SRC-I TECHNOLOGY AND ITS ECONOMICS

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Abstract

The Solvent Refined Coal (SRC-I) Demonstration Plant is the only remaining major coal liquefaction development initiative of the United States Department of Energy. This 6,000 short ton coal feed per day plant is planned to be erected in Newman, Kentucky. Using the most developed direct liquefaction technology available, it will produce a flexible slate of liquid and solid fuels and anode coke from bituminous coal.

The SRC-I demonstration project has proceeded through conceptual and process designs since mid-1978, and has reached the "project baseline" milestone. This baseline provides an integrated technical, schedule, and cost benchmark for the SRC-I Demonstration Plant to aid in budgeting and control. The project baseline will also be used by the Congress to determine the desirability of proceeding with detailed design, procurement, and construction and operation of the SRC-I Demonstration Plant.

This paper presents the program status, the results of the project baseline, including demonstration plant costs, and commercial plant economics.

Introduction and Background

In cooperation with the Commonwealth of Kentucky, International Coal Refining Company has contracted with the United States Department of Energy (DOE) to design, build, and operate one module of a commercial plant that will demonstrate the economic, environmental, socioeconomic, and technical feasibility of the direct coal liquefaction process known as SRC-I. The plant is intended to promote energy independence by generating products that can substitute for those derived from petroleum, as well as to promote the establishment of a commercial, private-sector SRC-I industry without additional demonstrations or experimental work.

Since 1962, the SRC-I coal liquefaction technology has been developed in the U.S. through bench-scale programs. The demonstration program traces its roots to 1977, when Rust Engineering Company, a subsidiary of Wheelabrator-Frye Inc., received a contract from the Commonwealth of Kentucky to design a 2,000 ton-per-stream-day (tpsd) solid-SRC facility near Owensboro, Kentucky. At that time, the Rust-designed direct liquefaction plant was considered the most ambitious project of its kind.

Additional tests, review of the technical information provided by the 2,000-tpsd plant design data, and consideration of the economics of various plant sizes led the U.S. government, Wheelabrator-Frye, and Air Product and Chemicals, Inc. to sign a contract supporting the design and construction of a 6,000-tpsd demonstration plant producing 20,000 barrels per day (bpd) of fuels. To accomplish this task, Air Products and Wheelabrator-Frye formed the International Coal Refining Company (ICRC). The DOE contract provides ICRC with the option of buying out the government's interest in the plant following the demonstration period as a prelude to enlarging the facility to commercial size.

In 1978, the Phase 0 conceptual design of a demonstration size plant began. In October 1979, the Phase I detailed design was initiated, and in April 1981, an interim baseline was established. During Phase I, tests conducted by the Pittsburgh Energy Technology Center indicated that SRC could be burned as a powder, melt, or solid-coal liquid slurry mixture in utility boilers designed for "oil only". In addition, SRC's characteristics are close to oil in many respects. These and other tests indicated that this new fuel could directly displace No. 6 fuel oil, and could command a comparable price on the open market.

In April 1982, ICRC submitted the SRC-I Project Baseline to DOE. ICRC believes the versatile plant design contained in the Project Baseline incorporates the most advanced coal liquefaction systems available in the synthetic fuels field. In addition, product slate flexibility, high process thermal efficiency, and low hydrogen consumption make SRC-I the state of the art in coal liquefaction technology.

The SRC-I Demonstration Plant

Process Description

All major technology systems and processes associated with the production of synthetic fuels from coal will be demonstrated by the SRC-I Demonstration Plant. Generally, these systems and processes must be proven at or near commercial scale before a coal-based U.S. synthetic fuels industry can proceed to commercialization. The demonstration plant will accomplish this in a single, integrated facility.

The plant is designed to produce transportation fuel, low-sulfur solid fuel, anode coke, and fuel oils, as well as propane and butane gases, sulfur, and other by-products from high-sulfur, western Kentucky, washed #9 or similar coal. The plant will be a self-sufficient facility; although coal, water, air, chemicals, catalysts, and electricity will be supplied, all other utilities and process raw materials, including hydrogen, will be generated within the plant.

The proposed SRC-I plant site at Newman, Kentucky contains 28 separate land parcels, representing approximately 1,484 acres. The plant will require approximately 750 acres to be graded to meet requirements for flood elevation, erosion, and the plot plan. Approximately 4,300,000 cubic yards of grading will be required for the area. Additional site acreage will be reserved for expanding the plant to commercial size.

A description of the SRC-I Process follows. Figure 1, a simplified process flow diagram, is included for clarity.

Plant process steps will include the following: coal drying and pulverization; coal gasification; coal liquefaction; production of coal-based liquid process solvent; removal of ash and sulfur from coal; solidification of low-ash, low-sulfur products; upgrading of SRC via expanded-bed hydrocracking; naphtha hydrotreating; production of high-carbon anode coke; production of elemental sulfur; and generation of enough process gases, including oxygen, nitrogen, and hydrogen, to sustain the plant at design level.

