TECHNOLOGY ASSESSMENT GUIDE
NO. 7
FISCHER-TROPSCH INDIRECT LIQUEFACTION

CHAPTER ONE: EXECUTIVE SUMMARY

1.1 OVERALL PROSPECTS FOR THE TECHNOLOGY

The Fischer-Tropsch technology for the production of liquid fuel products through coal gasification and catalytic gaseous reforming has been in existence since the early 1920's. It was used by Germany during World War II as a means of using domestic coal supplies to provide transportation fuels which previously had been petroleum based and were no longer available due to wartime hostilities. A shortage of domestic petroleum combined with a political trade embargo against South Africa was the incentive for its commercial application near Johannesburg in 1955, and continuing to the present.

Although the Fischer-Tropsch technology provides great potential for product yield flexibility based upon catalyst selection, reactor design, and operating conditions, it is ironically this reason which may limit its applications in countries not faced by politically induced shortages of petroleum. The primary incentive for implementing this technology in the United States would be for the production of gasoline and diesel fuels. The wide diversity of products obtained from a Fischer-Tropsch plant would include these two fuels, but they would be accompanied by large quantities of highly oxygenated chemicals and light hydrocarbons. Over half of the energy output of the facility would be C_4 and lighter hydrocarbons, mostly SNG. The capital investment required for such a facility requires a strong market for all of the plant products. Future deregulation of energy markets in the United States may provide conditions conducive to implementation of Fischer-Tropsch technology in this country.

1.2 ENGINEERING ASPECTS

The commercial plant described in Chapter Two is similar in design to many coal gasification plants. The Fischer-Tropsch technology comes into play following purification of the synthesis gas. The clean gas is catalytically reformed to produce a raw product stream which is then processed in several operations to separate the wide diversity of products including SNG, C_4's, naphthas, alcohols, diesel and fuel oils, and sulfur. By-product electricity is also produced. An overall process efficiency of approximately 71 percent is achieved in this design, which is somewhat higher than previous design studies employing Fischer-Tropsch technology. Extensive use of heat transfer equipment in the gas cooling step made possible the generation of large amounts of steam. This internally recovered energy is used to generate power and satisfy process heating requirements. Additional improvements in process efficiency may be made by developing a slag quench heat recovery system.

Other improvements which should be considered involve simplification of the gas cleaning system using advanced ionization particulate collection technology, and advanced catalyst application procedures.

1.3 CURRENT COSTS

The total capital requirement for this 125×10^{12} Btu/year plant is \$2.91 billion, which is dominated by a capital investment of \$1.96 billion. Interest during construction, working capital and start-up costs make up the additional \$952 million.

Annual operating and maintenance (at a 90% plant capacity factor) costs, exclusive of coal costs total \$127 million, and are largely comprised of maintenance supplies, insurance and local taxes. Sulfur and electricity are given by-product credits of $40/ton and 3.5¢/kWh respectively, giving a net operating and maintenance cost of $117 million.

Taken together with a 20 percent capital charge, these operating costs result in a product cost of $6.22/million Btu, which is exclusive of coal costs.

1.4 RESEARCH AND DEVELOPMENT DIRECTIONS

Although the Fischer-Tropsch process has been commercial for many years, technology improvements within the field of chemical engineering should be continuously reviewed for applications to Fischer-Tropsch processing. Changes in the liquid and gaseous fuels markets may also directly impact aspects of the process, possibly requiring R&D activities. Process improvements which currently could be made include:

- Development of a slag quench heat recovery system.
- Operation of the Fischer-Tropsch reactor at higher pressures, reducing equipment sizes.
- Employment of ionization particulate collectors.
- Improvement in catalyst application procedures.

CHAPTER TWO: ENGINEERING SPECIFICATIONS

2.1 GENERAL DESCRIPTION OF THE TECHNOLOGY

In the Fischer-Tropsch indirect liquefaction process, coal is reacted in a pressurized gasifier to produce a medium-Btu synthesis gas, which is cooled and passed through cyclones and precipitators to remove particulates. Hydrogen content of the synthesis gas is increased by shift conversion and H_2S and CO_2 are removed by an acid gas removal system. The cleaned gas stream enters a pressurized Fischer-Tropsch synthesis vessel, in which catalyst applied to internal coils and walls induces the production of straight-chain paraffin and olefin hydrocarbons. These products are refined to produce a variety of liquid and gaseous products - including LPG, naphthas, diesel fuel, fuel oil, and high-Btu SNG.

The Fischer-Tropsch technology was originally developed in Germany in the 1920's and has been used commercially in South Africa since 1955. The particular process analyzed below is based on one specific utilization of Fischer-Tropsch technology. However, it is important to realize that the Fischer-Tropsch process provides great potential for product yield flexibility based on catalyst selection, reactor design, and operating conditions.

2.2 PROCESS FLOW, ENERGY, AND MATERIAL BALANCES

Plant area numbers designating process units which are integral to the Fischer-Tropsch system are listed in Table 2-1. The interaction of these units is illustrated by the conceptualized process flow diagram given in Figure 2-1. In Table 2-2, a detailed analysis of the composition and flow rates of process streams shown in Figure 2-1 is presented. Processing of these flow streams throughout the system is described in detail below.

Run-of-mine coal from a captive source is delivered to a coal preparation area for separation and disposal of inerts. These crushing, sizing, and beneficiation processes are accomplished by a series of breakers, cyclones, centrifuges, and jigs. The cleaned coal is then conveyed to a stockpile area. From storage the coal feed is delivered to grinders which produce suitably sized gasifier feed (minus 20 mesh by 0). Heat from process steam is used to reduce the ground coal's moisture content from 8 percent to 2.7 percent.

The sized, dried coal feed is reacted with steam (the hydrogen source for the process) and captively-produced oxygen in a two-stage slagging entrained-bed gasifier, which is operated at a pressure of approximately 470 psig. Coal ash becomes molten in the high-temperature regions of the gasifier. The slag thus produced is collected at the bottom of the gasifier and is quenched with water. The resulting slag/water slurry is conveyed to a disposal area.

Raw synthesis gas with entrained char leaves the gasification unit at 1700°F and is sent to a gas cooling unit. A particulate removal system recovers the char from the gas stream and recycles it to the gasifier to provide heat. At this point in the process, the "clean" syngas is composed of approximately 41 percent carbon monoxide and 35 percent hydrogen by volume. To adjust the H_2:CO ratio prior to Fischer-Tropsch synthesis, a portion of the gas stream is delivered to a shift conversion unit where the water-gas shift reaction takes place:

$$CO + H_2O \longrightarrow CO_2 + H_2.$$

Remaining particulates in the gas stream are removed by a gas cleaning unit, which also cools the gas to 110°F. Steam generated by this unit is used for plant power generation while scrubber wastewater is sent to a treatment plant.

The dust-free syngas which leaves the gas cleaning unit contains sulfur-bearing compounds such as H_2S, COS, and SO_2. These gases, as well as CO_2, are removed by solvent absorption in an acid gas removal unit and are delivered to a sulfur recovery unit. Elemental sulfur is recovered and tail gases are treated to produce a clean vent gas. The essentially sulfur-free syngas, composed primarily of hydrogen (56.5% $^v/_v$) and carbon monoxide (39.0% $^v/_v$), enters the Fischer-Tropsch synthesis reactor at approximately 400 psig. Iron-based catalyst applied to the interior of the reactor vessel induces the following exothermic reaction:

$$(3n+1)\ H_2 + 3nCO \rightleftarrows C_nH_{2n+2} + C_nH_{2n} + nCO_2 + nH_2O.$$

Steam produced by the synthesis is recovered for use in plant reactors in which it is required.

