Section 10

THE SRC-II DEMONSTRATION PROJECT

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SUMMARY

A 6000 T/D demonstration plant to produce liquid fuels from high-sulfur bituminous coal by the SRC-II process is now being designed. The total cost of the project, estimated to be about 1.5 billion dollars, will be shared between the United States Department of Energy, the governments of West Germany and Japan, and Gulf Oil Corporation. The governments of West Germany and Japan will each contribute 25% of the total cost, while Gulf will contribute up to 100 million dollars. The remainder of the project cost will be borne by the United States Department of Energy. The primary contract for design, construction, and operation of the plant has been assigned to a joint venture company consisting of P&M, Ruhrkohle and Veba of Germany, and Japan SRC-II, a Japanese corporation in which Mitsui Inc. is the principal firm.

The SRC-II demonstration plant will produce fuel oil for use in boilers and turbines, naphtha suitable as reformer feedstock to make high octane gasoline, and by product light hydrocarbons, from West Virginia coal. Design work is proceeding and is expected to be completed in early 1983. The major effort thus far has been to finalize the process design, so that subsequent detailed engineering can proceed. Experimental work is being pursued at the Fort Lewis pilot plant to confirm certain process features which have not yet been tested at that scale.

Work is also proceeding on site acquisition, arrangements for a supply of feed coal and arrangements for product sales. A draft environmental impact statement has been issued and is now being revised; and a

construction management subcontractor is now being selected. Site preparation is expected to begin late this year and mechanical completion is scheduled for late 1984. After an initial operating period of two and one half years, the joint venture company will have the option of purchasing the plant. It is expected that such purchase would lead to expansion of the plant to a full-size commercial facility.

INTRODUCTION

The Pittsburg & Midway Coal Mining Co. (P&M), a wholly owned subsidiary of Gulf Oil Corporation has been working on development of the solvent refined coal technology for 18 years, primarily under the sponsorship of the United States Department of Energy and its predecessor agencies. During the last four years, a major part of this effort has involved operation of a 30-ton-per-day pilot plant at Fort Lewis, Washington on an improved version of the process known as SRC-II. The SRC-II process converts high-sulfur coal to distillate liquids, naphtha, and light hydrocarbons. As a result of encouraging results in both the pilot plant program and supporting laboratory work, P&M has contracted with the Department of Energy to design, build and operate a 6000 ton -per-day demonstration plant using the SRC-II process. The proposed site for the plant is near Morgantown, West Virginia and it is anticipated that the plant will use high-sulfur West Virginia and other bituminous coals.

Initial work on the demonstration plant contract involved developing a preliminary design for the 6,000 ton-per-day demonstration plant, as well as conceptual designs for a 30,000 ton-per-day commercial plant developed by expanding the 6,000 ton-per-day demonstration plant and for a 30,000 ton-per-day grass roots commercial plant. In addition, schedules and cost estimates were developed and supporting studies, both technological and market oriented, were conducted. All of this work was completed in what is now known as Phase Zero of the demonstration plant project. Phase Zero was completed in July of 1979 and Phase One was started in October of 1979. This paper discusses the current progress of the demonstration plant project, now in Phase One, and the funding and organizational agreements that have been put in place to carry it out.

PROCESS DESCRIPTION

The SRC-II process converts coal to liquid and gaseous products by first dissolving the coal in a slurry recycled from the process, then hydrogenating and hydrocracking the dissolved coal in the presence of hydrogen at elevated temperature and pressure. The hydrogenation and hydrocracking reactions are enhanced by the catalytic activity of the inorganic matter contained in the recycle slurry, as well as the inorganic matter in the feed coal.

A schematic flow diagram for the 6000 ton-per-day SRC-II demonstration plant is shown in Figure 1.

Raw coal is pulverized and dried, then mixed with hot recycle slurry from the process in a mixing system comprising a small, highly agitated, mix tank and a larger slurry feed tank. The coal-recycle slurry mixture is pumped, together with hydrogen, through a fired preheater to a reactor maintained at about 860°F and 2000 psig. By the time the coal exits the preheater, it is almost completely dissolved in the solvent portion of the recycle slurry. The hydrocracking reactions occur primarily in the reactor, and the heat generated by these reactions rapidly raises the temperature of the reactants to the design temperature. For this reason, the temperature at the outlet of the preheater can be considerably lower than the required reactor temperature. Hydrogen quench is injected at various points in the reactor for better temperature control, to maintain adequate gas distribution, and to help maintain the hydrogen partial pressure in the system.

The reactor effluent flows through a series of vapor-liquid separators, where it is ultimately separated into process gas, light hydrocarbon liquids and slurry. The first separator is maintained at as high a temperature as practical for heat economy. The vapor stream from the hot separator is cooled and condensed in a series of heat exchangers. These heat exchangers are used to make 1500 psig steam and to heat boiler feed water.

The process gas, consisting primarily of hydrogen and gaseous hydrocarbons, together with minor amounts of H_2S and CO_2, is cooled to about 100°F and goes through an acid gas removal step for removal of the H_2S and CO_2. The treated gas then goes to a cryogenic separation step for removal of the hydrocarbons. The purified hydrogen is recycled to the process, while the recovered hydrocarbons become by-products of the process. The C_1 fraction is sent to a methanation unit to convert any remaining CO to methane, then is sold as pipeline gas. The other light hydrocarbon gases are fractionated to produce ethane, propane and butane streams. All of the light hydrocarbon liquid collected from the various condensation steps, plus the overhead stream from the vacuum tower, are sent to a fractionator. In the fractionator the total liquid is separated into naphtha (C_5 - 380°F nominal boiling range), a middle distillate (380-600°F) and a heavy distillate (600-900°F).

The product slurry is split, with one portion being recycled to the process for slurrying with the feed coal. The other portion of the product slurry goes to a vacuum tower where the lighter portion of the distillate is removed overhead and sent to the fractionator. A heavy distillate product is removed as a side stream. The residue from the vacuum tower is sent to a high pressure slagging gasifier for production of synthesis gas. A portion of the synthesis gas goes through shift conversion and acid gas removal steps to produce pure hydrogen for the process. The synthesis gas in excess of that required for hydrogen production is passed through a separate acid gas removal step for removal of CO_2 and H_2S, then through a power recovery turbine, and is finally burned as plant fuel.

