5.3 SENSITIVITY CASE I-C: MOBIL FLUID-BED TECHNOLOGY

5.3.1 Material Balance

The overall material balance is shown below:

Input	M lb/hr
Coal, as mined	2,277.8 (1)
Air	5,862.6
Water	2,981.5
	11,121.9

Output	M lb/hr
Coal fines (excess)	137.8 (2)
Ash	138.3
Products	529.9 (3)
Byproducts	13.7
Blowdown water	781.7
Stack and evaporation losses	9,520.5
	11,121.9

(1) 27,334 T/SD

(2) 1,654 T/SD

(3) 45,560 FOE Bbl/SD @ 6.0 MM Btu/FOE Bbl

Overall plant consumptions per FOE barrel of product are:

Coal:	0.564	T
Water:	4.49	Bbl
Air:	1.54	T

Stack and evaporation losses amount to about 2.5 tons per FOE barrel of product. The barrels of methanol feed required to yield a barrel of 10 RVP gasoline (without the Lurgi gasifier naphtha) is 2.33.

The overall plant performance is slightly superior when shifting to fluid-bed operation.

5.3.2 Product Yields and Quality

Stream numbers are shown below for reference to BFD ZO-GEM-7038.

(a) SNG (49)

Quantity	16,756 lb-mol/hr
	270.7 M lb/hr
	152.6 MMSCF/SD

Composition (Only compounds greater than 0.1% are listed.)

	Percent
Hydrogen	1.8
Methane	95.9
Carbon dioxide	0.5
Inerts (N_2 + Ar)	1.8
	100.0

Other

Heat of combustion	
HHV	976 Btu/SCF
LHV	878 Btu/SCF
Carbon monoxide (0.1% max)	0.02%
Water	0.01%
Sulfur	None

Compatibility Indexes (versus pure methane)

Index	Calculated	Preferable	Objectionable
Lifting, I_l	1.03	under 1.0	above 1.06
Flash-back, I_f	1.02	under 1.15	above 1.2
Yellow-tip, I_y	1.06	above 1.0	under 0.8

The SNG product is of satisfactory quality and is interchangeable with pure methane.

Its composition and properties differ only slightly from those for the SNG produced in Base Case I.

(b) Gasoline (50)

Quantity	23,065 Bbl/SD 246.1 Mlb/hr

Blending

Component	Wt. %
Mixed Butanes	2.3
Alkylate	24.6
Stabilized gasoline	66.8
Hydrotreated gasifier naphtha	6.3
	100.0

Properties

Estimated properties of the unleaded gasoline are presented in Table 5.3.1. (Gasoline specifications are listed in Table 3.2.2.)

Alkylation of the C_3 and C_4 olefins reduces the iso-butane to such a low net yield that the Reid Vapor Pressure of the blended gasoline is only 9.4 psig, falling slightly short of the 10 RVP target. To make 10 RVP, an additional 285 Bbl/SD of n-butane is estimated to be required.

The fluid-bed operation yields less stabilized gasoline and more alkylation feed stock than the fixed-bed operation, resulting in a higher final gasoline yield, 23,065 vs. 22,045 B/SD, and a more paraffinic final gasoline, 63 vs. 51%. The motor octane of the fluid-bed gasoline is two numbers higher. In addition, its durene content is much lower at 2.3 wt. %. Thus, the fluid-bed gasoline is of excellent quality and slightly superior to the Base Case I, or fixed-bed, gasoline.

(c) Mixed Butanes (103)

Quantity	0 Mlb/hr

All the butanes are used in alkylation and pressuring the gasoline.

TABLE 5.3.1
ESTIMATED GASOLINE PROPERTIES FOR
SENSITIVITY CASE I-C: MOBIL FLUID-BED TECHNOLOGY

	Estimated Unleaded Properties
Gravity, °API	61.8
Octane Numbers	
Research	93
Motor	85
(Research + Motor)/2	89
Volatility	
Reid Vapor Pressure, lb	9.4*
Distillation, °F	
IBP	87
10%	111
30%	152
50%	216
70%	259
90%	341
EP	404
V/L Ratio (=20), °F	@ 132
Sulfur, wt. %	nil
Composition, vol. %	
Paraffins	63
Olefins	6
Naphthenes	5
Aromatics	26
Durene Content, wt. %	2.3
Molecular Weight	96

* Target = 10.0 RVP

(d) Propane LPG (102)

Quantity	1,790 B/SD 13.1 Mlb/hr

Properties

Estimated properties are as follows:

Vapor pressure at 100°F, psig	180*
Butane and heavier, Vol. %	1.2

*Commercial specifications are given in Table 3.2.3.

This product is a satisfactory commercial propane fuel.

