SECTION 19

ALTERNATE 2: POWDER RIVER REGION OF THE ROCKY MOUNTAIN COAL PROVINCE

The major difference between a Western POGO project (Powder River Region of the Rocky Mountain Coal Province--Rocky Mountain Region) and a base case Eastern project (Eastern Region of the Interior Coal Province), lies in the western sub-bituminous coal type and its unique analysis. The ROM coal high inherent water content, approximately 25%, requires extensive drying facilities. In addition, coal seams are thicker, coal is softer and cleaner. Accordingly, mining is simplified, as shovels are used for both overburden and coal removal. The relatively clean coal contains a minimum amount of rubble, and has a low ash and sulfur content; consequently, a coal preparation unit can be omitted.

The net result is a slightly lower fixed capital investment, a higher capacity power plant, and a lower overall thermal efficiency of approximately 67%, because of the high drying load and a lower product output volume. This is approximately 80% of that for the base case on a Btu content basis, and results from the need for a proper overall plant hydrogen balance.

The POGO process, Alternate 2, is shown in the block flow diagram, Figure 19-1. The overall material balance is summarized in Figure 19-2.

19.1 COAL MINE

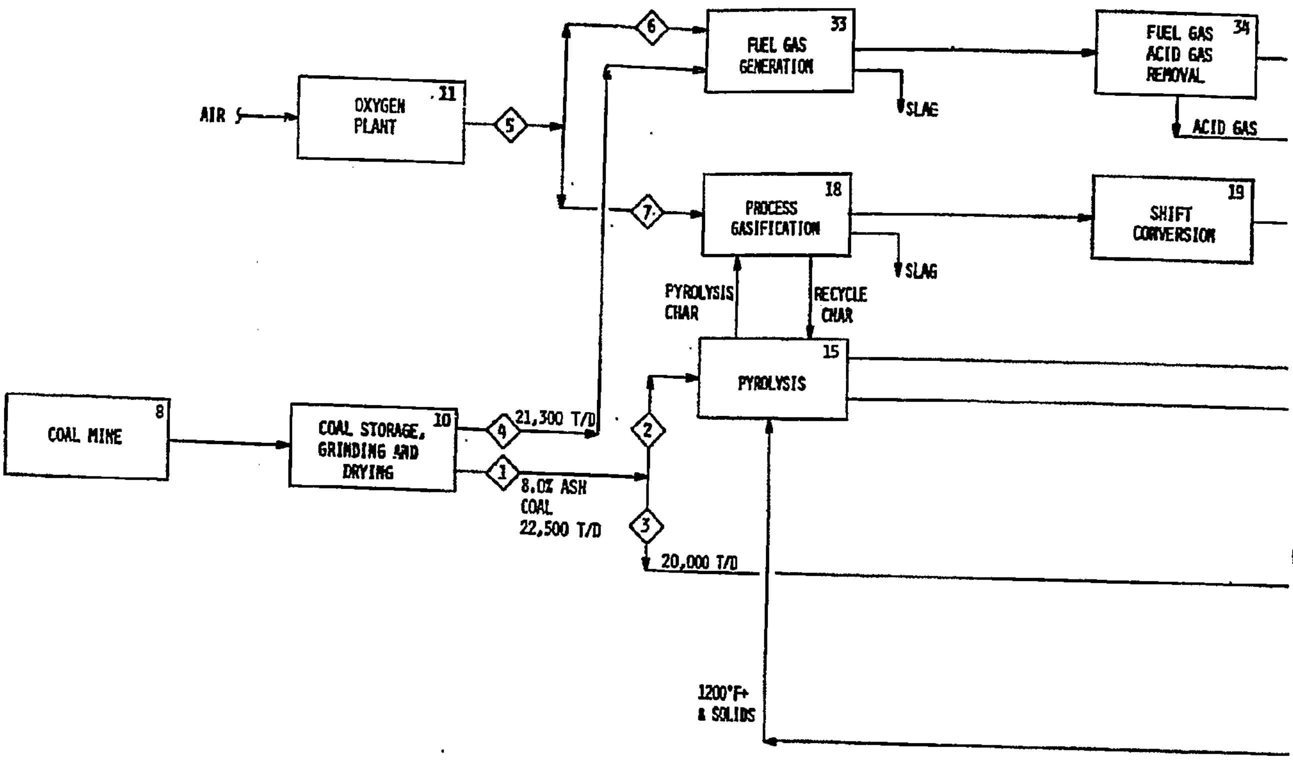
Based on production requirements for the POGO process and the physical deposition of the selected mining area, a mining plan was formulated, and capital and operation costs were estimated. The cost estimate excludes land acquisition and the relocation expense of any existing buildings, roads, pipelines, or related items that would interfere with the mining operation.

19.1.1 PRODUCTION REQUIREMENTS AND BASIC CRITERIA

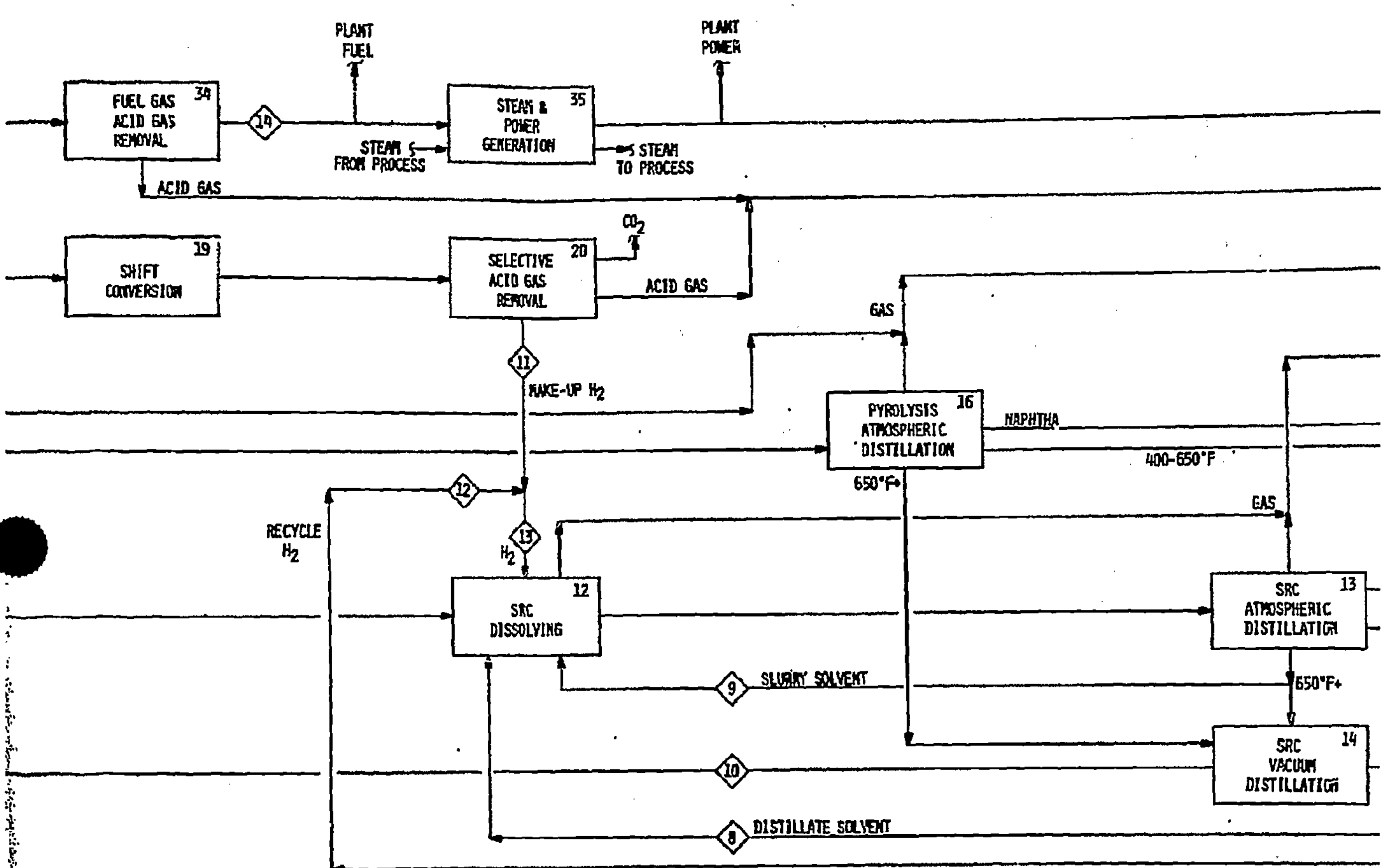
The mine can produce approximately 70,000 TPD of ROM coal for 330 days per year.

