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SRC-II DEMONSTRATION PROJECT
PHASE ZERO
TASK NUMBER 3

DELIVERABLE NUMBER 8

VOL. 1 OF 5

CONCEPTUAL COMMERCIAL PLANT SUMMARY

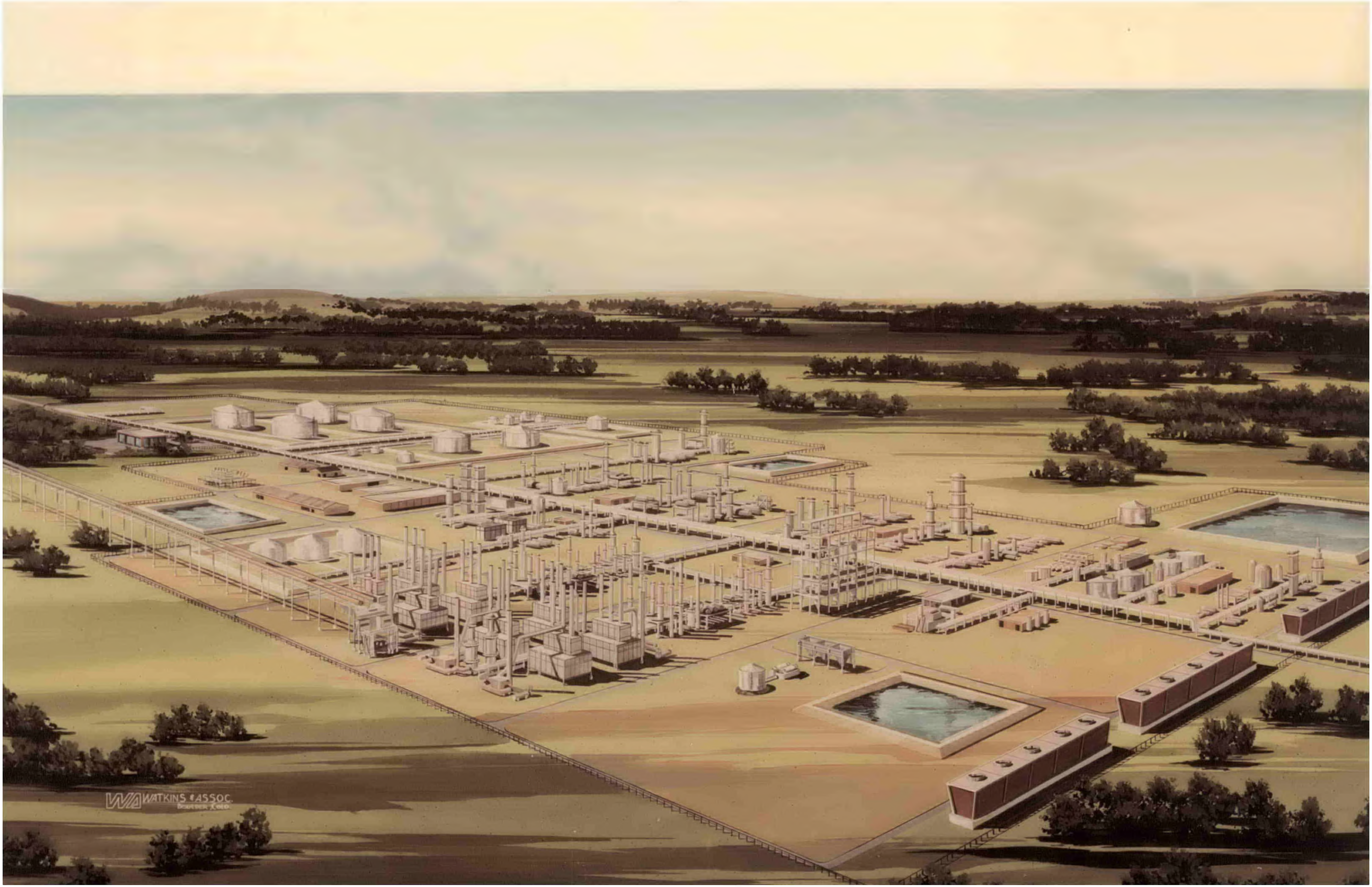
JULY 31, 1979

MASTER

THE PITTSBURG & MIDWAY COAL MINING CO.
DENVER, COLORADO

PREPARED FOR

UNITED STATES DEPARTMENT OF ENERGY
UNDER CONTRACT
DE-AC05-780R03055


WATKINS & ASSOC.
Boulder, Colo.

NOTICE

FOREWORD

The synthetic fuels production technology has been under development since the 1920's. In North America, the application of coal to synthetic fuels technology has lagged because of the abundance and low cost of natural crude oil. On other continents and under different circumstances, however, synthetic fuels have been produced successfully in quantity from coal --- for example in Germany during World War II.

World energy requirements are increasing faster than petroleum supplies. Even with the greatly increased world price of crude oil, petroleum discoveries appear incapable of meeting future demands. Therefore, the time is right for deployment of a synthetic fuels industry. The United States, with its abundant coal resources, is in an excellent position to benefit from the successful development of a coal-based synthetic fuels industry.

This Deliverable describes a Conceptual Commercial Plant (CCP) using the SRC-II Solvent Refined Coal process for the production of liquid and gaseous hydrocarbon synthetic fuels and by-products from coal. This plant is visualized as one of a number of "coal refineries" which would utilize domestic coal resources for the production of liquid fuels.

A CCP would charge about 33,500 tons of coal per stream day (tpsd) and be comparable to a 100,000 barrels per stream day (bpsd) petroleum refinery in energy output. The Conceptual Commercial Plant envisioned in this report would produce 56,000 bpsd of fuel oil and 51 million cubic feet per day (MM cfd) of pipeline gas. Other products would include an aromatic naphtha which when further processed would produce a high octane blending stock for gasoline, and light hydrocarbons which could be converted to ethylene (a basic petrochemical building block), providing the basis for a downstream petrochemical complex.

The location selected for an SRC-II coal refinery can anticipate substantial economic stimulus during plant construction, startup and operation. The CCP would generate additional economic activity by its own needs for supplies and services and supply feedstocks leading to the construction of downstream and ancillary plants. The economic benefits for the area would be substantial.

The SRC-II plant described here is designed to protect the environment. Recognizing that the SRC-II feedstock is to be a high sulfur bituminous coal which is not suitable for direct firing under current EPA regulations without expensive sulfur removal equipment, this plant has been designed to remove the sulfur contaminant as a by-product. Disposition of other wastes will be accomplished economically in an environmentally acceptable manner.

This report is Volume 1, Management Summary of Deliverable 8, Conceptual Commercial Plant for Phase Zero of the SRC-II Demonstration Project. Other volumes in this deliverable are:

Volume 2 - Plant Description
Volume 3 - Supporting Reports
Volume 4 - Advanced Process Technology
Volume 5 - Economic Analysis

This volume is a general summary of the information presented in the succeeding volumes and touches briefly on feedstocks, products, thermal efficiency, companion plants, future technology, environmental considerations, and projected capital and operating costs.

CONTENTS

FIGURES

SECTION 1

FACILITIES DESCRIPTION

As part of Phase Zero of the SRC-II program, DOE authorized preparation of a conceptual design for a Conceptual Commercial Plant (CCP) to estimate commercial-scale economics for SRC-II. The conceptual design presented in this report assumes an unspecified site in the Eastern United States and is predicated on the successful operation of the Demonstration Plant. It assumes performance verification of the various technologies prior to construction of the Conceptual Commercial Plant. Since many of the operating characteristics of SRC-II are yet to be demonstrated, only limited attempts have been made to optimize this CCP configuration. Continuing work on plant design should result in improvements in the plant operability and economics as more data become available.

In the development of the Conceptual Commercial Plant, it became apparent that at least two companion plants should also be considered. The first is a High Octane Blending Stock Plant, the second is an Ethylene Plant. Estimated capital costs for these plants are presented in Volume 5.

In the development stage of the Conceptual Commercial Plant, several design features and fabrication techniques were identified as being critical and requiring advanced process and mechanical technology. A complete discussion of prototype processes and equipment is included in Volume 2, Project Description. While these design features are not presently proven, it is reasonable to expect advances in technology which will make them possible in the next decade. However, for each of these items, alternates based on present-day technology exist so that the success of the SRC-II CCP is not dependent on any specific technological advances.

An engineering consultant, Scientific Design Company, Inc., of New York, has been engaged to provide an independent overview of the Conceptual Commercial Plant design. Their reports are included in Volume 3.

1.1 SRC-II CONCEPTUAL COMMERCIAL PLANT

Because a specific site for the Conceptual Commercial Plant has not yet been designated, site characteristics have been assumed in order to develop a basis for estimating engineering and plant costs. It is assumed that the site will be in close proximity to major highways, railroads, pipelines, and a navigable river. The completed plant will include all support facilities such as offices, maintenance shops, utility systems, roads, and railyards for independent operation. Electric power in excess of that generated internally would be purchased from a local utility. Raw water requirements would be met by the nearby river. Coal supply to the plant would be by rail while transportation of products would be accomplished by a combination of rail, truck and pipeline. The design basis assumes barge facilities are not required, although final site selection may prove barge shipment to be desirable.