PHASE ONE DESIGN

The Phase One design work was begun in October, 1979, upon completion of the Phase Zero work. The process design subcontractor is Badger Engineering, Inc. of Cambridge, Massachusetts, while design of the non-process areas, as well as detailed design in all areas, is the responsibility of Stearns-Roger Corporation of Denver, Colorado. A construction management subcontractor is now being selected. The Phase p

One process design was initiated with a review and evaluation of the Phase Zero design by both Gulf and Badger during the latter part of 1979 and early 1980. This work has led to a somewhat modified design basis for Phase One. The design priorities for this Demonstration Plant are different than they might be for a subsequent commercial venture. Yields and thermal efficiency will be compromised where necessary to maximize operability, and also to incorporate additional flexibility which might not be warranted in a commercial plant.

The Phase One design is based on a specific West Virginia Coal rather than the hypothetical coal used for the Phase Zero design, as a result of further laboratory and pilot plant experiments on a number of West Virginia coals. The design feed coal properties are given in Table I. The overall yields and hydrogen consumption for the hydrogenation step are given in Table II. The C_1-C_4 hydrocarbons, naphtha, light fuel oil and heavy fuel oil are primary products of the process, while the 900°F residue, insoluble organic material, and ash go to the gasifier as a hot molten mineral residue slurry.

SYSTEM CONFIRMATION - FT. LEWIS PROGRAM

The SRC-II process has been scaled up from bench scale laboratory units at the Merriam Laboratory to a one-ton per day process development unit at the Harmarville Research Laboratory and to the 30 ton per day pilot plant at Fort Lewis, Washington. The scale-up work has thus far been encouraging, and has provided much valuable information for the design of the demonstration plant. There are some key features of the current demonstration plant design, however, which are or are soon to be tested further at the 30-ton-per-day level at Fort Lewis. These are:

- Dissolver effluent cooling and separation at higher temperatures.
- Handling and pumping of hot vacuum bottoms to high pressure.
- Mixing and pumping of hot slurries at the incipient gel stage.
- Operation of the slurry preheater at flow rate and heat flux comparable to the demonstration plant design.

These design confirmation programs are summarized as follows:

Dissolver Effluent Cooling and Separation

Since the failure of an air-cooled heat exchanger in the early days of operation, the Fort Lewis Pilot Plant has been using a water quench to cool the dissolver effluent to a temperature of about 700°F. This is about the maximum operating temperature allowable by the rating of the separator vessel immediately downstream. For heat economy in large-scale plants, however, it is advantageous to operate this separator at a higher temperature. This will allow the slurry to remain at a higher temperature during the let-down phase and will avoid the necessity of preheating the vacuum tower feed. Furthermore, heat can be recovered at a higher level from the hot separator overhead vapor stream and from subsequent downstream steps.

The combination of high temperature, the presence of hydrogen, and the potential for vapor entrainment of solid particles, however, introduces uncertainties which must be addressed by actual operation, preferably prior to and on a unit smaller than the demonstration plant. Work is now proceeding to modify the Fort Lewis Pilot Plant to gain experience in operation of the vapor-liquid separation system at higher temperatures than have been used in the past at such a scale. This involves installation of a new hot separator vessel, as well as several downstream separators, pumps, and heat exchangers.

Handling and Pumping of Vacuum Bottoms

The demonstration plant design provides for gasification of the vacuum residue at high pressure to provide synthesis gas for process hydrogen and plant fuel. The pilot plant, however, has no gasifier and the vacuum bottoms stream has been cooled and solidified at atmospheric pressure on a stainless steel cooling belt. While this is a satisfactory means of handling the vacuum residue from pilot plant runs, it provides no information on pumping of the vacuum bottoms to high pressure (as to a gasifier).

To provide such information, a specially designed vacuum bottoms test loop is to be incorporated in the existing vacuum tower system at Fort Lewis. The new equipment consists of a vacuum tower surge drum and a high pressure reciprocating pump for handling the vacuum residue, together with a pumparound loop to allow the pumped fluid to return to the surge drum.

Mixing and Pumping of Hot Slurries

Mixing of the hot recycle slurry with pulverized coal should be carried out at as high a temperature as possible for reasons of heat economy, but the unique characteristics of the slurry put an upper limit on the temperature which can be used. The coal begins to swell and form a gel when first contacted with hot coal-derived liquids. This is the first step in solution of the coal and results in a very pronounced increase in viscosity. The rate of increase in viscosity increases with temperature, and is especially pronounced at high coal concentrations. The initially high viscosity of the recycle slurry, plus the rapid increase in viscosity upon mixing, makes this a very critical design problem to balance temperature, residence time, and coal concentration during the mixing operation.

Two separate mixing and pumping systems are now in operation at Fort Lewis. These are (1) an eductor system where pulverized coal is drawn from the bottom of the hopper by the low pressure created by the slurry moving at high velocity past the bottom of the hopper and (2) a small highly agitated mix tank feeding a larger slurry blending tank. The latter system is being considered for the demonstration plant, and the pilot plant system is being modified somewhat to overcome difficulties observed in initial pilot plant testing of the system.

Slurry Preheater

Initial operations at the Fort Lewis Pilot Plant using the original preheater were carried out at lower velocities and lower heat flux than planned for the demonstration plant design. This was a result of a substantial overdesign built into the original pilot plant, primarily to allow for the uncertainty existing at that time. To provide more pertinent data a new preheater, parallel to the original preheater, was installed at the Fort Lewis Pilot Plant last year. Experiments are now being carried out on the new preheater at velocities and heat flux rates within the general range of the demonstration plant design. This work has given considerable support to the belief that the preheater could be successfully operated at the normal conditions of the demonstration plant design. Furthermore, the results indicated that at certain conditions the pressure drop through the slurry preheater was lower than expected on the basis of earlier information at lower flow rates.

SITE ACTIVITY

The demonstration plant site is located on the Monongahela River in Monongalia County, West Virginia, just south of the Pennsylvania state line (Figure 2). This was the one site selected as optimum during an intensive Phase Zero evaluation.

Figure 3 shows the proposed site and identifies the major plant areas. Total acreage is about 2,400, including land required for expansion to a commercial facility. Topographically, most of the site is gently rolling upland. A narrow strip of river terrace, generally about 200 feet wide, parallels the river. At the southern end this strip is some 600 feet wide, and will be used for tankage and rail facilities. The Ft. Martin electric generating station occupies the northern terrace.

A draft Environmental Impact Statement was issued by the DOE on May 30, and received criticism from the EPA and several environmental groups. DOE has responded to the concerns of EPA with some changes that were already in progress and others involving supplemental work now being performed for a final EIS to be issued for comment next month - December. DOE believes that while a delay has occurred, the EIS should be approved without overall schedule impact as shown on the project schedule.

The acquisition of feed coal in sufficient quantities for an initial operating period of 2½ years is now proceeding. Factors in determining coal selection for the initial operating period include: (1) the need for near-future contracts on coal for the initial operating period to freeze design; (2) the time required for pilot plant testing of coals to be sure of their suitability; and (3) the decision to use the rivers to barge coal to the Plant.