Overburden thickness varies between 20 and 180 feet. The average thickness used in this study is 100 feet.

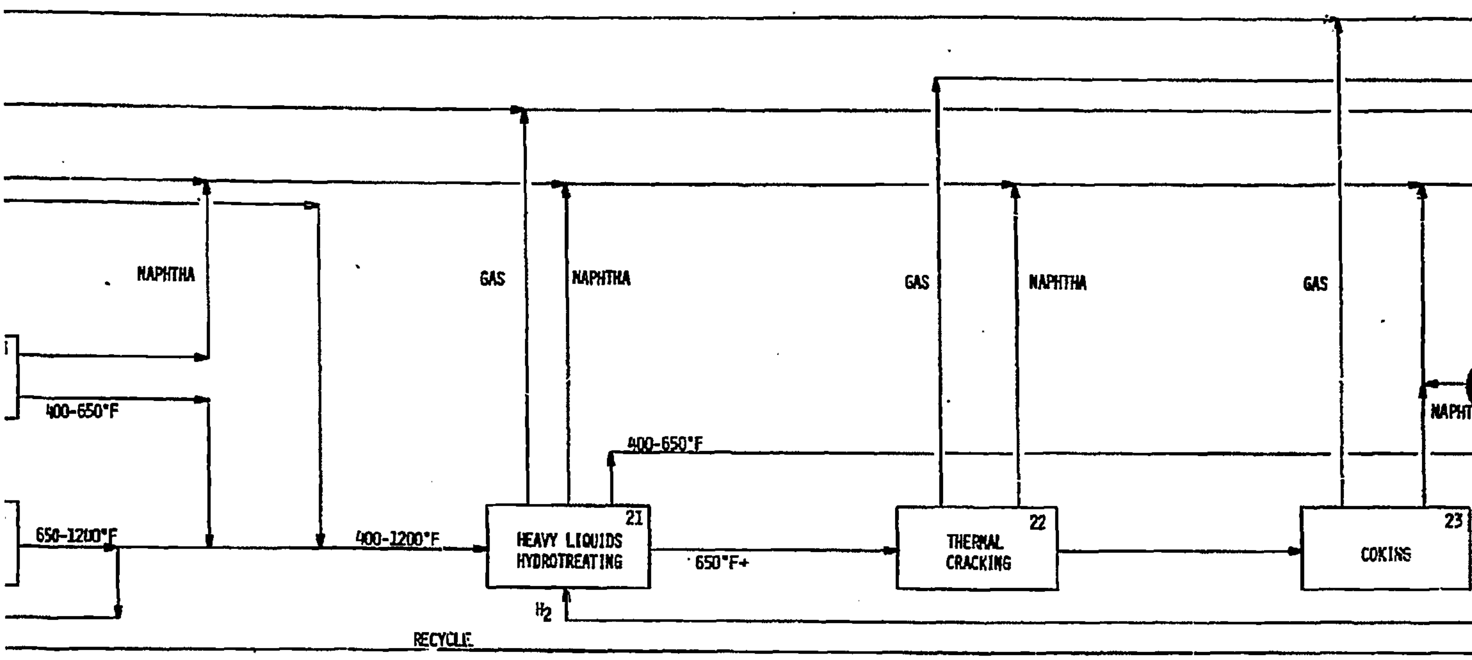
There are three nearly horizontal seams of coal. The top seam is 14 feet thick, the middle is 32 feet thick, and the bottom is 8 feet thick. Each seam is separated by 8 feet of shale.



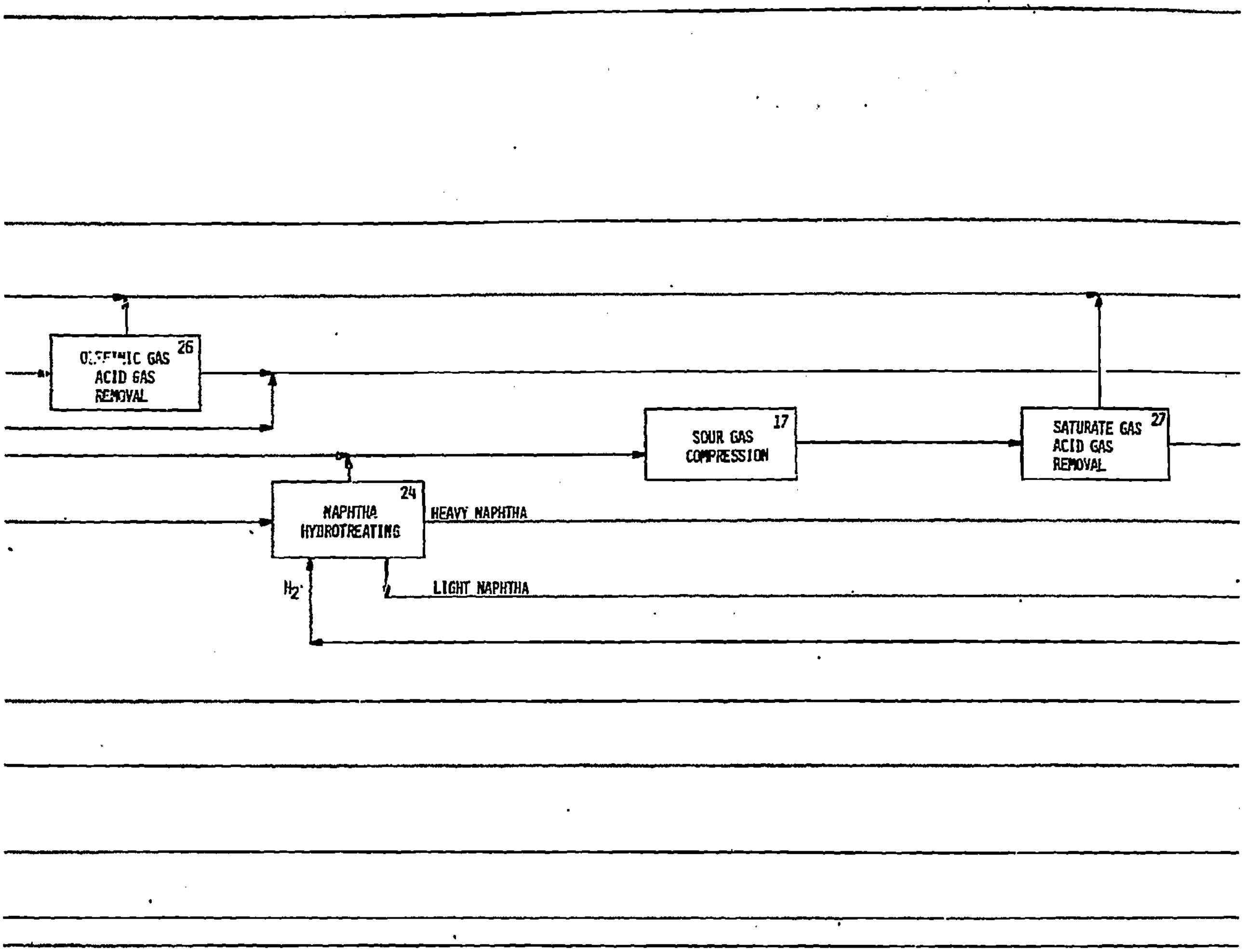
STREAM NO.
DESCRIPTION
COMPONENT
O_2, T/D
H_2
N_2
CO
CO_2
NH_3
H_2S
H_2O
CH_4
C_2H_4
C_2H_6
C_3H_6
C_3H_8
C_4H_8
C_4H_{10}
IBP-400
400-650
650-950
950-1200
1200+
RESIDUE
ASH
COAL (MAF)
COKE
SULFUR
TOTAL, T/D
MMSCFD
BPD
HEATING VALUE
BILLION BTU/D