The general arrangement of the plant is shown on Figure 1-1 and a schematic flow sheet is shown on Figure 1-2. The plant would consist of two main areas, the Coal Preparation and Storage Area and the Main Process Area. These and the Slag Disposal Area would cover approximately 500 acres. The final arrangement of equipment and units will be determined after the actual site is selected.

Field construction of the plant would require approximately 21 million craft labor hours over the construction phase of 42 months. The labor force during construction would average 3100 and peak at 5400. Upon completion, an operating force of over 500 would be required.

SCHEMATIC FLOWSHEET OF SRC-II CONCEPTUAL COMMERCIAL PLANT

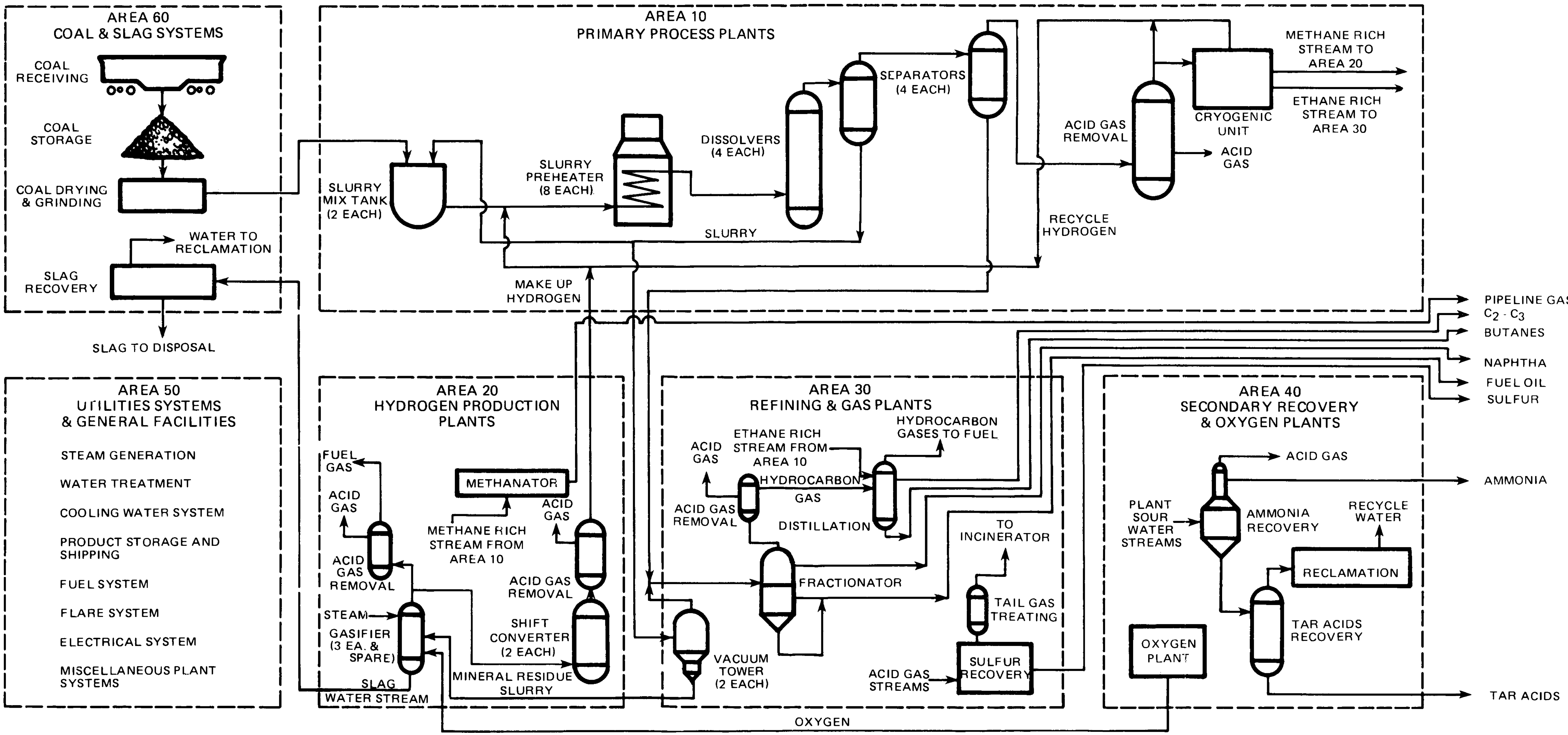
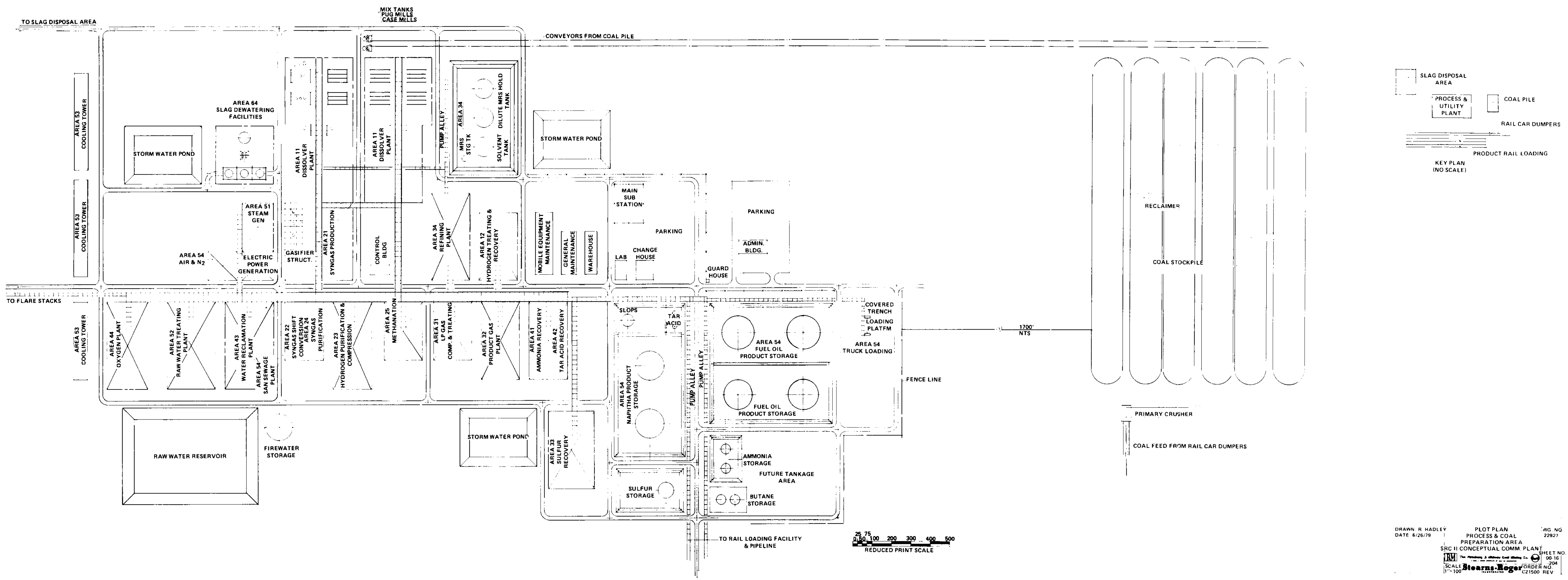