For this initial operating period, a dual-source coal supply, based on process evaluations already in hand and on proximity to the rivers is being pursued. The two coals are from Powhatan #6 and Ireland. Negotiations have been opened with representatives of both sources.

It is anticipated that a subsequent 2-3 years operating period could employ other bituminous coals (as yet undetermined) after operating performance has been established during the initial demonstration period. Figure 4 shows the counties in the tri-state area considered as possible sources.

PROJECT SCHEDULE

The overall schedule for the demonstration plant project is shown in Figure 5. As previously discussed, the Phase Zero studies provided the preliminary plant design, cost and schedule estimate, and evaluation of market potential. The project is now in Phase I (process and detailed design) in which the contractor will prepare a basic design, including the process flow diagrams, engineering documents, drawings, specifications, etc. required for timely construction of a safe, environmentally acceptable and operational demonstration plant. The scheduled completion date for Phase I is March, 1983.

In Phase II, the contractor is to construct the Plant in accordance with the approved design. It is hoped to break ground in January, 1981 and commence earthwork in March, 1981. Mechanical completion of the construction work is scheduled for September, 1984. In Phase III, the contractor is to operate the demonstration plant and evaluate the commercial viability of the SRC-II process. Although this schedule shows operation into and beyond 1988, the contractor has an option to purchase the plant before that time.

PROGRAM AGREEMENTS

The organization, funding and international participation of the SRC-II project was recently established with the agreements signed on July 31 in Washington at a White House ceremony between Gulf and DOE and between the governments of the United States, Germany and Japan, and the formation of a joint venture company on September 30th with Gulf and German and Japanese industrial concerns to carry out the SRC-II demonstration project.

Total cost of the project is expected to be approximately $1.5 billion, DOE paying roughly 50%, the foreign governments about 25% each. The contractor's total contribution in cash and kind is $100 million, a $50 million front-end contribution and a $50 million performance fund which would not be drawn until later in the project.

The $50 million performance fund, (DOE will contribute a like amount) will be drawn after the completion of mechanical construction. At that time, the contractor will have this level of financial exposure to share equally the costs of any modifications required to make the plant meet its performance goals.

The project will be under DOE's direction from the Oak Ridge operations office. DOE's program managers will in turn be responsible to a 6-person Steering Committee comprised of two appointees each by the governments of Germany, Japan and the United States.

Within this framework, Gulf has accepted responsibility for performing the contract. Gulf has assigned the contract to a joint venture company, comprised of its subsidiary, The Pittsburg & Midway Coal Mining Co., Ruhrkohle and Veba of West Germany and a Japanese corporation, Japan SRC-II, in which Mitsui is the principal firm. The joint venture company is Solvent Refined Coal International, Incorporated or SRC International as it will be known.

DOE's objective in supporting the SRC-II demonstration project is to enable the acceleration of the commercialization of synfuels technology. To this end, it is intended that SRC International will have an option to purchase the plant at the end of an initial period of operation (2½ years) and expand it to commercial size.

PRODUCT PROGRAM

In addition to designing, building and operating the demonstration plant, Gulf, through the joint venture - SRC International, has agreed to develop and demonstrate (or cause to be demonstrated) markets for the products of the SRC-II process.

Table 3 gives projections of the Demonstration Plant product slate. Excess synthesis gas (above that required for reactant hydrogen), butane and methane rich gas (prior to methanation) are assumed used as plant fuel. The pipeline gas, propane, by-product sulfur and ammonia will be produced to industry specifications and marketed accordingly.

The raw liquid products, naphtha and fuel oil, are not directly interchangeable with comparable products derived from petroleum. Their composition is different, and their acceptance in place of conventional fuels will require the development of somewhat different methods of use. The Fort Lewis pilot plant has been producing small quantities of these materials for several years; and they are being tested for a wide variety of applications by U.S. industry.

This report, however, will be largely confined to the status of applications in steam boilers and stationary engines. These are applications judged to form a principal market for SRC-II products from early commercial plants, and the electric utility industry is a major segment of that market.

NAPHTHA

The SRC-II Demonstration Plant will include a naphtha hydrotreater. The raw naphtha (C_5-380^oF), comprising about 1/3 of the total liquid product, will be severely hydrotreated to meet the specifications for a naphtha reforming chargestock, and distributed to a petroleum refiner for that purpose. Gulf has established reaction conditions required for the hydrotreating, and is currently developing the data base needed to complete hydrotreater design.

Properties of raw and hydrotreated SRC-II naphtha are shown on Table 4 The total cycloparaffins and aromatics are much higher than in most petroleum naphthas, indicative of a feedstock which should yield a high octane reformate with relative ease. This has been borne out by reforming studies. Figure (6) compares the performance of Kuwait and SRC-II derived naphthas in a conventional platforming operation. The SRC-II naphtha produces equivalent R.O.N. at substantially lower reforming temperatures and with much improved reformate yields. These reforming studies have shown no problems with catalyst aging.

FUEL OIL - BOILERS

The marketing plan for the remaining two-thirds of the liquid product (380^{o} - 900^{o}F) is quite different. DOE and its contractor, Chevron Research, have shown that it is possible to hydrotreat the entire liquid product to produce conventional fuels such as jet fuel, automotive diesel fuel or home heating oil. But, the marketing studies conducted during Phase Zero suggested that the use of raw SRC-II fuel oil in steam boilers, industrial direct heat applications and stationary engines was preferred. The rationale behind this conclusion is that the petroleum fuel oils displaced from such markets can be refined to transportation fuels at less cost than can be the coal liquids product.

To substitute SRC-II products for petroleum fuel oils in applications such as those given above, two different sets of criteria must be satisfied. The first relates to the ability to handle, transport and store the fuel by conventional means. Figure (7) compares SRC-II fuel oil with some typical Gulf products in this regard. The SRC-II fuel oil measures up well in important respects. It has low viscoscity, high flash point and low pour point, and is satisfactorily stable. Gulf Research and Development Company is conducting studies in this area on behalf of the DOE. Preliminary results on the properties of blends of SRC-II fuel oil with conventional products suggest that such blends are stable. Early work on the compatibility of SRC-II fuel oil with common materials suggests that metal corrosion is unlikely to be a problem. However, common elastomers are degraded with the exception of Viton,and Nylon 6/6 and teflon.

The second set of criteria relates to combustion performance. Coal-derived fuel oils have a substantially lower hydrogen content and thus higher content of aromatics than petroleum fuel oils. Fuels of high aromaticity burn with a more luminous (hotter) flame and have a greater tendency to produce smoke. SRC-II fuel oil also has a substantially higher nitrogen content than conventional fuels, raising the possibility that NO_x emission regulations might not be met.

