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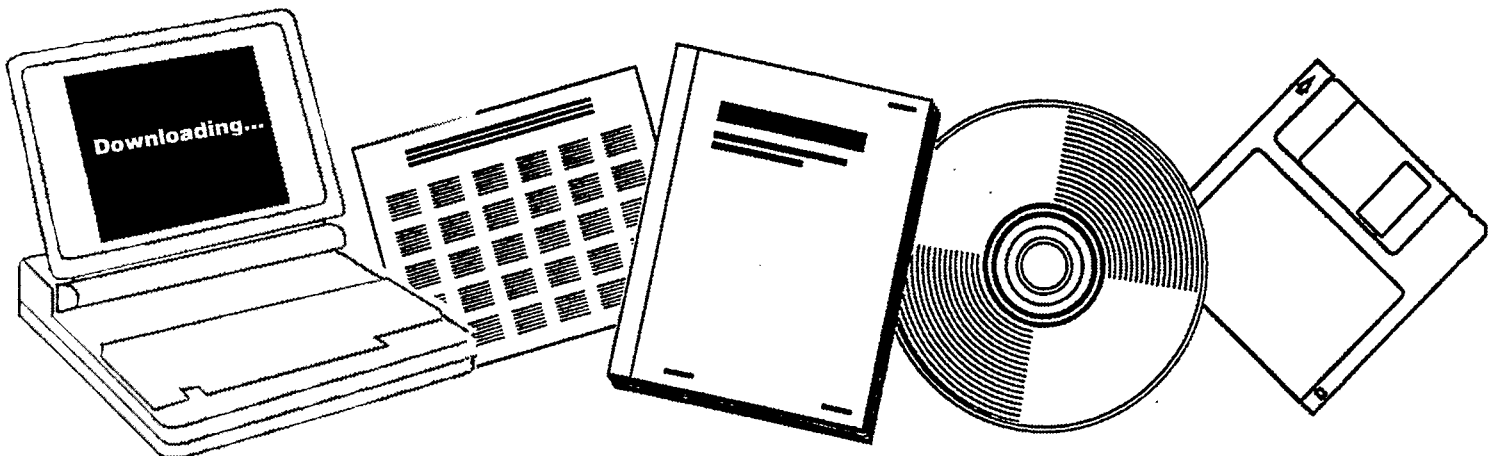
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**PRELIMINARY DESIGN SERVICES, COAL
CONVERSION DEMONSTRATION PLANTS. RESEARCH
AND DEVELOPMENT REPORT NO. 114, QUARTERLY
REPORT, JULY--SEPTEMBER 1976**

PARSONS (RALPH M.) CO., PASADENA, CALIF

NOV 1976



U.S. Department of Commerce
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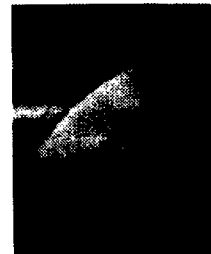
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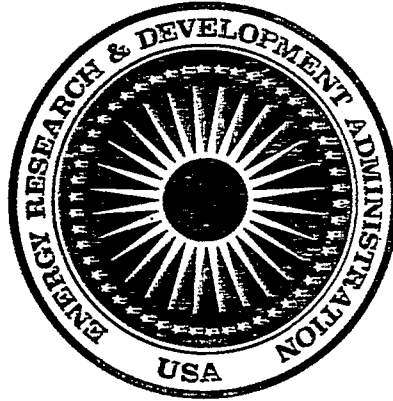
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PRELIMINARY DESIGN SERVICES COAL CONVERSION DEMONSTRATION PLANTS

RESEARCH AND DEVELOPMENT REPORT NO. 114
QUARTERLY REPORT
FOR THE PERIOD: JULY - SEPTEMBER 1976

Prepared by:

THE RALPH M. PARSONS COMPANY
100 West Walnut Street
Pasadena, California 91124

Under Contract No. E(49-18)-1775

November 1976

Prepared for

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D. C. 20545

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PRELIMINARY DESIGN SERVICES

RESEARCH AND DEVELOPMENT REPORT NO. 114

QUARTERLY REPORT

For the Period July - September 1976

Prepared by:

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THIRD 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 coal processing plant to produce power, oil, gas, and other products (POGO).
- 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 consideration of 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 transmitted to ERDA draft copies of the final R&D reports describing the designs/economic evaluations for the Fischer-Tropsch and Oil/Gas plants. A document containing a proposed design basis for the COG design was transmitted to ERDA who directed that this task effort hereafter be referred to as POGO, an acronym for Power, Oil, Gas, and Other. We reached agreement with ERDA regarding primary elements of the POGO design basis. POGO designs will be developed for the following areas of the U.S.:

- Eastern Region of the Interior Coal Province
- Southern Appalachia
- Rocky Mountain Province

We obtained geological information from state agencies on coal availability in Southern Appalachian and Rocky Mountain Provinces for mining up to 100,000 tons per day.

We continued to refine the Oil/Gas and Fischer-Tropsch R&D draft reports in response to comments received from ERDA. We completed the profitability analysis for these tasks.

We obtained additional information on the subject of liquid/solids and gas/solid separation and coal feeding devices. We obtained information that ionizer units can agglomerate fines in gas streams with a resulting increase in downstream cyclone efficiency.

We completed the study of the environmental factors pertaining to the Oil/Gas plant.

A brief summary of results by assigned task follows.

Coal Mining/Coal Preparation

We continued to assemble geological information and started to prepare reports on coal reserves required for 100,000 T/D mine operations in the Southern Appalachia and Rocky Mountain areas. We concluded that it will take a number of coal mines to supply this operation in the Southern Appalachia area.

Potential exists in the Rocky Mountain Province to develop single captive mines producing 100,000 tons per day of coal.

Oil/Gas Plant Design

We completed the profitability analysis and continued work on the R&D report. We transmitted a draft copy to ERDA and reviewed it with them. As a result of this review, we worked to expand the reports at ERDA's request to include:

- A detailed section describing the marketability and characteristics of the products.
- A summary of the experimental data base used for the design.
- A description of the gasifier effluent waste heat boiler design.

Fischer-Tropsch Plant Design

We continued preparation of the R&D report including revision to the power generation facilities to optimize cooling tower operation. We transmitted a draft copy to ERDA and reviewed it with them. Following the review, we began work to expand the report to include the same three sections described above under the "Oil/Gas" design.

POGO Plant Design

We completed a draft of the Design Basis Recommendation Report and transmitted it to ERDA. ERDA accepted our recom-

mended design basis with some modification. It was agreed that the heaviest hydroliquefaction stream would be upgraded to a higher value consumer product. At the direction of ERDA, we also began revision of the report in preparation for issue as an interim ERDA R&D report.

We completed case definitions and specifications for engineering development and pricing for a number of process alternate studies. We completed preliminary alternate economic assessments for options to upgrade heavy coal liquids to higher value consumer products. We will transmit the results to ERDA for review and decision. The decision on this point will provide the final element of the design basis.

We established tentative current market price structures for coal liquefaction products saleable in fuels, chemical and petrochemical markets.

Multipurpose Demonstration Facility

We received economic data, including capital cost, utilities requirements, etc. for a medium pressure (approximately 1,500 psig) methanol plant. We are analyzing these data. We developed operating cost data for the Fischer-Tropsch process based on a 50-50 liquid/SNG product slate.

We worked to develop a recommended design basis for transmittal to ERDA.

Equipment Development

We continued contacts to obtain information regarding results generated in the ERDA program for development of ground coal compression screw feeders which are specified for use in our Oil/Gas and Fischer-Tropsch designs; also for gas/solids separation equipment. Information obtained on solid coal screw feeders included estimates of power requirements and capital costs.

Materials of Construction

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

Environmental Considerations

We completed the study of the environmental factors pertaining to the Oil/Gas plant. This study will be included in the R&D report. We will also prepare a paper describing the key results of this study and present it at the AIChE meeting to be held in Chicago on November 30 - December 2, 1976.