FIGURE 1-1



TO SLAG DISPOSAL AREA
MIX TANKS
PUG MILLS
CAGE MILLS
CONVEYORS FROM COAL PILE
AREA 53 COOLING TOWER
AREA 53 COOLING TOWER
AREA 53 COOLING TOWER
STORM WATER POND
AREA 64 SLAG DEWATERING FACILITIES
AREA 11 DISSOLVER PLANT
AREA 11 DISSOLVER PLANT
PUMP ALLEY
AREA 34
MRS STG TK
SOLVENT TANK
DILUTE MRS HOLD TANK
STORM WATER POND
AREA 51 STEAM GEN
AREA 54 AIR & N2
ELECTRIC POWER GENERATION
GASIFIER STRUCT.
AREA 21 SYNGAS PRODUCTION
CONTROL BLDG
AREA 34 REFINING PLANT
AREA 12 HYDROGEN TREATING & RECOVERY
MOBILE EQUIPMENT MAINTENANCE
GENERAL MAINTENANCE
WAREHOUSE
MAIN SUB STATION
PARKING
LAB
CHANGE HOUSE
PARKING
ADMIN. BLDG.
GUARD HOUSE
TO FLARE STACKS
AREA 44 OXYGEN PLANT
AREA 52 RAW WATER TREATING PLANT
AREA 43 WATER RECLAMATION PLANT
AREA 54 SAN SEWAGE PLANT
AREA 22 SYNGAS SHIFT CONVERSION
AREA 24 SYNGAS PURIFICATION
AREA 23 HYDROGEN PURIFICATION & COMPRESSION
AREA 25 METHANATION
AREA 31 LP GAS COMP. & TREATING
AREA 32 PRODUCT GAS PLANT
AREA 41 AMMONIA RECOVERY
AREA 42 TAR ACID RECOVERY
SLOPS
TAR ACID
AREA 54 NAPHTHA PRODUCT STORAGE
PUMP ALLEY
PUMP ALLEY
AREA 54 FUEL OIL PRODUCT STORAGE
FUEL OIL PRODUCT STORAGE
COVERED TRENCH
LOADING PLATFM
AREA 54 TRUCK LOADING
FENCE LINE
1700' NTS
RAW WATER RESERVOIR
FIREWATER STORAGE
STORM WATER POND
AREA 33 SULFUR RECOVERY
SULFUR STORAGE
AMMONIA STORAGE
FUTURE TANKAGE AREA
BUTANE STORAGE
TO RAIL LOADING FACILITY & PIPELINE
0 25 50 75 100 200 300 400 500
REDUCED PRINT SCALE
RECLAIMER
COAL STOCKPILE
PRIMARY CRUSHER
COAL FEED FROM RAIL CAR DUMPERS
SLAG DISPOSAL AREA
PROCESS & UTILITY PLANT
COAL PILE
RAIL CAR DUMPERS
PRODUCT RAIL LOADING
KEY PLAN (NO SCALE)
DRAWN R HADLEY
DATE 6/26/79
PLOT PLAN
PROCESS & COAL PREPARATION AREA
SRC II CONCEPTUAL COMM. PLANT
DWG NO 22927
SHEET NO 00 16 204
Stearns-Roger
SCALE 1"=100'
ORDER NO C21500
REV

FIGURE 1-2

1.1.1 Feedstock

Powhatan coal from the Pittsburgh seam has been selected for this Conceptual Commercial Plant because it represents a typical Eastern coal sufficiently abundant that the plant could be supplied for at least a twenty-five year period. This coal is neither the most nor the least reactive that could be charged.

Selection of Powhatan coal as a feedstock does not imply limited site selection since other coals may be used as charge for the Conceptual Commercial Plant. Depending on the specific coal or coals, relatively minor design changes might be needed to maintain the specified charge rate.

The Conceptual Commercial Plant has been designed to process a nominal 33,500 tons of coal per stream day, slightly in excess of the rate needed to handle 30,000 tons per calendar day at 90% on-stream efficiency. Coal delivery by unit-train is assumed, but the coal delivery system is outside the scope of this study.

Besides coal, the only raw material inputs to the plant are air and water. River water is assumed to be available; water treating is included in plant processing. The process also consumes minor amounts of catalysts and chemicals.

Table 1-1 and Figure 1-3 give the composition of the Powhatan coal selected for this particular design case.

TABLE 1-1

FEEDSTOCK COMPOSITION

Powhatan Coal

Coal Composition, WT% (Moisture Free Basis)

Carbon		70.49
Hydrogen		4.88
Nitrogen		1.12
Oxygen		7.87
Sulfur		3.59
Pyrite	2.00	
Organic	1.54	
Sulfate	0.05	
Chlorine		0.05
Ash		12.00
Contained Iron	1.75	
TOTAL		100.00

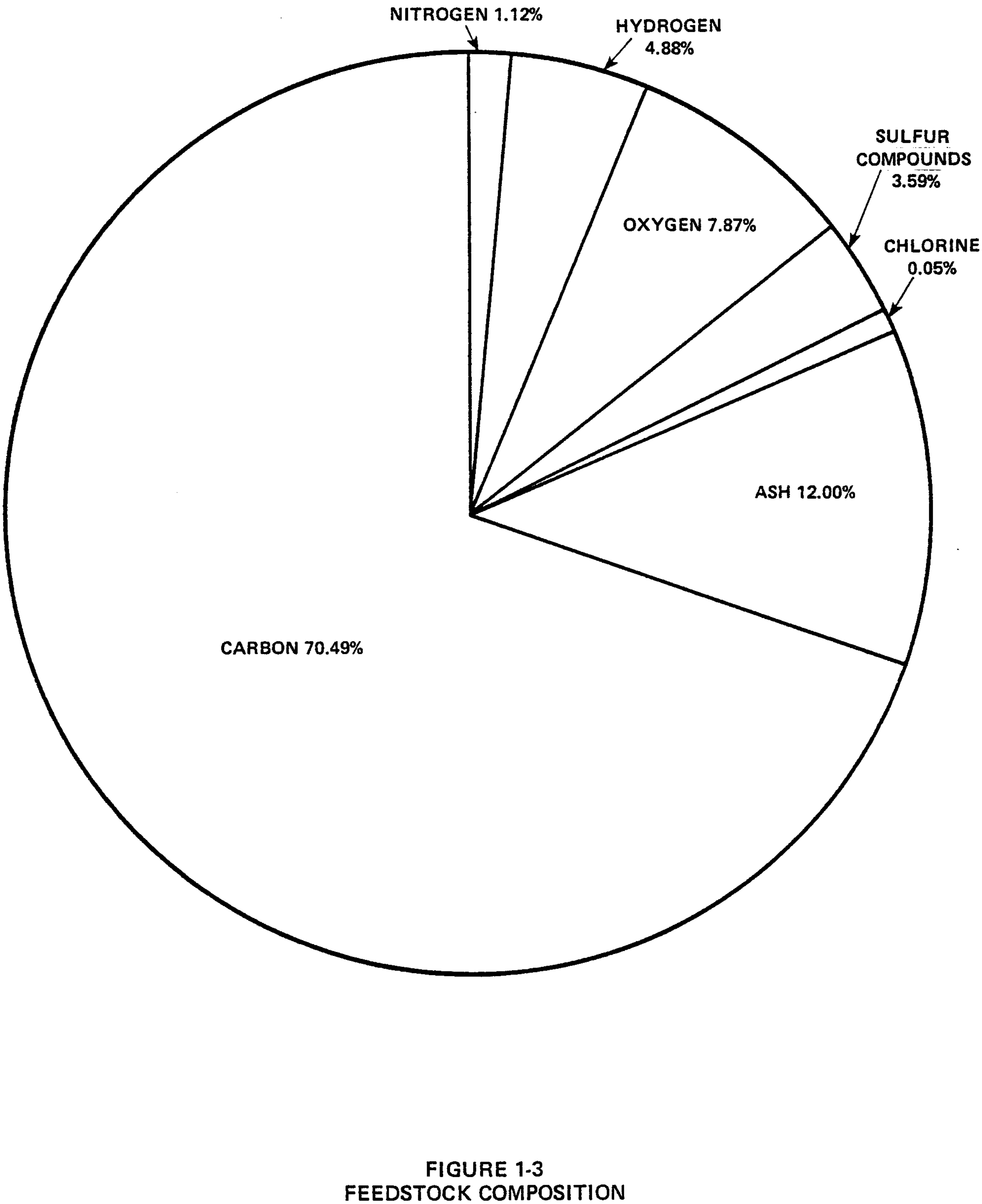


FIGURE 1-3
FEEDSTOCK COMPOSITION
(POWHATAN COAL CASE)

1.1.2 Products

The important products from the SCR-II Conceptual Commercial Plant are low-sulfur fuel oils, pipeline gas, butane, an aromatic naphtha stream and light hydrocarbon gases. By-products include sulfur, ammonia, and tar acids.

The fuel oils and pipeline gas will be used for domestic and industrial fuels, while the naphtha will be refined to produce a high octane blending stock for gasoline. The light hydrocarbon gases can be upgraded to ethylene, a basic raw material for the petrochemical industry. Sulfur, ammonia and tar acids can be sold as feedstocks for ancillary plants.

The fuel oil produced by the CCP will be sufficent to supply a typical electric utility generating station servicing a city of over two million. The pipeline gas will be equivalent to that consumed by a city of 350,000. The naphtha produced, when upgraded, will be the equivalent of approximately 16,000 barrels per day of motor fuel. The light hydrocarbons produced will provide sufficient feedstock for a one billion pounds per year ethylene plant.

The slag is assumed to have no immediate use. In this study it is planned to dispose of the slag as landfill on the site.

Table 1-2 and Figure 1-4 show the expected product slate based on Powhatan coal feedstock.