The principal products of the Fischer-Tropsch synthesis are straight-chain paraffin and olefin hydrocarbons. Trace amounts of cyclic compounds and diolefins are also formed. Primary Fischer-Tropsch synthesis products are conveyed to a fractionation and separation unit, which recovers liquid products consisting primarily of LPG, naphthas, premium fuel oil, and diesel fuel. A stream of gaseous products consisting of CO, CO_2, H_2, and CH_4 with a heating value of approximately 500 Btu/scf is sent to a methanation unit, in which the reaction

$$CO + 3H_2 \xrightarrow{\qquad\qquad} Ch_4 + H_2O$$

converts the gas to a high-Btu (~1000 Btu/scf) SNG product.

The Fischer-Tropsch synthesis also produces an alcohol solution stream, which is converted by a chemical product upgrading unit to a more pure and marketable stream of alcohol products.

An overall Fischer-Tropsch plant material and energy analysis is shown in Table 2-3. A total coal input of 43,000 tons per day would be required to produce 125 x 10^{12} Btu/year of liquid and gaseous fuel products. The relatively high overall plant efficiency indicated by Table 2-3 (~70%) is indicative of the extensive use of waste heat for process plant power generation in the particular design.

Table 2-1

Relevant Fischer-Tropsch Plant Area Numbers

100	COAL STORAGE AND HANDLING
	110 Coal Storage
200	COAL PREPARATION
	210 Coal Grinding and Crushing 230 Coal Beneficiation 240 Coal Drying 250 Coal Sizing
300	GASIFICATION
	310 Gasification 320 Slag Quench
400	HYDROGENATION
	410 Reaction (Fischer-Tropsch Synthesis)
500	PRODUCT SEPARATION
1000	CHEMICAL PRODUCTS RECOVERY
1200	RAW GAS COOLING
	1210 Particulate Removal 1220 Quenching and Cooling
1300	GAS CLEANING
	1310 Acid Gas Removal
1400	SULFUR RECOVERY AND TAIL GAS TREATING
	1410 Sulfur Recovery 1420 Tail Gas Treatment
1700	SHIFT CONVERSION
1800	METHANATION
2000	UTILITIES AND SUPPORT SYSTEMS
	2010 Power Recovery 2020 Wastewater Treatment
2100	OFFSITES AND MISCELLANEOUS

F' 2-1

Fischer - Tropsch Conceptualized Process Flow Diagram

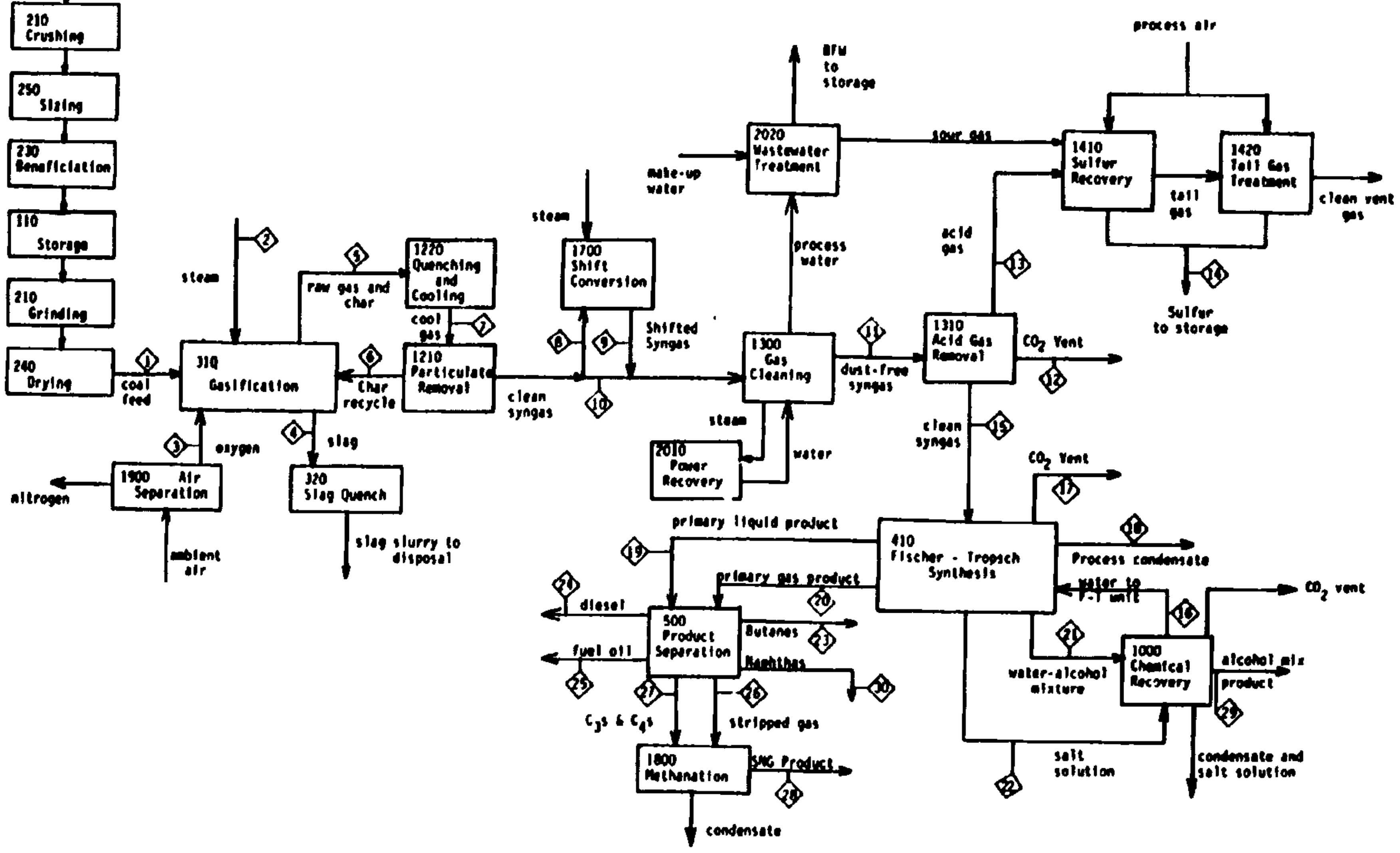


Table 2-2

Fischer-Tropsch Detailed Process Streams

Page 1 of 4

Stream	1		2		3		4		5		6		7		8		9	
Description	Coal Feed		Steam		Oxygen		Slag		Raw Gas & Char		Char Recycle		Cooled Raw Gas		Clean Syngas to Shift		Shifted Syngas	
Temperature, °F	200		1050		650		3000		1700		950		950		650		650	
Pressure, PSIG			470		470				468		470		467		452		451	
Flow	klb/hr	% wt	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %
H_2									129.200	34.8			129.200	34.8	39.692	34.0	76.638	46.6
CO									2122.424	40.9			2122.424	40.9	651.582	40.9	134.335	5.0
CO_2									780.830	9.6			780.830	9.6	239.752	9.6	1052.510	29.1
CH_4									52.756	1.8			52.756	1.8	16.203	1.8	16.203	1.2
H_2S									58.200	0.9			58.200	0.9	17.848	0.9	17.848	0.6
N_2					18.941	2.0			36.391	0.7			36.391	0.7	11.164	0.7	11.164	0.5
O_2					1060.946	98.0												
H_2O			951.333	100					377.154	11.3			377.154	11.3	115.854	11.3	238.072	16.1
NH_3									0.429	0.01			0.429	0.01	0.138	0.01	0.138	0.01
COS									2.153	0.02			2.153	0.02	0.638	0.02	0.638	0.02
SO_2									0.255	0.002			0.255	0.002	0.085	0.002	0.085	0.002
Ash							132.461	100										
Char									11.908		11.693	100	11.909		0.066		0.066	
Coal	1661.25	100																
Total	1661.25		951.333		1079.887		132.461		3571.702		11.693		3571.702		1093.020		1547.695	