We also completed the investigation of cyanides and their role in the coal conversion process.

General

We presented the following invited papers:

1. "Potentials for Petrochemical Feedstocks and Chemicals from Coal" presented to the AIChE Symposium on "Chemicals

from Coal - New Frontiers," at Atlantic City, New Jersey on August 31, 1976. Chemical Engineering Progress will publish this paper which presents a process plan, material balance, and market penetration information for a scheme to produce a billion pounds per year of ethylene plus large volumes of other petrochemicals from coal.

2. "The Materials Problems in Coal Gasification and Liquefaction Systems" presented at the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) Conference on Materials Requirements for Unconventional Energy Systems to be held September 19-23, 1976 at Niagara Falls, New York.

We participated in the following meetings:

1. Ingersoll-Rand's State of the Art Presentation to ERDA on coal conversion equipment applications in Washington, D.C. on September 9, 1976. Particular emphasis in this meeting was devoted to gas compressors, expanders, and coal slurry pumps.
2. United Technologies Research Center in Pasadena to discuss the potentials of applying their computer-assisted simulation capability to analysis and optimization of power generation/utilities system in coal conversion complexes.

3. T. Y. Lin International to discuss the potential for the use of pre-stressed concrete vessels in coal conversion plants. T. Y. Lin agreed to supply further information on the potential of this technique.

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

- a. We obtained geological information from state agencies on coal availability in Southern Appalachian and Rocky Mountain Provinces. We continued to assemble the most current geological information and planning data for the conceptual development of coal mines in these regions.

We concluded from information obtained that coal will have to be obtained from a number of mines to supply 100,000 tons per day of ROM coal production for the lower Appalachia area.

- b. We continued to investigate efficient coal preparation methods.

3. Results of These Activities

We have preliminarily concluded that a "water only" jigging and multi-stage cyclone system for reduction of ash content in conversion plant coal feed is adequate and preferable to a heavy media system. Two clean coal cuts can be produced: two-thirds of the total coal with an ash content of about 6.5 percent and one-third in a range of 8 to 8.5 percent.

4. Activity Forecast Next Quarter

- a. We will continue development of mine designs for the three areas required for the POGO design.
- b. We will continue to develop and confirm coal preparation plant designs with the aim of optimum practical separation of high from low ash/sulfur coal.

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

We submitted a draft of major elements of the R&D report to ERDA. We refined the report and maintained contact with ERDA in order to finalize it for publication. We transmitted updated economic projections to ERDA on August 27, 1976.

3. Result of These Activities

- a. We received ERDA's comments on our R&D report draft and revised it accordingly.
- b. We completed the energy and the utility summaries.
- c. We completed updated profitability analyses of the complex.
- d. We produced a model of the plant.

4. Activity Forecast Next Quarter

We are expanding the R&D report to include:

- a. Marketability of the products plus a detailed summary of product characteristics.
- b. Experimental data used for the design.
- c. A description of the gasifier effluent waste heat boiler design.

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 transmitted a draft copy of the R&D report to ERDA and reviewed it with them. We maintained contact with ERDA to finalize the report for publication.
- b. We completed the utility summary to conform to optimum cooling tower operations.
- c. We completed the economics section of the design report, including preparation of the final operations and maintenance manpower tables.
- d. At ERDA's request, we worked to expand the R&D report to include:
 1. Marketability of products plus a detailed summary of product characteristics; see Section III-C-3-d for further detail.
 2. A summary of experimental data used to design the Fischer-Tropsch shift and methanation reactors.

3. A description of the gasifier effluent waste heat boiler designs.

3. Result of These Activities

- a. The R&D report is nearing completion with a target to obtain release for publication during the next quarter.
- b. It was determined that natural draft cooling towers were unsuitable for the small cooling water temperature differential. Mechanical draft cross flow cooling towers were included in the design.
- c. We determined the total personnel requirements for the total complex to be approximately 2,100:
- | | |
|--------------------------|-----|
| Administrative Personnel | 343 |
| Operating Personnel | 978 |
| Maintenance Personnel | 764 |
- d. "Marketability Considerations" was added to the Product section of the R&D report. Details of the investigations and comparisons of certain product properties with corresponding petroleum product specifications are included. A synopsis of this analysis follows:

SNG: Meets properties requirements for sale as substitute natural gas; has a HHV of 1035 Btu/SCF; is produced at pipeline pressure.