TABLE 1-2

NET PRODUCT SLATE

(Stream Day Basis)

NET PRODUCTS (1)	UNITS	BASE CASE POWHATAN
Fuel Oil	barrels	56,303
Pipeline Gas	MM Std cu ft	51
Naphtha	barrels	17,120
Light Hydrocarbons	pounds	5,769,840
Butanes	pounds	603,912
Sulfur	short tons	1,181
Ammonia	short tons	183.5
Tar Acids	barrels	240

(1) PRODUCT PROPERTY BASIS

Fuel Oil	350°F to 900°F nominal boiling range
Pipeline Gas	940 Btu/cuft higher heating value
Naphtha	Pentanes to 350°F nominal boiling range
Light Hydrocarbons	93% of 50-50 wt% ethane and propane, 7% miscellaneous gases.
Butanes	96% by wt. of C_4 hydrocarbons, 4% C_3 and C_5 hydrocarbons

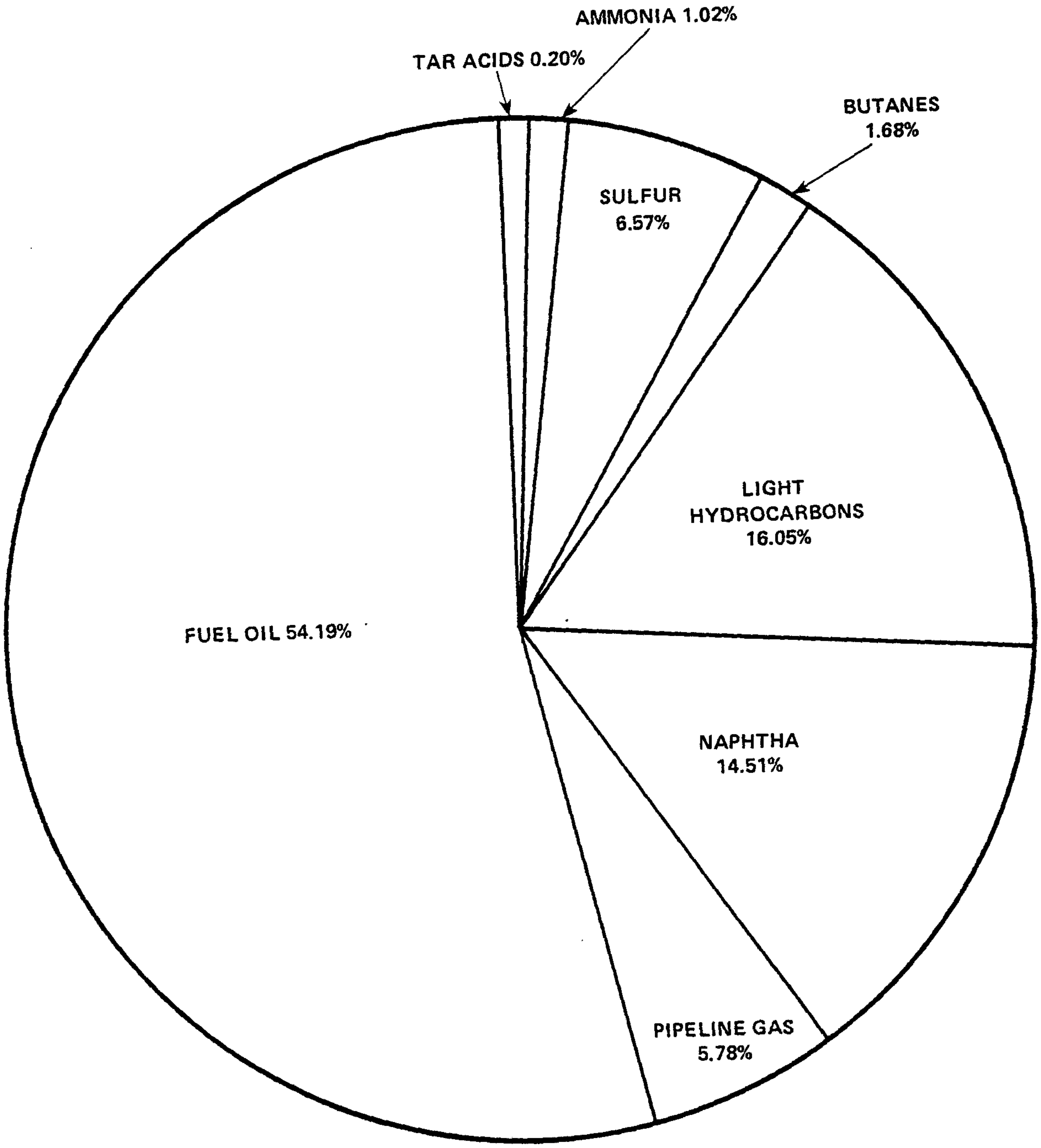


FIGURE 1-4
PRODUCTS (MASS BASIS)

1.1.3 Thermal Efficiency

The SRC-II process is an energy conversion process producing clean fuel products from coal. Petroleum refining and electric power generation are also energy conversion processes. One measure of energy conversion process performance is thermal efficiency; that is, the ratio of energy in plant products to the energy in the plant charge plus other energy inputs.

There are two major items contributing to inefficiency in an energy conversion process. First, the extent of thermodynamic change inherent in the process; and second, economic considerations influencing the degree to which heat recovery from process streams is justified. The first item is by far the most significant and accounts for the radical differences in thermal efficiency among petroleum refining, electric power generation, and SRC-II. Inefficiencies of the second kind are reduced to the extent possible by process optimization during the course of plant final design.

The thermal efficiency of the SRC-II Conceptual Commercial Plant presented in this report is calculated to be 71.4%, based on fuel type products only or 73.0% including the fuel values of by-product sulfur, tar acids and ammonia. By contrast, typical thermal efficiency of a petroleum refinery is over 90% and that of a coal-fired electrical generating station about 35%. Time constraints have so far limited optimization studies of the Conceptual Commercial Plant design. However, an evaluation of heat rejection equipment now included in the plant shows a likelihood that second-kind inefficiencies could be reduced and the thermal efficiency thereby increased by about as much as 1.5% when further optimization is carried out.

Improvement in SRC-II CCP thermal efficiency can be achieved by altering the extent of thermodynamic change required in the process. Numerous studies underway for improving and advancing SRC-II technology by this route are discussed in Volume 3, Section 2 and in Volume 4 of this Deliverable. One way to improve efficiency is to charge a more reactive feedstock, such as Illinois No. 6 Coal instead of Powhatan No. 5 (Pittsburgh seam coal). The differences in yields and thermal efficiencies are covered in detail in Volume 3, Section 2.

The thermal efficiency is estimated to rise by about 2.5% as a result of the more reactive Illinois coal. Studies indicate that efficiency could be increased an additional 0.3% if the Illinois coal were improved prior to charging to SRC-II processing. Although these improvements in thermal efficiency appear attractive, they do not necessarily indicate that Illinois No. 6 should be substituted for Powhatan No. 5 in the Conceptual Commercial Plant. By the time a number of plants are expected to be in operation, cost differences may exist between the two coals reflecting their reactivity differences in much the same way as crude oil prices vary with quality. Likewise, improvement costs may overcome efficiency advantages. In the final analysis, a complex series of factors will affect the selection of feed coal, including reactivity, market and plant location, transportion costs, etc.

The electrical energy input to the Conceptual Commercial Plant is less than to the First Commercial Plant (Deliverable No. 7, First Commercial Plant). This difference is a result of further optimization in the CCP where methanation of synthesis gas to produce pipeline gas has been reduced. Instead, the excess synthesis gas has been used as internal fuel, part of which generates electricity, reducing the amount of electricity purchased.

Table 1-3 and Figures 1-5 and 1-6 present the thermal efficiency and thermal input and output distribution data of the Conceptual Commercial Plant as presently designed.

TABLE 1-3

THERMAL EFFICIENCY

Input Energy	Pounds Per Hour	Million BTU's per Hour (HHV)
Coal	2,791,000	35,775
Electricity	10,430 kW (1)	99
INPUT TOTAL		35,874
Output Energy		
Main Products		
Fuel Oil	811,820	13,806
Pipeline Gas	86,580	2,002
Naphtha	217,400	3,974
Light Hydrocarbons	240,410	5,291
Butanes	25,163	526
Total Main Products only		25,599
By-Products		
Sulfur	98,417	391
Ammonia	15,292	150
Tar Acids	3,100	65
Total By-Products only		606
OUTPUT TOTAL		26,205
Thermal Efficiency		
Main Products only		71.4%
Including By-Products		73.0%

(1) Based on a heat rate of 9500 Btu/kWh for purchased power.

