APPLICATION OF THE TOSCOAL PROCESS TO THE ELECTRIC UTILITY INDUSTRY

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Introduction

Tosco Corporation is a leader in the effort to establish a commercial shale oil industry in the United States. The development of proven shale oil production technology has been at the center of Tosco's commercialization efforts. Now, after 25 years of development work, Tosco and Exxon have begun construction of the 47,000 B/D Colony Shale Oil Project in Colorado. The Colony Project which utilizes Tosco's retorting technology is scheduled for completion in late 1985.

Tosco has long considered its oil shale retorting technology to have significant potential for coal processing. With the commercial demonstration of the Tosco process now expected in the mid-1980's, Tosco is planning for similar large scale facilities producing synthetic crude oil from coal. This paper discusses the application of the Toscoal Process to coal-fired power plants for syncrude production. Commercial design information and economic evaluations are presented for a Toscoal plant operating on Utah coal. Previous Tosco publications presented the results from similar studies on Wyoming and Illinois coals.[1,2,3]

Development History

The Toscoal process is a low temperature coal pyrolysis process based on the Tosco II process for oil shale retorting.

Development of Tosco's pyrolysis process for oil shale was initiated in 1957 with the construction of a 25 ton-per-day pilot plant. Several process configurations were tested and successful operation of the "Tosco II" configuration was achieved.

In 1964, Tosco and its partners undertook to demonstrate the Tosco II process in a 1,000 ton-per-day semi-works plant and collect the data needed to design a commercial plant. The semi-works facility was constructed in 1965 and operated intermittently until 1972. During this period approximately 220,000 tons of oil shale were processed and about 180,000 barrels of shale oil were produced. The semi-works and pilot plant programs provided sufficient data to permit the scale-up of the Tosco II process to a commercial single train retort with a capacity of 11,000 tons-per-day. At the completion of the semi-works program in 1972, Tosco and its partners had invested approximately $55 million in the development of the Tosco oil shale technology.

In 1973, detailed engineering was initiated for the "Colony Oil Shale Project", a 66,000 ton-per-day oil shale complex, including six 11,000 ton-per-day Tosco II retorts and an oil upgrading plant. In 1974, a definitive design and capital cost estimate was completed at a cost of about $12 million. The cost estimates were updated in September, 1979. In 1980, Exxon Corporation joined Tosco to reactiviate plans to construct the Colony shale oil plant and start production of 47,000 BPD of syncrude product in 1985. The development of the Tosco II process and economics of shale oil production have been described in recent Tosco publications.[4,5,6]

In 1970, the possibility of applying the Tosco II process to coal was investigated. Wyodak subbituminous coal was selected for the initial tests in the existing 25 ton-per-day pilot plant. About 120 tons of coal were successfully processed in a continuous run lasting about five days. During these tests, the effects of retort temperature, particle size and other process parameters were investigated. Based on this experience, Tosco concluded that the Tosco II Process could be readily adapted to the processing of non-swelling coals.[7,8]

Subsequent to the initial work on subbituminous coal, Tosco processed in the pilot plant about 25 tons of a slightly caking Utah subbituminous coal and established that the Toscoal Process could be used to pyrolyze such coals.

Since 1976, Tosco has conducted additional pilot plant tests on low and high sulfur Illinois caking coals with free swelling indices in the 3.0 to 4.5 range. These tests established that these coals can be pyrolyzed if the coal is mildly oxidized to reduce the free swelling index to below 1.0 to 1.5. Benchscale and pilot plant deagglomeration studies in vessels up to 20-inch inside diameter established that Illinois coal could be deagglomerated over a range of conditions to produce a suitable feed for the Tosco retort.

The principal objectives of the Toscoal development program are to upgrade coal to increase its heating value and to recover gaseous and liquid products which are more valuable on a Btu basis than the coal feedstock. The coal char produced contains sufficient volatile matter to permit utilization in existing power plants without extensive modification of the facilities or need for significant supplemental fuels.

Other potential benefits of the Toscoal process are (1) reduction in coal transportation costs by rail or slurry pipeline, (2) reduction in sulfur emissions from coal-fired power plants, (3) production of a char which may be attractive for gasification by entrained flow or fluid bed processes, and (4) production of char for manufacture of formed coke from non-metallurgical grade coals.

This paper presents the results of recent feasibility studies of the Toscoal process for recovering oil and gas from Utah coal prior to combustion in power plants. To establish realistic costs for a marketable liquid product, a hydrotreating unit was integrated with the basic Toscoal unit. The hydrotreater converts the raw coal liquid into a lighter syncrude product which is low in sulfur, nitrogen and other impurities.