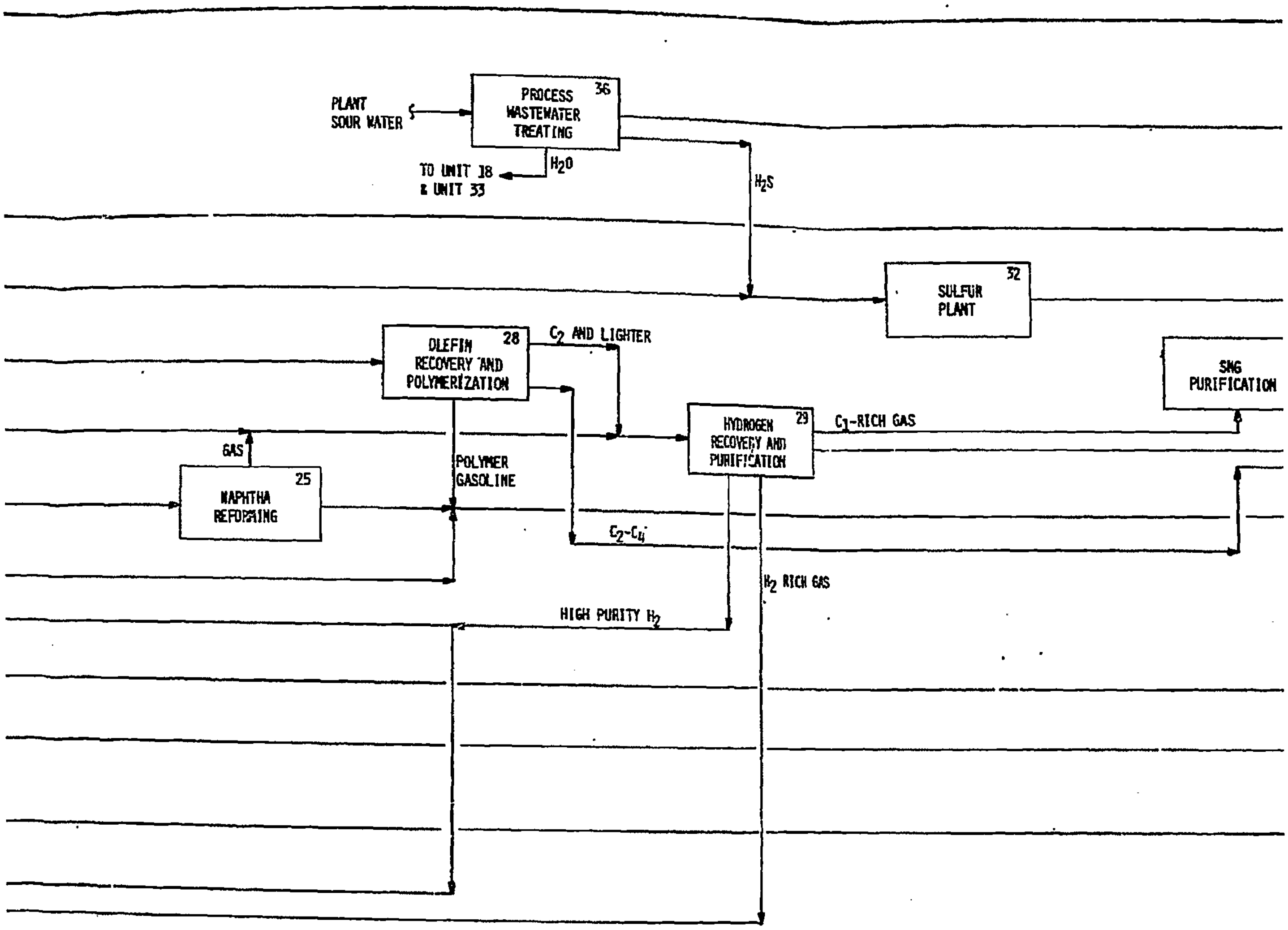
STREAM NO.	1	2	3	4	5	6	7	8	9	10	11
DESCRIPTION	COAL TO PROCESS	COAL TO PYROLYSIS	COAL TO SRC	COAL TO FUEL GAS GENERATION	TOTAL OXYGEN	O_2 TO FUEL GAS GENERATION	O_2 TO PROCESS	DISTILLATE SOLVENT	SLURRY SOLVENT	SRC VACUUM BOTTOMS	MAKEUP HYDROGEN
COMPONENT											
O_2, T/D	-	-	-	-	19720.86	14454.49	5266.37	-	-	-	-
H_2	-	-	-	-	-	-	-	-	-	-	1004.70
N_2	-	-	-	-	352.54	258.44	94.10	-	-	-	207.02
CO	-	-	-	-	-	-	-	-	-	-	644.18
CO_2	-	-	-	-	-	-	-	-	-	-	27.02
NH_3	-	-	-	-	-	-	-	-	-	-	-
H_2S	-	-	-	-	-	-	-	-	-	-	1.51
H_2O	607.50	67.50	540.00	575.C5	-	-	-	-	-	-	9.73
CH_4	-	-	-	-	-	-	-	-	-	-	96.08
C_2H_4	-	-	-	-	-	-	-	-	-	-	-
C_2H_6	-	-	-	-	-	-	-	-	-	-	-
C_3H_6	-	-	-	-	-	-	-	-	-	-	-
C_3H_8	-	-	-	-	-	-	-	-	-	-	-
C_4H_8	-	-	-	-	-	-	-	-	-	-	-
C_4H_{10}	-	-	-	-	-	-	-	-	-	-	-
IBP-400	-	-	-	-	-	-	-	400.00	622.13	8.85	-
400-650	-	-	-	-	-	-	-	8946.00	13959.58	194.56	-
650-950	-	-	-	-	-	-	-	7194.00	12069.49	55.55	-
950-1200	-	-	-	-	-	-	-	3460.00	8997.67	656.73	-
1200+	-	-	-	-	-	-	-	-	2348.31	2846.98	-
RESIDUE	-	-	-	-	-	-	-	-	2002.82	1905.85	-
ASH	1800.00	200.00	1600.00	1703.48	-	-	-	-	-	1604.82	-
COAL (MAF)	20092.50	2232.50	17860.00	19014.93	-	-	-	-	-	-	-
COKE	-	-	-	-	-	-	-	-	-	-	-
SULFUR	-	-	-	-	-	-	-	-	-	-	-
TOTAL, T/D	22500.00	2500.00	20000.00	21293.46	20073.40	14712.93	5360.47	20000.00	40000.00	7273.34	1950.24
MMSCFD	-	-	-	-	477.30	349.84	127.46	-	-	-	406.78
BPD	-	-	-	-	-	-	-	-	-	-	-
HEATING VALUE BILLION BTU/D	504.495	56.055	448.440	477.442	-	-	-	-	-	-	-



STREAM NO.	12	13	14	15	16	17	18	19	20	21	22
DESCRIPTION	RECYCLE HYDROGEN	TOTAL HYDROGEN	TOTAL FUEL GAS	AMMONIA	SULFUR	SNG	C_3 LPG	C_4 LPG	POOL GASOLINE	FUEL OIL	COKE
COMPONENT											
O_2, T/D	-	-		-	-	-	-	-	-	-	-
H_2	515.30	1520.00	1585.55	-	-	-	-	-	-	-	-
N_2	71.74	278.76	465.54	-	-	240.31	-	-	-	-	-
CO	183.86	828.04	23911.70	-	-	-	-	-	-	-	-
CO_2	-	27.02	1216.88	-	-	292.96	-	-	-	-	-
NH_3	-	-	-	128.28	-	-	-	-	-	-	-
H_2S	-	1.51	0.02	-	-	-	-	-	-	-	-
H_2O	-	9.73	70.55	-	-	0.14	-	-	-	-	1.20
CH_4	33.38	129.46	180.29	-	-	1135.3	-	-	-	-	-
C_2H_4	-	-	-	-	-	79.13	0.27	-	-	-	-
C_2H_6	-	-	-	-	-	616.11	19.79	-	-	-	-
C_3H_6	-	-	-	-	-	5.06	47.26	0.11	0.14	-	-
C_3H_8	-	-	-	-	-	42.86	695.69	23.67	29.8	-	-
C_4H_8	-	-	-	-	-	-	2.33	11.86	14.94	-	-
C_4H_{10}	-	-	-	-	-	-	13.43	295.64	608.14	-	-
IBP-400	-	-	-	-	-	-	-	6.50	3503.94	228.14	-
400-650	-	-	-	-	-	-	-	-	-	2645.13	-
650-950	-	-	-	-	-	-	-	-	-	192.25	-
950-1200	-	-	-	-	-	-	-	-	-	-	-
1200+	-	-	-	-	-	-	-	-	-	-	-
RESIDUE	-	-	-	-	-	-	-	-	-	-	-
ASH	-	-	-	-	-	-	-	-	-	-	-
COAL (MAF)	-	-	-	-	-	-	-	-	-	-	-
COKE	-	-	-	-	-	-	-	-	-	-	1198.06
SULFUR	-	-	-	-	353.15	-	-	-	-	-	-
TOTAL, T/D	804.28	2794.52	27430.57	128.28	353.15	2411.17	778.77	337.78	4156.96	3075.52	1199.26
MMSCFD	202.51	609.29	-	-	-	83.79	-	-	-	-	-
BPD	-	-	-	-	-	-	8820.91	3326.35	32207.99	20236.88	-
HEATING VALUE BILLION BTU/D	-	-	410.112	2.48	2.82	87.98	33.69	14.393	168.35	119.55	36.87