Realization of these potential problems, not just for SRC-II, but for a variety of synthetic liquid products, led DOE, EPA and EPRI to put in place a number of programs to assess the magnitude of the problem and to seek solutions. Such programs are ongoing, but sufficient progress has been made to suggest a positive prognosis.

In general, the aromaticity of the fuel does not seem to cause a particular problem. Smoke formation does not appear to be an issue. Flame luminosity is not found to be problematic in most applications, and may even be advantageous in some industrial uses where high heat release is desirable. Flame luminosity did create problems for Westinghouse in an EPRI-funded study, which used coal liquids in a conventional gas turbine combustor. Combustor overheating occurred and combustor life was unacceptable. But Westinghouse concluded that a modified combustor design should avoid such problems. Brown-Boveri, with a different turbine design which uses only one large combustor, recently burned highly aromatic fuels without problems, and in fact guarantees performance for fuels with hydrogen contents similar to SRC-II fuel oil.

NO_x

Conventional combustion of SRC-II fuel oil leads to high NO_x emissions in boilers, stationary turbines and other applications. Rich/lean or staged combustion looks promising as a solution. A short full-scale test of this concept, sponsored by Consolidated Edison of New York, was carried out in a 450,000 lb./hr. steam electric utility boiler in the fall of 1978.

The results were impressive as shown in Figure (8). Performance with the SRC-II fuel oil met all applicable NSPS emission regulations, including NO_x.

The Consolidated Edison unit was a tangentially fired, low heat release (coal designed) boiler, ideally suited to take maximum advantage of the staging concept, (a lazy, well-mixed flame in the fuel rich zone, and lots of room for soot burn-out in the fuel lean zone).

The degree of success which may be anticipated in other types of electric utility boiler is not certain, but EPRI has ongoing programs to develop this data. Future tests are planned in single wall-fired, low heat release units, moving eventually to high-heat release (oil and gas designed) units of both the tangential and wall-fired types. Also worthy of note are EPRI's fundamental combustion studies at MIT which recently focused on defining minimum NO_x emissions from SRC-II fuel oil during staged combustion. Values less than 100 ppm NO_x were obtained. Obviously this may not be attainable in a practical boiler design, or by retrofitting an existing boiler; but it does provide a reference point.

Although the precise strategy used for rich/lean firing may differ, there is no reason to suppose that the success occurring in utility boiler applications cannot be extended to industrial steam raising and a variety of industrial direct heat applications.

FUEL OIL - COMBUSTION TURBINES

The stationary combustion turbine has also been identified as a potential market for SRC-II fuel oil. The ability to control NO_x emissions in combustion turbines is being addressed in several developmental programs underway. DOE has a major effort to develop low-NO_x turbine combustors managed by NASA-Lewis, which has been using SRC-II product as a baseline fuel. In Phase I most domestic turbine manufacturers have been funded to develop and test their individual designs. The results will be used to focus future efforts on the best concepts, leading to a single design which should be field tested around 1984. NASA-Lewis expects to review final Phase I results early in 1981, and little information appears likely to be made public until then. However, EPA funded pioneering work in this field earlier, in which United Technologies developed a rich/quick-quench/lean bench-scale combustor which met NSPS limits on NO_x when firing SRC-II fuel oil. EPRI is also funding studies related to low-NO_x combustors for stationary turbines. Given the success of the early United Technologies work and the well conceived current programs of the various agencies, the prospects for success are judged to be good.

The manufacturers themselves are exploring other approaches. Several are evaluating Japanese technology for catalytic de-NO_x of the turbine exhaust; and new combined cycle systems and repowering concepts offer the interesting possibility of combating turbine emissions in the steam boiler fed with turbine exhaust gas.

Another consideration in qualifying alternate fuels for stationary combustion turbines is their potential for causing corrosion or erosion of the turbine blades. Gulf has conducted laboratory distillations of SRC-II fuel oil which suggest that the entire product can be obtained satisfactorily clear of ash and trace metals which are known to cause corrosion. But metal contaminant levels in the Demonstration Plant full-range fuel oil are uncertain at this time. For this and other reasons, the Demonstration Plant fractionation system is being designed to produce two distillate fuel oil streams, a middle distillate, boiling from 380^{o} to about 600^{o}F, and a heavy distillate boiling from about 600^{o} to 900^{o}F. The plant will have the flexibility to store and market either stream or to reblend in various proportions depending on product application requirements. Table 5 gives typical properties of these two streams as produced by the Fort Lewis pilot plant. The middle distillate will meet required trace metal levels for turbine use and is currently projected as the most likely product for that application.

DIESELS

Stationary diesel engines are not a major prime mover in the domestic electric utility industry, but are of interest to many smaller utilities. Sulzer Brothers Incorporated of Switzerland, the major manufacturer of slow-speed diesels, have tested SRC-II fuel oil. Due to its high aromaticity, autoignition was too slow to permit satisfactory engine performance. Blends with conventional fuels (80% SRC-II product) performed well however; and in tests with two injectors per cylinder, only 3.5% diesel fuel was required in the pilot injector to permit smooth burning of the remaining 96.5% SRC-II fuel.

In reviewing the status of the SRC-II project, it must be remembered that the objective of the demonstration is in large part to enable accelerated commercialization of the coal liquids technology beyond the pace that might otherwise occur. In the product area, this calls for definition of market, demonstration of applications, determination of acceptable product properties and setting of product specifications. Over the next few years, SRC International will carry out studies needed to finalize product applications and to define the precise nature of the fuel-oil products. In the same time period, many of the DOE, EPA and EPRI programs described previously will be demonstrating what can be accomplished by new combustion technology and by defining minimum acceptable quality for coal-derived liquids.

CONCLUSION

Process design work is proceeding for the 6,000 T/D demonstration plant to convert West Virginia coal to synthetic liquid fuels by the SRC-II process. A construction subcontractor is being selected, and construction is expected to begin early next year. Mechanical completion of the plant is scheduled for late 1984. Successful demonstration of the process at this scale could lead to an expansion of the plant to a full-scale commercial facility within the decade. The current status of product development suggests that SRC fuel-oils as produced can be important liquid fuels for the electric utility industry.