Toscoal Process Description

Figure 1 is a schematic flow diagram of the Toscoal process for non-swelling coals. In the Toscoal process, crushed dry coal is preheated in lift pipes using hot flue gas from the ball heater. Preheating of coal in this manner increases the thermal efficiency of the process. Preheated coal is fed to a rotating pyrolysis drum where it is contacted with hot ceramic balls. The ceramic balls are heated in a ball heater fired by clean process derived fuel gas or fuel oil. In the pyrolysis drum, coal is decomposed at about 900^{o}F to produce coal char and hydrocarbon vapors. The coal char is separated from the balls by a trommel screen and withdrawn from the char hopper. The balls are elevated, reheated and returned to the pyrolysis drum. Hydrocarbon vapors are cooled and condensed to recover light hydrocarbon gases and coal liquids.

Design Bases for the Utah Case Study

In general, the economics of coal pyrolysis are improved for coals with a high volatile matter content, low moisture and sulfur content and low swelling tendency. Since the Utah bituminous coals meet these criteria, a typical Utah coal was selected for evaluation as a Toscoal feedstock. Table 1 contains the feedstock design basis.

A plant design and cost estimate has been prepared for a two-train Toscoal plant located in Utah. Each train has a nominal design capacity of 11,000 tons per day. The plant is located adjacent to a large existing or new power plant capable of burning the char product.

The yield structure for Utah coal was derived from laboratory and pilot plant data and adjusted to develop a consistent material and energy balance. The raw liquids hydrotreating yields were obtained from process licensors and based on recent pilot plant tests of coal liquids provided by Tosco.

Specifications and cost estimates for the pyrolysis facilities were developed by adjusting the detailed designs and costs for the Colony Shale Oil Project. The capital costs for other sections of the plant were obtained by scaling detailed estimates of similar facilities or from budget estimates provided by process licensors.

Plant Description

A block flow diagram for the Utah Toscoal plant is shown in Figure 2. The plant is located at a power plant site and operates in parallel with an existing coal delivery system. The plant design capacity is 21,250 tons per stream day.

Coal from the existing storage pile is conveyed to the Toscoal plant. The coal is crushed to 100% minus 3/8 inch and transported to process feed bins. Crushed coal is fed to parallel entrained flow dryers. The dried coal is preheated to about 550°F and fed to the Toscoal retort. The hot char from the retort is cooled and transported to char bins ahead of the existing pulverizers feeding the power plant.

The vaporized hydrocarbons are collected, cooled and the liquid and gaseous hydrocarbons are separated. The gases are processed in conventional refinery equipment to remove carbon dioxide and hydrogen sulfide. The clean retort gas is used for ball heater and other plant fuel and feedstock for the hydrogen plant.

The raw retort liquids consist principally of a heavy coal liquid high in nitrogen and oxygen which cannot be upgraded in existing petroleum refineries. An important advantage of the Toscoal process is the production of a high Btu gas by-product which can be used to manufacture the hydrogen needed to upgrade the raw liquid product.

In order to produce a marketable syncrude, an ebulated-bed catalytic hydrotreater has been included in the plant. For this study, an LC-Fining unit licensed by CE-Lummus was used to upgrade the heavy portion of the raw liquids. Lummus has successfully hydrotreated Utah coal pyrolysis liquids in pilot plant facilities. The naphtha boiling range liquids from the retort and LC-Finer are hydrotreated in a fixed-bed catalytic reactor to further reduce heteroatom impurities to meet reformer feedstock specification. The unconverted residual oil from the LC-Finer is consumed in the power plant.

The remaining units in the plant consist of a Claus sulfur recovery plant with tail gas clean-up, a sour water stripper, wastewater treatment and other conventional processes and off-site facilities.

Plant Material Balance

The plant feed and produce summary is shown in Table 2. The Toscoal plant is located at a hypothetical power plant of the size required to consume the char product. For the two train Toscoal plant, the power plant capacity is rated at 1650 MW. Assuming 75% availability, the power plant without a Toscoal unit consumes 14,000 tons per stream day of as-mined coal or 4.6 million tons per year. The Toscoal plant, with a capacity of 21,250 tons per stream day and operating at a 90% availability will produce 4.29 million tons per year of char. This amount is sufficient to fuel the same power plant at a 75% load factor.

The net yield from the Toscoal unit is 21,700 barrels per stream day of blended syncrude liquids consisting of 13,100 B/D of middle distillates, 7,770 B/D of naphtha and 820 B/D of LPG. The yield of refined liquids per incremental ton of coal mined to support the Toscoal unit is 3.0 barrels per ton.

Properties of Syncrude Products

The properties of the syncrude products are shown in Table 3. The naphtha is low in sulfur, oxygen and nitrogen and is expected to be a premium reformer feedstock. The middle distillate is a syncrude which will require further refining to produce transportation fuels or can be sold as a low sulfur No. 2 or No. 6 fuel oil product.