Of the 6,000 tpsd coal feed rate, approximately 5,600 tpsd will be processed in the SRC coal liquefaction unit; the remainder will be fed to the gasification system to produce hydrogen for the process.

In the SRC liquefaction area, coal will be mixed with a process solvent. The mixture will be hydrogenated at high temperature and pressure, and converted into solvent-refined coal (SRC), plus liquid and gaseous fuels.

The slurry, containing SRC, ash, and unconverted coal, will be deashed by the Kerr-McGee critical solvent deashing process. Residue from the deashing step will be sent to the gasification system for hydrogen production. Gasifying the SRC ash residue will render it an environmentally acceptable solid waste.

One-third of the molten SRC will be solidified as product, another third will be fed to the delayed coker/calciner to produce anode coke, and the final third will be fed to the expanded-bed hydrocracker for additiona upgrading to cleaner and lighter solid, liquid, and gaseous fuels. Althougi the Baseline calls for one-third of the first-stage SRC product to be hydrocracked, design provisions will allow up to two-thirds of this product to be routed to the hydrocracker. This design flexibility will enable ICRC to adapt to market demands when products are offered for sale. The product slate produced when the plant is operated as specified in the Baseline is shown in Table 1.

Project Baseline

In April 1982, ICRC provided DOE with an integrated cost, schedule and technical baseline, which substantially defined the project's major technical characteristics, and provided an overall design, construction, and operation schedule, and a definitive cost estimate. The Baseline includes activities involved in completion of Phase I, detailed design; Phase II, procurement and construction activities; Phase IIIA, a start-up period of 6 months; and Phase IIIB, an operational period of 2 years. Environmental requirements, R&D support, all legal requirements, marketing costs, and waste disposal are also addressed.

Cost Baseline. The Baseline cost estimate divides the project into Phases 0, I, II, and III to represent feasibility evaluation, design engineering, construction, and commissioning and operation, respectively. These estimates are reported in Table 2 in escalated dollars. The schedule calls for demonstration plant construction to be completed in December 1987. Using inflation rates as directed by DOE, ICRC has included $565 million in the Baseline estimate for a total of $2.44 billion. To this total, $452 million in contingency funds are added for a grand total of $2.89 billion. It should be noted that if current inflation trends continue during the pla construction period, the escalation will be less. For example, if inflation were to continue at the rate of 6%, the plant cost would be $201 million lower.

ICRC estimates that during the first 2½ years of operation (test period), revenues from plant production will exceed expenses by approximately $200 million. This estimate is based on: (1) the 1981 Energy Information Agency's price projection in their "Annual Report to Congress"; (2) DOE's recommended escalation rates; and (3) ICRC's Baseline cost projections. The industrial partners have the option to purchase the plant at the conclusion of the demonstration period for its economic value, which is estimated at $1.558 billion. Therefore, the total estimated net cost to the government for the Baseline plant would be approximately $1.3 billion--when construction cost, net operation revenues, buyout, and the industrial partner's cost-sharing are considered.

DOE and its support contractors reviewed ICRC's Baseline cost estimate and made the following assessment:

> In general, the cost estimates are in the same order...of magnitude and suggest the acceptability of ICRC's baseline cost estimate for use in contractual configuration management. The methods used by ICRC in developing their cost estimate conform to accepted industrial practice. The accuracy of ICRC's cost estimate was evaluated as being ±25% (although ICRC declined to state an accuracy). Their cost estimate was built up from design data and A, B and C Engineering Change Proposals and assembled by Work Breakdown Structure down to the fourth level.
>
> The Department's Oak Ridge Operations Office (DOE/ORO), assisted by Burns and Roe and Humphreys and Glasgow, assessed the cost, schedule and technical baseline in detail. They followed acceptable industrial cost estimating practice in assessing Phases I, II, IIIA and IIIB and thoroughly reviewed all aspects of the project. Their assessment supports ICRC's cost estimate and confirmed it is reasonable and complete. An independent check of 70% of the equipment was done, contingency was analyzed, labor productivity was reviewed, and factors for other costs during Phases I and II were reviewed and applied. For Phases III A&B, product prices, plant operability, labor, and materials were reviewed. The thorough comprehensive review by DOE/ORO confirms the acceptability of the ICRC Cost Baseline.

Schedule Baseline. More than 65,000 individual activities will be performed by ICRC and its subcontractors during the life of the SRC-I Project. The project schedule is a time-phased depiction of this network of tasks that defines the ways in which the tasks interrelate during the 8 years required to complete the project. The schedule provides both early and late start/complete dates for each activity. This permits progress monitoring for all activities and enables ICRC to exercise particular control, where necessary, for activities critical to timely completion of the project.

Although the SRC-I Demonstration Plant Project consists of four phases, only Phases I, II, and III have been included in the Baseline schedule, since Phase 0 was completed in September 1979 (Figure 2). The three remaining phases are summarized below to provide a brief overview.