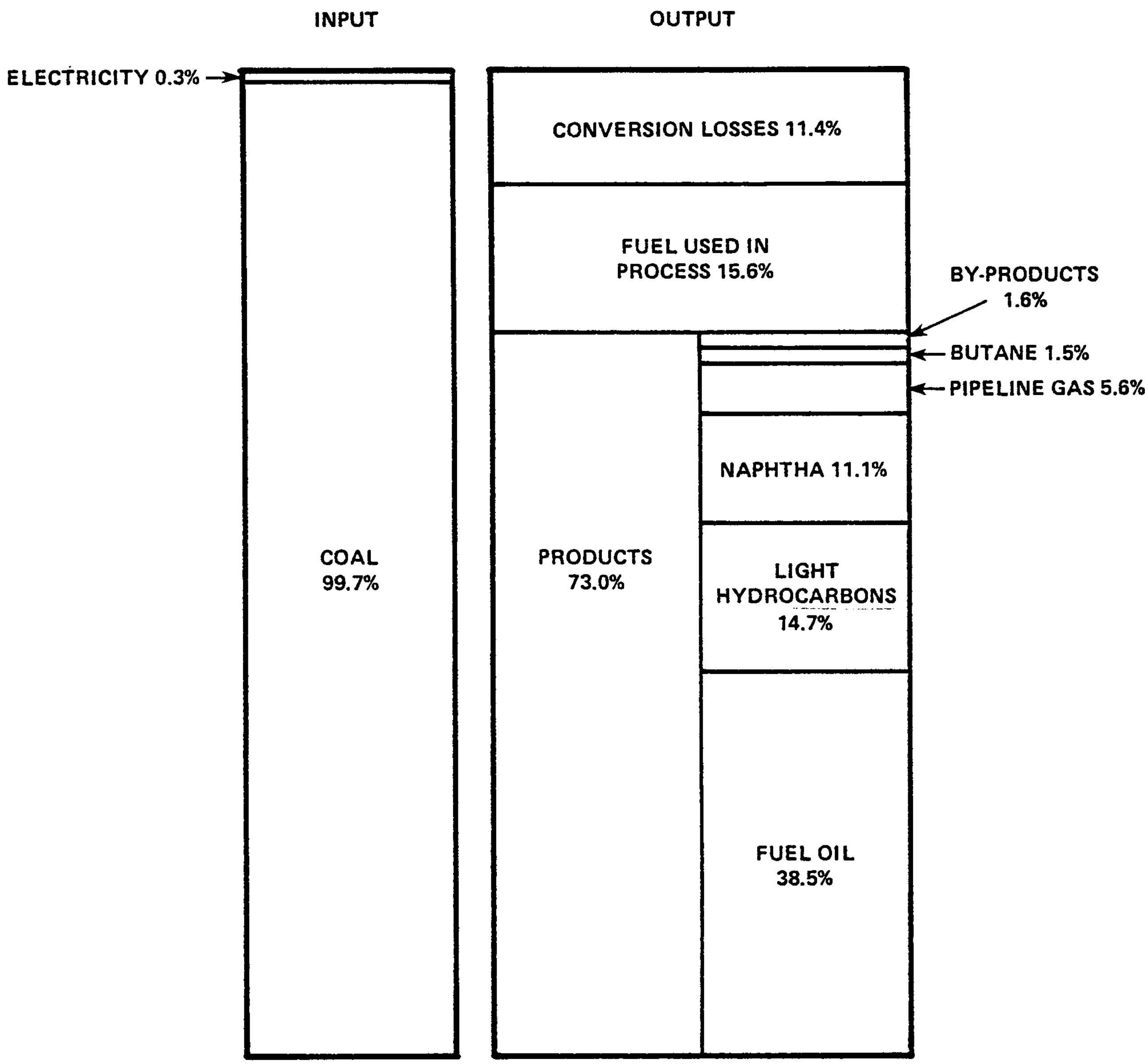


FIGURE 1-5
ENERGY INPUT/OUTPUT DISTRIBUTION

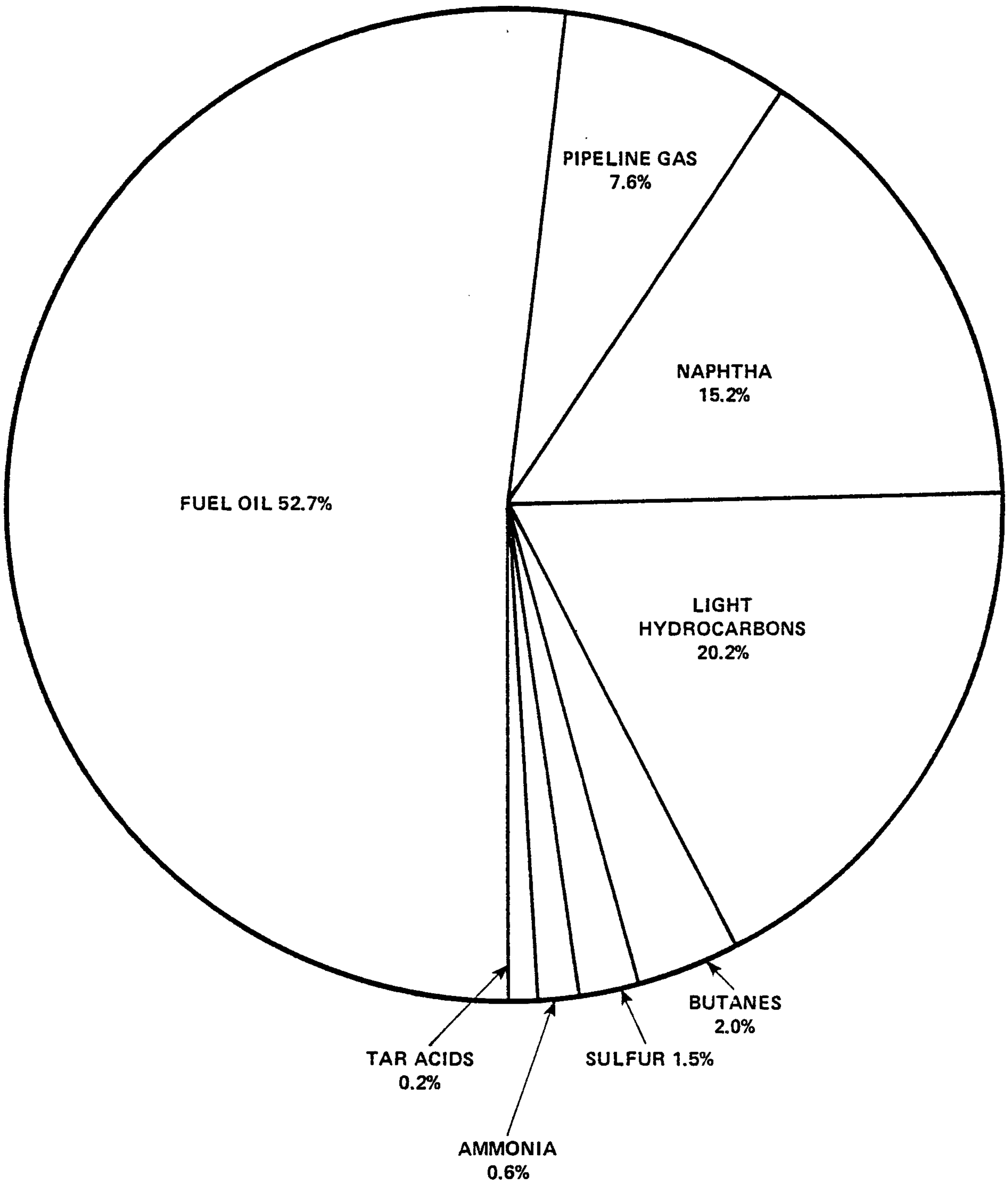


FIGURE 1-6
ENERGY OUTPUT DISTRIBUTION
(MAIN & BY-PRODUCTS)

1.2 POSSIBLE COMPANION PLANTS

1.2.1 High Octane Blending Stock Plant

In designing the Conceptual Commercial Plant, it became apparent that the naphtha product could be upgraded to produce high octane blending stock for the production of gasoline. The naphtha product of the SRC-II CCP would produce the equivalent of 656,000 gpsd of gasoline.

The plant for upgrading naphtha is considered to be completely isolated from the CCP and might be installed in a conventional petroleum refinery.

The cost of a CCP facility for upgrading the naphtha product to a high octane blending stock is estimated at $44.3 million. November 1978 dollars have been used in all estimates presented in this report. This cost for a hydrotreating-reforming plant to upgrade the naphtha product to gasoline is not included in the SRC-II CCP estimate.

1.2.2 Ethylene Plant

As in the case of the High Octane Blending Stock Plant in the preceding section, the SRC-II Conceptual Commercial Plant design indicates that an ethylene plant could be a companion plant.

Ethylene could be a starting point for developing a petrochemical complex. Rather than install storage and shipping facilities for light hydrocarbon products of the SRC-II Conceptual Commercial Plant, it might be more practical to upgrade them to ethylene in the immediate area. The quantity of light hydrocarbons produced would be sufficient for a one billion pounds a year ethylene plant.

The companion ethylene plant would be engineered and constructed separately and would include all utilities and services necessary to operate it independently of the SRC-II Conceptual Commercial Plant.

The cost of such an ethylene plant is estimated at $209 million. This cost is not included in the estimate of the SRC-II Conceptual Commercial Plant, nor are the costs of any facilities to provide utilities, services or support for the ethylene plant included in the Conceptual Commercial Plant estimate.

SECTION 2
PROCESS DESCRIPTION

2.1 SRC-II CONCEPTUAL COMMERCIAL PLANT

The CCP plant is designed to process 33,500 tpsd of high-sulfur bituminous coal. Principal products from the plant are low-sulfur fuel oils, pipeline-quality gas, butane, ethane, propane and naphtha. By-products are sulfur, ammonia and tar acids.