(e) Byproducts

Sulfur (29)	61 T/SD
Ammonia (17)	103 T/SD
Excess Power	-0.08 MW(e) (required)

(f) Coal Fines (2.1) 137.8 Mlb/hr

(g) Comparison with Base Case I

Methanol conversion in a fluid-bed yields a higher percentage of light hydrocarbons. Consequently, more product ends up in SNG, thereby increasing the SNG yield from 53.3 to 54.5 percent of the hydrocarbon thermal yield. On the other hand, the C_3 and C_4 mix of iso-butane and olefins enables greater use of alkylation to increase the percentage of gasoline from 41.2 to 43.0 percent. The LPG yield is reduced from 5.5 to 2.5 percent.

The total weight of hydrocarbon yield is slightly lower by 1.0 Mlb/hr, principally, due to the disposition of the offgases from methanol conversion. In fixed-bed operation, they are blended into the SNG train after methanation. Because of the increased H_2 and CO content in fluid-bed operation, they are added before methanation. Consequently, water is formed and a SNG weight loss occurs.

TABLE 5.3.2
SENSITIVITY CASE I-C - THERMAL EFFICIENCY

	Quantity, Unit/SD	High Heating Value (HHV)	Total HHV, MMBtu/hr	Percent of Input
Input				
Coal, DAF	18,286 T	12,720 Btu/lb	19,383	
Fines (excess)	(1,106 T)	" "	(1,172)	
Net Coal	17,180	" "	18,211	
Power (required)	0.08 MW(e)	3,415 Btu/kwh*	nil	
Total			18,211	
Output				
SNG	152.6 MMSCF	976 Btu/SCF	6,206	34.1
C_3 LPG	1,790 Bbl	3.793 MMBtu/Bbl	283	1.5
C_4 LPG	0	-	-	
10 RVP Gasoline	23,065 Bbl	5.100 MMBtu/Bbl	4,901	26.9
Sub-Total			11,390	62.5
Sulfur	61 T	3,780 Btu/lb	19	0.1
Ammonia	103 T	9,693 Btu/lb	83	0.5
Total			11,492	63.1

*Direct thermal conversion used.

5.3.3 Thermal Efficiency

The overall plant thermal efficiency (HHV) is shown in Table 5.3.2. The fluid-bed methanol conversion technology is slightly more efficient, about 1%, than the fixed-bed technology. It arises not only because of marginally improved yields, but because of less HP steam required - large fixed-bed recycle compressor eliminated - and 550 psig steam generation in the fluid-bed unit.

5.3.4 Processing Description (BFD ZO-GEM-7038)

The introduction of a fluid-bed reactor results in only very minor changes in the block flow diagram, i.e., (1) elimination of fuel gas stream 101 to Unit 150, (2) shifting of Unit 150 steam yield stream to the 571 psig steam header, (3) slightly different handling of the light gas yield in and out of Units 150 and 152, and (4) elimination of stack gas stream 108.

One large fluid-bed reactor, instead of six fixed-bed reactors, is the nucleus of Methanol Conversion Unit 150. The projected operating temperature and pressure are 750°F and 40 psig, respectively. The conceptual reactor design used in this study includes internal baffles and an outside catalyst flow leg to insure intimate catalyst/methanol mixing. To absorb the heat of reaction, the feed is 100 percent liquid. Current on-going pilot plant studies are indicating that for better operation, vapor feed should be used with temperature control via internal steam generation coils. A small recycle stream may also be required. A slipstream of catalyst is continuously removed and regenerated in a separate regeneration vessel. For catalyst activity control, the coke level of the regenerated catalyst is maintained at about 12 wt. %. The reactor effluent cooling system is somewhat more complex for catalyst fines recovery and return to the reactor. The yields, summarized in Appendix C, are based on work completed under DOE Contract No. E(49-18)-1773(2). The development of the fluid-bed technology continues under pilot plant DOE Contract No. EX-76-C-01-2490.

In Fractionation Unit 152, a deethanizer absorber is employed in place of the Base Case I high-pressure deethanizer tower. The light gas overhead is split into a recycle stream to Unit 150 for increasing the C_3 plus yield via additional ethylene reaction, a fuel gas stream and an SNG stream. In addition, a rich oil tower is required to produce a lean stream for recycle. Other than size shifts, Alkylation Unit 153 and Gasoline Blending Unit 154 are identical to those used in Base Case I.

5.3.5 Capacities of Process and Offsite Units

The following is a list of the process and offsite unit capacity ratios with Base Case I equaling 100 percent.