Butanes: Can be marketed as LPG and as ethylene plant feedstock.

Naphtha, light and heavy: Aromatics content would be near zero. Octane numbers are low. Since they consist largely of straight chain saturated hydrocarbons with nil sulfur content, they would be preferred petrochemical feed stocks.

As an alternate, they would be suitable as feedstock for gasoline manufacture, requiring further processing and reforming.

Diesel Oil: This product is a superior diesel engine fuel with nil sulfur content and high Cetane number. It meets all ASTM D975 No. 1-D Diesel Fuel Oil specifications and all ASTM D396 No. 1 Fuel Oil specifications.

Fuel Oil: This product meets all ASTM D2880 No. 3-GT specifications for Gas Turbine Fuel Oil in addition to containing nil sulfur and nil nitrogen.

- e. The Data Base section of the report was expanded to include experimental results and data on which the flame sprayed catalyst synthesis reactor designs were based. This will be incorporated as a major report

section in the R&D report. It includes detailed descriptions of experimental procedures and data on individual runs.

- f. Gasifier effluent waste heat boiler design: Details of the design of the heat exchangers used as steam superheaters and steam generators recovering heat from the gasifier synthesis gas were prepared and added to the R&D report.

These exchangers are vertical shell and tube units with the gas-char mixture flowing downward through two-inch tubes. The tubes are 321 stainless steel selected because of its toughness. Their thickness is equivalent to schedule 80 pipe. The tube inlets are protected against abrasion by ceramic ferrules. Velocities through the tubes are those customarily used in pneumatic conveying systems.

The Syngas coolers are patterned after similar units operated at similar pressures as petroleum fluid cracker regenerator gas outlet coolers and fluid catalyst line exchangers. They are also similar to boilers cooling Syngas and ash in a coal-based ammonia plant located in South Africa.

4. Activity Forecast Next Quarter

- a. We will complete the final draft of the R&D report and transmit it to ERDA with the objective to obtain approval to publish it.

D. POGO 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 This Quarter

- a. We completed the Design Basis Recommendation document and transmitted it to ERDA. It includes the following:
 1. Block Flow Diagrams for Candidate POGO process configurations.
 2. Preliminary Technical/Economic Assessment.

3. Process Comparison Study.
 4. Short List Comparison (4 alternative configurations).
 5. Recommended Design Basis; key coal conversion steps are flash pyrolysis and hydroliquefaction.
- b. We received agreement from ERDA on major points of the design basis. At ERDA's request, we defined procedures to upgrade the heaviest liquid product to higher valued consumer products.
 - c. At ERDA's direction, we will prepare the design basis document in a form suitable for publication as an R&D report. To accomplish this, we initiated a final check of documents included in the report.
 - d. We started a preliminary study to determine the advantages and economics of adding a Fischer-Tropsch section to the selected POGO configuration.
 - e. We made progress on a study to set the maximum economical pressure level for gasification of char with air.
 - f. We completed a preliminary study of pyrolysis processes. Three basic types of pyrolysis processes

were considered: flash, hydrolysis, and catalytic "fast" pyrolysis.

- g. We prepared a case study for integration of process furnaces and gas turbine operations.
- h. We prepared economics comparisons for four POGO configurations.

3. Results of These Activities

We completed alternate economic assessments for the revised design to include upgrading the heaviest liquid product. A preliminary technical description and economics of base Case IV were then transmitted to ERDA for review.

Economic comparisons are based upon the following cases:

Case IVB: The base pyrolysis hydroliquefaction case plus gasification of heavy oil.

Case IVC: Case IVB, adding coal feed to pyrolysis to provide sufficient extra char to feed a 250 billion Btu/day Fischer-Tropsch train.

Case IVD: The base case, but coking the heavy oil.