The primary processing sections consist of coal unloading and storage, coal-slurry preparation, dissolver treatment, refining, recycle gas treating and compression and hydrogen recovery. Other sections include hydrogen production, gas plants and secondary recovery systems. The plant is designed as a grass roots installation with integral utilities included, with the exception of electric power which will be purchased from a local utility.

Coal is transported in unit trains to the plant site, where it is unloaded, crushed, and stockpiled. Onsite storage provides for a 30-day supply at design rate.

The feed coal is reclaimed from the stockpile, pulverized, and mixed with a recycle slurry stream from the production process. It is then combined with hydrogen and pumped through a preheater to a dissolver operated at high pressure and temperature. The coal is first dissolved in the liquid portion of the recycle slurry and then is hydrocracked into liquids and gases. Much of the sulfur, oxygen, and nitrogen in the original coal is converted to hydrogen sulfide, ammonia, and water. The rates of these reactions are increased by the catalytic activity of the undissolved mineral residues. The recycle of a portion of the product slurry contributes substantially to the process by increasing the concentration of catalytic mineral residues in the reactor.

The dissolver effluent is separated into gas, light hydrocarbon liquid, and slurry streams using conventional refinery technology. A portion of the mineral-residue slurry and hydrocarbon liquid from the separation area is returned to the slurry preparation plant and blended with the feed coal. The balance of the mineral-residue slurry is vacuum flashed to recover the fuel oil product.

The dissolver gas stream, consisting primarily of hydrogen, light hydrocarbons and hydrogen sulfide is washed with solvent to remove any entrained liquid hydrocarbons. It is then contacted with diethanolamine (DEA) in an absorption system to remove acid gases. After acid gas removal, a small portion of this gas is recycled to the process. In order to maintain high hydrogen purity, however, most of the hydrogen gas is treated cryogenically to remove nitrogen, methane and heavier hydrocarbon gases. The purified hydrogen stream is then combined with the untreated hydrogen and returned to the dissolvers.

An important feature of the SRC-II technology is gasification of the mineral residue slurry to produce hydrogen needed for the process. Mineral residue slurry produced in a vacuum flash system is gasified by high-pressure partial oxidation to yield a syngas rich in hydrogen and carbon monoxide. This gas mixture is passed through a water gas shift conversion by reaction of carbon monoxide and steam to produce additional hydrogen.

Undesirable acid gases (carbon dioxide and hydrogen sulfide) are then removed from the hydrogen in a purification plant and the resulting 97% pure hydrogen stream is compressed and fed to the dissolvers along with recycle hydrogen.

Liquid products from the main process area are refined in the fractionation section. This section separates the coal liquids into gases, naphtha, and fuel oil. Various by-product liquid and gas streams are treated further in the gas plant to produce ethane-propane, butane, and pipeline gas. Facilities are provided to recover ammonia, tar acids, and sulfur; these are conventional commercially available processes.

Figure 2-1 is a block flow diagram which illustrates the SRC-II process.

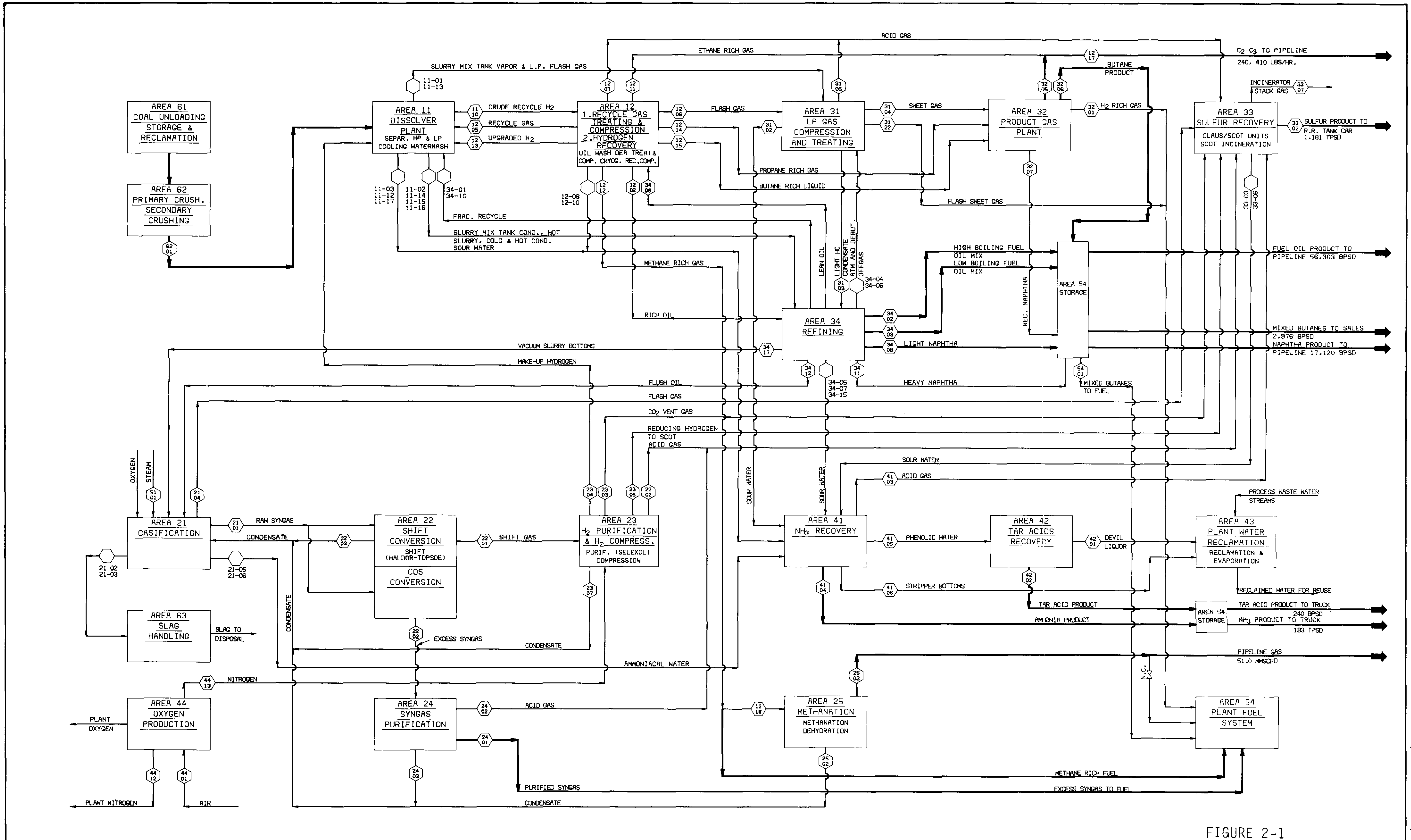


FIGURE 2-1

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PRELIMINARY ENGINEERING	5		
FINAL ENGINEERING			
APPROVED FOR CONSTRUCTION	REV.		

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REVISION NO.

PROCESS FLOW DIAGRAM
OVERALL PLANT BLOCK FLOW
AREA 00
SRC II CONCEPTUAL COMMERCIAL PLANT

The Pittsburg & Midway Coal Mining Co. — Gulf
A WHOLLY OWNED SUBSIDIARY OF GULF OIL CORPORATION

DRAWN: J.W. WOODRUFF

Stearns-Roger INCORPORATED

ORDER NO. C-21500 X-00006

DWG NO. 22927
SHEET NO. 00C06-101
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2.2 HIGH OCTANE BLENDING STOCK PLANT

Naphtha produced in the SRC-II plant would be upgraded to a high octane motor fuel component in this plant. Two catalytic procesing steps would be required;a pretreating step and a reforming step. The pretreating step utilizes specially developed Gulf catalyst and operating conditions. The reforming step can be accomplished by any of a number of catalytic reforming processes available for commercial license.

Figure 2-2 is a block flow diagram which illustrates upgrading of naphtha to gasoline.