Unit	Name	Ratio, %
101 thru 111	Gasification et al	100
112	Methanation	100
113	CO_2 Removal	103 (gas flow)
114	SNG Drying	103 (gas flow)
121	Oxygen Production	100
122/123	Boiler/Superheater	92
124	Superheater	104 (heat fired)
125/126	Stackgas Precipitator & Clean-Up	95 (gas flow)
127	Instrument & Plant Air	100
128/129	Coal & Ash Handling	100
131/1	BFW Deaerator	97
131/2	BFW Demineralizer	100
132	CW Make-Up Preparation	96
133	CW Towers	96
134	Electric Power Generation	94
135	Waste Water	100
136	Relief and Blow Down Facilities	97
137	Storage	*
138	Interconnecting Piping	100
141	Refrigeration	100
150	Methanol Conversion (Fluid-Bed)	100 (methanol feed)
151	Naphtha Hydrotreating	100
152	Fractionation	100 (3 tower system)
153	Alkylation	800 (alkylate yield)
154	Gasoline Blending	105

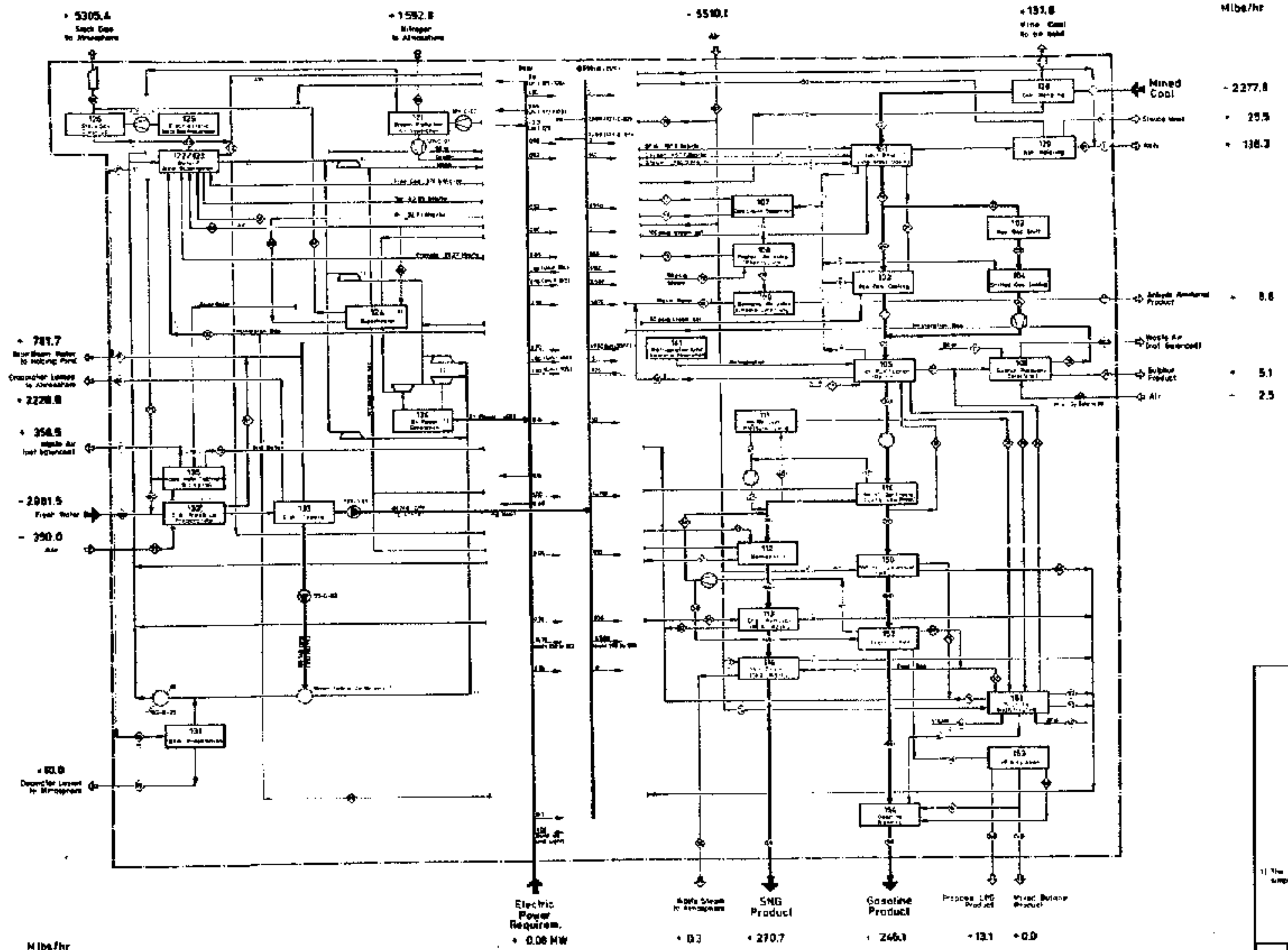
*Storage adjustments:

C_3 LPG (15 days)	29,000 Bbl (pressure)
C_4 LPG	Delete
Gasoline (15 days)	378,000 Bbl (floating roof)

All other storage remains the same as for Base Case I.

