PRELIMINARY DESIGN SERVICES COAL CONVERSION DEMONSTRATION PLANTS. RESEARCH AND DEVELOPMENT REPORT NO. 114. QUARTERLY REPORT, APRIL--JUNE 1976

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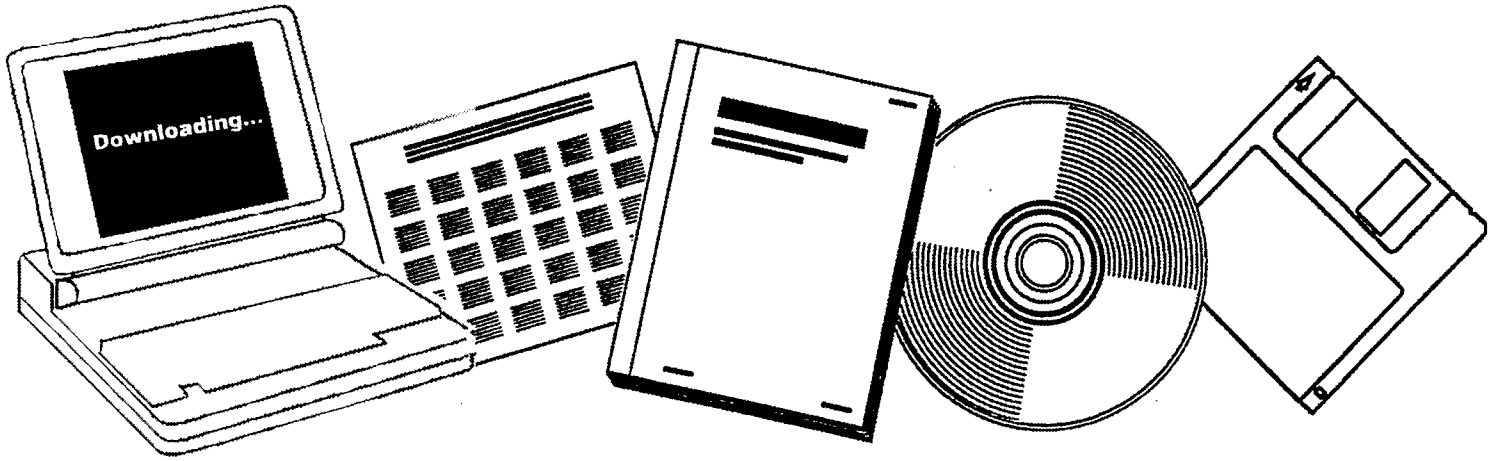

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PRELIMINARY DESIGN SERVICES COAL CONVERSION DEMONSTRATION PLANTS

RESEARCH AND DEVELOPMENT REPORT NO. 114 QUARTERLY REPORT FOR THE PERIOD: APRIL - JUNE 1976

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SECOND QUARTERLY REPORT

PRELIMINARY DESIGN SERVICES

THE RALPH M. PARSONS COMPANY

I. OBJECTIVE AND SCOPE OF WORK

The objective is to develop preliminary designs and economic evaluations for a number of coal conversion plants. The following designs are included in the scope of work:

- o A conceptual commercial plant for a coal-oil-energy-development (COED) plant.
- o An oil/gas plant to produce liquid fuels plus substitute natural gas (SNG).
- o A commercial-scale Fischer-Tropsch plant with motor fuel and SNG as the main products.
- o A commercial-scale plant for the production of solvent-refined coal (SRC).
- o A coal oil gas (COG) refinery to produce clean liquids, gas, and electrical power.
- o A facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during pilot plant operations.

The facilities will be considered for conversion of coal to:

1. Low-to-high Btu fuel gas.

2. Methanol/motor fuel by Fischer-Tropsch process.

3. Clean liquid fuels by alternate liquefaction processes.

In addition, supporting efforts will be provided to the above activities. These efforts include planning and progress monitoring, equipment development, and environmental factors.

II. SUMMARY OF PROGRESS TO DATE

A brief review of the status of the major active design efforts is given below, followed by a more detailed reporting on the progress of individual tasks.

During the past quarter we completed the process design work and fixed capital cost estimates for the Oil/Gas and Fischer-Tropsch plants. We also advanced the profitability analyses for these two plants. Additional adjustments to the thermal efficiency of the Fischer-Tropsch plant were completed which resulted in a corrected figure of 69.7 percent.

