysis is performed on the Fischer-Tropsch complex designed by the Ralph M. Parsons Company, to locate areas of energy inefficiency. The complex has an overall first law efficiency of 70% and a second law efficiency of 68.7%. Two areas in the complex where efficiencies could be improved are: unit 14, acid gas removal, and unit 21, sulfur recovery, which have second law efficiencies of 80.2% and 66.4% respectively. The other process units of the plant had efficiencies greater than 87%, indicating energy recovery and conservation techniques had been implemented in the design of the complex.

OIL/GAS PLANT DESCRIPTION

The Ralph M. Parsons Oil/Gas Complex is a coal conversion facility designed to use high-sulfur coal and convert it to SNG (substitute natural gas), LPGs (liquified petroleum gases), fuel oil and naphtha using hydroliquifaction technology. The industrial complex consists of a large captive coal mine that produces 47,000 tons per day (TPD) of run-of-mine coal which is supplied to a coal preparation plant, which in turn supplies 36,000 TPD of clean, washed coal with a heating value of 12,125 Btu/lb. Along with the above mentioned products, the plant produces by-products of ammonia and sulfur. All electricity and steam required for the Oil/Gas Complex are generated within the plant, therefore, the input to the plant is coal, oxygen and water. The overall material balance is shown on Figure 1 and the energy balance is shown on Figure 2. The estimated fixed capital investment is $1.25 billion; this figure is based on fourth quarter 1975 dollars.