Phase I is the detailed engineering and design of the SRC-I Demonstration Plant, and is based upon the technical output from Phase 0. Examples of work under this phase include the completion of all engineering design activities required to successfully construct the plant, including but not limited to the preparation of detailed heat and material balances, process flow diagrams, equipment specifications, and detailed piping and instrument diagrams. Additionally, procurement activities to provide vendor engineering and the activities leading to site acquisition are included.

Phase II, defined as procurement and construction, includes all work necessary to provide materials, equipment, and services needed to construct, check out, and commission the plant; all work needed to construct the plant; and, all work needed for checkout and commissioning to effect an overall turnover of the facilities for start-up and operation.

Phase III includes all work necessary to start up (Phase IIIA), operate (Phase IIIB), and evaluate the integrated demonstration plant. Examples of work under this phase include the recruitment and training of all personnel to staff the plant; the complete shakedown and initial operation for start-up; the operation of the plant for an extended period (2 years) to establish optimum operating parameters; and the collection of all data necessary to evaluate the SRC-I technology as defined by the Baseline.

Product Market

The SRC-I plant will incorporate a first-stage liquefaction section (SRC-I) followed by an LC-Finer, referred to as two-stage liquefaction (TSL), and a delayed coker and calciner to produce the following product slate:

- Naphtha - A feedstock for production of high-octane, unleaded gasoline or BTX chemicals.
- Middle Distillate - An oil for stationary turbine fuel and light- to medium-weight fuel oils.
- Heavy Oil - An oil for boiler and furnace fuel and carbon products feedstocks.
- SRC Fuels - Low-sulfur, low-ash, solid boiler and furnace fuels and coker feedstock.
- Anode Coke - Coke for aluminum smelting.

An important part of the product slate from the SRC-I plant will be liquid distillates that can perform like those derived from petroleum. The plant will be producing a C_5-400°F naphtha fraction that can be upgraded via hydrotreating and catalytic reforming to produce a high-octane unleaded gasoline blendstock; a 400-650°F cut that can be used as fuel oil similar to No. 2 fuel oil; and a 650-850°F heavy-oil fraction that can be used either directly as a substitute for No. 6 fuel oil, or blended with pulverized SRC to form a mixture that can be fired as No. 6 fuel oil substitute.

Laboratory work has shown that SRC fuels can be processed to produce green coke, which can be calcined to a high-quality anode coke for aluminum smelting. The SRC-derived anode coke appears to be superior to conventional petroleum coke in several respects, including lower sulfur content and potentially lower power consumption during the aluminum smelting process.

SRC fuels are significantly different from and offer definite advantages over coal. The low-sulfur content results in fuels that comply with stringent New Source Performance Standards (NSPS), thus eliminating the need for scrubbing devices. In addition, such unique properties as very low ash content, low melting temperature, and very high Hardgrove grindability index enable SRC fuels to be used in three firing modes that are applicable to oil- and coal-designed boilers and furnaces: pulverized; melted and atomized like oil; and mixed in SRC liquid.

Several by-products resulting from the SRC-I process can be used to fill existing needs in the marketplace. The removal and recovery of sulfur from the coal feed permits the production of both an environmentally acceptable solid fuel, and a sulfur by-product that is projected to be in short supply, especially in northeastern markets easily served by the Newman, Kentucky demonstration plant. Ammonia and carbon dioxide by-products are also expected to be produced in sufficiently large quantities in the commercial plant for sale to existing markets. One alternative being considered is the piping of the carbon dioxide to nearby southern Illinois or Indiana oil fields for use in enhanced oil recovery.

SRC-I Commercial Plant

As indicated earlier, ICRC has the option to buy the SRC-I Refinery from the federal government, and expand the plant to full commercial scale. For this reason, ICRC has undertaken a study of the economics of a commercial-scale SRC-I Refinery, which could be put into operation in 1996.

The 1996 commercial plant start-up date is based on the demonstration plant completion in 1987 and 2 years of operation before the decision to commercialize. Delays in the demonstration plant will impact on the on-stream date for the commercial plant, which will have a 20-year operating life.

An economic analysis of an SRC-I Commercial Plant is important in determining the long-term viability of the technology, and may influence decisions regarding development of the technology. The following sections provide an outline of the plant process units, capital costs, and results of the financial and economic analysis.

Summary Process Description

The commercial plant evaluated here is a grass-root facility designed to process 30,000 tpsd of washed, moisture-free Kentucky #9 or similar coal, and produce approximately 100,000 bpd of solid and liquid products. Approximately 28,400 tpsd of the feed coal is conveyed to liquefaction; the remainder is sent to the gasifier to supplement the critical solvent deashing (CSD) ash concentrate as feedstock for hydrogen generation. Figure 3 is the process block diagram for this plant.