26
ACID GAS
REMOVAL
17
SOUR GAS
COMPRESSION
27
SATURATE GAS
ACID GAS
REMOVAL
24
NAPHTHA
HYDROTREATING
HEAVY NAPHTHA
LIGHT NAPHTHA
H_2

A


PLANT
SOUR WATER
PROCESS
WASTEWATER
TREATING
36
H_2O
TO UNIT 18
& UNIT 33
H_2S
SULFUR
PLANT
32
OLEFIN
RECOVERY AND
POLYMERIZATION
28
C_2 AND LIGHTER
SNG
PURIFICATION
GAS
NAPHTHA
REFORMING
25
POLYMER
GASOLINE
HYDROGEN
RECOVERY AND
PURIFICATION
29
C_1-RICH GAS
C_2-C_4
H_2 RICH GAS
HIGH PURITY H_2

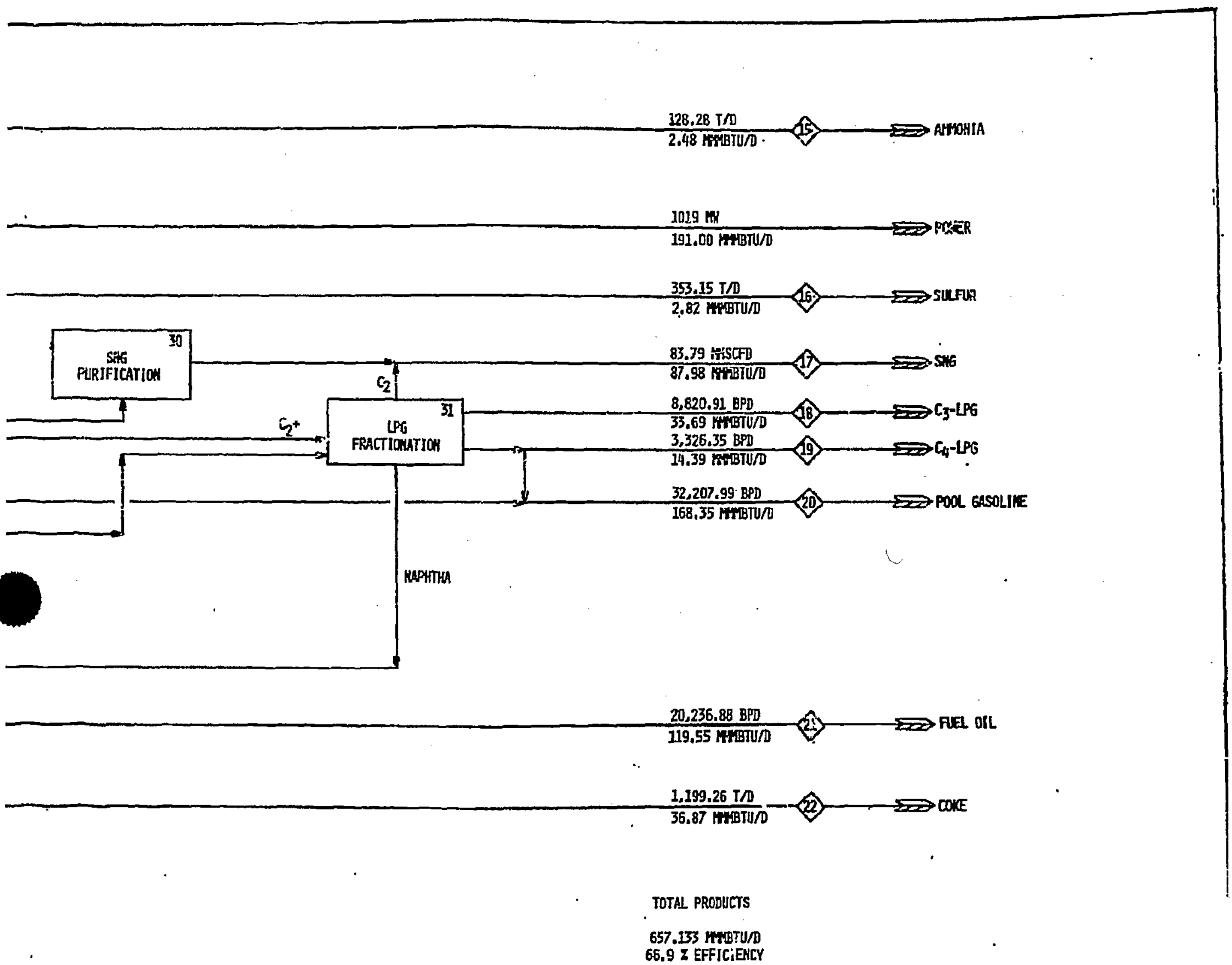


FIGURE 19-1

0.	ISSUED FOR REPORT	

DEPARTMENT OF ENERGY - DIVISION OF COAL CONVERSION
POGO PLANT
BLOCK FLOW DIAGRAM
ROCKY MOUNTAIN REGION COAL

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
5435-4
R-01-FS-3

DR.RM. REV.B 12/6/77

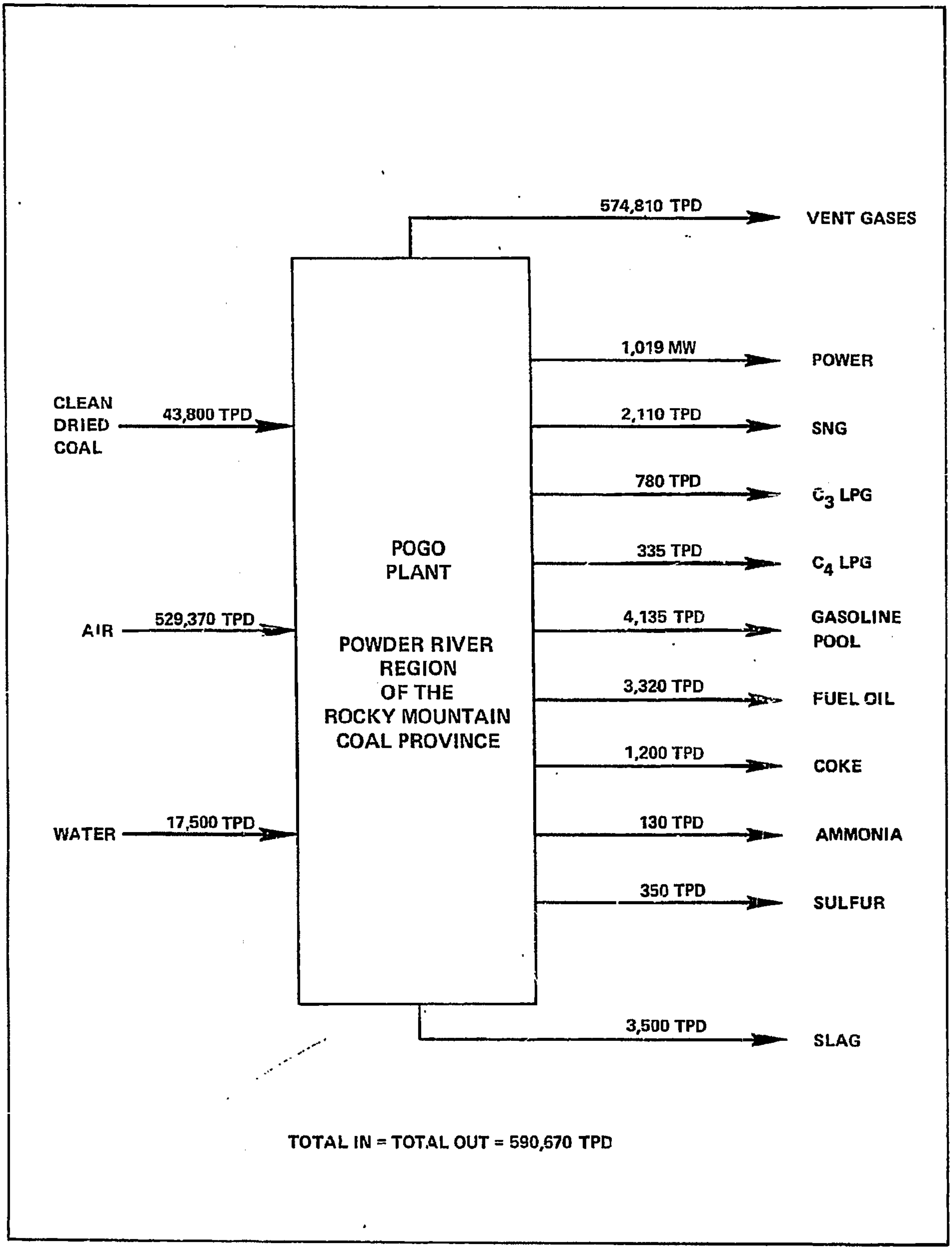


Figure 19-2 - Overall Material Balance — Process and Power Units

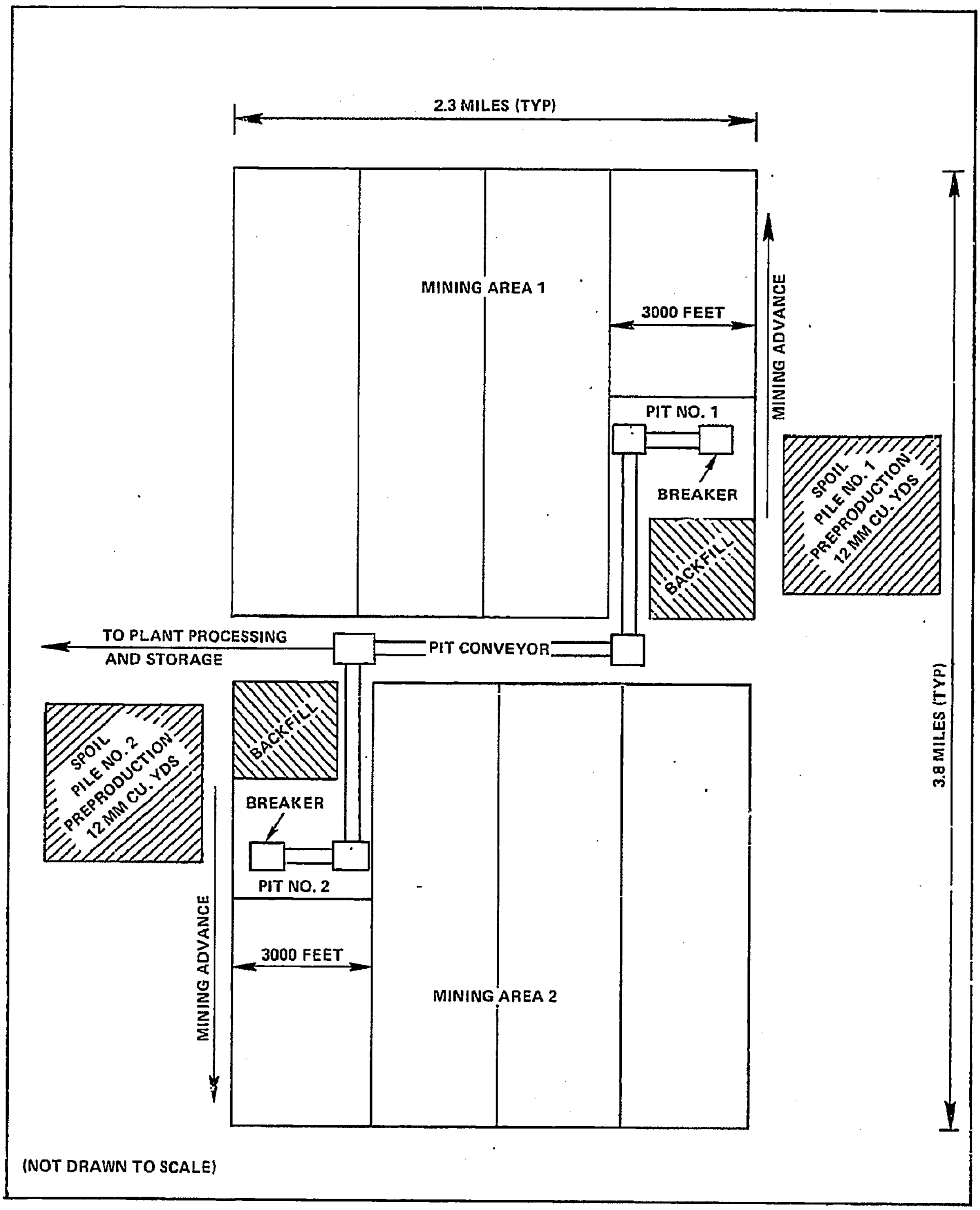


Figure 19-3 - Mine General Layout

About 12,000,000 BCY of overburden will be removed from each pit and will be stockpiled adjacent to the pit. Overburden benches will be 50 feet in height, and stripping can be accomplished with the pit shovels and end dump trucks. The preproduction stripping cost is treated as a capital cost item.

B. Overburden Stripping

The overburden covering the coal seams varies in thickness between 20 and 180 feet and is composed of a friable sandstone underlain by a shale that forms the roof of the coal seam. Light blasting will be required before shovel loading.

Approximately 65,000 BCY of overburden will be removed daily at each pit to uncover the coal. Using a haulback technique, the mining shovels will load the 170-ton-capacity end dump truck; the trucks will transport the waste material and dump it in the pit where the coal has been removed. This haulback system continually restores the land surface to near its