Preliminary Design bases for COG-type plant concepts were prepared and we made progress on the preparation of a status summary of our work on liquefaction processes and economics. A draft report of a design basis, including a block flow diagram for the most likely combination of operations is being prepared. Work on the Multi-purpose Demonstration Facility is underway. We initiated requests

for commercial methanol process and economic information. We started preparation of a simplified plant design; the purpose of this design is to evaluate information received from methanol plant licensors.

We obtained additional information on the subject of liquid/solids separation and coal feeding devices. Test information available to us indicates the potential that capital cost of cleaning gas can be substantially reduced. We continue to receive conceptual configurations, capital cost and power requirement estimates for ground coal compression screw feeders from equipment manufacturers.

We have selected appropriate materials of construction for process units in the Oil/Gas and Fischer-Tropsch designs and are in the process of developing the environmental factor analyses.

Outlined below is a brief summary by assigned task.

A. Coal Mining/Coal Preparation

We completed design and capital cost estimates for the Oil/Gas plant coal preparation units. We completed and reviewed the report describing the design and economic information for mining and coal preparation facilities to serve the Oil/Gas and Fischer-Tropsch plants.

B. Oil/Gas Plant Design

We completed the utility balance, process flow diagrams, and equipment sizes for the complex. We completed the fixed capital cost estimate and operating cost estimates for the plant, and worked on the profitability analysis. We completed rough drafts of portions of the R&D report.

C. Fischer-Tropsch Plant Design

We completed the utility balance and all process design work for the facility. We completed capital and operating cost estimates and made progress on development of the economic evaluation. We completed a rough draft of the R&D report.

D. COG Plant Design

We prepared a brief text and preliminary economic guidance for determining the preferred process design basis. We made progress on development of a design basis. We prepared a status draft report covering all liquefaction processes currently under evaluation.

E. Equipment Development

We made contacts to obtain available information regarding results generated in the ERDA program for ground coal compression screw feeders development. Information included estimates for power requirements and capital costs.

F. Materials of Construction

We completed material selection services for engineering specification of equipment for the Oil/Gas and Fischer-Tropsch designs.

G. Environmental Considerations

We reviewed the waste treatment processes planned for use in the Oil/Gas and Fischer-Tropsch projects. We obtained proposals for a slag/ash leaching study from competent analytical laboratories; this study is desirable to assure acceptable disposal of a slag/ash from the coal conversion complexes.

H. General

We presented the following invited papers:

1. "Preliminary Economic Analysis: Oil and Power by COED-Based Conversion" -- to the American Chemical Society Symposium on Comparative Economics of Synfuels, in New York on April 8, 1976.

2. "Coal Liquefaction; Materials Systems Design" -- for presentation to the American Society for Metals, in Pittsburgh, Pennsylvania on April 26, 1976.

3. "Coal Conversion Development - An Overview" -- before the Engineering Institute of Canada (EIC) Conference on May 12, 1976, in Calgary, Alberta.

We participated in a Technical Data Book Advisory Committee Meeting on Coal Conversion Systems in Chicago, Illinois, on May 27, 1976.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. Coal Mining/Coal Preparation

1. Objectives

A long-range objective is to conceptually design and evaluate as feed facilities to conversion plants, coal mine and preparation facilities for five assigned geographic areas where conversion facilities are being studied. Capacities up to 100,000 tons per day are being considered.

2. Activity This Quarter

We completed all designs, fixed capital investment estimates, and operating and maintenance cost estimates for the Oil/Gas plant and Fischer-Tropsch mining and coal preparation facilities. We completed and reviewed the drafts of the final report sections.

3. Activity Forecast Next Quarter

We will advance work on a report covering mine development in at least one additional geographic area.

B. Oil/Gas Plant Design

1. Objectives

To develop a preliminary design and economic evaluation for a commercial Oil/Gas plant to produce synthetic fuels and SNG from coal. To define the maximum practical capacity single-train plant using the process.

2. Activity This Quarter

a. We completed flow diagrams for all process units.

b. We completed all required details of equipment engineering specifications.

c. We completed the capital cost estimates for the complex.

d. Utility Balance: We reviewed plant electrical and steam requirements with utility specialists to minimize fuel and cooling water requirements.

e. Raw Water Treating: We completed the detailed process design of the raw water treating unit.

f. Fuel Gas Gasifier: We completed modifications for a gasifier design to reduce the capital and operating cost. The revised unit operates at 55 psia thus producing fuel gas at 37 psia after cooling and cleanup. This eliminates fuel gas compressors and reduces the number of gasifiers from two to one.

g. We advanced the profitability analysis and the preparation of the R&D design report.

3. Result of These Activities

The completed process design of the plant complex includes a captive coal mine with capacity to produce approximately 15.5 million TPY for 20 years. Units are included which will clean, wash, size, grind, and dry the coal and feed it to the process units.