The plant configuration allows all of the SRC from the first stage to be processed at low conversion (approximately 50%) in the second-stage ebullated bed hydrocracker (EBH). An integrated fractionation unit common to both stages is incorporated to reduce capital costs and increase operating flexibility. Naphtha from both stages is first sent to a hydrotreater, and is then reformed to produce a gasoline blendstock. Other fuel products include middle distillate, heavy oil, TSL (two-stage liquefaction) SRC, and LPG. The commercial plant product slate is shown in Table 3. Total heat content is 587 billion Btu per stream day.

Inputs to the plant include 407 MW of electricity along with the 30,000 tpsd of coal. Using 9,500 Btu/kWhr, the combined energy to the plant is 867 billion Btu per stream day of heat content. Therefore, thermal efficiency for the entire plant is 67.8%.

A significant process efficiency enhancement projected for the commercial plant is due to the use of pressurized gasifiers. For this specific case, gasifiers from GKT operating at about 400 psi are used. It is anticipated that these gasifiers, which operate on a dry feed, will be commercially demonstrated at the time of SRC commercialization.

Capital Costs. Table 4 is a capital cost summary for the major sections of the plant: SRC liquefaction and deashing; expanded-bed hydrocracking; hydrogen production and treatment; and utilities and offsites, including coal preparation. The subtotal for plant and equipment cost is $3990 million (1982 $). With the addition of engineering, spare parts, and an initial charge for catalysts and chemicals, and allowing a contingency of 20% on the above total, the total project cost is $5700 MM.

Operating Costs. The operating cost summary (also in 1982 $) is presented in Table 5. After startup in 1996, the plant is assumed to have a 20-year operating life. The operating costs presented are for a typical operating year having a 90% onstream factor, or 328 1/2 days per year onstream.

Major annual operating costs for the facility will be:

- Coal (at $41.80/ton) = $420 MM
- Power (at $0.03/kWhr) = $101 MM
- Catalyst and chemical consumption = $77 MM
- Maintenance materials = $114 MM
- Operating and maintenance crew of 1,900 people = $79 MM

The subtotal for the various expenditures is $910 MM per year.

Demonstration Plant Scale-up

Considerable economies of scale are attainable when extrapolating the demonstration plant design to commercial size. The basic scale-up philosophy was to incorporate two large trains into the design where it was prudent to do so. Otherwise, four trains were used.

One of the process areas requiring four trains is the first stage for slurry preparation, slurry preheating, and dissolving. Each train is about 30% larger than the corresponding demonstration plant train. Preliminary analysis indicates that vessel sizes for the dissolvers and the high-pressure separator remain in the commercially acceptable range for the larger trains. Each train is to contain two 50% slurry preheaters. It is felt that the reliability of these heaters will be proven during the demonstration phase, permitting the use of larger heaters in a commercial plant without sacrificing the plant utilization factor. In addition, each pair of slurry preparation units is provided with only one full-size spare train. This produces a savings from the demonstration plant, in which 100% sparing is included.

The deashing step will be accomplished in two large trains. To ensure an adequate plant utilization factor, each unit contains two 60% first stages, two 60% second-stage preheaters, and two 60% second-stage settlers. The third stage has been excluded because, with the integrated fractionation system, ample process solvent with superior hydrogen donor capability is available for recycle to the first liquefaction stage without the use of the light SRC stripper.

The second-stage hydrocracker consists of two trains, each nearly four times the capacity of the demonstration plant EBH. An exception to this general scale-up of the EBH occurs for a very significant cost item, the reactors themselves. Based on recent test results from a larger pilot plant, the total reactor volume required for both trains is only about three times the demonstration plant requirement, although the flow rate is nearly eight times as large in the commercial case.

Economic Analysis

The major financial assumptions used for this analysis are shown in Table 6. A general inflation rate of 8% per year has been assumed. The total plant cost of $5.7 billion in 1982 dollars is expended over a 6-year construction period between 1990 and 1995, and is inflated to the actual year of expenditure. The plant cost in current dollars is $14.5 billion. The plant is financed 65% with debt at an 11% interest rate, and 35% with equity. The capital estimate includes a 20% contingency.

The plant operating costs are assumed to escalate at the rate of inflation. The coal will be purchased with long-term contracts, and therefore should show no real price growth during the project life.

The projected energy prices are critical in developing the expected revenues from the SRC-I Commercial Plant, and in evaluating commercial viability of the technology. Over the last few years, energy prices have escalated rapidly and erratically. Although currently the prices seem to have stabilized, future prices will depend on many factors over which the United States has very little control.

For the base case analysis, the product prices are assumed to increase at a rate of 2% per year above the inflation rate. The project was analyzed on a Discounted Cash Flow (DCF) return on equity (ROE) basis, using a

65/35 debt-to-equity ratio. The base case resulted in a 27% DCF return on a current-dollar basis, and a 22% DCF on a constant 1982 dollar basis. Table 7 lists estimated prices for SRC-I products.

Tax and depreciation assumptions have a significant impact on economics because of the capital-intensive nature of the SRC-I technology. Based on the Economic Recovery Act of 1981, the total plant investment is depreciated over a 5-year period in accordance with the schedule set by the act.