5.3.6 Steam Balance (as related to Base Case I)

The elimination of the large recycle compressor for the fixed-bed Unit 150 and the generation of 550 psig steam in the fluid-bed Unit 150 reduces slightly Boiler/Superheater Units 122/123 heat duties, thereby releasing more coal fines for sales. The elimination of LP steam generation in Unit 150, however, reduces the amount of electric power generated.



1) The steam/BFW circuit of the complex is shown simplified

GEM 00-C855		LURGI
BLOCK FLOW DIAGRAM COAL TO GASOLINE CONV (FLUID BED) VIA METHANOL SENSITIVITY CASE I-C		ZO-GEM-7038

5.4 SENSITIVITY CASE I-D: SECOND GENERATION GASIFIER

As stipulated in the contract, the data for the second generation gasifier sensitivity case were to have been provided by DOE. Subsequently, DOE advised that they were having difficulty in obtaining the necessary proprietary gasifier data. As a consequence, MHDC contacted Davy Powergas, Inc. of Lakeland, Florida, to determine if they would provide data on the Winkler pressure fluid-bed gasifier, a second generation gasifier currently under development in Germany, for use in a sensitivity case. Davy Powergas offered to provide Winkler data without any fee. However, Davy requested to review the portions of the report dealing with the Winkler process. Davy Powergas subsequently provided an equipment list, process flow diagrams, gasifier feed data, syn gas yield and composition, utility requirements, and an investment estimate.

A sensitivity case has been developed around these data. However, in developing the case, it became evident that it would be unrealistic to integrate the Winkler gasifier into a plant complex based on the yields and process parameters of the Lurgi gasifier. Briefly, problem areas include syngas of different composition, smaller purge gas streams, large production of char, and the different gasifier temperature and pressure levels. Integrating these process variations directly into the Lurgi process scheme did not allow proper optimization of equipment, purge gas utilization, and waste heat recovery. A sensitivity case using the advanced gasifier requires developing the plant complex in the same detail as for the Lurgi base case. Such a case is entirely beyond the current scope of work. A Davy Powergas review of the work confirms the problem areas discussed above, and makes concrete suggestions to improve the process. Consequently, the second generation sensitivity will not be reported here.

The sensitivity for using second generation gasifiers should be done in a separate study and in the same depth that this study was performed. The study could cover the high pressure Winkler, the Texaco Partial Oxidation gasifier, the slagging Lurgi, and other promising gasifiers and would provide guidance toward the development of the entire coal-to-gasoline process.

5.5 SENSITIVITY CASE II-A: MOBIL DIRECT SYNGAS CONVERSION

5.5.1 Material Balance

The overall material balance is shown below:

Input	Mlb/hr
Coal, as mined	2,277.8 (1)
Air	6,917.5
Water	3,306.2
Other	3.2
	12,504.7

Output	Mlb/hr
Coal Fines (excess)	28.0 (2)
Ash	144.4
Products	522.0 (3)
Byproducts	13.7
Blowdown water	840.3
Stack and evaporation losses	10,953.8
Other	2.5
	12,504.7

(1) 27,334 T/SD

(2) 336 T/SD

(3) 45,650 FOE Bbl/SD @ 6.0 MM Btu/FOE Bbl

Overall plant consumptions per FOE barrel of product are:

Coal:	0.591 T
Water:	4.96 Bbl
Air:	1.82 T

Stack and evaporation losses amount to about 2.9 tons per FOE barrel of product.

Product yield, overall consumptions and stack emissions show an improvement over those obtained for the Fischer-Tropsch technology in Base Case II.

5.5.2 Product Yields and Quality

Stream numbers are given below for reference to BFD ZO-GEM-7040.

(a) SNG (49)

Quantity

	19,530 lb-mol/hr
	323.0 Mlb/hr
	177.9 MMSCF/SD

Composition (Only compounds greater than 0.1% are listed.)

	Percent
Hydrogen	1.5
Methane	93.9
Ethene	0.2
Ethane	2.1
Propene	0.1
Propane	0.2
Carbon dioxide	0.4
Inerts (N_2 + Ar)	1.6
	100.0

Other

Heat of combustion	
HHV	1,002 Btu/SCF
LHV	902 Btu/SCF
Carbon monoxide (0.1% max.)	0.1%
Water	0.01%
Sulfur	None

Compatibility Indexes (versus pure methane)

Index	Calculated	Preferable	Objectionable
Lifting, I_l	1.02	Under 1.0	Above 1.06
Flash-back, I_f	1.03	Under 1.15	Above 1.2
Yellow-tip, I_y	1.02	Above 1.0	Under 0.8

The SNG product is of satisfactory quality and is compatible with pure methane. Its composition approaches the composition of the Base Case I SNG in that the methane content is over 90% and the olefin content is a low 0.3%.