In general, the quality of coal liquids is lower than natural crude oils. However, existing refining technology can be used to upgrade coal liquids at some cost penalty. The relative quality of various petroleum liquids can be observed from the data in

Figure 3. This figure, published by Bridge, et al,[9] shows the hydrogen content of hydrocarbon liquids versus boiling range and molecular weight, expressed as carbon number. Data for the raw and hydrotreated Toscoal liquids have been added to the figure for purposes of comparison. The hydrogen content of raw Toscoal liquids is significantly higher than most coal liquids and only slightly lower than raw shale oil. The hydrotreated Toscoal syncrude is a bottomless 900°F end point liquid with a hydrogen content slightly below the distillate material in Arab heavy crude oil.

Unlike direct coal liquefaction processes which add hydrogen to achieve maximum conversion to low grade liquids, the Toscoal process rejects carbon in char for boiler fuel and recovers hydrogen-rich liquids and gases which can be upgraded to petroleum products. Although the precise costs of refining the Toscoal liquids to finished products are not yet available, Figure 3 indicates that those costs can be expected to be substantially less than the direct coal liquefaction processes.

Properties of the Char Product

The char product specifications are shown in Table 3. The char contains 16.1% volatile matter. The intermediate level volatile matter char is considered an important and unique advantage of the Toscoal process which results directly from the use of inert heat carriers.

The preferred level of volatile matter in the char product can only be determined after optimizing the integrated pyrolysis, upgrading and power plant system. The Toscoal retort operating conditions can be varied to produce chars over the range of volatile matter believed to contain the optimum. In general, as temperature increases, the quality of the char and liquid products deteriorates. For the study presented here, a 900°F pyrolysis temperature was selected. More pilot plant data and engineering work are planned to determine the optimum plant design.

Capital and Operating Costs

The capital cost estimate for the Toscoal plant shown in Figure 2 is presented in Table 4. The plant cost is estimated at $274.8 million. Including indirect charges, a 15% contingency and working capital, the total capital investment is estimated to be $400 million.

The plant operating costs are shown in Table 5. Excluding the coal cost, the direct operating cost is $32.5 million per year or about $4.66 per ton of coal feed or $4.56 per barrel of syncrude product.

Economic Evaluation

The economics of the Toscoal plant have been analyzed for both private industry and public utility financing. The bases for economic analysis for a privately financed Toscoal plant selling the char to a utility and syncrude to a refinery are summarized in Table 6. The discounted cash flow (DCF) rate of return has been determined assuming coal is supplied by the utility at $0.85/MMBtu ($20 per ton) and 100% equity investment by the private owner.

The two principal economic determinants are the value of the syncrude and char products. Table 7 presents the % DCF return as a function of char value assuming a syncrude value of $36 per barrel. In constant 1981 dollars, the Toscoal plant owner could sell char for coal value and achieve a 22.6% return on 100% equity. If the char is discounted by 50% to 100% as an incentive to the utility, the DCF return is lower to 11.9 to 17.8%.

Table 7 also shows the effect of inflation of the DCF economics. A 10% inflation rate on all costs and product prices, boosts the % DCF return to 20.4 to 32.5% over the full range of char values. If the oil products escalate at 12%, instead of 10%, the range of DCF returns rises to 27 to 36%.

Table 8 shows the effect of syncrude price on return assuming a char value of $0.85/MMBtu. A 1981 price of $40 per barrel increases the DCF return to 25.2%. A lower syncrude price of $32 per barrel lowers the DCF return to 19.8%. Assuming inflation continues at a 10% annual rate, the economics are enhanced further. Over a 1981 syncrude price range of $32 to 40 per barrel, inflation increases the DCF return to 29.4 to 38.7%.

The economics of a Toscoal plant owned by a public utility have also been evaluated. In this case, the utility consumes the char internally and passes the full benefit from syncrude sales to its rate payers. For this evaluation, the levelized cost of power production from a new Utah coal fired power plant with or without a Toscoal unit was estimated. Levelized costs were calculated in 1981 dollars with a 6% equity return and 4% land interest rate. A levelized escalated cost of power was calculated assuming a 10% rate of inflation and a cost of equity and debt at 16% and 14%, respectively. Table 9 contains the key assumptions underlying the utility economic evaluation.

The levelized costs are shown in Table 10. In 1981 dollars the cost of power is 25.6 mils without Toscoal and 15.1 mils with Toscoal. Assuming a 10% inflation rate on all costs, the Toscoal unit reduces the levelized cost of power from 54.6 mils to 32.3 mils. If the syncrude product escalates at 12%, the cost of power is further reduced to 20.3 mils. This analysis shows that a Toscoal unit can hold power production costs in an inflationary economy down to the level expected when there is no inflation.