FIGURE 1

FLOW DIAGRAM FOR SRC-II DEMONSTRATION PLANT

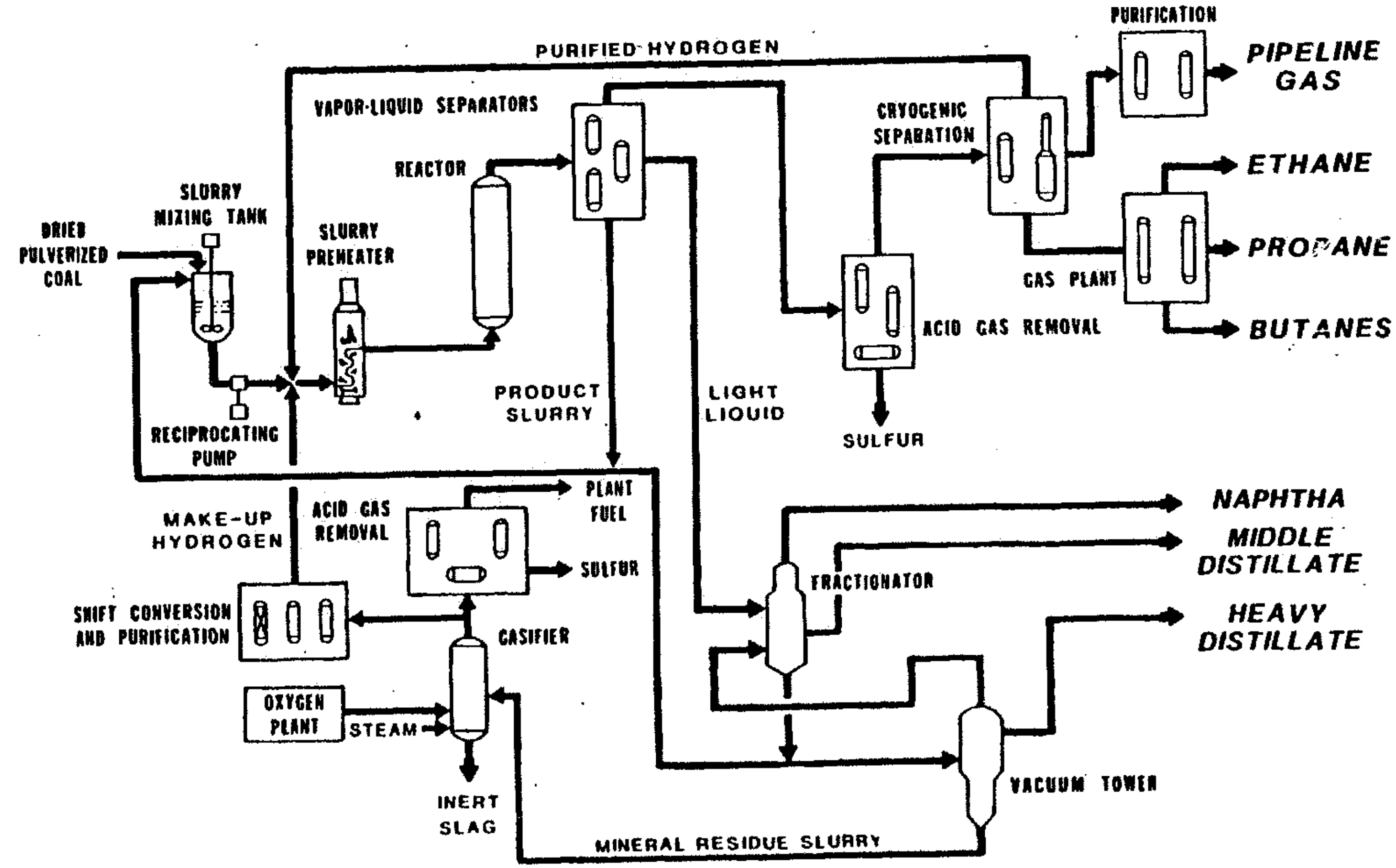

TABLE 1

ANALYSIS OF DESIGN FEED COAL

Coal Analysis (moisture-free basis), Wt. %

Carbon	70.5	
Hydrogen	4.9	
Nitrogen	1.1	
Oxygen	7.9	
Sulfur (total)	3.6	
Pyritic		2.0
Organic		1.6
Ash	12.0	
TOTAL	100.00	

TABLE 2

YIELDS FROM SRC-II HYDROGENATION STEP

	WT. % OF MOISTURE-FREE COAL CHARGE
Methane	5.8
Ethane	4.4
Propane	4.1
Iso-Butane	0.2
n-Butane	2.0
C_5-380°F Naphtha	10.2
380-600°F Middle Distillate	17.9
600-900°F Heavy Distillate	7.9
900°F + Residue	24.0
Pyridine-Insoluble Organic Material (10M)	4.6
Ash	12.0
Residual S	1.1
Carbon Monoxide	0.1
Carbon Dioxide	1.0
Hydrogen Sulfide	2.5
Ammonia	0.4
Water	6.2
TOTAL	104.4
Hydrogen Consumption	4.4