Table 2-2

Page 2 of 4

Fischer-Tropsch Detailed Process Streams (cont'd)

Stream	10		11		12		13		14		15		16		17	
Description	Shift Bypass		Dust-Free Syngas		CO_2 Vent		Acid Gas		Sulfur to Storage		Clean Syngas		Water to F-T Unit		CO_2 Vent	
Temperature, °F	650		110		90		100				97		110		105	
Pressure, PSIG	452		438		1		30				406				1	
Flow	klb/hr	mole %	klb/hr	mole %	klb/hr	ppmV	klb/hr	mole %	klb/hr		klb/hr	mole %	klb/hr	mole %	klb/hr	mole %
H_2	89.590	34.8	164.237	45.3	0.027	455					164.237	56.5				
CO	1470.697	40.9	1605.177	31.2	0.164	200					1605.177	39.0				
CO_2	541.148	9.6	1593.580	19.7	1271.093	98.951%	259.341	75.4			64.733	1.0			806.481	93.9
CH_4	36.572	1.8	52.756	1.8	0.744	1593					54.864	2.2				
H_2S	40.285	0.9	57.341	0.9	~0	5	57.341	21.6								
N_2	25.198	0.7	36.393	0.7			0.856	0.4			36.393	0.9				
O_2																
H_2O	281.496	11.3	11.961	0.4	4.426	8423	3.038	2.2			10.861	0.4	115.667		21.264	6.1
NH_3	0.307	0.01														
COS	1.440	0.02	2.153	0.02			0.040	0.5								
SO_2	0.192	0.002	0.255	0.002			0.255	0.01								
Ash																
Char	0.149															
Coal																
Total	2467.074		3525.861		1276.454		320.871		56.150		1938.265		115.667		827.745	

Page 3 of 4

Table 2-2

Fischer-Tropsch Detailed Process Streams (cont'd)

Stream	18		19		20		21		22		23		24		25		26	
Description	Condensate		Primary F-T Gas Product		Primary F-T Liquid Product		H_2O, OH		Salt Solution		LPG (Butanes)		Diesel		Fuel Oil		Stripped F-T Gas	
Temperature, °F	110		110		110		110		194		120		120		140		90	
Pressure, PSIG																		
Flow	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %
H_2			43.968	54.8	0.055	1.3											44.079	57.3
CO			180.744	16.2	0.665	1.0											101.409	17.0
CO_2			15.284	0.9	0.55	0.1											13.955	0.8
N_2			36.326	3.3	0.111	0.2											36.437	3.4
H_2O	278.285	98.7	2.990	0.4			101.884	94.0	194.582	98.1								
C_1			110.861	17.4	0.886	2.4											111.304	18.2
C_{2-}			7.199	0.6	0.222	0.3											6.645	0.6
C_2			28.574	2.4	0.997	1.4											25.036	2.2
C_{3-}			4.541	0.3	0.443	0.4											2.104	0.1
C_3			15.616	0.9	1.661	1.6											5.870	0.4
C_{4-}			11.629	0.5	3.212	2.4					3.101	16.4					0.111	0.003
C_4			33.668	1.5	10.632	7.8					15.948	82.4					0.111	0.003
C_{5-}			2.658	0.1	2.215	1.3					0.111	0.4						
C_5			11.407	0.4	10.743	6.3					0.222	0.8					0.222	0.02
Light Naphtha			10.521	0.3	29.903	14.7											0.886	0.03
Heavy Naphtha			5.205	0.1	61.023	24.1							3.323	4.2			0.222	0.007
Diesel			0.775	0.01	122.157	31.3							113.851	95.4	4.541	15.3		
Fuel Oil					36.769	3.5							1.108	0.4	35.551	84.7		
Alcohols	5.502	0.8					17.726	6.0	5.646	1.1								
Acids	4.168	0.3							4.059	0.4								
Caustic	1.701	0.3							4.508	0.4								
Total	289.656		521.966		281.749		119.610		208.795		19.382		118.282		40.092		428.391	

Table 2-2

Fischer-Tropsch Detailed Process Streams

Stream	27		28		29		30	
Description	C_3 & C_4		SNG Product		Alcohol Mix Product		Naphthas	
Temperature, °F	120		120				115	
Pressure, PSIG			1000					
Flow	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %	klb/hr	mole %
H_2			0.443	1.0				
CO			0.554	0.1				
CO_2	1.040	2.5	11.740	1.4				
N_2			38.437	6.9				
H_2O					1.551	86.4		
C_1	0.443	2.2	256.719	83.0				
C_2=	0.665	2.0						
C_2	4.652	12.2	8.929	1.5				
C_3=	2.000	5.4						
C_3	11.297	20.5	15.173	1.8				
C_4=	11.780	18.6						
C_4	27.909	38.4	40.092	3.6			0.332	0.5
C_5=	0.111	0.1					4.762	4.6
C_5			0.111	0.01			21.202	20.2
Light Naphtha							39.539	31.4
Heavy Naphtha							62.694	40.3
Diesel							4.541	2.5
Fuel Oil								
Alcohols					29.792	13.6		
Acids								
Caustic								
Total	41.137		369.797		31.343		133.564	

Table 2-3

Overall Material and Energy Balances

Input	Mass Flow Rate klb/day	Gross Heating Value MMM Btu/day
Coal to plant	39870	500[1]
Steam	22832	
Oxygen	25917	—
Total Inputs	88619	500
Products		
SNG	8875	180.4
Butanes	465	9.8
Naphthas	3206	66.1
Alcohol mix product	752	9.4
Diesel Fuel	2838	57.5
Fuel Oil	962	19.1
Sulfur	1348	5.4
Electrical Power	—	7.6
Total Products	18446	355.3

Overall Process Efficiency = $\frac{355}{500}$ = 71%

[1] Based on coal composition shown in Table 2-4

2.3 PLANT SITING AND SIZING ISSUES AND CONSTRAINTS

The Fischer-Tropsch complex assessed in this study is designed to produce the equivalent of 125 x 10^{12} Btu/year of synthetic gaseous and liquid fuel products. The plant area includes a captive coal mine and coal preparation equipment, as well as the gasification and liquefaction equipment integral to the process. In addition, on-site facilities for oxygen production as well as for solid, liquid, and gaseous effluent treatment would be required. The resources of the area must be capable of supplying approximately 10 million tons of coal per year and approximately 17 million tons of water per year for an estimated plant operating lifetime of 20 years. While the majority of the water would be process water obtained from a river, a well-derived potable supply would be necessary. The onsite oxygen production plant must be capable of separating approximately 1.1 million pounds per hour of 98 percent pure O_2 from ambient air. The land area required for the facilities would include several hundred acres for the plant itself (500 acres are necessary for a plant of roughly twice the capacity) and up to 40 square miles for mining of the required coal.

2.4 RAW MATERIAL AND SUPPORT SYSTEM REQUIREMENTS

2.4.1 Coal Quantities and Quality

The coal assumed for use in this plant design would be mined from the Eastern region of the U.S. Interior Coal Province. Approximately 75 percent of the run-of-mine coal is actually delivered as cleaned, sized gasifier feed. Hence, about 10 million tons per year of coal would be required from the mine. Proximate and ultimate analyses of the coal are shown in Table 2-4.

2.4.2 Catalysts and Other Required Materials

Composition and estimated quantities of catalysts and other required chemicals are listed in Table 2-5. The primary reaction catalysts for the shift conversion and Fischer-Tropsch reactors are cobalt molybdenum oxides and magnetite respectively. Reactions in the methanation unit are facilitated by a metallic nickel catalyst.