Conclusions

The proven operation of large scale oil shale retorting plants in the mid-1980's could significantly accelerate the production of liquids from coal. The Toscoal process has unique advantages for recovering liquids from coal prior to combustion in power plants. Preliminary engineering and economic studies of a Toscoal plant operating on a Utah coal show that:

1) Syncrude can be produced at a competitive price in 1981.
2) The cost of boiler fuel can be reduced below coal values. and
3) Production of syncrude from coal by electric utilities can reduce the long term cost of power during a period of high inflation.

Additional data on the pyrolysis and liquids upgrading processes is needed to confirm the results of this study. Such data can be obtained from small pilot plant facilities. These data along with commercial oil shale operating experience should be sufficient to commercialize the Toscoal process in the late 1980's.

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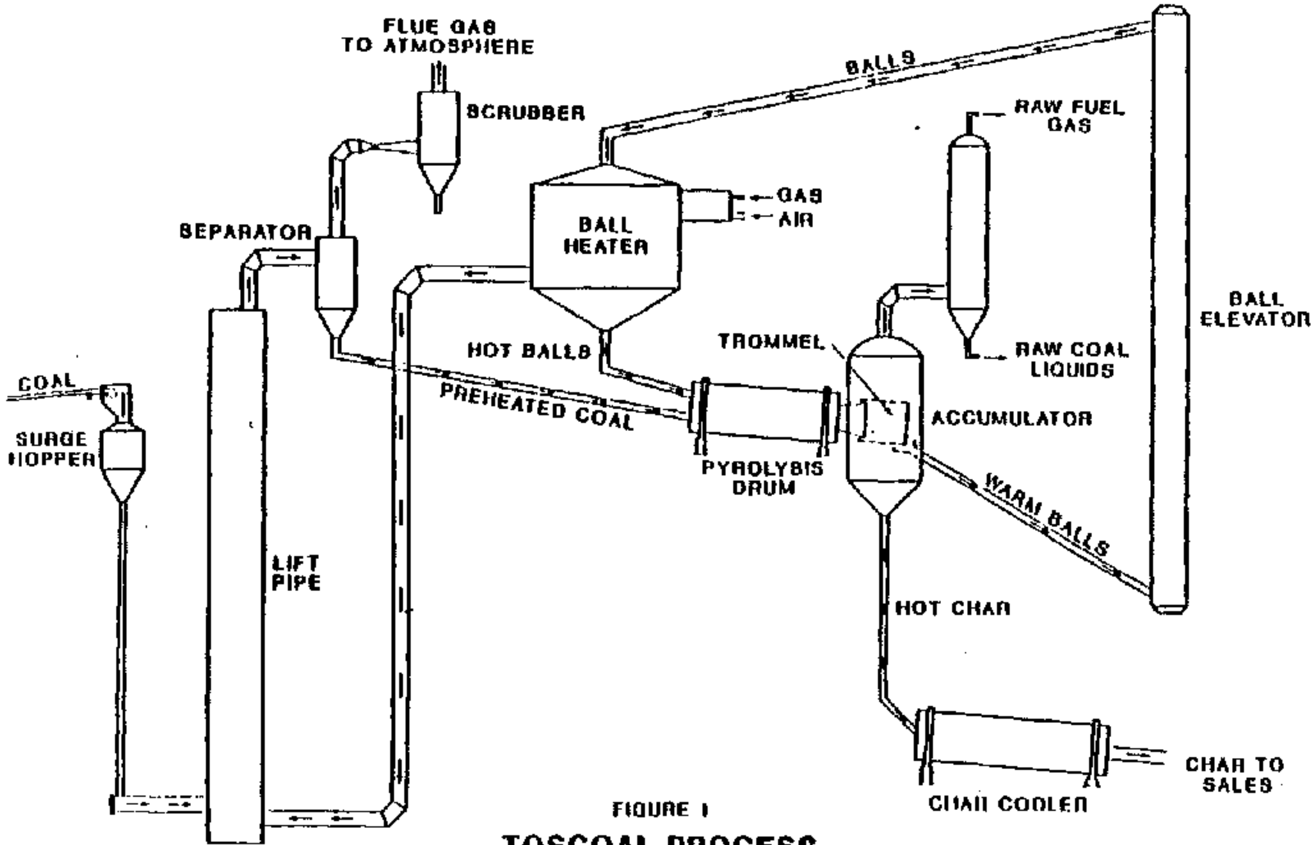