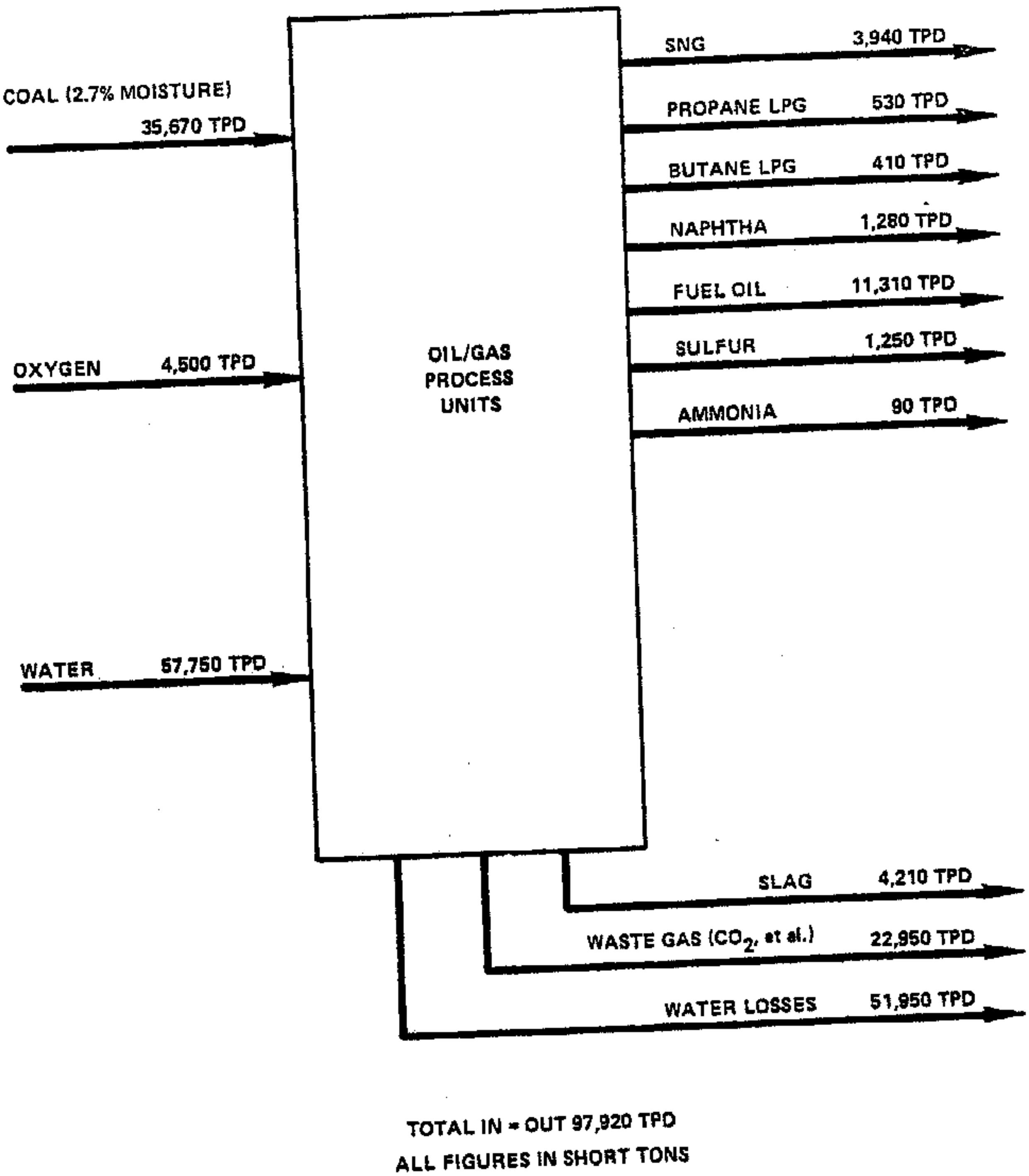

FIGURE 1

Overall Material Balance

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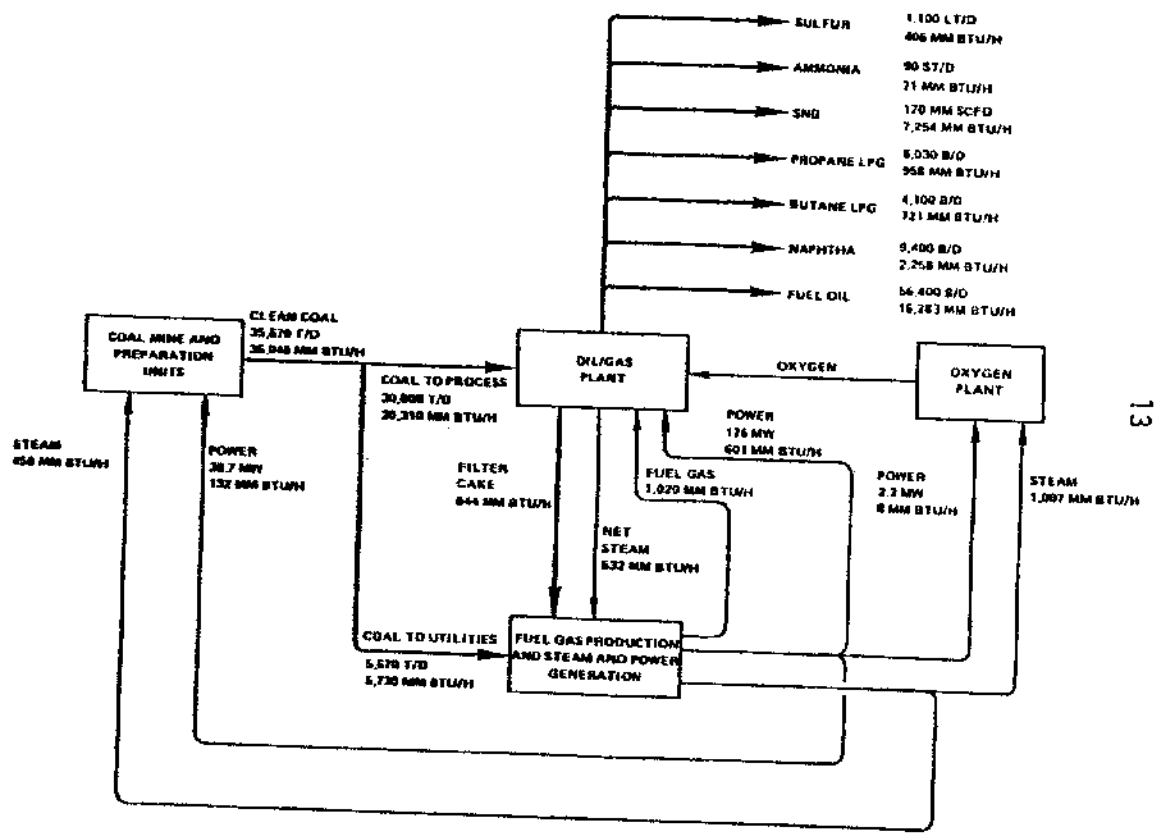

COAL ENERGY DISTRIBUTION		
STREAM	MM BTU/H	% CLEAN COAL
FEEDS		
COAL TO PROCESS	30,318	84.1
COAL TO UTILITIES	5,730	15.9
TOTAL	35,848	100.0
PROCESS COAL YIELDS		
SALEABLE PRODUCTS	27,951	77.6
FILTER CAKE	844	2.3
REACTION HEATS	1,515	4.2
TOTAL	30,310	84.1

UTILITY ENERGY DISTRIBUTION		
STREAM	MM BTU/H	% CLEAN COAL
INPUTS		
COAL	5,730	15.9
FILTER CAKE	844	2.3
STEAM	632	1.8
TOTAL	7,206	20.0
OUTPUTS		
TO MINING AND PREPARATION		
STEAM	456	1.3
POWER	132	0.4
TOTAL	588	1.7
TO OXYGEN PLANT		
STEAM	1,007	2.8
POWER	8	-
TOTAL	1,015	2.8
TO OIL/GAS PLANT		
POWER	601	1.7
FUEL GAS	1,020	2.8
TOTAL	1,621	4.5
LOSSES TO ATMOSPHERE	3,9[illegible]	11.0
TOTAL	7,206	20.0

FIGURE 2

Energy Balance

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