Case IVE: Case IVD, adding coal feed as in Case IVC for a 250 billion Btu/day Fischer-Tropsch train.

The evaluation procedure was as follows:

1. Establish a block flow diagram, including all units required for plant operation.
2. Establish a process material balance, using a hydroliquefaction unit of the same size as that used in the Oil/Gas plant, and, where required, a Fischer-Tropsch train equivalent to one train of our U.S.A. Fischer-Tropsch plant. Size other units to supply hydrogen needs for the plant and to treat all products to salable condition. Calculate utility requirements based on fuel gas needs at 15 percent of the heating value of coal fed to the process units.
3. Adjust the fixed capital estimate for all cases to 75,000 TPD coal feed by use of a 0.7 exponent capacity factor.
4. Calculate fuel selling price required to produce a 12 percent discounted cash flow return, based both on an average heating value basis and also probable product market values.
5. On the basis of the above evaluation Case IVD (coking of heavy oil) was recommended as being economically attractive, considering conservative product pricing. ERDA accepted our recommendation.

We obtained analyses of candidate alternate coals as required for the design basis of this task.

4. Activity Forecast Next Quarter

- a. The product slate for Case IVD will be specified and detailed design activities started.
- b. The coal mine design for all three locations will be started.
- c. Coal preparation units design is expected to be completed for the two eastern locations. None is contemplated for the western location.

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 very preliminary design and economics for a conceptual commercial methanol plant from coal. We worked to refine the design and economic estimates.
- b. We advanced the comparison of methanol processes for production of coal based methyl fuel.
- c. We studied a high pressure (5,000 psig) methanol plant design.
- d. We completed a preliminary single-stage gasifier design basis to produce gas with minimum methane and nitrogen as required for methanol plant feed.
- e. We reviewed Cresap designs to establish their suitability for inclusion into the multipurpose scheme.

3. Results of These Activities

The preliminary designs/economics were used as a basis to begin preparation of a recommended design basis.

4. Activity Forecast Next Quarter

The studies started during this quarter will be refined during the next quarter. A size determination study for the facility will be started.

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. Objective

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

2. Activity This Quarter

- a. We presented a paper entitled "The Materials Problems in Coal Gasification and Liquefaction Systems" to the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) Conference on Materials Requirements for Unconventional Energy Systems on September 19-23, 1976 at Niagara Falls, New York.
- b. We supported the Oil/Gas and Fischer-Tropsch 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 This Quarter

- a. We assembled a report on "Environmental Factors Related to the Surface Mining of Coal." This report considers mining techniques which facilitate the task of land reclamation, federal and state regulations concerning the surface mining of coal, prevention of water pollution, land reclamation procedures, and representative costs.

- b. We reviewed the conceptual design of the Fischer-Tropsch and the Oil/Gas plants to define the proportion of capital and operating expenses which is allocated to environmental control facilities. For the Oil/Gas plant, ten plant units contribute to environmental control and the fixed capital investment for environmental units amounts to approximately 12.5 percent of the total fixed capital. This is the same order of magnitude as required for a grassroots petroleum refinery.

- c. We will investigate the role of cyanides in coal conversion processes. The following subjects will be phases; reactions and equilibria with other chemical species; detoxification of gaseous phases; liquid effluent cleanup.

3. Activity Forecast Next Quarter

We will continue the environmental work along the two main directions followed so far, namely (1) investigation of environmental factors related to coal conversion and identification of environmentally sensitive areas or operational aspects where additional study is required, (2) design monitoring to insure that the Parsons conceptual commercial designs are environmentally acceptable and in compliance with present and projected environmental requirements.

In the first area, we will further investigate the fate of trace elements during coal conversion in view of recent information collected by the Institute for Gas Technology at the Hygas Pilot Plant. We will also further the study of formation of cyanides during gasification or liquefaction of coal and their detoxification during effluent treatment.

We will review the preliminary design work for the POGO Plant and the Multipurpose Demonstration Facility; specific environmental areas requiring consideration will be analyzed and discussed with the design engineers.

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