FIGURE I

TOSCOAL PROCESS

FIGURE 2
TOSCOAL PROCESS FLOW DIAGRAM
UTAH COAL

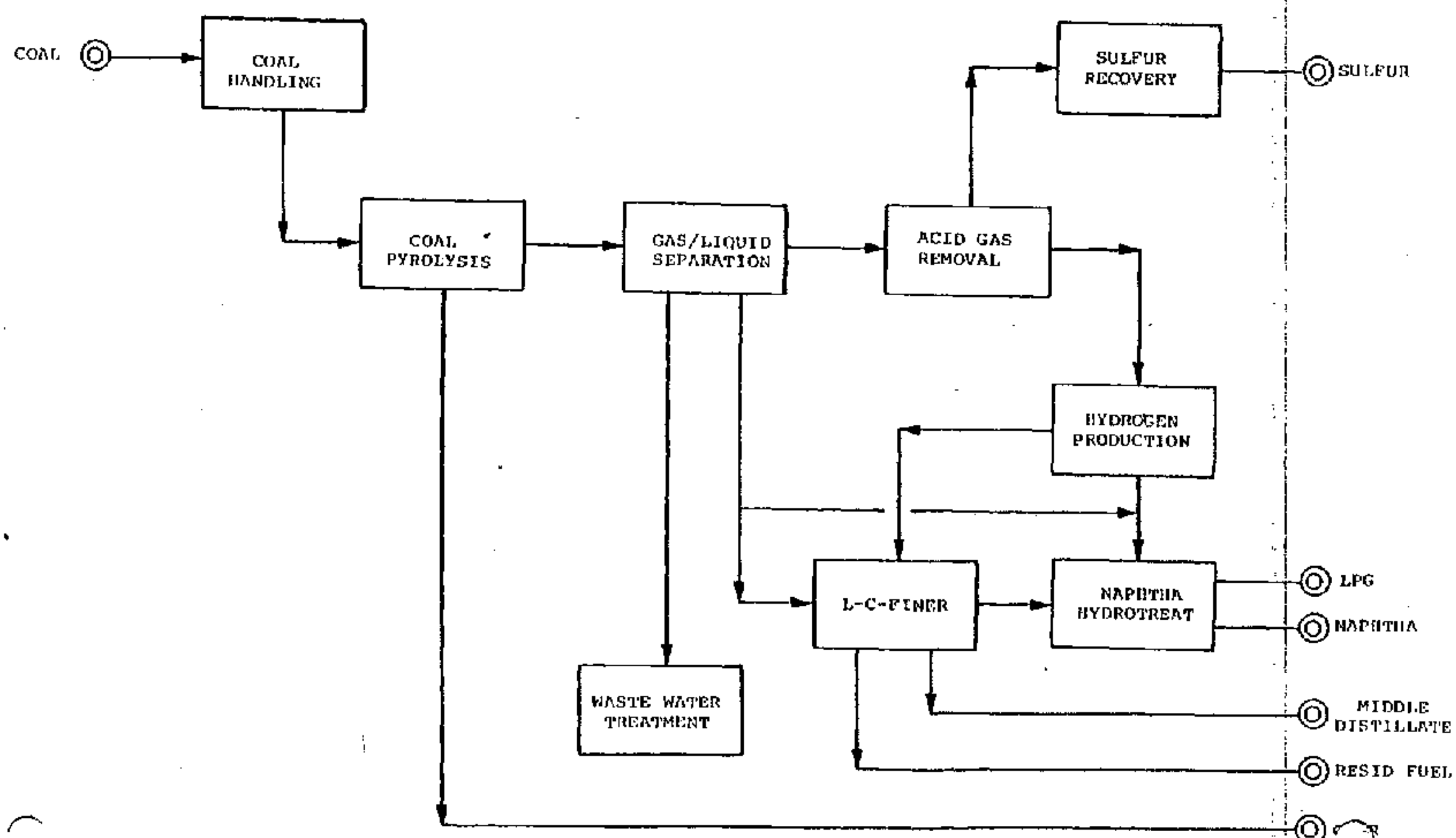

FIGURE 3
HYDROGEN/CARBON RATIOS IN FUELS AND RAW MATERIALS

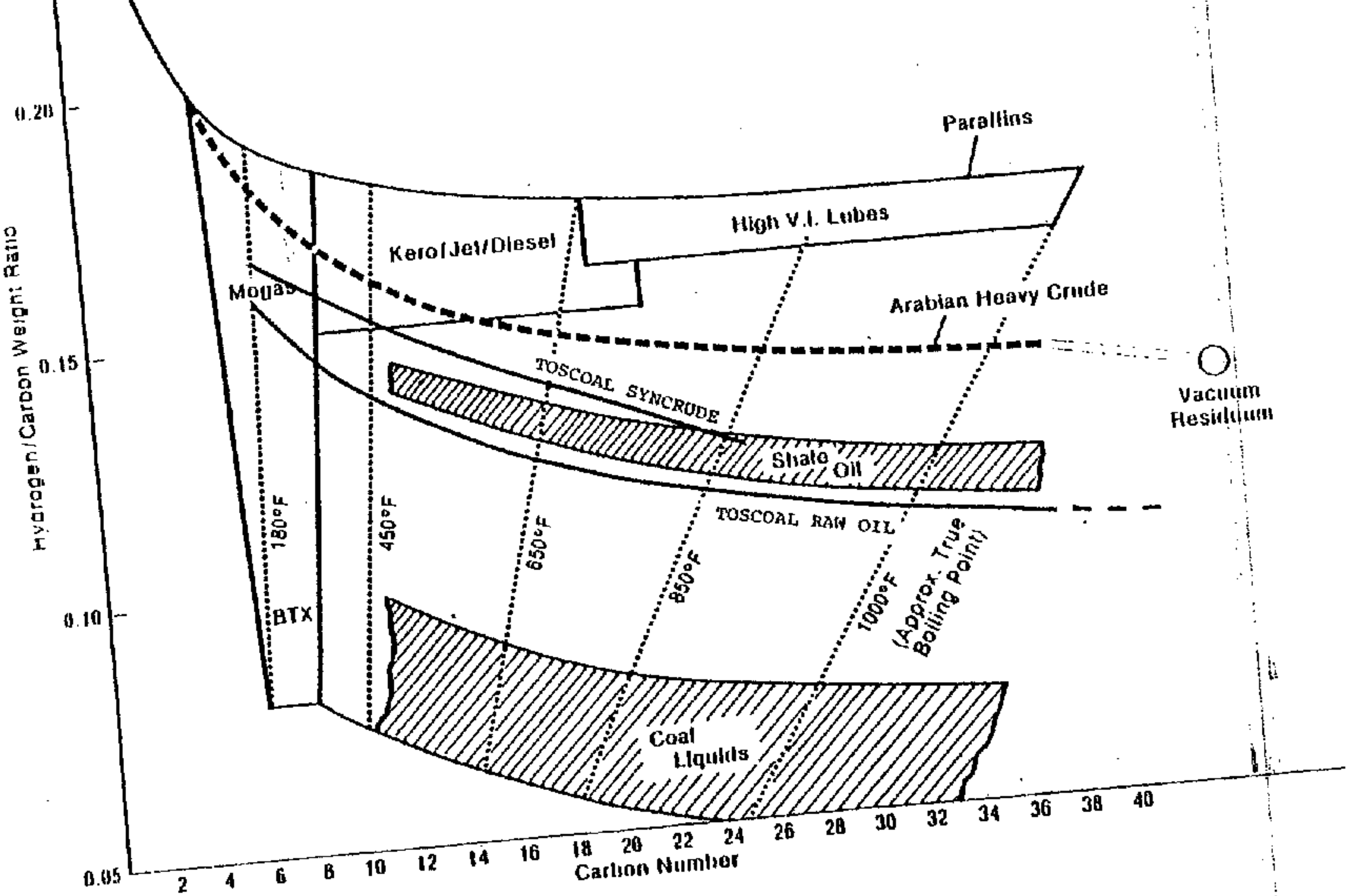

TABLE 1

UTAH COAL ANALYSIS

Proximate Analysis	As Received Weight %
Moisture	9.00
Ash	8.38
Volatile Matter	41.03
Fixed Carbon	41.59
TOTAL	100.00

Ultimate Analysis	
Moisture	9.00
Carbon	65.56
Hydrogen	5.19
Oxygen	9.97
Nitrogen	1.35
Sulfur	0.55
Ash	8.38
TOTAL	100.00

Gross Heating Value, Btu/lb 11,735

TABLE 2

TOSCOAL PROCESS
PLANT FEED AND PRODUCT SUMMARY
UTAH COAL

	Steam Electric Power Plant	Steam Electric Power Plant with Toscoal
Capacity		
Power Plant Rating, MW:	1650	1650
Plant Factor, %:	75	75
Average Annual Output, MW:	1235	1235
Char Production, M Tons/Yr:	-	4,290
Plant Feed		
Coal, Tons/Stream Day:	14,000	21,250
Annual Coal Consumption, M Tons/Yr:	4,600	6,980
Plant Production		
Power Output, MMKWH/Yr:	10818	10818
Syncrude:		
LPG, BBL/SD	-	820
Naphtha, BBL/SD	-	7,770
Middle Distillate, BBL/SD	-	13,110
TOTAL		21,700
Annual Syncrude Production M BBL/Yr:	-	7,128
Elemental Sulfur, LT/SD:	-	115
Annual Sulfur Production LT/Yr:	-	37,777
Incremental Values		
Coal Mined, Tons/SD:	-	7,250
Syncrude Yield per Incremental Ton of Coal Mined, BBL/Ton:	-	3.0