2.4.3 Water Requirements

The plant will require approximately 46,300 tons per day of raw river water for processing and 200 tons per day of well water for potable use. The river water is purified and filtered for use as cooling water and is deionized for boiler water makeup. A mine-based pond supplies water required for coal sizing and handling.

Table 2-4

Coal Composition

Proximate Analysis (composition weight percent):

Item	%
Moisture	2.7
Ash	7.1
Volatile Matter	38.5
Fixed Carbon	51.7
	100.0
Heating Value	12,550 Btu/lb

Ultimate Analysis (Composition weight percent):

Item	%
Carbon	70.7
Hydrogen	4.7
Nitrogen	1.1
Sulfur	3.4
Oxygen	10.3
Moisture	2.7
Ash	7.1
	100.0

Source: Reference 2-1

Table 2-5

Process Plant Catalyst and Chemical Requirements

Facility	Chemical or Catalyst	Initial Charge (tons)	Consumption (tons per year)
Acid Gas Removal	Physical Solvent	997	160
Shift Conversion	Cobalt/Molybdenum Metal Oxides (CoO/MoO_3 = 0.3:1)	232	77
	Hydrogen (100%)	7974 Mscf	3987 Mscf
Fischer-Tropsch Synthesis	Magnetite (Fe_3O_4)	648	648
	Zinc Oxide/Co-Mo Hydrogenation Catalyst	58	58
	Potassium Carbonate	2.1	5.1
	Hot Carbonate Solution		
	Sodium Carbonate	0	9489
	Hydrogen (100%)	10632 Mscf	10632 Mscf
Methanation	Raney Nickel (42% Ni)	546	546
	Ni Hydrogenation Catalyst (40% Ni)	58	19
	Co/Mo Hydrogenation	49	17
	Caustic (100% NaOH)	328	272
	Tri-ethylene Glycol (100%)	9	29

Table 2-5 (cont'd)

Process Plant Catalyst and Chemical Requirements

Facility	Chemical or Catalyst	Initial Charge (tons)	Consumption (tons per year)
Liquid Product Refinement	Ethylene Glycol	66	33
	Refrigerant	86	

Supporting Unit Chemicals

Unit	Chemical	Consumption (Tons per year)
Cooling Water System	H_2SO_4	425
Raw Water System		
o Demineralizer	H_2SO_4	1389
	NaOH	1110
o Clarifier	Lime	1223
	Aluminate	332
	Polyphosphate	20
o Boiler Feed Water	Chelant	5
	Hydrazine	5

Source: Reference 2-1

2.5 EFFECT OF COAL TYPE

Both the liquid and gaseous products of the Fischer-Tropsch process are derived from synthesis gas produced by a gasification unit. Since downstream units adjust this gas to produce the desired product spectrum, the effect of coal type on overall operation will be evident in the function of these units as well as in that of the gasifier. By design, entrained bed gasifiers are capable of accepting a wide range. of coal types. Thus, variations in important feedstock properties - such as caking behavior - would not pose serious problems in the gasification section.

Since the chemical composition of the coal determines CO, CO_2, and H_2 proportions in the synthesis gas, operating conditions in the shift conversion unit may require adjustment to account for variations in coal composition. Given the proper mixture of reactant gases, the Fischer-Tropsch and methanation units can operate without adjustment.

Another potential effect of a variation of coal type would result from properties of the ash in the coal feedstock. Variations in ash formation and slagging characteristics of the ash may restrict flow of slag in the gasifier - possibly requiring the addition of fluxing agents. Other coal properties, such as moisture and energy content and grindability, may influence feed rate requirements of coal and steam as well as equipment sizing but will not radically alter overall plant operation.

2.6 AIR POLLUTION CONTROL TECHNOLOGY

2.6.1 Ability of Existing Technology to Meet Regulations

Although no source emission standards exist for coal conversion plants in particular, the Fischer-Tropsch plant discussed herein meets regulations established for utility and petrochemical plants (including 1979 NSPS regulations).

Fugitive particulate emissions from coal sizing and handling operations are controlled by water sprays when not in a closed environment. The only source of particulate emissions from the plant is the coal drying and grinding unit, in which a baghouse system controls the emissions quantities to the order of 0.01 lb/MMBtu. Char carried out of the gasifier with synthesis gas is collected in cyclones and precipitators and recycled to the gasifier.

Sulfur is recovered in a series of steps throughout the process. A sulfur guard prior to the shift conversion unit converts H_2S to metal sulfides, which are removed semi-annually by a purging stream of air and steam. The sulfur is oxidized to SO_2 and vented to the atmosphere at a worst-case 30-day average rate of approximately 0.04 lb/MMBtu. Synthesis gas containing the remaining H_2S is sent to the acid gas removal unit, which utilizes a physical solvent to remove hydrogen sulfide (and a small amount of hydrogen cyanide). The sulfur-bearing compounds are conveyed to the sulfur recovery plant where they are converted to high-purity elemental sulfur.

Other gaseous effluent amounts released include carbon dioxide (28,340 TPD); carbon monoxide (7 TPD); carbon oxysulfide (0.9 TPD); C_2-C_6 hydrocarbons (0.7 TPD); and hydrogen sulfide which is vented from the tail gas treatment unit (173 lbs/day).

2.6.2 Impacts on Process Efficiency

Since the presence of sulfur inhibits the effectiveness of Fischer-Tropsch catalysts, its removal is vital for successful plant performance. Thus, gas desulfurization is an essential element of high overall process efficiency.

Removal of particulates from the synthesis gas stream involves the recycle of char to the gasifier for heat production. This process is also essential for efficient plant operation. Fugitive dust generated by the coal grinding and drying unit is contained in a baghouse in a manner which does not seriously hamper performance of the overall plant.

2.7 WATER POLLUTION CONTROL TECHNOLOGY

2.7.1 Ability of Existing Technology to Meet Regulations

Although no aqueous effluent standards relating specifically to coal conversion plants have been set, such pollutants emitted by the Fischer-Tropsch plant are within those established for similar facilities, such as petroleum refineries. Aqueous effluents of the Fischer-Tropsch plant are compared with these standards in Table 2-6.

2.7.2 Water Recycling Systems

Sources of aqueous contaminants as well as the treatment and disposition of wastewater streams are illustrated in Figure 2-2, and are described below. One of the major contaminated streams is generated by wet scrubbers which clean the products of the gasifier. Oily materials are removed by extraction and most of the gaseous contaminants (H_2S and NH_3) removed by a reboiler-stripper. Remaining organics in the stream are oxidized to gases which are conveyed back to the gasifier. The effluent stream from the oxidizer is treated by settlement, filtration, and deionization and is reused as boiler feedwater makeup.

Treatment of the Fischer-Tropsch reactor product stream with caustic chemicals produces a waste stream containing alkaline salts of organic acids. This stream is combined with waste products from the sour water settler and the boiler blowdown system and is conveyed to an evaporator. Condensate thus produced is used as boiler feedwater, while the residue is sprayed on the feed coal to be dried further and oxidized in the gasifier.