The investment tax credits were estimated at an effective rate of 9%. It was assumed that 90% of the plant cost would qualify for the 10% regular investment tax credit. No energy tax credits were considered in this analysis.

Sensitivity Analysis

The long-term economic viability of the SRC-I technology must be evaluated using the best currently available information. Since the plant start-up is almost 15 years away and the technology is expected to undergo changes as it is developed, various assumptions have to be made regarding plant costs, operating costs, product prices, and inflation rates.

The projected product prices represent a major uncertainty in estimating the project revenues and profitability. If prices remain stable in real terms at 1982 levels, the DCF return would drop to about 10%. However, if prices escalate at 6-7% per year above inflation, as predicted by DOE's Energy Information Administration (EIA), the project would result in a 40-50% DCF return on equity. The variability of DCF with product price escalation rate is shown in Figure 4.

The plant capital cost estimate includes a contingency for unforeseen cost increases. However, the plant cost can change with time as the SRC-I project proceeds toward demonstration plant operation and design of the commercial facility. The results indicate that a capital cost increase of 10% over the base case estimate decreases the DCF return on equity by about 2%.

Another variable that would impact the results is the operating costs of the plant, including coal, labor, utilities, and maintenance. A 10% increase in operating costs would lower the DCF return by 1%. Combination of a 10% increase in operating costs with a 10% decrease in revenues would decrease the DCF return by 4.4%.

Conclusions

The results of commercial plant economic analysis indicate that the SRC-I technology is economically viable in the long-term. To achieve commercialization by the mid-1990s, it is necessary to proceed with the design, construction, and operation of the demonstration plant to prove the technical feasibility, economic viability, and environmental acceptability of the SRC-I technology.

Today, synthetic fuels development no longer holds the urgency that elevated it to a position of national prominence a few years ago. However, most analysts agree that the underlying circumstances that will determine the U.S. energy future are unchanged. World oil supplies are dwindling, and the largest source of U.S. petroleum supplies remains one of the most politically volatile regions. In fact, the oil glut proclaimed only a few months ago shows signs of evaporating. Already, spot shortages of crucial energy products have been reported--most notably transportation fuels.

The U.S. still has within its borders the largest coal reserves in the free world. The potential of western and eastern oil shales remains largely unexploited. Inflation has subsided, which makes cost projections for plant construction more attractive than they were a year ago. Unemployment has climbed in the past year, and this suggests that development of a synthetic fuels industry could help rejuvenate the economy.

The risks inherent in the pioneer development of synthetic fuels technologies, as well as the unpredictable fluctuations in energy supplies, point toward the necessity for continued government involvement as a risk-sharing partner in synthetic fuels development, now and in the future. In recent months, this reality has been underscored by the withdrawal from the field of major industrial partners who have concluded that the risks are too large to be borne by the private sector alone.

We at ICRC continue to believe that the development of a domestic synthetic fuels industry is an inevitable reality for the United States in the near- and long-term. We also continue to believe that accelerated development of this industry--beginning now and continuing at a determined pace during the next decade--is a responsibility that must be shared by the federal government and the private sector working in partnership. Only through such a partnership can we guarantee a reliable source of vital energy products for present and future generations.

TABLE 1

SRC-I DEMONSTRATION PLANT PRODUCT SLATE

	High-conversion Expanded-bed hydrocracker		Low-conversion Expanded-bed Hydrocracker	
	TPSD[a]	BPSD[b]	TPSD	BPSD
Naphtha	520	3,710	532	3,800
Distillate fuel (400-650°F)	807	4,620	805	4,600
Fuel oil (650-850°F)	155	826	151	803
SRC (850°F+)	883	--	0	--
Two-stage liquefaction/SRC	169	--	981	--
Calcined coke	570	550	570	595
LPG	49	--	53	--
Sulfur	189	--	195	--
BPSD oil equivalent	17,700	--	17,400	--

[a]TPSD = Tons per stream day.
[b]BPSD = Barrels per stream day.

TABLE 2

SRC-I DEMONSTRATION PLANT TIME-PHASED COST[a]

Fiscal year[b]	Prior years	80	81	82	83	84	85	86	87	88	89	90	Total
Escalation %	N/A	N/A	N/A	10	10	9	9	8	8	8	8	8	--
Phase 0	10												10
Phase I		20	52	108	156	55	9						400
Phase II					191	385	632	443	295	86			2,032
Subtotal	10	20	52	108	347	440	641	443	295	86			2,442
Contingency													452
Total Phase 0, I, & II													2,894
Phases IIIA & B Revenues										340 (243)	386 (498)	306 (494)	1,032 (1,235)
Total Phases IIIA & B										97	(112)	(188)	(203)
Total Phases 0-IIIB													2,691

[a]Cost is escalated and shown in $ MM.
[b]Fiscal year = Oct 1 to Sept 30.