original contours and makes it available for planting. Major equipment used for overburden stripping at each pit are four 15-cubic yard shovels, twenty 170-ton end dump trucks, a truck-mounted rotary drill, plus support items: dozers, graders, and the like, for haul road upkeep, cleanup, and dressing the dump area.

C. Coal Mining

The three coal seams and interbedded shale seams between the coal will be mined in benches. Bench heights will vary and correspond to the thickness of the member being mined. To provide a high degree of mobility and flexibility, both coal and interbedded waste will be mined with front-end loaders and trucks. Large track dozers with rippers will be used to rip the waste seams prior to loading, and a truck-mounted rotary drill will be available for drilling and blasting when required for both coal and waste. Twelve-cubic yard front-end loaders will load the coal into bottom dump coal haulers. The haulers will transport the coal to a breaker station located within the pit, and the coal will be transported from the breaker out of the pit by a belt conveyor system. The breakers will be periodically relocated within the pit to minimize the truck haulage distances. Figure 19-4 depicts the mine pit operation.

D. Waste Disposal

The interbedded waste between the coal seams will be mined with the same equipment used for mining the coal. As the waste seam is removed to uncover the coal, it will be transported in the bottom dump haul trucks to the mined out portion of the pit for disposal. Interbedded waste will amount to approximately 10,00 BCY per day.

19.2 COAL STORAGE, GRINDING, AND DRYING

This is a major operating unit by virtue of the high inherent moisture content of sub-bituminous coal. Accordingly, a greater quantity of ROM coal is required than for the base case.