(b) Gasoline (50)

Quantity 17,485 B/SD
186.6 Mlb/hr

Blending

Component	Wt. %
Mixed butanes	2.5
Alkylate	5.1
Hydrotreated gasifier naphtha	8.2
Stabilized gasoline	84.2
	100.0

Properties

Estimated properties of the unleaded gasoline are presented in Table 5.5.1 (Gasoline specifications are listed in Table 3.2.2).

The gasoline formulation is quite similar to that in Base Case I. Its composition and properties are approximately in between those of the base case gasolines and make a satisfactory commercial motor fuel.

(c) Mixed Butanes (139)

Quantity 0 Mlb/hr

All the butanes are used in alkylation and pressuring the gasoline.

(d) Propane LPG (138)

Quantity 1,675 Bbl/SD
12.4 Mlb/hr

Properties

Estimated properties are as follows:

Vapor pressure at 100°F, psia	178*
Butane and heavier, vol. %	0.7

*Commercial specifications are given in Table 3.2.3.

This product is a satisfactory commercial propane fuel.

TABLE 5.5.1
ESTIMATED GASOLINE PROPERTIES FOR
SENSITIVITY CASE II-A: MOBIL DIRECT ROUTE

	Estimated Unleaded Properties
Gravity, ^{o}API	61.8
Octane Numbers	
Research	92.5
Motor	82.5
(Research + Motor)/2	87.5
Volatility	
Reid Vapor Pressure, lb	10.2
V/L Ratio (=20), ^{o}F	estimated satisfactory
Sulfur, wt. %	nil
Composition, vol. %	
Paraffins	54
Olefins	18
Naphthanes	7
Aromatics	21
Molecular Weight	93

(e) Byproducts

Sulfur (29)	61 T/SD
Ammonia (17)	103 T/SD
Excess Power	-1.01 MW(e) (required)

(f) Coal Fines (2.1) 28.0 Mlb/hr

(g) Comparison with Base Cases

Converting to a FOE barrel, the direct route has a liquid product yield slightly greater than that for the Fischer-Tropsch technology, 45,650 vs. 44,950 Bbl/SD. Product selectivity, however, is improved as shown below by a comparison of the hydrocarbon product distributions on a thermal, or Btu, basis.

Hydrocarbon Product Thermal Yields

Case	I	II	II-A
SNG, %	53	65	65
Gasoline, %	41	25	33
Gasoline, Bbl/SD	22,045	13,580	17,485
Other, %	6	10	2
Total Product, % of input	61.5	57.0	59.6

The direct conversion technology results in a 3 percent improvement in the hydrocarbon yield over Base Case II, but it fails to achieve the Base Case I yield by 2 percent. Although there is a significant increase in the gasoline yield, about 28%, for the sensitivity case over its base case, it falls short by about 28 percent (4,560 Bbl/SD) of equaling the yield for Base Case I. Although more selective in yielding gasoline, the direct conversion technology, however, does not show a reduction in the SNG yield.

5.5.3 Thermal Efficiency

The overall plant thermal efficiency (HHV) is shown in Table 5.5.2. The direct syngas conversion technology yields a 2 to 3 percent efficiency improvement over the F-T technology. It falls about half-way between the two base cases. This improvement is realized, in 70/30 ratio, by a lower coal input and a higher product yield.

TABLE 5.5.2
SENSITIVITY CASE II-A - THERMAL EFFICIENCY

	Quantity, Unit/SD	High Heating Value (HHV)	Total HHV, MMBtu/hr	Percent of Input
Input				
Coal, DAF	18,286 T	12,720 Btu/lb	19,383	
Fines (excess)	(225 T)	" "	(238)	
Net Coal	18,061 T		19,145	
Methanol	8 T	9,724 Btu/lb	7	
Power (required)	1.01 MW(e)	3,415 Btu/kwh	3	
Total			19,155	
Output				
SNG	177.9 MMSCF	1,002 Btu/SCF	7,427	38.8
C_3 LPG	1,675 Bbl	3,822 MMBtu/Bbl	267	1.4
C_4 LPG	0	--	--	--
10 RVP Gasoline	17,485 Bbl	5,105 MMBtu/Bbl	3,719	19.4
Sub-Total			11,413	59.6
Sulfur	61 T	3,780 Btu/lb	19	0.1
Ammonia	103 T	9,693 Btu/lb	83	0.4
Total			11,515	60.1

5.5.4 Processing Description (BFD ZO-GEM-7040)

The development of the direct syngas conversion technology is currently in progress under the DOE Contract EX-76-C-01-2276. The product selectivity and properties used are extrapolations, or targets, of recent (July, 1977) laboratory data. The resultant yields are given in Appendix C. Also, there is insufficient data upon which to make a scoping reactor design. Consequently, the Fischer-Tropsch reactor, Unit 250, of Base Case II is used directly. The product recovery and upgrading units are modified to fit the target yields and properties.