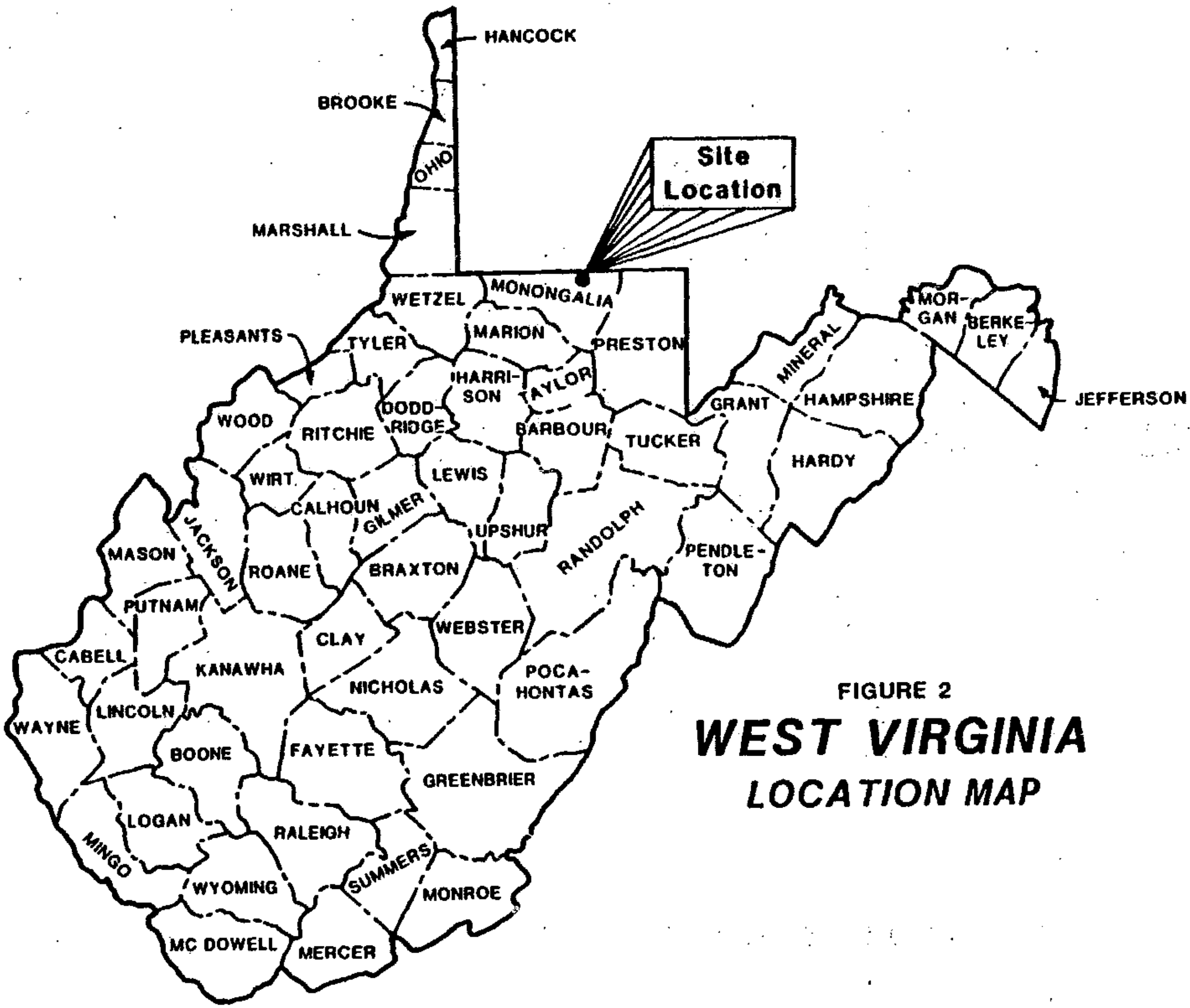

FIGURE 2
WEST VIRGINIA
LOCATION MAP

FIGURE 3

PROPOSED SITE FOR SRC-II DEMONSTRATION PLANT

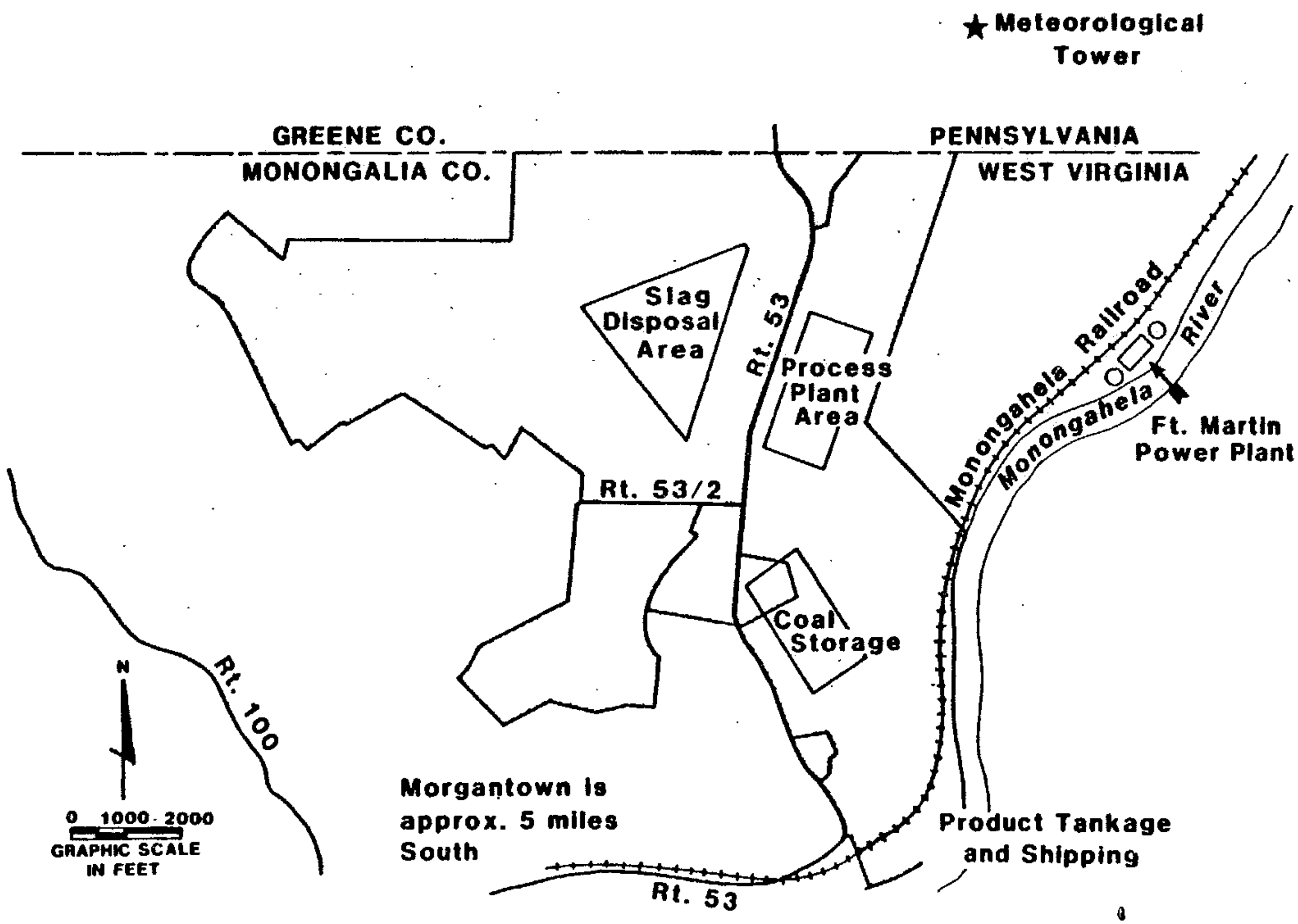

FIGURE 4

AREA OF POTENTIAL COAL SUPPLY FOR THE SRC-II PLANT

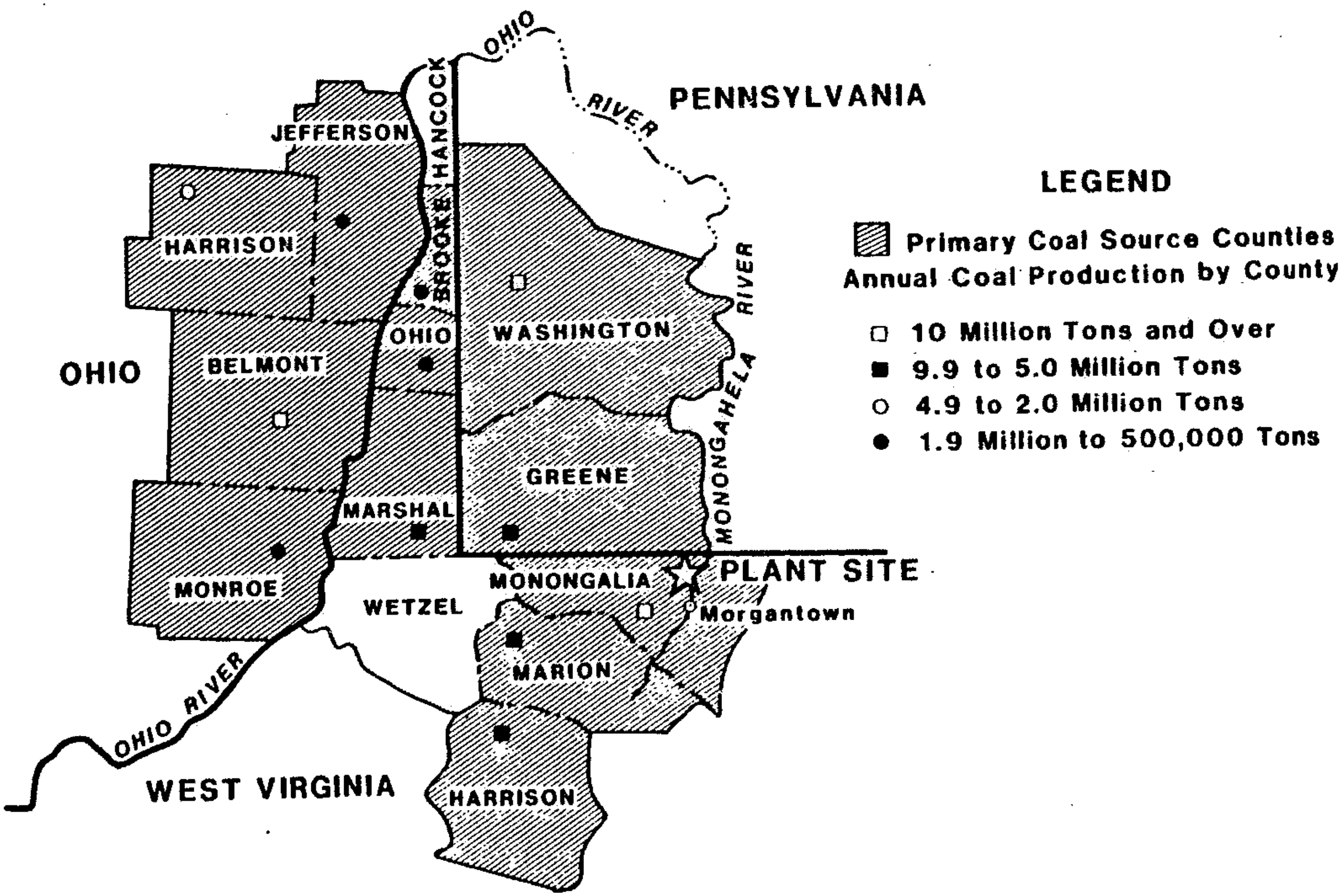

FIGURE 6

SRC-II DEMONSTRATION PROJECT

PHASE I, II, III TIME LINE DIAGRAM

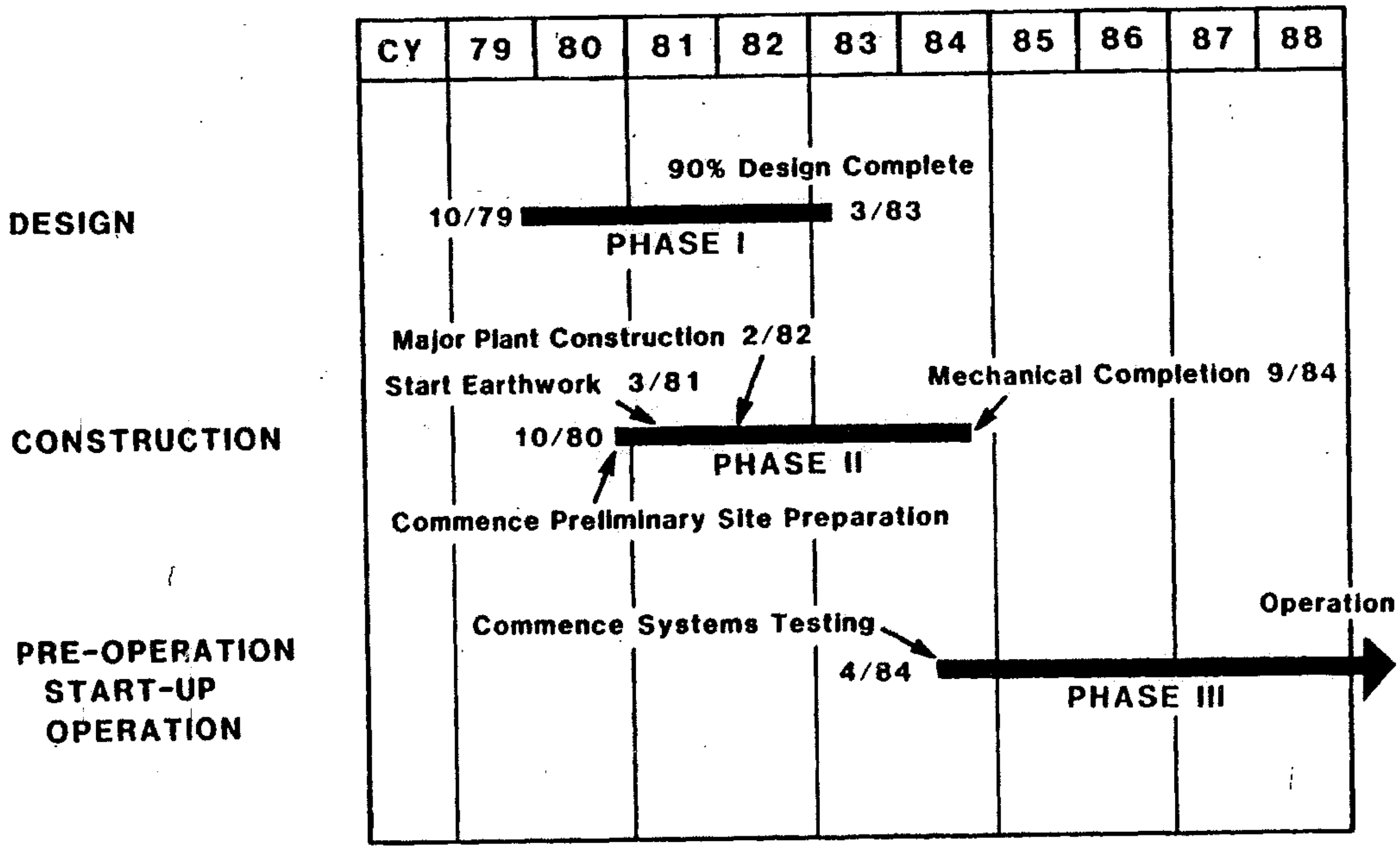

TABLE 3

PRELIMINARY ESTIMATE OF PRODUCT SLATE

NET PRODUCT OUTPUT *	M LB/HR	BBLS/DAY
(Main Products)		
Pipeline Gas	19.0	1,670
Liquid Propane	17.4	2,320
Naphtha	51.0	3,850
Fuel Oil	120.4	8,350
TOTAL	207.8	16,190
(By-Products)		
Sulfur	16.7	
Ammonia	2.5	
Tar Acids	0.6	

* Products after fuel consumption and power generation

FIGURE 6

CATALYTIC REFORMING

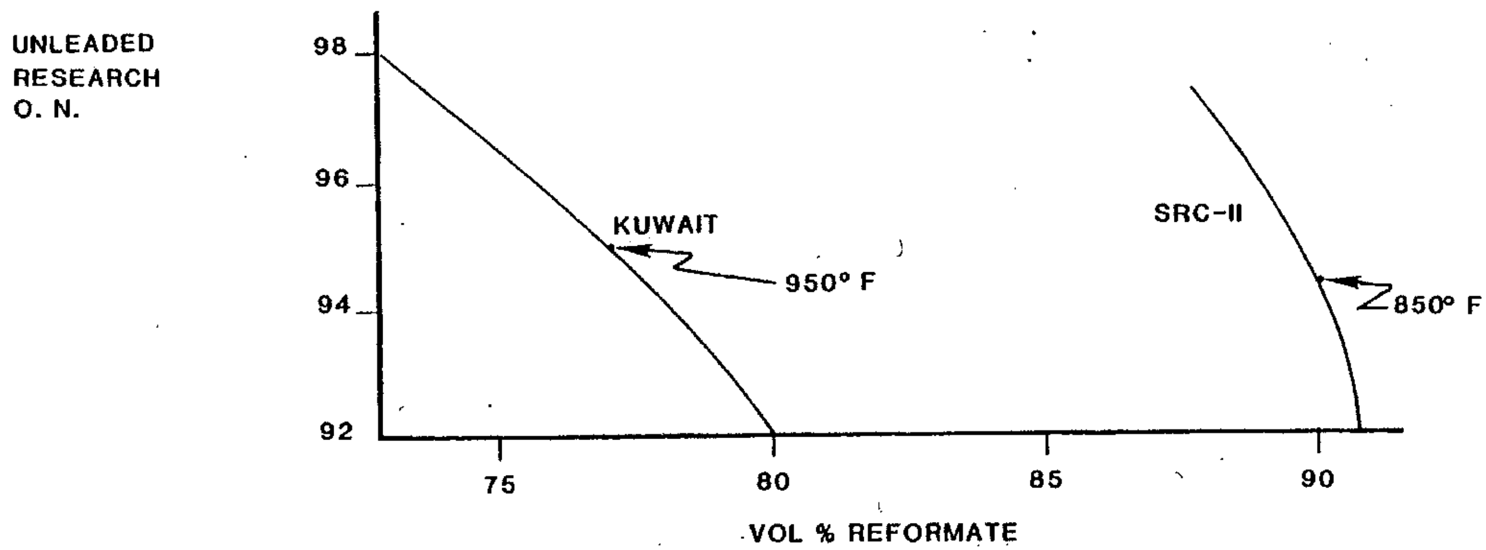

FIGURE 7

SRC-II FUEL OIL PROPERTIES