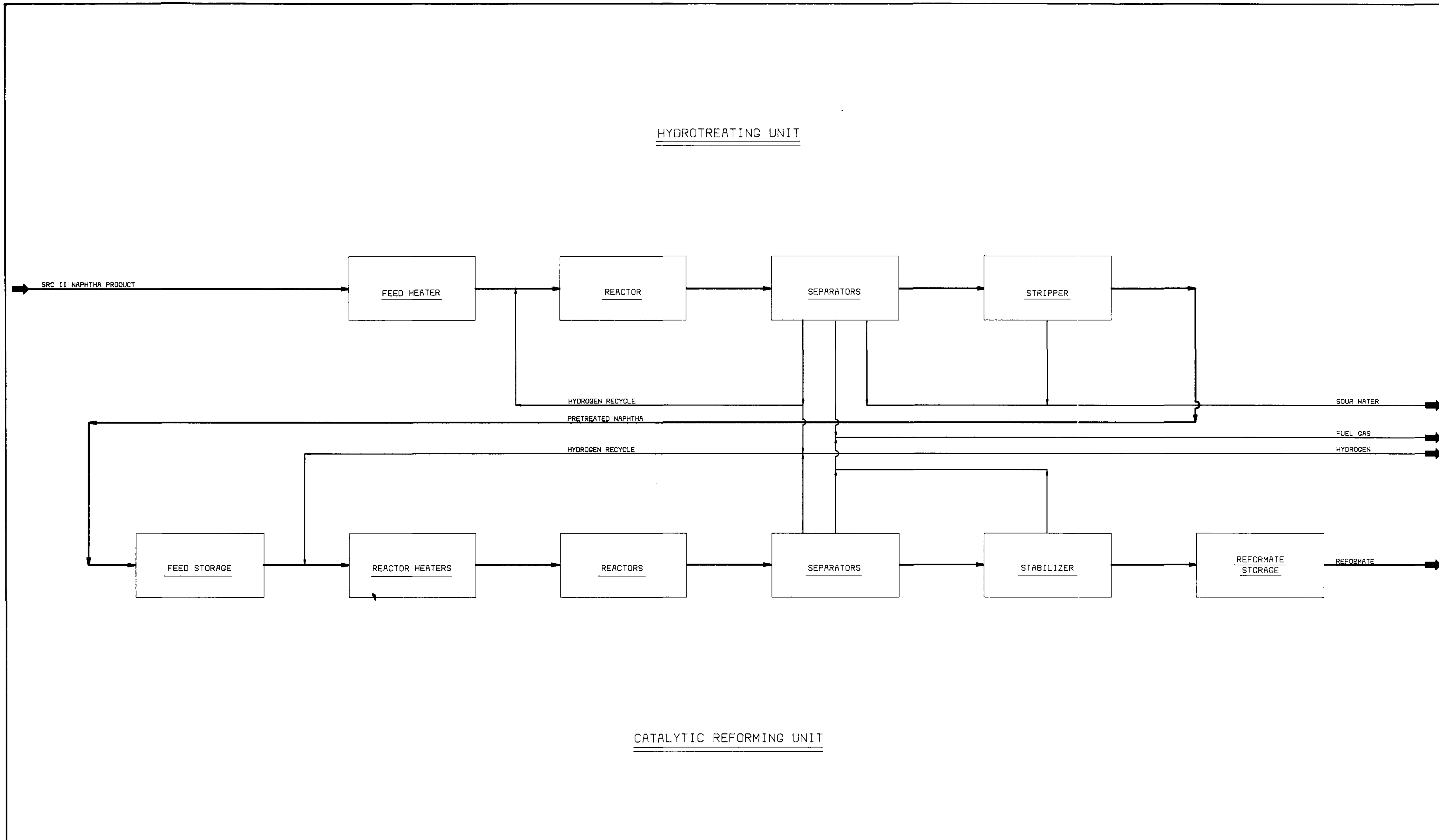

FIGURE 2-2

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BLOCK FLOW DIAGRAM
HIGH OCTANE BLENDING STOCK PLANT
SRC II CONCEPTUAL COMMERCIAL PLANT

The Pittsburg & Midway Coal Mining Co.
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DRAWN IGS 7/10/79

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2.3 ETHYLENE PLANT

The ethane-propane mixture produced by the SRC-II plant provides an ideal feed for ethylene production in that ethylene plant investment is least with feeds of this quality.

Ethane-propane from the SRC-II plant would go by pipeline to an ethylene plant located on a site near the SRC-II plant. The ethane-propane mixture is cracked in the presence of steam. After heat recovery and quench, the product gases are compressed, dried, separated, and purified. Unreacted ethane and propane would be recycled to cracking.

Major products are ethylene and propylene which are sent to separate storage and then shipped to customers via pipeline. By-products include a butadiene concentrate, aromatic distillate which can be used for chemical feed or upgraded to motor fuel, and high purity hydrogen which can be used in chemical processing or returned to the SRC-II plant.

Figure 2-3 is a block flow diagram which illustrates upgrading of ethane-propane to ethylene.

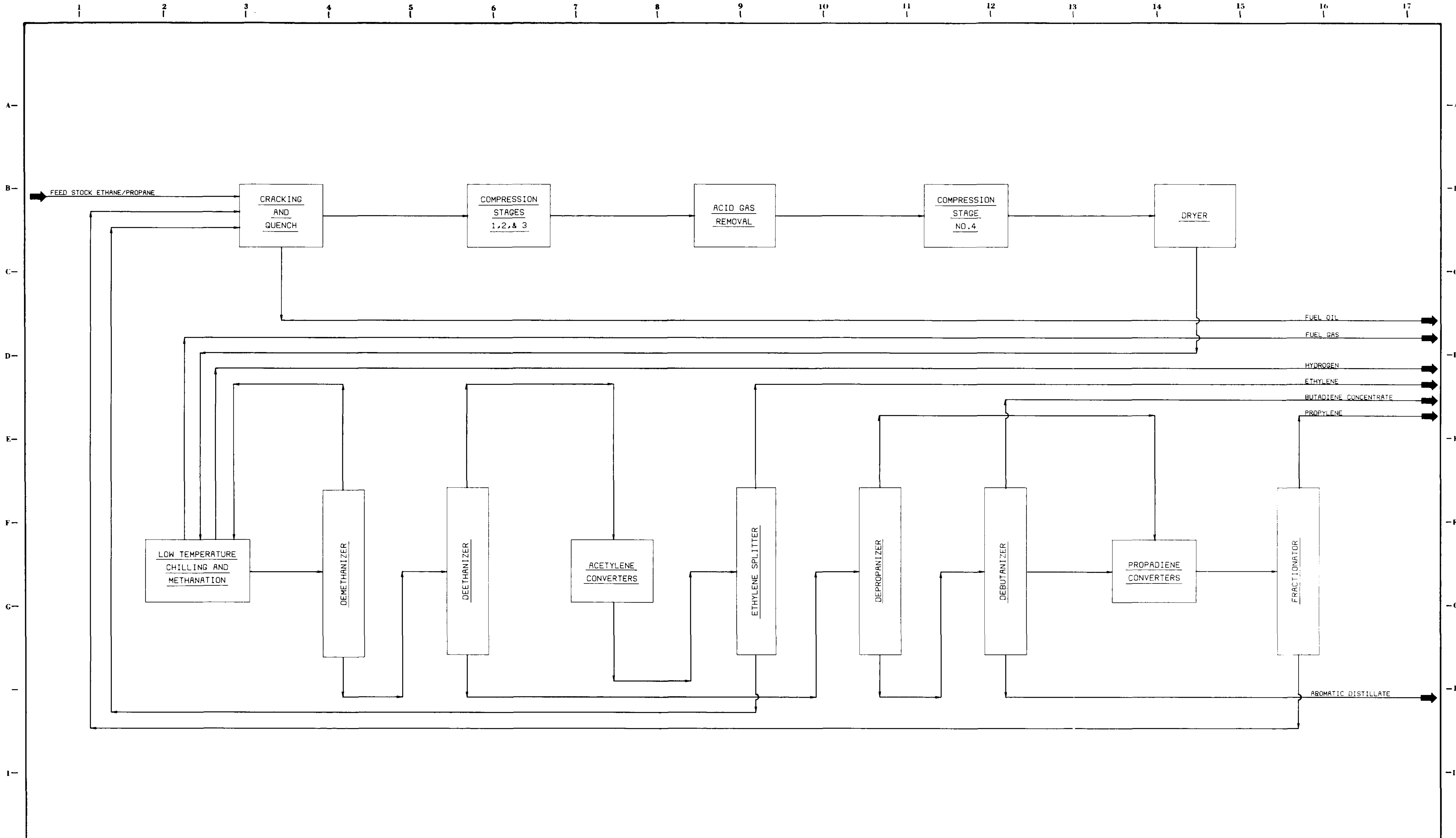

FIGURE 2-3

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BLOCK FLOW DIAGRAM

ETHYLENE PLANT

SRC II CONCEPTUAL COMMERCIAL PLANT

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2.4 ADVANCED PROCESS TECHNOLOGY

Gulf scientists and engineers working in the field of coal liquefaction have underway a number of promising R & D programs for improving the SRC-II process. Expected potential benefits would include reduced costs, improved process operability and increased feedstock flexibility.

The concepts included in the advanced process technology and economics study (Volume 4) are those which have a reasonable probability of success from R & D, a sound technical basis in background and other research and a potential for net improvement of the process.

Two of the possible process changes analyzed in the studies of advanced technology economics were special preparation of the coal feedstock and the use of added catalysts. Other concepts and potential improvements are discussed in Volume 4.

SECTION 3
ENVIRONMENTAL SUITABILITY

3.1 COMMUNITY MASTER PLAN

An SRC-II Conceptual Commercial Plant charging coal at the rate of 33,500 tons per stream day would have substantial impact on the community in which it is located. Such a plant is not only a large entity in itself, but it would inevitably be the source of considerable growth in petrochemical and related industrial development. Downstream development might take several forms. A commercial-scale plant could produce enough ethane-propane to provide feed stock for a large-scale ethylene plant. The ethylene and propylene produced would in turn become sources for plastics, ethylene glycol, styrene and a host of other potential products. These products may represent end uses or be the raw materials for still further processing. The main plant and its downstream facilities would require technical, mechanical, and supply services.