As with the F-T technology, a large gas stream containing unreacted H_2 and CO, inerts, methane and conversion products is sent from Conversion Unit 250 to HC Recovery Unit 210. In this unit, SNG precursors and liquid hydrocarbons are separated, with the latter going to Fractionation Unit 252.

Since the reaction product has been estimated to be very similar to the one obtained in the methanol conversion technology, product recovery and upgrading is much simplified over Base Case II. Thus, only Fractionation Unit 252 and HF Alkylation Unit 258 have been retained and the following units have been deleted:

F-T Product Hydrotreating Unit 253
Hydrotreated Product Fractionation Unit 254
Catalytic Reforming Unit 255
C_5/C_6 Isomerization Unit 256
Catalytic Polymerization Unit 257
Poly Gasoline Hydrogeneration Unit 259
Light Ends Recovery Unit 260
H_2 Purification Unit 261
Alcohol Recovery Unit 262

Fractionation Unit 252 is a 3-tower system: deethanizer absorber, debutanizer and lean oil regenerator. The light gases are used as process heater fuel with the excess being added to the SNG train. The debutanizer overhead is the feed to Alkylation Unit 258. Other than size shifts, Unit 258 and Gasoline Blending Unit 270 are identical to those used in Base Case I. Catalyst Preparation Unit 271 has been eliminated.

5.5.5 Capacities of Process and Offsite Units

The following is a list of the process and offsite capacity ratios with Base Case II equaling 100 percent.

Unit	Name	Ratio, %
201 thru 209	Gasification et al	100
210	Hydrocarbon Recovery	120
211	H_2 Recovery	100 (H_2 yield)(2)
212	Methanation	103
213	CO_2 Removal	100
214	SNG Drying & Compression	103 (gas flow)
221	Oxygen Production	100
222/223	Boiler/Superheater	88 (steam flow)
224/1 & 2	Superheater	517
225/226	Stackgas Precipitator & Clean-Up	91 (gas flow)
227	Instrument & Plant Air	100
228/229	Coal & Ash Handling	100(2)
231/1 & 2	BFW Deaerator & Demineralizer	100
232	CW Make-Up Preparation	100
233	CW Towers	100
234	Electric Power Generation	99
235	Waste Water Treatment	97
236	Relief and Blow Down Facilities	100
237	Storage	(1)
238	Interconnecting Piping	100
241	Refrigeration Unit	107
250	Conversion Reactor	100 (gas flow)
251	Naphtha Hydrotreating	100
252	Product Fractionation	New Design
253 thru 257	Product Upgrading	0
258	HF Alkylation	126 (alkylate)(2)
259 thru 262	Product Upgrading	0
270	Gasoline Blending	79 (2)
271	Catalyst Preparation	0

(1) Complete storage is as follows:

Product (15 days)

Ammonia	1,700 T (refrigerated)
Sulfur	1,000 T (covered)
Gasoline	288,000 Bbl (floating roof)
C_3 LPG	20,000 Bbl (pressure)

Intermediate (15 days)

Unit 251 feed	22,000 Bbl (floating roof)