TABLE 3

PRODUCT SPECIFICATIONS

Syncrude Products

LPG:		
	C_3H_8, % wgt:	49.0
	C_4H_{10}, % wgt:	51.0
Naphtha:		
	Gravity, °API	55.0
	Boiling Range:	C5-400°F
	Sulfur, PPM:	1.
	Nitrogen, PPM:	6.
	Oxygen, PPM:	200
Middle Distillate:		
	Gravity, °API	23.0
	Boiling Range:	400-900
	Sulfur, % wgt:	0.02
	Nitrogen, % wgt:	0.35
	Oxygen, % wgt:	1.2

Char Product:

Proximate Analysis	Weight %
Moisture	0.0
Ash	13.40
Volatile Matter	16.10
Fixed Carbon	70.50
TOTAL	100.00

Ultimate Analysis	
Moisture	0.0
Carbon	75.84
Hydrogen	3.25
Oxygen	4.94
Nitrogen	1.97
Sulfur	0.60
Ash	13.40
TOTAL	100.00

Higher Heating Value, Btu/lb 12,600

TABLE 4

UTAH COAL
TOSCOAL PROCESS
CAPITAL COST ESTIMATE

	$M
Installed Plant Cost	
Process Units and Offsites	$274,800
Plant Indirects	
Process License Fees	
Initial Catalysts & Chemicals	
Spare Parts	
Owners Expense (1)	
Total Plant Indirects	49,600
Total Installed Plant & Indirects	$324,400
Project Contingency (2)	48,600
Total Plant Cost	$373,000
Working Capital (3)	27,000
Total Capital Requirement	$400,000

(1) Owner's expense includes permits, fees, construction expenses, taxes, insurance, startup and fixit.
(2) Project contingency @ 15% of installed plant cost and indirects.
(3) Working capital @ 30 days operating costs including allowance for accounts receivables.

TABLE 5

TOSCOAL PROCESS
UTAH COAL
ANNUAL OPERATING COST ESTIMATE
(Stream Factor 90%)

		$M/Yr.
DIRECT LABOR AND OVERHEAD		
Operating Labor (1)		$ 2,900
Operating Labor Supervision (2)		600
Maintenance Labor (3)		5,700
Maintenance Supervision (4)		1,300
Administration and General Overhead (5)		7,300
	Subtotal	$ 17,800
SUPPLIES		
Catalysts & Chemicals (6)		3,400
Operating Supplies (7)		900
Maintenance Supplies (8)		3,800
	Subtotal	$ 8,100
RAW MATERIALS		
Coal (9)		$143,000
Water (10)		600
Electric Power		6,000
	Subtotal	$149,600
FIXED COSTS		
Taxes and Insurance (11)		$ 8,500
	TOTAL	$184,000

(1) Operating labor 120 men.
(2) Operating labor supervision @ 22% operating labor.
(3) Maintenance labor @ 1.8% total plant investment.
(4) Maintenance supervision @ 22% maintenance labor.
(5) Administration and general overhead @ 70% total labor (27% payroll burden and 43% overhead).
(6) Annual catalyst usage @ 90% stream factor.
(7) Operating supplies @ 30% operating labor.
(8) Maintenance supplies @ 1.2% total plant investment.
(9) Coal @ 0.85/MMBtu.
(10) Raw water @ 0.50/M Gals.
(11) Taxes and insurance 2.7% total plant investment.

TABLE 6

UTAH COAL
BASIS OF ECONOMIC ANALYSIS
BASE: 1981 1st QUARTER

I MATERIALS	
Fresh Water Makeup	$0.50/Mgal
Utah Coal	$0.85/MMBtu
Operating Supplies	30% of operating labor
Maintenance Supplies	1.2% of plant investment
II BY PRODUCT CREDITS	
Sulfur	$25.00/Long Ton
III LABOR COSTS	
Operating Labor	$24,100/man-year
Operating Labor Supervision	22% operating labor
Maintenance Labor	1.8% of plant investment(1)
Maintenance Supervision	22% of maintenance labor
Administration & General Overhead	70% of total labor
IV CAPITAL RELATED COSTS	
Insurance and Taxes	2.7% of plant investment(1)
Project Contingency	15% of plant installed cost
Project Life	20 years
Operating Factor	(90%) 329 Days/Year
Federal Taxes	46%
State Taxes	6.0%
Working Capital	1 month operating expense plus allowance for accounts receivables
Investment Tax Credit	10% applied in 1st year of operation
Owner's Equity	100%
Depreciation	13 years
Year 1 double declining balance	
Year 2 - 13 sum of years digits	
Construction period	3 years

Capital Spending During Construction

Quarter	Percent Expended	Cumulative Percent
1	2	2
2	2	4
3	3	7
4	3	10
5	5	15
6	8	23
7	9	32
8	15	47
9	18	65
10	16	81
11	10	91
12	9	100

(1) Plant investment includes project contingency.