Table 2-6

Comparison of Aqueous Effluents With Federal Petroleum Refinery Standards[a]

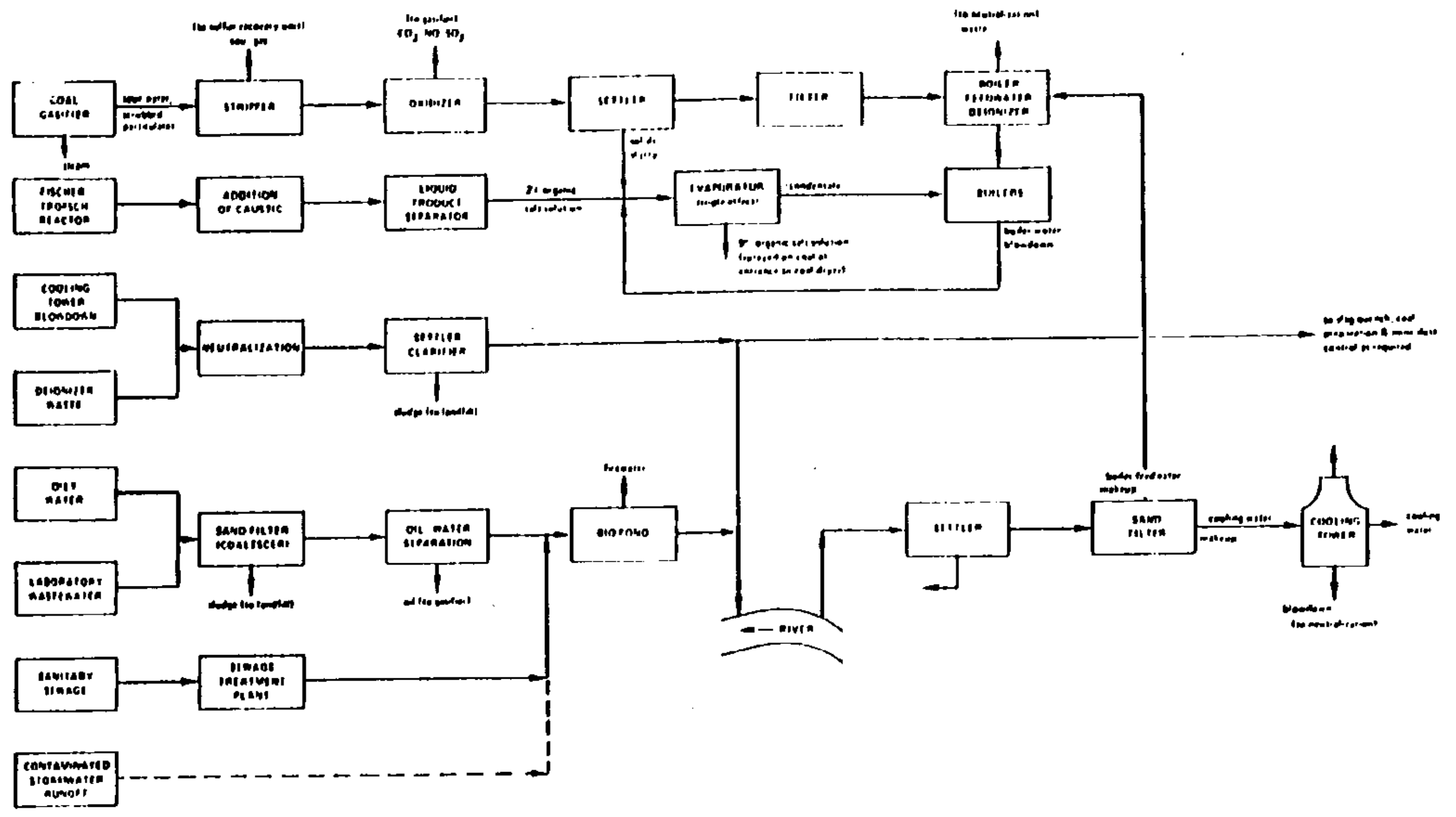
Parameter	Federal Standards, Petroleum Refinery	Aqueous Effluents, Fischer-Tropsch Plant (mg/ℓ)
BOD 5	15	10
COD	100	100
Total Organic Carbon	33	33
Suspended Solids	10	10
Oil and Grease	5	5
Phenol	0.1	nil
Ammonia-N	80% removal	nil
Sulfide	0.1	nil
Cr. tertiary	0.25	nil
Cr. hexavalent	0.005	nil

[a] Average attainable concentrations from the application of best practicable control technology currently available (EPA-440/1-74-014a).

Source: Reference 2-1

Figure 2-2

Wastewater Treatment System Detail



Source: Reference 2-1

A large quantity of cooling tower blowdown water is contaminated by corrosion inhibitors and scale control agents. However, these compounds are easily removed by neutralization and lime treatment. The treated stream is returned to the river.

Water streams contaminated with oil and laboratory wastes are treated by sand filtration and physical separation. The remaining aqueous effluent is sent to a biopond, where bacterial agents convert organic waste to inorganic matter. Pond overflow is conveyed to the river, with the remaining water used for fire control.

2.7.3 Impacts on Plant Efficiency

Treatment of wastewater (generated primarily by gas cleaning operations) is necessary in order to remove solids, chlorides, and organic material. Much of the treated stream is fed back to the gas cleaning unit or used for heat transfer purposes throughout the plant. The treatment unit requires power and steam from the plant for the operation of pumps and reaction vessels. However, this processing facilitates the efficient use of river water by recycling most of it back to the plant.

2.8 SOLID WASTE HANDLING

2.8.1 Disposal Requirements

Solid waste is generated by the Fischer-Tropsch plant in the form of ash from the coal gasifier and as sludges from wastewater treatment units. In addition, solid wastes produced by mining and coal cleaning and sizing operations are used for land reclamation purposes at the mine site.

Ash from the gasification process is captured as molten slag at the bottom of the vessel and as flyash from the synthesis gas stream. In addition, unreacted carbon is collected in cyclones and precipitations and combusted in the gasifier to supply it with additional heat. The gasifier slag is quenched with water, broken up, and along with other collected ash, is buried with mine wastes or sold to construction materials companies for use as a concrete aggregate.

Sludge produced by treatment of oily water and laboratory wastes is combined with that generated by cooling tower water treatment units and disposed of in a landfill.

2.8.2 Leachate Problems

Leaching of trace metals from flyash or unslagged gasifier ash into ground or surface water has been found to occur in laboratory simulations. Slagged gasifier wastes may be less susceptible to such leaching although further study may be required.

Contamination of water supplies from leaching of zinc derived from cooling tower water treatment sludges would be a problem if this waste were buried with mine wastes. Therefore, as stated above, this sludge is disposed of in a landfill.

2.9 OSHA ISSUES

Handling and storage of coal will expose workers to coal dust and noise. Coal dust can cause black lung disease and must be controlled. The coal pile presents the risk of spontaneous combustion.

The end-products of the Fischer-Tropsch proce s are not known to be carcinogenic. In the scheme described in Section 2.1 above, there are no liquid by-products from the gasifier. In Fischer-Tropsch schemes using the Lurgi gasifier, coal tars and oils are produced. These tars and oils have carcinogenic properties and exposure to them must be limited.

2.10 PROCESS PERFORMANCE FACTORS

2.10.1 Product Characteristics and Marketabilities

The products of the Fischer-Tropsch process-SNG, butanes, naphthas, diesel fuel, fuel oil, and oxygenates are generally similar to petroleum products available in the U.S. The characteristics of these products are presented below.

- SNG: Synthetic gas generated by the Fischer-Tropsch synthesis is a high-Btu (1,035 Btu/scf) product composed of hydrocarbons, hydrogen, carbon monoxide, carbon dioxide, and nitrogen in the following quantities:[2-1]

Compound	Volume%
CH_4	83.8
C_2H_6, C_3H_8, C_4H_{10}	6.9
CO	0.1
H_2	1.0
CO_2	1.4
N_2	6.8

This product could be marketed for either industrial or residential use a gaseous fuel. In terms of meeting American Gas Association (AGA) standards for natural gas properties, Fischer-Tropsch SNG exhibits acceptable flashback and yellow tip indices but has a flame lifting index which is slightly higher than acceptable.[a]

- Butanes: This mixture of light (s.g.=0.6) liquid products is virtually free of sulfur and nitrogen and has a HHV of 21,000 Btu/lb. It is composed of various hydrocarbons in the following quantities:

---

[a] Higher hydrogen contents in SNG will bring the flame lifting index to an acceptable level.