TABLE 3

SRC-I COMMERCIAL PLANT PRODUCT SLATE
(100% SRC to Low-Conversion EBH)

	lb/hr	MM Btu/hr (HHV)	TPSD	BPSD
Naphtha reformate[a]	231,690	4,292	2,780	19,300
Middle distillate	377,580	6,780	4,530	26,100
Heavy oil	84,240	1,490	1,010	5,400
TSL SRC	623,250	10,410	7,480	
LPG	53,460	1,150	642	7,220
Sulfur	85,330	346	1,020	
Total	1,455,550	24,468	17,462	

[a]Hydrotreated and catalytically reformed naphtha; octane number = 100 (RON).

TABLE 4

SRC-I COMMERCIAL PLANT CAPITAL COST SUMMARY

(Cost in Millions of 1982 $)

SRC liquefaction, deashing, and solidification	1,065
Expanded-bed hydrocracking and fractionation	370
Hydrogen production and treatment	1,100
Oxygen plant	165
Utilities, offsites, and coal preparation	1,290
Subtotal (plant and equipment)	3,990
Engineering	600
Spare parts and initial catalysts and chemicals	160
Subtotal	4,750
Contingency (20%)	950
Total project cost	5,700

TABLE 5

SRC-I COMMERCIAL PLANT
OPERATING COST SUMMARY
(1982 Dollars)

	MM $/yr @ 90% utilization
Coal: 30,000 tpd @ $41.80/ton	420.1
Power: 407,000 kWh @ $0.03/kW	101.1
Catalyst and chemicals	77.0
Labor:	
Operating: 865 people	32.8
Maintenance: 1,035 people	46.0
Plant overhead	13.4
Maintenance material	114.0
Tax & insurance	85.5
G&A	20.0
Total operating costs	909.9

TABLE 6

SRC-I COMMERCIAL PLANT ECONOMIC ASSUMPTIONS

1.	On-stream	1996
2.	Construction period	6 years
3.	Plant utilization factor	50% 1st year 75% 2nd year 90% 3-20 years
4.	Plant life	20 years
5.	Depreciation	5 years schedule
6.	Investment tax credit	9%
7.	Inflation rate	8% per year
8.	Operating cost escalation	Equal to rate of inflation
9.	Product price escalation	2% real escalation
10.	Debt/equity rate	65/35
11.	Interest rate on debt	11%
12.	Plant size	30,000 tons per day coal feed
13.	Plant cost, 1982 $ Current $	$5.7 billions $14.5 billions

TABLE 7

SRC-I PRODUCT PRICING

Product	Unit	1982 prices
LPG	$/MM Btu	6.25
Naphtha reformate	$/gal	1.19
Medium oil	$/MM Btu	7.25
Heavy oil	$/MM Btu	5.25
TSL SRC	$/MM Btu	4.75
Sulfur	$/ton	140