TABLE 7

UTAH COAL
DISCOUNTED CASH FLOW RATE OF RETURN ANALYSIS

CHAR VALUE $/MM Btu	Percent of Coal Value	Case 1 Zero Escalation	Case 2 10% Escalation	Case 3 12% Oil Escalation
0.85	100%	22.6	32.5	36.0
0.43	50%	17.8	27.3	31.8
0.0	0%	11.9	20.4	27.0

Plant Capacity:	21,700 BBL/SD
Capital Investment:	$400 MM
Owner's Equity:	100%
Base:	1st Quarter 1981
Oil Value:	$36./BBl
Resid Value:	"Same as Char"
Coal Cost:	$0.85/MM Btu

TABLE 8

UTAH COAL
DISCOUNTED CASH FLOW RATE OF RETURN ANALYSIS

SYNCRUDE VALUE $/BBL	Case 1 Zero Escalation	Case 2 10% Escalation	Case 3 12% Oil Escalation
32.00	19.8	29.4	33.1
36.00	22.6	32.5	36.0
40.00	25.2	35.3	38.7

Plant Capacity:	21,700 BBL/SD
Capital Investment:	$400 MM
Owner's Equity:	100%
Base:	1st Quarter 1981
Char Value:	$0.85/MM Btu
Resid Value:	$0.85/MM Btu
Coal Cost:	$0.85/MM Btu

TABLE 9

UTILITY ECONOMICS BASIS
BASE: 1981 1st QUARTER

FINANCING STRUCTURE		
Owner's Equity, %:	50	
Debt Portion, %:	50	
COST OF CAPITAL		
Inflation Rate:	10.0%	0%
Owner's Equity, %:	16.0	6.0
Debt Portion, %:	14.0	4.0
ECONOMIC PARAMETERS		
Project Life, years:	25	
Tax Life, years:	22	
Depreciation method:	sum of years digits	
Deferred taxes:	(1)	
COSTS		
Power Plant Installed Costs, $/KW:	1100.	
Power Plant Fuel Costs, $/MMBtu:	0.85	
Power Plant O&M Costs, Mils/KWH:	2.7	
Power Plant Operating Factor, %:	75	
Toscoal Plant Installed Costs, $/MM:	373.	
Toscoal Plant Fuel Costs, $/MMBtu:	0.85	
Toscoal Plant O&M Costs, $MM:	41.0	
Toscoal Plant Operating Factor, %:	90.	
Preconstruction Costs, $M:	0.0	
Land, $MM:	0.0	
Start-up Costs:	(2)	
Working Capital:	(3)	
Interest during construction:	(4)	

(1) Computed on difference between tax depreciation and book depreciation.
(2) Included in capital investment.
(3) Working capital 14% of operating costs.
(4) Capitalized.

TABLE 10

UTILITY ECONOMICS

A. NON ESCALATED COST OF POWER (1981 $)

	Steam Electric Power Plant Mils/KWH		Steam Electric Power Plant w/TOSCOAL Mils/KWH	
	Levelized	1st Year(5)	Levelized	1st Year(5)
Fuel	8.5	8.5	12.9	12.9
O & M	4.4	7.2	6.4	10.5
Capital (3)	9.6	15.2	11.6	18.3
Taxes (4)	3.1	4.8	3.7	5.9
Subtotal	25.6	35.7	34.6	47.6
By-Product Credits:				
Syncrude	-	-	-	-
COST OF POWER	25.6	35.7	15.1	23.9
B. ESCALATED COST OF POWER (1)				
Fuel	15.4	12.4	23.2	18.9
O & M	12.0	10.6	17.5	15.4
Capital (3)	18.4	41.5	22.2	50.2
Taxes (4)	8.8	16.8	10.6	20.3
Subtotal	54.6	81.3	73.5	104.8
By-Product Credits:				
Syncrude	-	-	53.2	37.3
ESCALATED COST OF POWER	54.6	81.3	20.3	67.5
C. ESCALATED COST OF POWER (2)				
Fuel	15.4	12.4	23.2	18.9
O & M	12.0	10.6	17.5	15.4
Capital (3)	13.4	41.5	22.2	50.2
Taxes (4)	8.8	16.8	10.6	20.3
Subtotal	54.6	81.3	73.5	104.8
By-Product Credits:				
Syncrude	-	-	41.2	34.7
ESCALATED COST OF POWER	54.6	81.3	32.3	70.1

(1) 10% inflation on all costs excluding Syncrude, 12% inflation on Syncrude products.
(2) 10% inflation on all costs including Syncrude.
(3) Capital charges include depreciation, interest expense and return on owners equity.
(4) Federal and state income taxes.
(5) 1st year of operation, $1984.

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