The complex is designed as a self-contained unit. All necessary facilities for production of oxygen, hydrogen, and all required utilities are included in the design as well as treatment and disposal of solid, liquid, and gas waste streams. The design is based on a site location capable of providing the necessary quantity of water for process requirements, utilities makeup, and for potable and sanitary water.

The core of the coal conversion plant is the dissolvers. They convert the coal suspended in internally generated solvent in the presence of hydrogen to gases and liquids with an undissolved coal residue and ash constituting 18.9 percent of the moisture-free coal feed. The solids are filtered and dried to maximize liquid recovery. The liquids are fractionated to remove filter wash oil, product fuel oil, a naptha-range liquid and a gas stream. Column bottoms are split to provide a portion of the dissolver feed solvent, and filter feed slurry. The filtrate, in turn, is split to provide the remainder of the dissolver feed solvent, and product liquid.

Hydrogen is required for the dissolving process. It is produced in a high pressure gasifier fed with coal, steam and oxygen. The product gas is rich in carbon monoxide. The ratio of this component to hydrogen is improved in a sour shift unit. The hydrogen sulfide is removed and the sweet gas is mixed with additional hydrogen obtained by cryogenic separation. This gas mixture is used as feed to the dissolvers.

Gases evolving from the dissolvers and from the fractionation are treated to remove their hydrogen sulfide contents. The clean gas is split in a cryogenic unit into methane-rich gas, hydrogen-rich gas and heavier fractions. A portion of the hydrogen-rich gas steam is treated to methanate the remaining carbon monoxide. The resultant 95 percent pure hydrogen steam is used to hydrogenate the napthas produced in liquefaction.

The heavier fractions produced in the cryogenic separation are fractionated into product butane, propane, methane, and naphtha which is sent to the previously mentioned hydrogenation unit.

The methane-rich product of the cryogenic unit is purified by methanation to produce substitute natural gas product.

All hydrogen sulfide streams mentioned above are treated to obtain product sulfur and environmentally acceptable clean tail gas.

The solid products of the dissolver step are gasified in a low pressure air-blown unit to produce fuel gas required for generation of plant utilities. Coal is added to this gasifier to make up the necessary amount of in-plant fuel. The resultant low-Btu gas is treated to remove hydrogen sulfide, making additional product sulfur. The purified gas is used in the plant furnaces. It is also used in the utility plant to produce the steam and electricity required for the operation of the complex.

The throughput of the plant is based on 35,650 TPD of 2 percent moisture coal. This corresponds to approximately 47,000 TPD of ROM coal. This throughput will produce the following approximate output rates:

Fuel Oil (approximately equivalent to No. 6 Fuel Oil)	56,000 BPD
Naphtha	10,000 BPD
LPG (C_3 and C_4)	10,000 BPD

SNG	165,000 MM SCFD
Elemental Sulfur	1,300 STPD
Anhydrous Ammonia	90 STPD

The simultaneous production of coal from five mine faces and the mixing of this coal in the breakers and storage will produce a coal of relatively uniform composition; it is concluded that the product slate will also be reasonably uniform.

4. Activity Forecast Next Quarter

We will complete the economic analysis of the oil/gas complex and incorporate it into the R&D report. We will submit a draft of the report to ERDA for review and prepare to publish the report in its final form.

C. Fischer-Tropsch Plant Design

1. Objectives.

To develop a conceptual commercial plant design and economic evaluation for a plant using Fischer-Tropsch technology to produce pipeline gas and motor fuel.

2. Activity This Quarter

a. We completed preparation of equipment engineering specifications.

b. We completed the capital cost estimates for all process units.

c. We completed flow diagrams, equipment and engineering specifications for the utilities and steam power generating facilities and started their capital cost estimate.

d. Raw Water Treating: We completed flow diagrams, engineering and equipment specifications. We started the preparation of capital cost estimates.

e. We completed the comparisons of gasifiers and Fischer-Tropsch reactor types for inclusion in the design report.

f. We reviewed the Fischer-Tropsch reactor design incorporating revised catalyst requirements per information from ERDA-PERC. We further investigated cost reduction possibilities for the reactors.

g. We completed the preparation of a start-up and shut-down procedure for inclusion in the design report.

h. We advanced the profitability analysis and the preparation of a rough draft R&D report.