Compound	Volume %
Butylene	15.8
Butane	82.6
Propane-propylene	0.1
Pentanes	1.6

The butane products could be marketed as a variety of products in the LPG field, blended into gasoline, or used as a feedstock for ethylene production. They fall within commercial butane standards established by the ASTM.

- Naphthas: This mixture of straight-chain monounsaturated and saturated hydrocarbons is free of sulfur and nitrogen, has a higher heating value (HHV) of approximately 20,600 Btu/lb, and a specific gravity of between 0.65 (light naphtha) and 0.70 (heavy naphtha). The primary value of this class of Fischer-Tropsch products would be as ethylene feedstock. Because of low aromatic content and octane numbers, these products would require complex additional processing in order to be used in gasoline manufacture.

- Diesel Fuel: The Fischer-Tropsch product is composed primarily of straight chain hydrocarbons and has a HHV of 20,250 Btu/lb. Its properties - particulary its cetane number of above 60 - qualify it as an acceptable diesel fuel. In addition it meets ASTM specifications for fuel oil and could be used in industrial or residential boilers.

- Fuel Oil: Fischer-Tropsch fuel oil is a waxy, sulfur-free liquid with a pour point of 150°F, specific gravity of 0.82, and a HHV of approximately 19,850 Btu/lb. It could be marketed as utility and industrial fuel oil as well as turbine fuel, as it meets ASTM specifications for these products.

- Oxygenates: This chemical product is composed primarily of alcohols as shown in the following analysis:

Compound	Volume % (dry basis)
Acetone	3.2
Methyl Ethyl Ketone	0.7
Methanol	6.0
Ethanol	67.6
Propanol	18.0
Butanol	2.4
Amyl Alcohol	1.1
Higher Alcohols and Oxygenates	1.0

With a moisture content of up to 5 percent and a HHV of approximately 13,000, this Fischer-Tropsch product would be sold to chemical processors for separation and refining to yield relatively pure alcohol products.

2.10.2 Capacity Factors, Flexibility Reliability

This Fischer-Tropsch plant is designed to operate with a 90 percent capacity factor (see Chapter 3) and to produce synthetic fuel products at approximately 70 percent overall thermal efficiency. Its design is based on prior experience gained from South African (SASOL) and German commercial plants as well as from American experimental efforts. Commercialization of this design as well as determination of flexibility and reliability of the overall plant will require development work on both the individual plant units and their overall compatibility.

2.11 TECHNOLOGY STATUS AND DEVELOPMENT POTENTIAL

2.11.1 Current Status

The Fischer-Tropsch technology is one of the most commercially advanced coal liquefaction processes. The technology was orginally developed in Germany in the 1920's and was used by that country to produce fuel during World War II. South African Coal, Oil, and Gas (SASOL) has operated a 6,600-TPD Fischer-Tropsch plant since 1955 and expects to place two more such facilities on line by 1984. The success of the technology has been such that South Africa is expected to be a net exporter of energy by the mid-1980's.

2.11.2 Key Technical Uncertainties

In order to maximize reliability and efficiency, several plant improvements and modifications must be studied. These developments include the following:

- A slag quench heat recovery system, which would recover slag heat as steam to increase overall process efficiency (slag disposal system modification design required)

- Simplification of the gas cleaning system using advanced "ionizer" particulate collection technology

- Advanced catalyst application procedures to simplify and reduce cost of plant operation

2.11.3 Availability for Commercial Production

The likelihood of commercial operation of a Fischer-Tropsch plant in the U.S. will depend on a number of factors involving both engineering and economic considerations. Although successful operation of a similar plant has been demonstrated by SASOL, design refinements such as the ones outlined in the above section need to be studied to improve overall process thermal efficiency. In addition, a coal liquefaction plant of the Fischer-Tropsch type requires a great deal of capital, and the synthetic fuels market climate must be favorable before such an investment would be made.

2.11.4 Unit Design and Construction Times

Estimated time required for design, procurement, construction, and startup of the complex will be approximately five years.

2.12 REGIONAL FACTORS INFLUENCING ECONOMICS

2.12.1 Resource Constraints

As outlined in Section 2.4 above, the Fischer-Tropsch plant would require 10 million tons of coal, 17 million tons of river water, and 110,000 lbs of potable well water per year. The resources would need to be consistently available for the duration of the plant's operating lifetime.

2.12.2 Environmental Control Constraints

Gaseous, aqueous, and solid effluents generated by the plant are described in Sections 2.6, 2.7, and 2.8 respectively. The regional regulations regarding the particular types and quantities of pollutants produced would depend on local meteorology, topography, and existing air and water quality.

2.12.3 Siting Constraints

The site selected for the complex must be located near the required coal and water resources. In addition, several hundred acres of relatively flat land area capable of safely supporting the required heavy equipment would be required for the actual plant.

References

2-1. Ralph M. Parsons Co., Fischer-Tropsch Complex Conceptual Design/Economic Analysis, January 1977, ERDA Report FE-1775-7.

SECTION THREE

ECONOMIC ANALYSIS

This section contains information on the non-fuel costs of the Fischer-Tropsch indirect coal liquefaction process. Section 3.1 explains the methodology used. Section 3.2 details capital costs for building a 125-trillion-Btu/year Fischer-Tropsch synthetic fuel plant. Section 3.3 compiles operating and maintenance costs for the plant. Section 3.4 assesses the effect of experience on plant capital costs. In Section 3.5 the average cost, excluding fuel, of the Fischer-Tropsch end-products is computed.

3.1 Methodology and Introduction

3.1.1 Economic Analysis Methodology

The economic analysis relies on a preliminary commercial design for a full-scale Fischer-Tropsch liquefaction plant (3-1). The economic information presented in the report was adjusted for inflation, contingencies were added and the data were scaled to a plant size of 125 trillion Btu/year. This size was judged to be typical for indirect liquefaction facilities. The adjusted data were assessed for their reliability and used to compute a cost per million Btu for the plant's end-products.

3.1.2 Scaling Factors

The costs of the Fischer-Tropsch plant described in reference 3-1 was scaled to 125 trillion Btu/year according to the formula:

$$\text{New Plant Costs} = \left(\frac{\text{New Plant Size}}{\text{Reference Plant Size}}\right)^{se} \times \begin{array}{l}\text{Reference}\\ \text{Plant Cost}\end{array}$$

where se is the cost scaling exponent.

A cost scaling exponent of 0.7 was used for plant capital costs and operating costs other than supplies, catalysts, and chemicals. This exponent was derived from ERCO experience with similar synthetic fuels projects. The other costs were scaled with an exponent of one. The scaling exponent of 0.7 implies that a doubling of plant size from the reference results in a 62 percent increase in costs. The 0.7 scaling exponent was based on the assumption that the two trains in the reference plant (3-1) would both be scaled down. In this case, the reference plant capacity, 166 trillion Btu/year, was scaled down to 125 trillion Btu/year, for a capital cost reduction of approximately 18 percent.

3.1.3 Price Indices

Costs for the reference plant were presented in 1975 dollars, which were corrected here to third quarter 1980 dollars. Since 1975, components of plant construction and operating costs have inflated at different rates. To ensure accuracy several different indices were used to inflate costs. 1980 market prices were used to compute by-product credits. The *Chemical Engineering* Plant Cost Index was chosen as the constructed equipment cost inflator (3-2). The *Chemical Engineering* Plant Cost Index is a weighted average of the equipment, construction and engineering costs incurred during the construction of chemical process plants.