FIGURE 1
SRC-I DEMONSTRATION PLANT
SIMPLIFIED BLOCK FLOW DIAGRAM

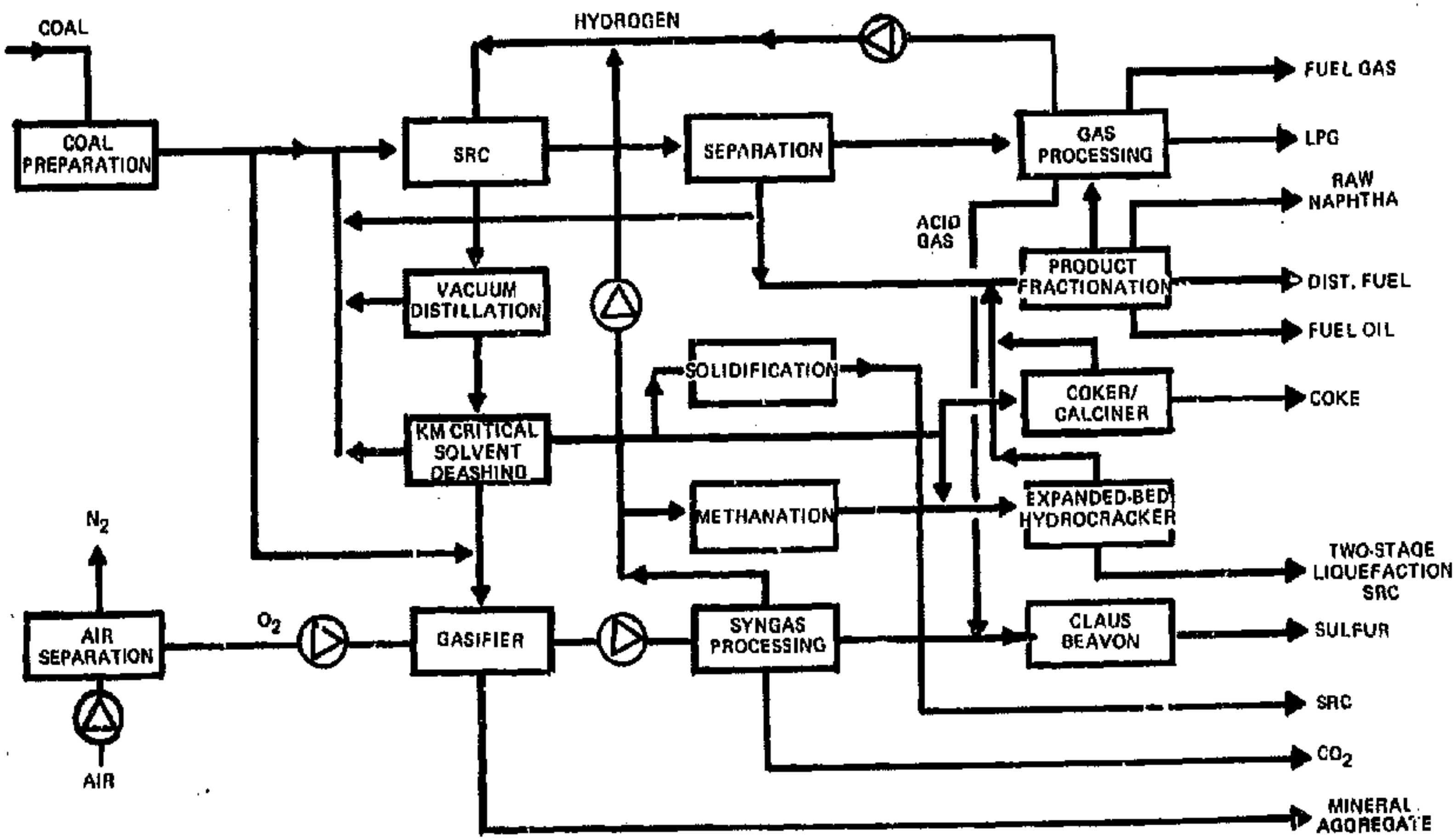

FIGURE 2
ICRC SCHEDULE BASELINE

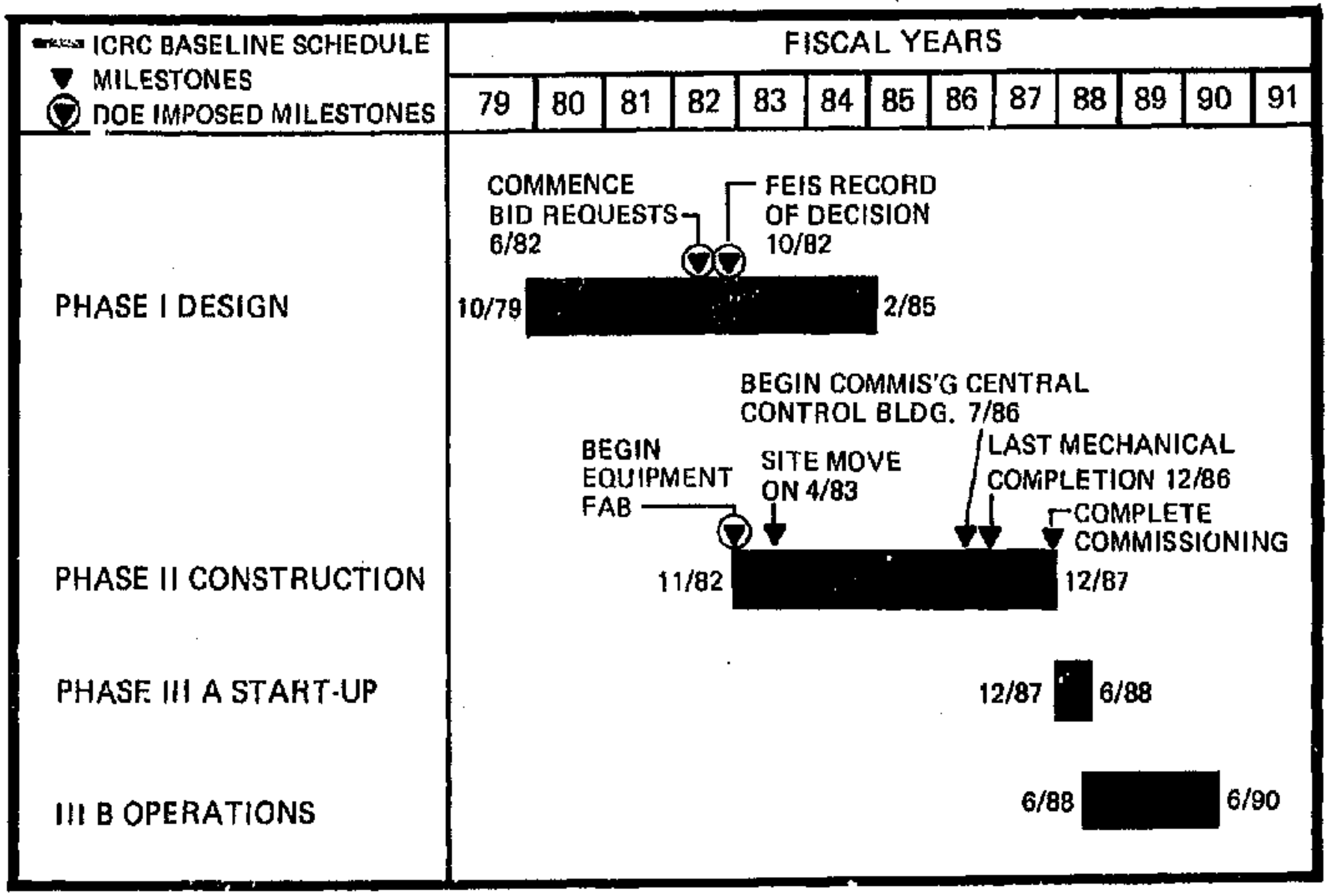