3. Results of These Activities.

The products of this complex are produced in a two-train plant and have a collective total heating value of 516 billion Btu per day. The design includes a captive coal mine, coal handling, crushing, beneficiation, grinding and drying facilities, and all process plants, utility production, and ancillary units to convert this coal by steam-oxygen gasification to synthesis gas for manufacture of 50 percent liquid hydrocarbons and 50 percent SNG on a Btu basis. Oxygenates and alcohols are produced as a mixed product. Elemental sulfur is a by-product and coal ash is a solid waste material.

The SNG is produced as 1050 Btu per SCF HHV gas at pipeline pressure. The liquid products are LPG, naphtha, diesel oil, premium fuel oil and oxygenates. Oxygenates are comprised primarily of mixed alcohols with ketones and aldehydes.

The design allows a range of coal and carbonaceous charge stocks. Coal handling and preparation equipment is sized for peak rates of 25 percent over average required in order to assure necessary performance at times of lower grade coal production. Flexibility for sulfur and ash content provides for expected range of analyses which might be expected over a 20-year operating life, using coal typically mined in the Eastern Region of the U.S. Interior Coal Province.

The complex is designed with four coal mine faces operating simultaneously, each producing 10,000 TPD. The coal is processed through a coal preparation plant to produce approximately 30,000 TPD of clean, washed and dried coal feed.

The process efficiency of this design is achieved by:

a. Use of a two-stage entrained slagging type gasifier.

b. Use of ERDA-developed flame-sprayed catalyst techniques. The reactors for catalytic reaction are logical extensions of pilot plant designs and a design development peculiar to this report.

c. Generation of 1200 psig steam from the heat of catalytic reactions.

d. Utilization of recovered heat by high efficiency power plant turbo-generators.

e. Extension of the Fischer-Tropsch technology using scale-ups of technology and equipment developments.

The data investigated during design development included iron catalyst in bed and sprayed-on-plate forms for the Fischer-Tropsch synthesis and Raney nickel catalyst for methanation. The sprayed-catalyst-on-plates method was used as developed at Bruceton. The shift reactor is designed with this same technique.

The efficient recovery of the majority of the reaction heat as steam at 1200 psig, and the subsequent superheating of the steam with hot synthesis gas to 950°F, allows use of central power plant steam turbine-driven generators. This steam is converted to electrical power at a 41.5 percent efficiency. Excess process steam produced in the plant at 500 psig, 135 psig and 55 psig is used as bleed steam with electrical power extracted. The boiler feed water is preheated by process heat and bleed steam to provide the stipulated efficiency.

The pressure used by the gasification and Fischer-Tropsch synthesis is 400 psig in the Fischer-Tropsch reactor as was used in most ERDA data runs. At this pressure, experience indicates that carbon formation encountered at lower pressures is avoided. If the Fischer-Tropsch synthesis were carried out at 1000 psig, the overall plant efficiency might improve.

4. Activity Forecast Next Quarter.

We will complete the economic analysis of the Fischer-Tropsch complex and incorporate it into the R&D report. We will submit a draft of the report to ERDA for review and prepare to publish the report in its final form.

D. COG Plant Design

1. Objectives.

To develop a preliminary design of a coal processing plant which will produce liquid and gaseous fuels as principal products. The processes employed in this plant design shall be the result of an economic selection from the candidate coal conversion processes available.

To develop a model capable of calculating material and heat balances for a number of coal conversion processes using computer capability, and to estimate the overall utility balance of the complex.

2. Activity for the Quarter.

a. We advanced a summary of the comparison of liquefaction processes studied to date. The comparisons include the process and yield characteristics, utility requirements, capital and operating costs. The summary also includes a status report on development efforts.

b. We completed the preparation of preliminary block flow diagrams of candidate COG complex combinations.

c. We met with ERDA representatives on May 6, and June 8 to establish basic design concepts for a COG-type plant. A meeting was planned in July to finalize the design basis.

d. We initiated a study to determine the best use for char considering possible production of hydrogen, SNG, Fischer-Tropsch feed gas, and power.

e. We prepared a draft of a design basis, including a block flow diagram for a recommended preferred combination of operations, and a material balance.

f. We initiated a study to determine what type of pyrolysis could be incorporated in the plant design. We are investigating flash, hydropyrolysis and the dry catalytic pyrolysis processes. We completed a literature search to obtain additional information on direct flash pyrolysis.

g. We initiated a study to establish the pressure level at which char can be economically gasified with oxygen and below which char should be gasified with air. The study is restricted to fuel gas production.

3. Results of These Activities.

The above activities are in the process of development; final conclusions await their completion.

4. Activity Forecast Next Quarter.

We will complete the status report covering the utilization of various coal liquefaction processes for COG. We will finalize

a recommended design basis and transmit this to ERDA. We will start the detailed design of the complex when authorized to do so by ERDA.