TABLE 3-1

COST INDICES AND PRICES

ITEM	SOURCE OF INFLATOR OR PRICE	INFLATOR OR PRICE
Plant Capital Costs, Local Taxes and Insurance, Supplies	*Chemical Engineering* Plant Cost Index	1.60
Labor, Administration, and General Overhead	Bureau of Labor Statistics Index of Petroleum Refining Wages	1.59
Catalysts and Chemicals	Producer Price Index for Industrial Chemicals	1.58
By-Product Sulfur	Market Prices Adjusted for Market Size	$40/ long ton
By-Product Electricity	Market Prices	3.5¢/kWh

Because equipment costs were not presented independently of engineering and construction costs in the reference document, each element of construction costs could not be inflated separately. The Chemical Engineering Index, as a weighted average of all elements of the construction cost, is a valid substitute for inflating each element of plant costs separately. Electricity was assigned a value of 3.5 ¢/kWh and sulfur $40/long ton. Sulfur prices, at $40/long ton, are lower than actual 1980 prices of $50-55/long ton. This discount was made because the market for elemental sulfur is relatively small, and byproduct sulfur from coal conversion plants will probably force market prices down. The price indices or prices used to inflate each component of plant construction costs are shown in Table 3-1.

3.1.4 Economic Criteria

Standard economic criteria were used to estimate costs other than direct operating and construction costs. These costs include working capital, preproduction costs, and interest during construction. The criteria used for these costs are listed below.

- Working capital: 6.1 percent of Total Plant Investment
- Startup Costs: 6 percent of Total Plant Investment
- Interest During Construction: According to Reference 3-1, construction costs are incurred according to the following schedule:
    - 5 years before startup - 2 percent
    - 4 years before startup - 6.5 percent
    - 3 years before startup - 17.5 percent

- 2 years before startup - 54 percent
- 1 year before startup - 20 percent

Compounded annual interest of 15 percent is applied to each year's outlays as if all the outlay in the year is borrowed at the beginning of the year.

Other economic criteria include a project life of 20 years, time needed to design, procure, construct and startup the facility of 57 months, and a capacity factor of 90 percent (3-1). Because of the long construction time, interest during construction becomes a very large component of plant capital costs. Plant investment costs exclude mine costs and escalation during construction.

3.1.5 Contingencies

Two contingencies were applied to the capital cost estimates: a process contingency and a project contingency. The process contingency covers technical uncertainties within a particular process which might cause costs to increase. The process contingency was applied on an area-by-area basis according to the level of technical development of each area, as is shown in Table 3-2. The process contingency varies from 0 percent for a commercialized technology to 50 percent for a technology not yet at the pilot plant stage. These percent contingencies were derived judgmentally by ERCO with reference to industry contacts. The percent process contingency applied to each area is shown in Table 3-3. Gasification, acid gas removal and hydrogenation all receive a 10 percent contingency. All other areas were judged to be fully commercially developed and received no process contingency.

TABLE 3-2

PROCESS CONTINGENCIES BY LEVEL OF TECHNICAL DEVELOPMENT

LEVEL OF OF DEVELOPMENT	PROCESS CONTINGENCY (PERCENT)
Commercial scale	0
Demonstration Plant	10
Pilot Plant	25
No Pilot Plant	50

Source: ERCO.

TABLE 3-3

PROCESS CONTINGENCY BY PLANT AREA

NUMBER	ITEM	CONTINGENCY (PERCENT)
100	Coal storage and handling	0
200	Coal preparation	0
300	Gasification and power recovery	10
400	Hydrogenation	10
1200	Raw gas cooling	0
1300	Acid gas removal and gas cleaning	10
1400	Sulfur recovery and tail gas treating	0
1700	Shift conversion	0
1800	Methanation	0
1900	Air separation	0
2000	Utilities and support systems	0
2010	Offsites and miscellaneous	0

Source: ERCO.

TABLE 3-5

TOTAL CAPITAL REQUIREMENT[a]

ITEM	COST (10^6 $)	PERCENT OF TOTAL
Total Plant Investment	1962.8	67.3
Interest During Construction	714.4	24.5
Working Capital	119.7	4.1
Start-Up Costs	117.8	4.0
Total	2914.7	100

---

[a] Source: Reference (3-1), scaled to 125 trillion Btu per year and corrected to 1980, third quarter dollars by ERCO.

3.2.2 Variability of Capital Costs

The Fischer-Tropsch plant cost estimate found in Reference 3-1 was based on detailed information about a commercialized process. This level of information reduces the uncertainties associated with the costs of such a facility. Substantial technical development of the process, however, is still possible. The gasification and hydrogenation sections, which together account for 16.1% of total plant investment are particularly good candidates for technical development. This development may increase or reduce costs.

Reference 3-1 estimates the accuracy of its estimate at -5 to +20 percent.

3.3 Operating and Maintenance Costs

3.3.1 Itemized Operating and Maintenance Costs

The Fischer-Tropsch plant will require continuous expenditures on labor, administration and general overhead, supplies, catalysts and chemicals, and local taxes and insurance. Itemized annual costs for these non-fuel expenditures are presented in Table 3-6. Annual operating and maintenance costs total $127 million. The largest components of these costs are maintenance supplies, at $37.5 million, and local taxes and insurance at $45 million. Labor and overhead charges are relatively unimportant, at $18.5 million and $18.7 million respectively.

TABLE 3-6

ANNUAL OPERATING AND MAINTENANCE EXPENSES[a]

ITEM	COST[c] (10^6 $)	PERCENT OF TOTAL
Administration and General Overhead	18.7	14.7
Local Taxes and Insurance	45.0	35.4
Labor		
Process Operation	6.7	5.3
Maintenance	11.8	9.3
Supervision[b]		--
Total	18.5	14.6
Supplies		
Operating	.7	.6
Maintenance	36.8	29.0
Total	37.5	29.6
Catalysts and Chemicals	7.3	5.7
Purchase Water	--	
Total Operating and Maintenance	127	100.0

By-Product Credits	Annual Credits (10^6 $)[c]
Sulfur @ $40/long ton	$ 8.86
Electricity @ 3.5¢kWh	$ 1.07
Total By-Products	$ 9.93

Summary	Annual Expenses (10^6 $)[c]
Operating and Maintenance	127
By-Product Credits	(9.93)
Net Operating and Maintenance	117.07

---

[a] Source 3-1, updated and scaled by ERCO.

[b] Supervision labor included in operating and maintenance labor accounts.

[c] Third quarter 1980 dollars.

The Fischer-Tropsch process produces by-product sulfur in elemental form, which is salable and more electricity than it uses, which can be sold back to the grid. These by-product credits offset the other operating and maintenance costs. Yearly sulfur credits, based on a price of $40/long ton, total $8.86 million, while electricity credits, based on 3.5¢/killowatt-hour, total $1.07 million. The annual by-product credits total $9.93 million, which is also shown on Table 3-6. Net operating and maintenance costs, which take into account both operating and maintenance expenses and by-product credits, total $117.1 million.

3.3.2 Variability of Operating and Maintenance Costs

Operating and maintenance costs per Btu would increase if the capacity factor fell below the rated 90 percent. The by-product credit would be reduced while expenses would remain nearly unchanged.

In general, the operating and maintenance cost estimates seems at least as accurate as the capital cost estimate, within -5 to +20 percent.

3.4 Effect of Technology Development on Costs

As the Fischer-Tropsch process is commercialized in the United States, the cost of constructing Fischer-Tropsch plants will fall in real dollars. New techniques and better methods of using older techniques will be developed. The effect of increased experience on technology costs is often quantified through the use of "experience" (sometimes called "learning") curves. The experience curve describes an inverse relationship betwen the cumulative number of units of an item produced and the unit capital cost of the item. The effects of experience are shown with a log-linear curve which exhibits a constant percent decline in the unit cost of production capacity for each doubling of completed capacity. The slope of this curve is called the experience factor. For example, a 10 percent experience factor implies that the cost of the fourth plant would be 81 percent (90 percent times 90 percent) of the cost of the first plant. It has been estimated that 10 percent is the upper limit on the experience factor for new energy process technologies (3-3).