In short, the establishment of a Conceptual Commercial Plant is the beginning of a substantial industrial community, even if the plant is built in an area relatively remote from existing population centers. Such a community might easily number in excess of 20,000 people. Its development would not be left to chance.

Community requirements, industrial and service needs of a coal refinery and its downstream satellite industries, demand careful planning. For the industrial sector and the community as a whole, sound master planning would be important to meeting physical and social needs and should be done well in advance of construction and startup. There would be plans for housing, schools, public utilities and services, hospitals and other social services, governmental organizations, cultural activities, and recreation.

3.2 SAFETY

The SRC-II process technology has those risks and hazards normally associated with high pressures, high and very low temperatures, very large mechanical equipment and combustible materials. Most of the risks are commonly encountered and coped with in many other industrial plants, particularly in petroleum refineries and chemical plants. Some of the technology, however, advances beyond current practice. Therefore, the safety measures that have been evaluated and designed into the process have been deliberately made more stringent than are those for the typical petroleum refinery or a coal tar processing plant.

The design parameters used include definition and recognition of the hazards and risks for each processing unit; acceptable safety measures for the physical plant, its personnel, and the surrounding environment; compliance with government regulations and industry standards; inclusion of multiple trains and installed spare equipment.

Protective measures, practices, and equipment available from the refining and petrochemical industries and particularly those developed during the Demonstration Project will be used for this plant wherever applicable and feasible. Where and when needed, protective systems from other industries will be adapted.

3.3 HEALTH

Because the products are not yet in production, only limited statistical information is currently available on the health effects of human contact with specific SRC-II products or intermediate process streams. However, since these materials are complex mixtures of organic compounds including polynuclear aromatics, the potential for such effects must be considered. Health-related investigatory programs have been underway for about five years along with development and pilot plant work conducted to date in the SRC-II program. In five years of operation at the Fort Lewis pilot plant, no serious environmental or health effects have been observed in a careful monitoring program. In particular, no employment related cancers have been found in the 200-300 people who have been employed at the plant.

As the starting point in the CCP's industrial hygiene program, each employee would be educated concerning the potential effects of the materials being processed, necessary precautions, and good industrial hygiene practices. This would be a continuing education program, with periodic revisions as further information in the area of industrial hygiene becomes available and with periodic repetition to emphasize the importance of good work practices. Each employee would be furnished with work clothes and be required to shower and change into street clothing at the end of each shift as has been practiced so successfully at the Fort Lewis plant.

Each employee would be given a complete medical examination when employed, followed by periodic examinations to determine any changes in bodily condition or functions. This is also standard practice at Fort Lewis and has proved very effective in monitoring as well as keeping employees alert to health protection.

One part of the industrial hygiene program underway at Fort Lewis is providing quantitative data on the amounts of various contaminants to which the employee could be exposed. This program will be continued and the results used to determine what actions must be taken if a problem should arise. A similar monitoring program would be used in commercial SRC-II plants.

Substantial industrial hygiene programs are underway as part of the present pilot plant program and environmental information will result from the Demonstration Project. Before any commercialization of SRC-II occurs, sound and safe protection methods and process and product handling systems will be established.

3.4 SOLIDS DISPOSAL

The design of the SRC-II Conceptual Commercial Plant provides for a slag disposal system. Slag would be produced by the gasifiers in processing mineral residue to provide hydrogen. Disposal of approximately 4800 tpsd of this material would be a substantial waste-handling effort.

It is planned that slag would be disposed of onsite as landfill. Final site selection may, however, permit its return to the mines for disposal.

3.5 LIQUIDS DISPOSAL

The Conceptual Commercial Plant was designed based on the requirement that there will be no contaminated liquid effluent. All waste streams are to be collected and treated onsite. Water streams containing oil and inorganic contaminants are directed to a gravity separation system where the water and oil would be recovered and the waste incinerated.

Streams containing inorganic waste are to be evaporated, with the distillate being recovered as cooling water and the contaminants being incinerated. Incinerator wastes are to be filtered and disposed of onsite as solids.

Rainwater that falls in areas where contaminants can be picked up is to be collected and reprocessed with the other waste water streams.

3.6 AIR EMISSIONS

The plant is designed to comply with all applicable Federal, state and local regulations. Inasmuch as all fuels burned in the plant are to be free of ash, the emission of particulate matter is not expected. There would be dusting of the raw coal during unloading, grinding, and transfer, and the coal-handling systems are to be provided with dust-collecting devices. Experience at the Fort Lewis plant has shown that air emissions from an SRC-II plant are controllable to minimal levels.

The raw coal selected for SRC-II contains sulfur in quantities which make it unacceptable for direct firing in steam boilers not having extensive sulfur dioxide removal equipment. However, the SRC-II process removes sulfur as a by-product. Even so, a small amount of sulfur dioxide must be burned in a flare in the plant. Design calculations show that this can be accomplished in a manner complying with regulations and will avoid unacceptable concentrations.

During startups and process upsets, flammable hydrocarbons are to be flared. Two systems would be installed to recover liquid hydrocarbons and to burn the flammable gases in smokeless flares.

SECTION 4
COST ESTIMATES AND ECONOMICS

4.1 COST ESTIMATES

The Direct Capital Costs were developed by the Stearns-Roger Computer-Aided Preliminary Estimating Sytem (CAPES). CAPES uses basic equipment design information and preliminary conditions of service to calculate the complete installed cost for each piece of equipment through simulation based on a volumetric model technique. The volumetric models are typical mechanical flow diagrams for specific types of equipment. These models are used in conjunction with the size and service data to generate material take-offs and labor requirements.

The cost estimate is based on fourth quarter 1978 dollars and contains a 20 percent contingency in accordance with DOE guidelines. More accurate estimates can be prepared as additional design information is available, particularly once the Demonstration Project is successfully completed, a site has been selected, a number of design assumptions have been confirmed, and a definitive construction schedule has been established.

The Capital Cost by Unit and the Annual Operating Cost estimated on this very preliminary basis are tabulated on Tables 4-1 and 4-2..

TABLE 4-1

CAPITAL COSTS

(November 1978 Dollars)

	Millions of Dollars
Unit 10 - Primary Process Plants	$ 615.2
Unit 20 - Hydrogen Purification Plants	237.0
Unit 30 - Refining and Gas Plants	140.3
Unit 40 - Secondary Recovery and Oxygen Plants	262.3
Unit 50 - Utility Systems and General Facilities	230.5
Unit 60 - Coal and Ash Systems	74.7
TOTAL DIRECT CAPITAL COST:	$ 1,560.0
Catalysts and Chemicals	20.1
License Fees	13.2
Owner Management Costs	8.0
Land	7.8
Working Capital	
A. Raw Coal Inventory	$26.9
B. Finished Products Inventory	10.6
C. Catalysts and Chemicals Inventory	.6
D. Spare Parts and Maintenance	24.8
Subtotal Working Capital	$62.9
TOTAL INDIRECT CAPITAL COST ELEMENTS:	$112.0
TOTAL CAPITAL COSTS:	$1,672.0

Note: The capital cost has been estimated with a 20% contingency in accordance with DOE guidelines.

TABLE 4-2

ANNUAL OPERATING COST

(November 1978 Dollars)

	Millions of Dollars
I. Coal	$ 322.7
II. Direct Expense Elements	
A. Operating Labor	$ 6.5
B. Operating Supplies	.6
C. Maintenance Labor	5.8
D. Maintenance Materials	31.8
E. Contract Maintenance	9.8
F. Catalyst and Chemicals	8.0
G. Electricty	3.0
III. Indirect Expense Elements	
A. Property Taxes and Insurance	23.4
IV. Overhead	6.9
TOTAL ANNUAL OPERATING COST ELEMENTS	$418.5

Note: The annual operating cost has been estimated with a 20% contingency in accordance with DOE guidelines.

4.2 ECONOMIC EVALUATION

For the Conceptual Commercial Plant design, an economic evaluation has been performed incorporating the estimates for all direct and indirect capital costs, startup costs, and operating costs for a five-year construction period and twenty-year operating life. Key financial and economic factors include:

Capital Cost	1,625 MM$ (4th Qtr. - 1978)
Operating Costs (including coal at $1.15/MM Btu)	418 MM$ (4th Qtr. - 1978)
Escalation	6%
Debt/Equity	25%/75%
Interest on Debt	9%
Investment Tax Credit	10%
Internal Rate of Return (on Equity)	15%

Using a computer program prepared to follow guidelines established by the DOE, the derived price for al fuel products on a Btu basis is $3.76/MM Btu, equivalent to $22.55 /bbl. When considering the conceptual nature of the design-and-estimate basis for this commercial plant, confidence analyses would indicate a more likely value of $23 to $25/bbl. These derived results are expressed in fourth-quarter 1978 dollars.

Volume 5 of this Deliverable presents a detailed economic evaluation of sensitivities and confidence analyses of all key factors as well as appropriate financial statements for Conceptual Commercial Plant cases.