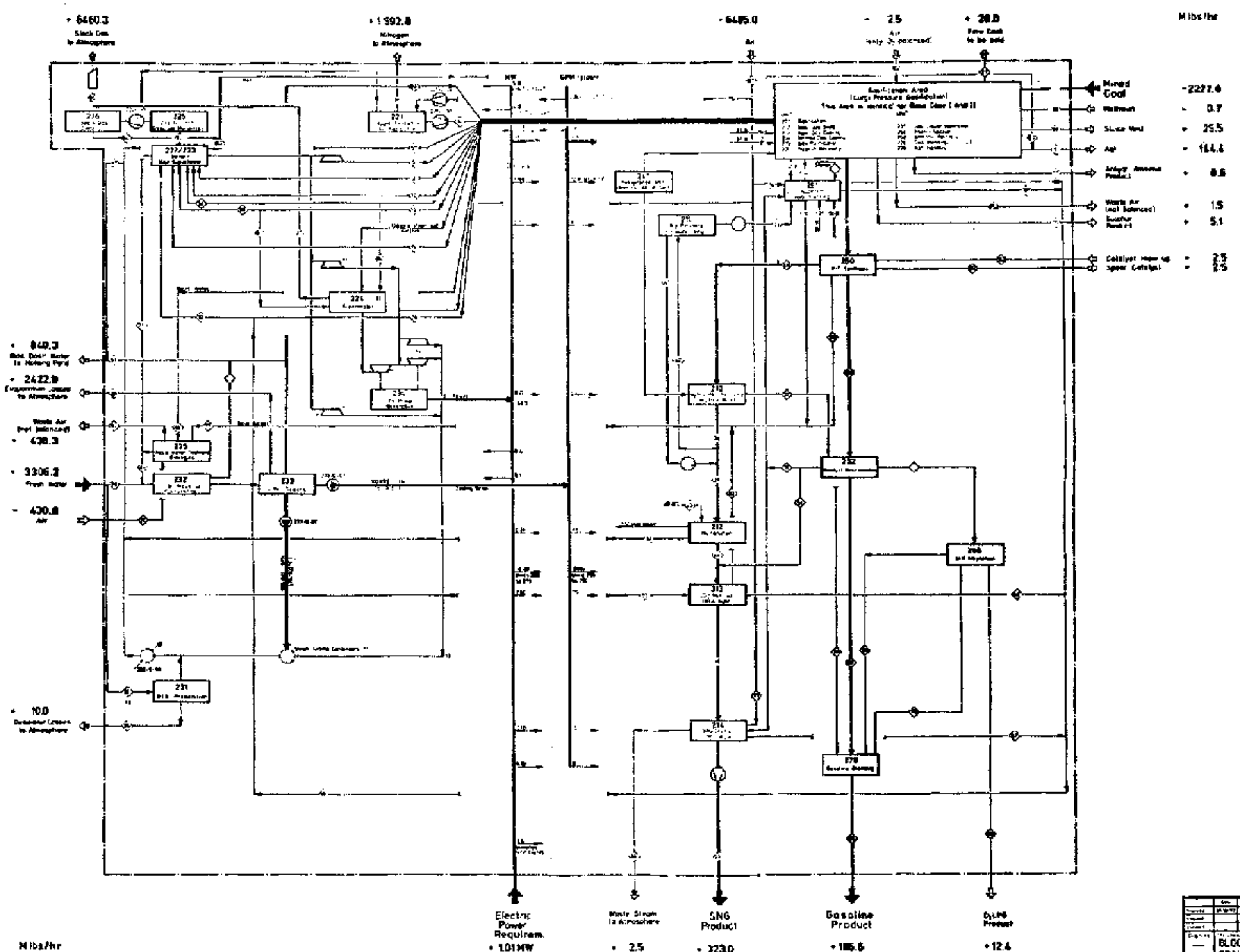
Chemical

Diisopropyl ether	1,500 Bbl
Methanol	2,300 Bbl

(2) Basis is 100% Base Case I.

5.5.6 Steam Balance (as related to Base Case II)

The deletion of the MP steam users (F-T upgrading units) reduces the need for MP steam generation from HP steam. Thus, the boiler size is significantly reduced releasing fines for sales.



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BLOCK FLOW DIAGRAM
COAL TO GASOLINE CONV.
VIA DIRECT ROUTE
SENSITIVITY CASE II A

ZO-GEM-7060

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SECTION 6

COST ESTIMATION

6.1 INVESTMENT

6.1.1 Bases

The bases for the investment estimates are outlined below:

(a) Pricing for equipment and material reflect October, 1977 costs. No escalation beyond October has been included.

(b) Direct labor unit rates used are based on Gulf Coast 1970, adjusted to represent the Gillette, Wyoming area for October, 1977. An overall weighted average wage rate of $11.38 per manhour, excluding fringes and burden, for a 40 hour week is used. The Wyoming labor productivity factor for October, 1977 has been estimated to be 1.63 times Gulf Coast 1970. No escalation beyond October has been included.

(c) Field indirect costs have been based on 110 percent of direct field labor costs.

(d) Freight on equipment and materials has been estimated at 6 percent.

(e) Home office (engineering + design) costs have been set at 11.5 percent of the field construction costs.

(f) Camp costs for construction labor equal 6 percent of the contractor cost. From experience, monies are required to establish suitable living conditions for the construction workers in remote, non-industrial areas, such as the Wyoming coal fields.

(g) Overtime premium of double-time pay for 14 hours per week is included. In order to attract the necessary large numbers of construction workers to this isolated site, a 54 hour work week has been projected. (Depending upon the construction environment assumed, the base work week could range from 45 to 60 hours.)

(h) Estimating allowance at 15 percent is used. This allowance is required to obtain an 80 percent probability for the cost estimate to be within ± 20 percent of the <u>actual</u> cost of the project.

(i) Sales tax of 3 percent of the material cost is included.

(j) Other items included are: contractor fee, capitalized spare parts, process unit data logger, project management cost, builder's all-risk insurance premium, catalyst and chemical cost, and paid-up royalties.