The 10 percent experience factor is valid for sections of plant using new technology. Most sections of the plant employ mature technologies whose costs would decline little as more Fischer-Tropsch plants are built. The accumulated volume of production of these components is already so large that the construction of one or several Fischer-Tropsch plants would result in negligible cost reductions because of experience. Areas employing immature technology, which include the gasification, hydrogenation, gas clean-up, and gasifier heat recovery areas, account for about 40 percent of plant costs (including the share of the contingencies assignable to these sections). The experience factor for Fischer-Tropsch technology is then 40 percent of the 10 percent maximum, or about 4 percent. Each doubling of Fischer-Tropsch capacity might result in a 4 percent reduction in unit capital costs.

3.5 Non-Fuel Product Costs

The cost of the product gas is composed of three components: capital charges associated with plant capital costs, plant operating and maintenance (O&M) costs, and coal costs. The cost of the gas excluding the cost of coal (non-fuel costs) yields an indication of the economic viability of the process. Non-fuel gas costs can be computed from capital charges and O&M costs according to the following formula:

$$P = \frac{K \times CRF + OM}{CAP \times F}$$

- P is the product cost excluding fuel

- K is the total capital requirements of the plant, $2914.7 million, from Table 3-5

- CRF is the capital recovery factor, assumed to be 20 percent

- CAP is the total plant annual capacity, 125 trillion Btu's

- F is the plant capacity factor, 90 percent

- OM is the net annual operating and maintenance expense, $117.1 million, from Table 3-6.

This formula yields a product cost (excluding fuel) of

$$P = \frac{(\$2914.7 \times 10^6) \times 20\% + \$117.1 \times 10^6}{125 \times 10^{12} \times 90\%}$$

$= \$6.22$/million Btu output.

This estimate of $6.22/million Btu output excluding fuel is as accurate at the capital, operating, and maintenance expenses discussed above. Therefore, $6.22/10^6 Btu should be considered part of a range of -5 to +20 percent. On a dollars per barrel of oil equivalent basis, this cost is about $34.

REFERENCES

3-1. Ralph M. Parsons Co. "Fischer-Tropsch Conceptual Design Economic Analysis," January 1977, ERDA, FE-1775.

3-2 "Cost Indices Maintain 13-Year Ascent" and "Economic Indicators," Chemical Engineering, May 8, 1978 and January 26, 1981.

3-3. Hederman, W.F. (Rand Corporation), "Prospects for the Commercialization of High-Btu Coal Gasification," U.S. Department of Energy; R-2294-DOE, April 1978, pp. 48-50.

CHAPTER FOUR: PUBLIC POLICY

The discussion of the effects of public policy on Fischer-Tropsch market penetration is divided into two sections. Section 4.1 explains Department of Energy (DOE) efforts directed toward improving Fischer-Tropsch market acceptability. In Section 4.2, the effect of the Synthetic Fuels Corporation on Fischer-Tropsch utilization is assessed.

4.1 Department of Energy Policy

The DOE encourages Fischer-Tropsch technology through its research program to improve the efficiency and reliability of indirect coal liquefaction technology. The R&D program has the following goals (3-2):

1. Improvement of the integration of gasification with liquefaction by developing process technologies that can use low ratio H_2/CO directly.
2. Improvement of process selectivity by use of shape selective catalysts.
3. Achievement of higher process efficiency by using large, thermally efficient liquid or slurry phase reactors.
4. Development of simpler method to upgrade conventional Fischer-Tropsch liquids through the use of zeolite catalysts.

Achievement of these goals will add significantly to Fisher-Tropsch technical acceptability.

In addition to its R&D efforts, the DOE issued solicitations for financial assistance to alternative fuels projects under the Alternative Fuels Production Act (P.L. 96-126) in 1980. A cooperative agreement to advance the design of a Fischer-Tropsch plant producing 56,000 barrels per day of oil equivalent was awarded to Texas Eastern Synfuels, a joint venture of Texas Eastern Corporation and Texas Gas Transmission Corporation. The project, to be sited near Henderson, Kentucky, will use 28,000 tons of coal per day and will produce transportation fuels, synthetic natural gas, and chemicals.

4.2 Synthetic Fuels Corporation

4.2.1 Introduction

The Synthetic Fuels Corporation (SFC) was established by the Energy Security Act of 1980. Its mandate is to foster the creation of a synthetic fuels industry in the United States by providing financial assistance to synthetic fuels producers. The SFC is to act only as a catalyst to private industry synthetic fuel development. Where private capital is available, the SFC will not provide assistance.

The SFC set the goal of creating a synthetic fuels industry with production of 500,000 barrels per day of oil equivalent by 1987 and 2,000,000 barrels by 1992. To implement this goal, the SFC was appropriated $6.2 billion for 1981 and part of 1982. The ESA also authorized appropriations of $20 billion to the SFC through 1984. In 1984, the SFC will be required to submit to Congress a comprehensive strategy for the achievement of the SFC's goals. If Congress accepts this strategy, Congress can authorize the appropriation of another $68 billion. In the near term (through mid-1982), however, the amount of financial assistance available is $6.2 billion.

4.2.2 Financial Assistance Available

The SFC can use a variety of methods to foster the creation of a synthetic fuel industry. These include:

1. Price guarantees, through which the SFC guarantees a minimum price for the products of a synthetic fuels plant.
2. Purchase agreements through which the SFC contracts to buy the outputs of a synthetic fuel facility.
3. Loan guarantees, through which the SFC agrees to guarantee loans to synthetic fuel facility producers.
4. Loans to the synthetic fuel producer.
5. Joint ventures with the synthetic fuel producer, in which the SFC will finance and own a share of the synthetic fuel project.

The SFC is directed to give preference to contingent liabilities, such as loan and price guarantees. These contingent liabilities will restrict the SFC's financial commitment to situations of total or partial project failure.

4.2.3 Synthetic Fuels Corporation Effect on Fischer-Tropsch Market Penetration

The SFC has the resources necessary to spur Fischer-Tropsch market penetration if this technology fits into the SFC's overall strategy. As of March 1981, this strategy had not been fully documented. However, the SFC had outlined some of the criteria it will use for choosing one technology or project over another (4-1).

The SFC will favor projects in which:

1. Project sponsors make a significant investment and will bear an important financial risk.
2. Financial assistance to the project is in the form of contingent liabilities such as loan guarantees, price guarantees, or purchase agreement.
3. The proposal shows sound promise of commercial viability. Operationally, this means that the SFC will favor projects which appear to be able to operate at a profit and to show a satisfactory rate of return either upon completion or within a relatively short time thereafter.
4. The technology has been successfully demonstrated on a commercial scale or where, for some other reason, the SFC has determined that the technical and engineering risks are prudent.

The first two of these criteria judge the financial structure of the proposed project. They are neutral with respect to the technology proposed, and will therefore neither favor nor disfavor Fischer-Tropsch projects.

The last two criteria focus on the economic and technical viability of the projects and clearly favor a conventional, proven technology such as Fischer-Tropsch. Fischer-Tropsch technology has been commercially demonstrated in South Africa and so is definitely technically viable. The costs of the technology can be accurately determined because it relies on commercially-demonstrated equipment. As a result, the economic risk associated with a Fischer-Tropsch project can be reliably quantified. This presents Fischer-Tropsch technology with an advantage over more technically advanced technologies for which cost data are not as reliable.