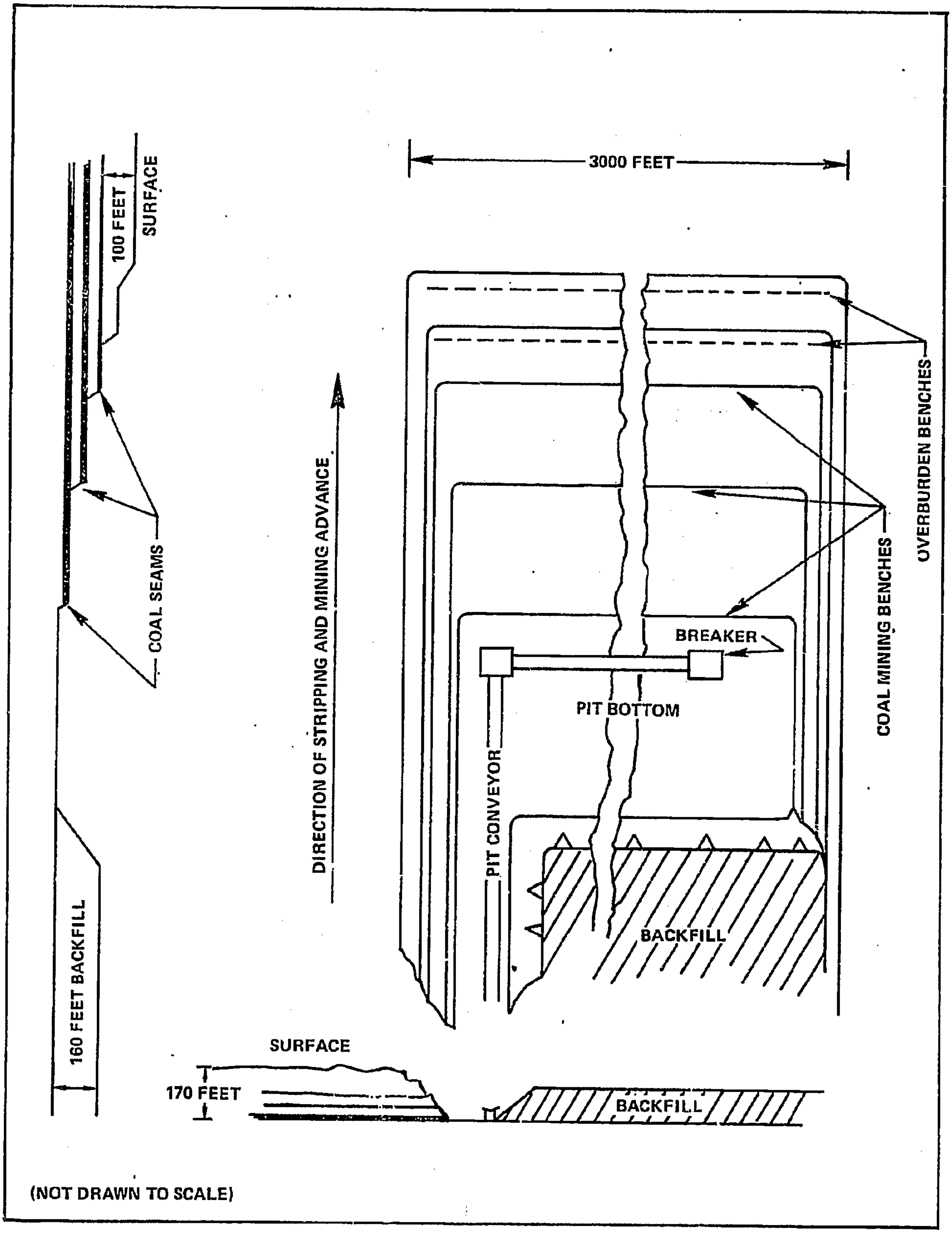


Figure 19-4 - Schematic Drawing of Pit

19.2.1 STORAGE

The coal, broken to a minus 3-inch size, is delivered, as it is in the base case directly to the grinding areas. The surplus coal delivered is stockpiled for later reclaiming during mine shutdown periods.

19.2.2 GRINDING AND DRYING AREAS

There are three coal grinding and drying areas for sizing and drying the coal to the feed condition required for each process.

(1) Pyrolysis and SRC Feed Coal

Approximately 33,000 TPD of wet feed coal for these processes are fed through intermediate storage and feed bins to six 2-row cage mills. This type of mill was selected in order to minimize the production of fines.

The coal is ground to minus 1/8-inch size and conveyed to a battery of fourteen fluidized bed/steam tube dryers, operating in parallel, for moisture reduction from a maximum combined inherent and surface moisture content of 25 to 30% to below 3%.

A dried coal stream of approximately 22,500 TPD is produced, of which 20,000 TPD are used to feed the SRC reactors. The remaining 2500 tons are reground in two 6-row cage mills to 70% minus 200 mesh as pyrolysis feed.

(2) Fuel Gas Gasifier Feed Coal

Approximately 31,000 TPD of wet feed coal are delivered through intermediate storage and feed bins to nine 4-row cage mills. The coal is ground to a minus 20-mesh size and conveyed to a battery of eleven fluidized bed/steam tube dryers for moisture reduction to below 3%.

The dried coal stream of approximately 21,300 TPD is conveyed and fed to the fuel gas gasification unit.

All coal conveyors, bins, feeders, mills, and dryers are completely enclosed and are operated in an inert cover gas atmosphere to eliminate the risk of coal dust explosions.

19.2.3 FEED COAL ANALYSIS

The analyses of process coal to be used as the basis for the POGO plant, Alternate 2, SRC, pyrolysis and fuel gas gasifier units design are shown on Table 19-1. The analyses are based on Powder River Coal Basin Wyodak Seam Sample Analyses.[30]

Table 19-1 - POGO Plant Alternate Case 2
Rocky Mountain Coal Analysis

Analyses	Coal to Process and Fuel Gas Generation
Proximate Analysis (Wt %)	
Moisture	2.7
Ash	8.0
Volatile Matter	44.2
Fixed Carbon	45.1
Total	100.0
Higher Heating Value, Btu/lb	11,211
Ultimate Analysis (Wt %)	
Carbon	66.3
Hydrogen	4.7
Nitrogen	1.0
Sulfur	0.8
Oxygen	16.5
Moisture	2.7
Ash	8.0
Total	100.0

19.3 FLASH PYROLYSIS

Flash pyrolysis heat and material balances for the Rocky Mountain Region coal are based on the yield pattern developed for the base case. There were no known pressurized flash pyrolysis experimental data for western sub-bituminous coals.

The details of the design procedure applied to the alternate case are:

(1) The yields and proportions of volatile products from flash pyrolysis of Rocky Mountain Region coal were derived from the base case. Flash pyrolysis of Illinois No. 6 coal yields total volatile product, including gas, water, and tar, which is 88 wt% of the volatile material (VM) of the coal. Likewise, total yield of volatile product from flash pyrolysis of Rocky Mountain Region coal is 88 wt% of the VM of the coal.

(2) Product compositions and properties from the base case were used as guidelines to compositions for pyrolysis products from Rocky Mountain Region coal. Adjustments of the product elemental composition were made to account for differences in the elemental composition of the Alternate 2 coal. This resulted in a lower sulfur and higher oxygen content in all flash pyrolysis products from Rocky Mountain Region coal, compared to the base case pyrolysis products.

   Calculated final yields and elemental balances for pressurized flash pyrolysis for Rocky Mountain Region coal are given in Table 19-2.

(3) The yields from flash pyrolysis of slurry feeds of Rocky Mountain Region coal were calculated by applying coking correlations to the liquids and calcining the solid portions of the feed, as described previously. Table 19-3 summarizes the vacuum bottoms slurry conversion for Rocky Mountain Region coal.

This procedure for estimating yields from pressurized flash pyrolysis of Rocky Mountain Region coal is considered logical and satisfactory for the current objectives. However, the effect of uncertainty on pyrolysis yields is greater for the alternate case than it is for the base case. The weight fraction of slurry feed in the total feed to the pyrolyzer is considerably greater for the alternate than for the base case. This reduces the amount of coal feed required to achieve the proper overall plant hydrogen balance.

The validity of reported yields, therefore, depends considerably on the procedure used for estimating pyrolysis yields from slurries, which, in turn, is based on limited information.

19.4 SRC DISSOLVING

As was noted in the discussion of the design basis for Alternate 1, Southern Region of the Appalachian Coal Province, it is not possible to

Table 19-2 - POGO Plant Alternate Case 2
Rocky Mountain Coal Pressurized Flash Pyrolysis Yields for Coal Feed

Basis: 10,000 Tons Per Day Feed Coal (2.7% moisture).
All figures are Tons Per Day.

Feed/Yield	Composition						
	C	H	N	S	O	Ash	Total
Stream							
Feed Coal	6630.00	470.00	100.00	80.00	1650.00	800.00	9730.00
Water in Coal		30.21			239.79		270.00
Total	6630.00	500.21	100.00	80.00	1889.79	800.00	10,000.00
Products							
H_2		21.76					21.76
CH_4	234.59	78.76					313.35
C_2H_4	23.22	3.90					27.12
C_2H_6	36.67	9.23					45.90
C_3H_6	35.88	6.02					41.90
C_3H_8	32.67	7.31					39.98
C_4H_{10}	10.06	2.11					12.17
CO	45.11				60.09		105.20
CO_2	100.20				266.97		367.17
N_2			17.00				17.00
H_2S		0.82		13.00			13.82
H_2O		66.30			526.23		592.53
Tar	2000.60	179.00	21.00	10.00	442.50		2653.10
Char	4111.00	125.00	62.00	57.00	594.00	800.00	5749.00
Total	6630.00	500.21	100.00	80.00	1889.79	800.00	10,000.00

Table 19-3 - POGO Plant Alternate Case 2
Rocky Mountain Coal Pressurized Flash Pyrolysis Yields from
Vacuum Bottoms Slurry Feed

Products	Yields Wt%
H_2	0.15
CH_4	2.57
C_2H_4	0.07
C_2H_6	0.48
C_3H_6	0.15
C_3H_8	0.44
C_4H_{10}	0.10
CO	0.46
CO_2	1.37
N_2	0.36
NH_3	0.14
H_2S	0.09
H_2O	1.57
Tar	4.63
Char	87.42
Total	100.00

predict the yield structure of a given coal based only on proximate and ultimate analyses. A literature search disclosed laboratory data for the dissolving of the Rocky Mountain Region coal.[31,32] These data, along with additional information on the effect of temperature and inorganic constituents[29], were used to develop dissolving yields for the Rocky Mountain Region coal used in this alternate.