	SRC FUEL OIL	TYPICAL PETROLEUM FUEL	
		NO. 4	NO. 6
Gravity (°API)	8.3	23	12
Viscosity (CS, 100°F)	4	14-20	900
Flash Point (°F)	> 150	>150	>150
Pour Point (°F)	-23	< -20	<+60
Sediment (%)	<0.03	0.05	0.25
Carbon Residue (%)	<0.3	5.5	6-16
Ash (%)	0.015	0.01	0.05
Sulfur (%)	0.25	1.00	0.3-2.2
Nitrogen (%)	.9	0.2	0.4
Net heating value (BTU/Gal.)	148,000	135,000	141,000

TABLE 4

NAPHTHA PROPERTIES

	STABILIZED & UNHYDROTREATED	STABILIZED & HYDROTREATED
Nitrogen, Wt. %	4,500 ppm	less than 0.2 ppm
Sulfur, Wt. %	1,900 ppm	less than 0.5 ppm
Oxygen, Wt. %	3.5%	
Hydrocarbon Analysis: Vol. %		
Aromatics	34	14
Cycloparaffins	45	62
Paraffins	21	24
Distillation: °F		
IBP	100°F	
10%	150°F	
50%	290°F	
90%	350°F	
End Point	380°F	

FIGURE 8

LARGE SCALE SRC-II FUEL OIL TEST AT CON ED - 4500 BBLS BURNED IN MANHATTAN POWER PLANT

	EPA REQUIREMENTS	TEST BURN RESULTS
NOx	375 PPM	175-300 PPM
Sulfur	85% Removal	95% Removed
Particulates	.03	< .03 (No precipitator)
Hydrocarbons	---	< 3 PPM
CO	---	< 50 PPM
SO_3	---	< 1 PPM
POM	---	~ 5 PPB
Boiler Efficiency	---	Comparable to Petroleum Fuel Oil

SRC-II coal liquids are in most respects superior to residual fuels. They are more like No. 2 distillates and can substitute for petroleum fuel oils in the more restrictive environments.

TABLE 6

PROPERTIES OF DISTILLATES

	MIDDLE DISTILLATE	HEAVY DISTILLATE
Specific Gravity	0.98	1.08
Viscosity, SUS	38 @ 100°F	200 @ 40°F 40 @ 200°F
Pour Point, max.	-50°F	50°F
Flash Point	170°F	300°F
Nitrogen, Wt. %	0.08	1.1
Sulfur, Wt. %	0.2 to 0.25	0.3 to 0.4
High Heating Valve, BTU/lb.	16,400	Approx. 17,000
Distillation: °F		
IBP	370°F	580°F
10%	390°F	610°F
50%	470°F	690°F
90%	570°F	800°F
End Point	600°F	900°F