FIGURE 3
BLOCK FLOW DIAGRAM
SRC-1 COMMERCIAL PLANT

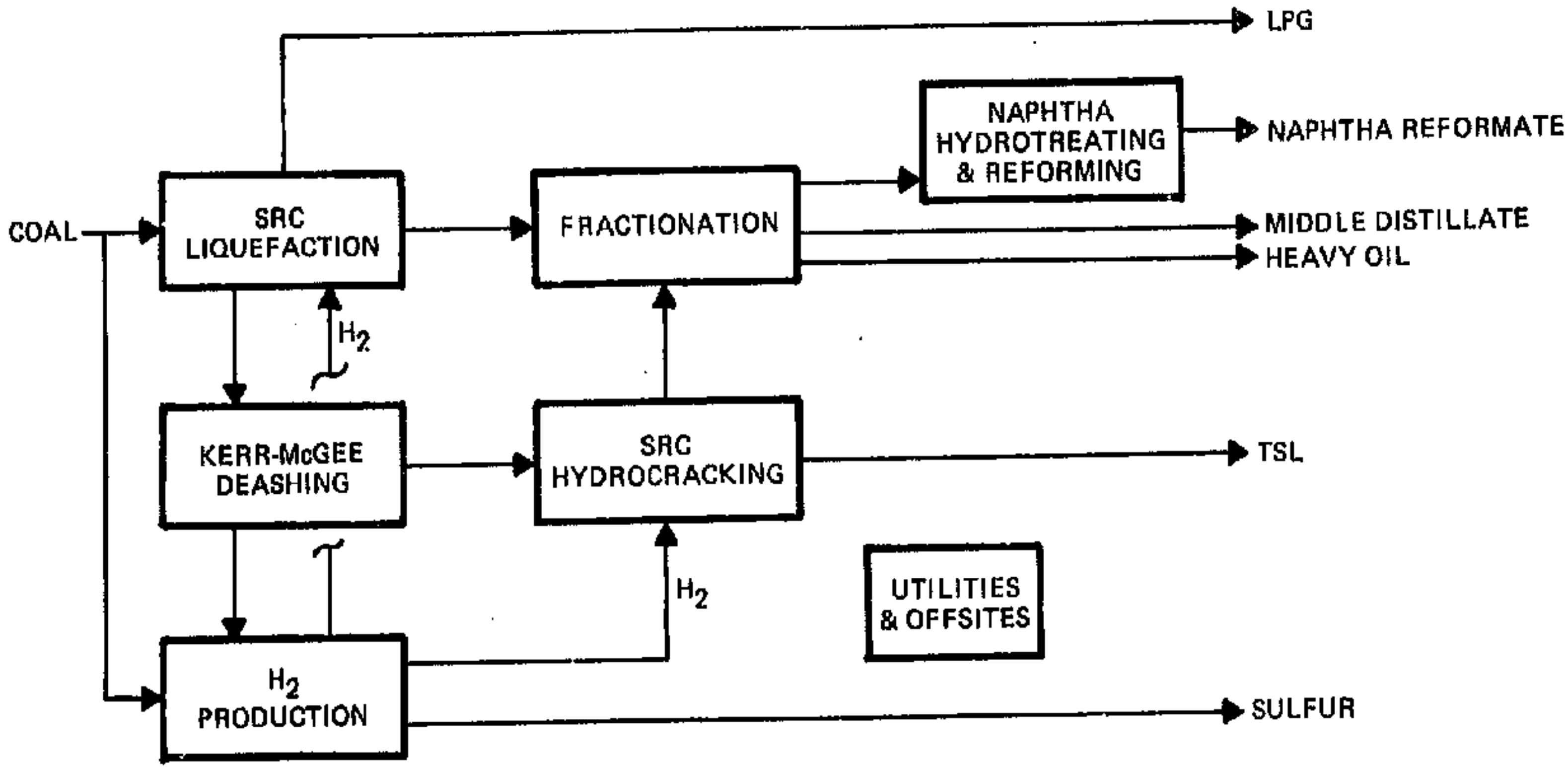

FIGURE 4
SRC-1 COMMERCIAL PLANT
PRODUCT PRICE ESCALATION SENSITIVITY