The details of the calculations procedure applied are as follows:

(1) A moisture and ash free yield structure was determined from the curves given in Reference 32 for the SRC-I mode of operation at the base case process operating conditions.

(2) A yield structure for the SRC-II mode of operation was estimated from the above yields and information given in Reference 31. This was necessary since only a single run was available in the SRC-II mode of operation and this was at operating conditions different from those used in the base case.

(3) These yields were applied to the Rocky Mountain Region coal with allowances made for the difference in ultimate analysis, primarily the oxygen, nitrogen, and sulfur content.

(4) Finally, an elemental balance was determined with the element distribution in the liquid cuts following trends as those given in Reference 32. The resulting balance after all adjustments were made is given in Table 19-4.

It is felt that this procedure is acceptable considering the minimal laboratory data available. Inasmuch as the data are not as complete as those used in the base case, there is greater uncertainty in the design; however, the data provide guidance for determining the impact of using Rocky Mountain Region coal in the POGO plant instead of the Eastern Region Interior Coal Province coal used in the base case.

19.5 STEAM AND POWER GENERATION

This unit is essentially identical to that of the base case, consisting of gas turbines, heat recovery steam generators, and steam turbines in the combined cycle mode. The total power generated is equal to that generated in the base case. However, an increased number of gas turbine units are required; 23 compared to 18 for the base case location.

The high altitude reduced atmospheric pressure of 12.5 psig results in an 11% reduction in gas turbine capacity requiring two additional units. The high drying requirement, with attendant increased electric power and steam usage, accounts for three more units. Accordingly, the power plant capital cost for this alternate is approximately 30% greater than for the base case. The use of standard available equipment does result in an additional 5% power available for sale.

Table 19-4 - POGO Plant Alternate Case 2
Rocky Mountain Coal SRC Yields

Feed/Yield	C	H	N	S	O	Ash	Total
	Composition						
Input, TPD							
MF coal	13,260	940	200	160	3,300	1,600	19,460
H_2O w/coal		60			480		540
H_2		760					760
Total	13,260	1,760	200	160	3,780	1,600	20,760
Output, TPD							
C_1	142	46					188
C_2	282	72					354
C_3	424	96					520
C_4	566	118					684
CO_2	258	-			686		944
CO	6	-			8		14
H_2O	-	248			1,972		2,220
H_2S	-	8		118	-		126
NH_3	-	6	32	-	--		38
Light oil	1,592	276	2	2	32		1,904
Wash solvent	684	90	2	-	18		794
Process solvent	2,852	296	28	4	142		3,322
SRC	5,244	436	98	10	388		6,176
Mineral residue	1,210	68	38	26	534	1,600	3,476
Total	13,260	1,760	200	160	3,780	1,600	20,760

Composition	Light Oil IBP-400	Wash Solvent 400-500	Process Solvent 500-950	SRC 950+	Mineral Residue
C	83.61	86.15	85.85	84.91	34.81
H	14.50	11.33	8.91	7.06	1.96
N	0.10	0.25	0.34	1.59	1.09
S	0.11	-	0.12	0.16	0.75
O	1.68	2.27	4.28	6.28	15.36
Ash	-	-	-	-	46.03
Total	100.00	100.00	100.00	100.00	100.00
HHV, Btu/lb	21,028	19,381	17,686	16,248	5,118
Heat of reaction = -52 Btu/lb AR coal					

19.6 PRODUCTS

The total quantity of products produced in this alternate design is 20% less than the base case production. This is the result of maintaining the same size SRC unit as was included in the base case and decreasing pyrolysis unit size in order to achieve a proper hydrogen balance. The SRC unit capacity could be increased such that, together with a larger pyrolysis unit, an equivalent total production could be realized; this would have resulted in a corresponding increase in the fixed capital investment.

The approximate product slate for this alternative is:

Product	Quantity
Fuels	
SNG	84 MM SCFD
C_3-LPG	8,820 BPD
C_4-LPG	3,330 BPD
Gasoline	32,210 BPD
Fuel oil	20,240 BPD
Power	1,019 MW
Byproducts	
Coke	1,200 TPD
Sulfur	550 TPD
Ammonia	130 TPD

Properties of these products would be similar to those of the base case products which are detailed in Section 7.

19.7 UTILITIES

The major differences between this alternate and the base case utilities requirements are the steam and cooling water usages. This alternate consumes approximately 40% more steam because of the extremely heavy coal drying load. Cooling water usage was eliminated in this alternate because water is scarce in the Rocky Mountain Region. This was accomplished through full utilization of air coolers. The water evaporated in the coal dryers is also recovered for use. After plant operation is achieved the only fresh water required will be a small amount for potable and sanitary use.

Table 19-5 summarizes the utility items sources and consumption areas.

19.8 ECONOMICS

The major economic factors covered in Section 14 were also developed for this alternate. Where major significant differences from the base case were involved, detailed designs were developed. As was appropriate, extrapolations from the base case design and conditions were made.

Table 19-5 - POGO Plant Alternate Case 2
Rocky Mountain Coal
Utility Summary

Unit		Power (kW)	Steam (lb/hr)				Fuel Gas (MM Btu/hr)	Condensate Boiler Feedwater (gpm)	Quench Water (gpm)	Sour Water (gpm)
Number	Description		1,250 psig	625 psig	150 psig	50 psig				
08	Coal mine	(8,000)	-	-	-	-	-	-	-	-
09	Coal preparation	Deleted	-	-	-	-	-	-	-	-
10	Coal storage, grinding, and drying	(38,800)	-	-	-	(3,237,500)	-	6,475	2,500	-
11	Oxygen plant	(103,105)	-	(1,220,800)	-	-	-	2,442	-	-
12	SRC dissolving	(52,015) 14,100	-	297,850	-	15,520	(730)	(646)	-	361
13	SRC atmospheric distillation	(1,300)	-	-	-	(49,830)	(720)	(23)	-	123
14	SRC vacuum distillation	(10,460)	-	-	280,680	(52,200)	(530)	(958)	-	284
15	Pyrolysis	(2,260)	103,840	-	15,930	16,810	-	(281)	-	50
16	Pyrolysis atmospheric distillation	(103)	-	-	(520)	-	-	-	-	
17	Sour gas compression	(1,894)	-	-	-	-	-	-	-	-
18	Process gasification	(852)	293,865	-	-	-	-	(605)[b]	(763)	-
19	Shift conversion	(1,253)	-	(174,810)	-	-	-	-	1,005 (1,280)	-
20	Selective acid gas removal	(9,169)	-	-	(67,850)	-	-	86	-	-
21	Heavy liquids hydrotreating	(18,426)	-	-	(3,600)	-	(238)	(153)	-	191
22	Thermal cracking	(2,253)	-	-	(7,500)	51,750	(414)	(107)	-	20
23	Coking	(1,177)	-	-	-	-	(180)	-	-	-
24	Naphtha hydrotreating	(5,328)	-	-	-	72,350	(32)	(199)	-	43
25	Naphtha reformer	(16,675)	-	-	-	-	(219)	-	-	-
26	Olefinic gas/acid gas removal	(473)	-	-	(2,030)	(45,900)	-	95	-	-
27	Saturate gas/acid gas removal	(1,095)	-	-	(11,790)	(276,540)	-	571	-	-
28	Olefin recovery and polymerization	(442)	(26,840)	(2,920)	(6,210)	(2,350)	(20)	71	-	-
29	Hydrogen recovery and purification	(28,182)	-	(10,650)	-	-	-	-	-	-
30	SNG purification	(23,748)	-	78,780	-	11,600	-	(186)	-	-
31	LPG fractionation	(4,088)	-	(458,000)	-	-	-	916	-	-
32	Sulfur plant	(1,700)	-	-	51,300	26,000	(20)	(159)	-	-
33	Fuel gas generation	(8,154)	1,006,600	34,000	-	-	17,013	(2,074)[b]	-	-
34	Fuel gas/acid gas removal	(16,655)	-	-	(105,500)	-	-	180	-	-
35	Steam and power generation	(20,700) 1,400,300	(5,965,985) 4,588,520	1,652,750	(142,910)[a]	3,708,290	(13,910)	(11,735)	-	-
36	Process waste water treating	(2,745)	-	(196,700)	-	(224,000)	-	841	-	(2,310)
37	Shops and buildings	(10,600)	-	-	-	-	-	-	-	-
38	Firewater system	-	-	-	-	-	-	-	-	-
39	Potable and sanitary water system	(50)	-	-	-	-	-	-	-	-
40	Raw water system	(500)	-	-	-	-	-	5,449	-	-
41	Effluent water treating	(200)	-	-	-	-	-	-	-	-
42	Product storage	(1,500)	-	-	-	(14,000)	-	-	-	-
43	Flare system	(50)	-	-	-	-	-	-	-	-
44	Site preparation, roads, and railroads	500	-	-	-	-	-	-	-	-
45	Treatment and plant air	300	-	-	-	-	-	-	-	-
	Subtotal used	(395,552)								
	Subtotal produced	14,100								
	Export	(1,018,848)								
	Total produced	1,414,400	5,992,825	2,063,380	347,910	3,902,320	17,013	17,126	3,505	2,310
	Total consumed	1,414,400	5,992,825	2,063,380	347,910	3,902,320	17,013	17,126	3,505	2,310

[a] Letdown to 50 psig.