E. Multipurpose Demonstration Facility

1. Objectives.

To develop preliminary designs for a facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during pilot plant scale operations. These designs shall be based on the concept that the operating units shall be constructed as module additions over a period of years. The completed facility shall include modules of facilities which can be common to two or more other processes, as well as allowances for future modification and/or replacement of various pieces of equipment to meet new requirements.

2. Activity This Quarter.

a. We developed a list of licensors and an approved form letter to solicit submittal of methanol plant technical and economic information from commercial plant licensors.

b. We reviewed the preferred steps to convert coal-derived liquids to marketable products such as gasoline. We initiated a study to determine the critical factors affecting the coal charge rate for the facility.

c. We prepared preliminary designs, planning type estimates, and approximate gas values for a low pressure, two-stage,

air-blown gasifier. This gasifier will gasify about 200 tons of Eastern bituminous coal per hour to produce a gas of about 160 Btu/SCF of heating value.

This gasifier would operate at about 40 psig and will produce about 160 billion Btu/day of calorific heat content in this gas. This type of unit could be used to supply gas for industrial heating and power boilers.

3. Activity Forecast Next Quarter.

We will continue to advance the preparation of a design basis for this task.

F. Equipment Development

1. Objectives.

To define the equipment and control system development programs required to assure reliability of coal conversion processes being developed. To recommend appropriate developmental programs to ERDA - Fossil Energy Division.

2. Activity This Quarter.

a. Gas/Solids Separation: We received additional information on cyclone sizing and efficiencies. We continued to work with electrostatic precipitator manufacturers.

b. Solids Feed to Gasifier: We continued to work with vendors on developments of ground coal compression screw feeders.

c. Valves: We met with valve manufacturers and discussed the adaptability of their products to coal conversion applications.

3. Activity Forecast Next Quarter.

We will continue collaboration with equipment manufacturers and monitor progress of their developments. We will propose development programs to ERDA where deemed practical.

G. Materials of Construction

1. Objectives.

To define the preferred materials of construction for use in coal conversion projects.

2. Activity This Quarter.

a. We presented a paper entitled "Coal Liquefaction: Materials Systems Design" to the American Society of Metals Conference on Materials in Coal Conversion Systems. The meeting was held in Pittsburgh, Pennsylvania on April 26, 1976.

b. We supported the Oil/Gas and Fischer-Tropsch design efforts by supplying materials of construction specifications.

3. Activity Forecast Next Quarter.

We will continue to support design efforts by supplying materials of construction specifications.

H. Environmental Considerations

1. Objectives.

To define environmental factors for proposed coal conversion complexes, to define facilities required for the coal conversion complexes to meet environmental standards, and to define product quality standards to meet environmental regulations for product users.

2. Activity for the Quarter.

a. We completed the design report section on Environmental Factors for the Fischer-Tropsch plant design study. This includes details of treatment of gaseous and liquid effluent streams generated by the complex. The disposal of solid wastes and noise control procedures were described. We also considered possible deleterious action of products, the possible release to the environment of heavy metals and trace elements, and pertinent mine area restoration procedures.

b. We reviewed the Oil/Gas plant design to study pertinent environmental factors. These include treatment of gaseous and liquid effluent streams generated by the complex, disposal of solid wastes, and noise control procedures. We are also considering possible deleterious action of products, the possible release to the environment of heavy metals and trace elements, and pertinent mine area restoration procedures.

3. Activity Forecast Next Quarter.

We will finalize the input to both Oil/Gas and Fischer-Tropsch complex design reports.

I. General

We participated in a Technical Data Book Advisory Committee Meeting on Coal Conversion Systems in Chicago, Illinois on May 27, 1976.

K. Publications

1. Objectives.

In the course of the development of the designs, our objectives will be to prepare and present invited papers before various

technical bodies to communicate the status of Parsons efforts and knowledge to the scientific and industrial community.

2. Activities This Quarter.

We presented the following papers:

a. Invited paper titled "Preliminary Economic Analysis: Oil and Power by COED-Based Conversion" to the American Chemical Society Symposium on Comparative Economics of Synfuel in New York on April 8, 1976.

b. Invited paper titled "Coal Liquefaction: Material System Design" for presentation before the American Society of Metals (ASM), Systems and Design Symposium, in Pittsburgh, Pennsylvania, on April 26, 1976.

c. An invited paper titled "Coal Conversion Development: An Overview" to the Engineering Institute of Canada, Petrochemicals West, Third Annual Western Regional Conference, Calgary, Alberta, on May 12, 1976.

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