[b] Injection and wash water requirements have been included in the boiler feedwater condensate rates.

NOTE: Quantities in parentheses indicate consumption. Quantities without parentheses indicate production.

19.8.1 FIXED CAPITAL INVESTMENT

The fixed capital investment, tabulated by cost centers, is:

Cost Center	$000
Coal	124
Coal preparation	None
Process plant	1,416
Power plant	588
Offsites	147
Total FCI	2,275

The coal mine estimate was based on a detailed design for a coal mine and associated equipment best suited for this Rocky Mountain Region location.

The process plant and offsite estimates were developed by prorating capital costs for the base case, unit by unit, in accordance with the size and capacity variations dictated by the process heat and material balances serving as the basis for the block flow diagram, Figure 19-1. The estimate for the coal storage, grinding, and drying portion of this cost center was based on a detailed system design.

The power plant estimate is based on a detailed design wherein the specific equipment requirements to produce the required electrical power and steam were specified.

19.8.2 OPERATING COSTS

The operating costs developed for this alternate are:

Cost Center	$000/yr
Coal mine	89.654
Coal preparation	0
Process plant	117.665
Power plant	39.068
Offsites	9.838
Total operating costs	256.225

These costs are based on specific equipment operating and labor costs for the detailed designed coal mine; coal storage, grinding, and drying; and power plant units. The balance was extrapolated from the similar base case units.

Table 19-6 is the manpower summary for this alternate. A total of approximately 2,330 people will be required to operate this alternate.

Table 19-6 - POGO Plant Alternate Case 2
Rocky Mountain Coal, Manpower Summary

Area	Personnel			
	Operating	Maintenance	Administrative	Total
Administration			340	340
Coal mine	518	268		786
Coal preparation				
Process plant	320	560		880
Power plant	155	60		215
Offsites	85	27	—	112
Total	1,078	915	340	2,333

19.8.3 REQUIRED ANNUAL REVENUE

The required annual revenue to achieve a 12% annual discounted cash flow based on 65/35 ratio of loan-to-equity financing at an interest rate of 9% is tabulated below, with corresponding product sales value and value-to-cost ratios:

Required Annual Revenue	$635.6 MM/yr
Possible Annual Sales Value	760.9 MM/yr
Value/Cost Ratio	1.2

The sales value is based on the same product sales values used in the base case economics, Table 14-23, Section 14.

The predicted required average fob product fuel and bus bar power selling prices, after taking credit for coke, sulfur, and ammonia byproducts, are shown in Figure 19-5. Typical price relationships are tabulated below:

Electricity Bus Bar Selling Price (in mils/kWh)	Average Fuel fob Selling Price	
	$MM/Btu	$/Bbl (6 MM Btu/Bbl)
20	3.00	18.00
30	2.50	15.00
40	2.00	12.00

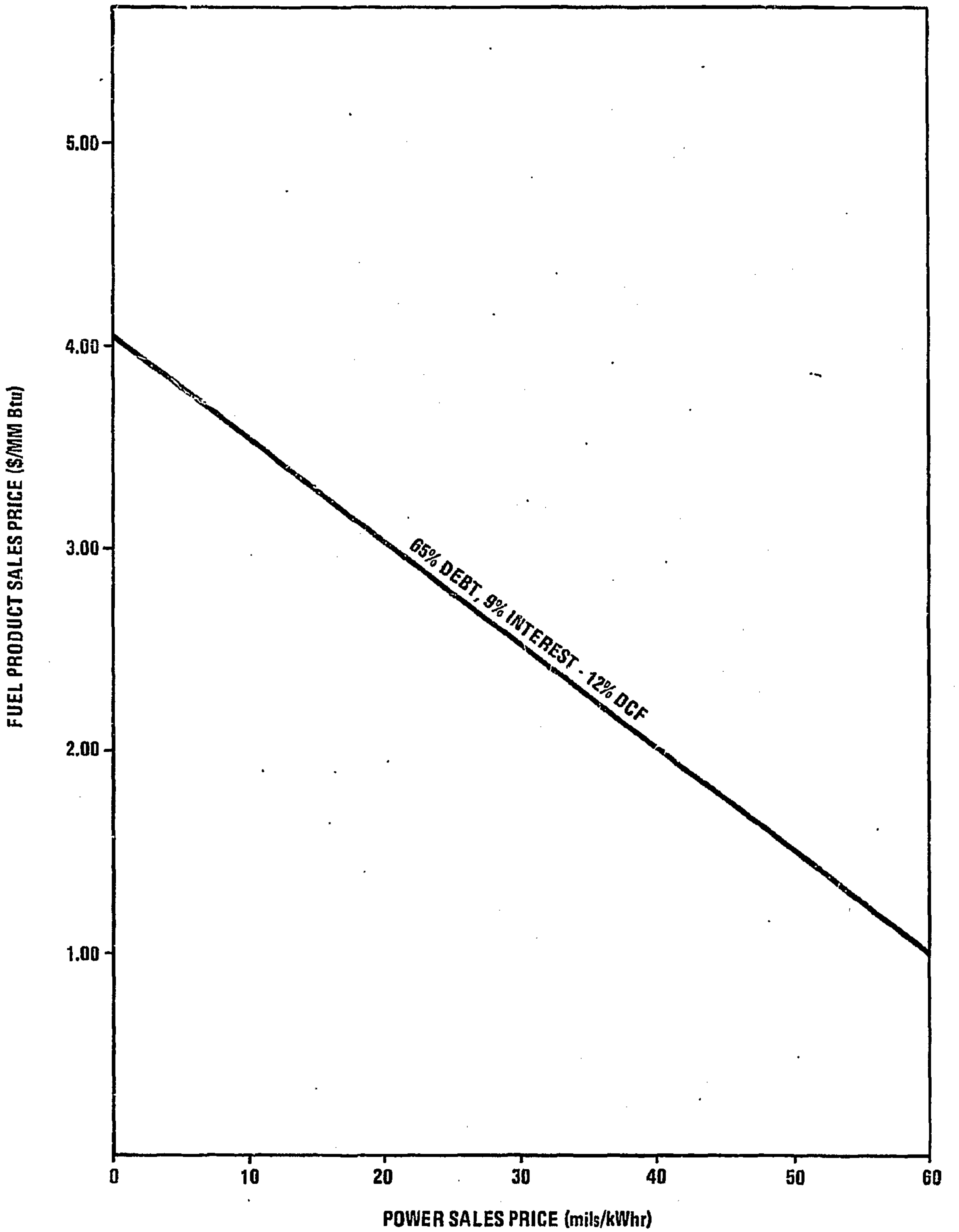


Figure 19-5 - Required Product Selling Price

19.9 SUMMARY AND CONCLUSIONS

A POGO plant with captive mines in the Rocky Mountain Region is indicated to have an economically favorable potential, but not quite as favorable as the base case location. The low cost of the mined coal partly compensates for the increased processing costs.

The work on this alternate is for a conceptual plant. A certain amount of investigatory and pilot plant work on the western coal is required to verify the assumptions used and establish a basis for an accurate plant design. The major areas requiring this would include coal grinding and drying, pressurized flash pyrolysis, two-stage entrainment slagging process gasification operated in conjunction with the pyrolyzer, further SRC hydroliquefaction, heavy liquids hydrotreating, thermal cracking, coking and two-stage pressurized entrainment fuel gas gasification.