An allowance of two million dollars for environmental studies and impact reports has been added to the first two years of the project.

Catalysts estimated to have lives greater than 2 years are capitalized.

The following items have been excluded:

a. Land or land rights
b. Escalation
c. Special foundation conditions
d. Tie-ins outside of plant area required for road, railroad, water supply, power and pipelines
e. Catalyst and royalties for Mobil methanol conversion and Mobil direct route technologies
f. Royalty for Fischer-Tropsch technology

In our opinion, the bases adopted above will yield more complete and realistic plant investment estimates than those delineated in the Gas Cost Guidelines.

6.1.2 Base Cases

The total plant investments for the base cases are estimated to be:

	MM $
Base Case I -	1,732
Base Case II-	1,887

The difference is less than 10 percent, or within the ± 20% accuracy of the cost estimate. Detailed breakdowns of the plant investments are shown in Tables 6.1.1 and 6.1.2.

The field construction costs for the individual process and offsite units are given in Tables 6.1.3 and 6.1.4. A summary comparison is as follows:

Base Case	Field Construction Costs, MM$ I	II
Process Units		
Gasification et al	430	430
Gasoline, etc., Production	132	180
SNG Production	26	26
Sub-Total	588	636
Offsite Units		
Oxygen Facilities	110	110
Steam Facilities	126	148
Water Facilities	68	76
Catalyst Preparation	0	28
Other	146	142
Sub-Total	450	504
Infrastructure	46	46
Total	1,084	1,186

The above comparison emphasizes the difficulty in using the total plant investment when comparing technical changes in only one sector of the plant complex. Again, the total cost comparison shows Base Case I to have less than a 10 percent improvement over Base Case II. When comparing those investments related to the gasoline production sector only, the Mobil methanol technology, however, shows a significant 36% reduction in the investment over that required by the Fischer-Tropsch technology. Moreover, a partial offsite breakdown also shows an investment saving of about 30 percent.

6.1.3 Sensitivity Cases

The total plant investments for the sensitivity cases are estimated to be:

Sensitivity Case	MM $
I-A	1,587
I-B	1,986
I-C	1,680
II-A	1,727

TABLE 6.1.1
PLANT INVESTMENT BREAKDOWN - BASE CASE I

	Investment, MM $
Depreciable Capital	
Process Units	588
Offsite Units	450
Infrastructure	46
Sub-Total, Field Construction Cost	1,084
Engineering & Design	125
Sub-Total	1,209
Contractor Fee	14
Sub-Total, Contractor Cost	1,223
Other Project Costs	
Capitalized Spare Parts	4
Process Unit Data Logger	3
Construction Workers' Camp	73
Overtime Premium	134
Project Management	31
Builder's All-Risk Insurance	3
Sub-Total	1,471
Estimating Allowance	220
Sub-Total	1,691
Catalyst	0
Royalties	17
Total Depreciable Capital	1,708
Expense Capital	
Sales Tax	16.5
Catalyst & Chemicals	6.0
Environmental Studies & Impact Reports	2.0
Total Expense Capital	24.5

TABLE 6.1.2
PLANT INVESTMENT BREAKDOWN - BASE CASE II

	Investment, MM $
Depreciable Capital	
Process Units	636
Offsite Units	504
Infrastructure	46
Sub-Total, Field Construction Cost	1,186
Engineering & Design	136
Sub-Total	1,322
Contractor Fee	16
Sub-Total, Contractor Cost	1,338
Other Project Costs	
Capitalized Spare Parts	4
Process Unit Data Logger	3
Construction Workers' Camp	80
Overtime Premium	147
Project Management	33
Builder's All-Risk Insurance	3
Sub-Total	1,608
Estimating Allowance	242
Sub-Total	1,850
Catalyst	0
Royalties	13
Total Depreciable Capital	1,863
Expense Capital	
Sales Tax	18.5
Catalyst & Chemicals	3.0
Environmental Studies & Impact Reports	2.0
	23.5

TABLE 6.1.3
UNIT INVESTMENT BREAKDOWN - BASE CASE I

Unit No.	Description	Field Construction Cost, MM $
Process Units		
101	Gasification	200.7
102	Raw Gas Shift	12.8
103	Raw Gas Cooling	13.3
104	Shifted Gas Cooling	6.0
105	Gas Purification	71.7
106	Sulfur Recovery	59.0
107	Gas Liquor Separation	18.6
108	Phenol Recovery	14.0
109	Ammonia Recovery	18.8
110	Methanol Synthesis	54.4
111	H_2 Recovery	2.6
112	Methanation	18.0
113	CO_2 Removal	6.8
114	SNG Drying	0.5
150	Methanol Conversion	59.4
151	Naphtha Hydrotreating	3.7
152	Fractionation	3.2
153	HF Alkylation	3.5
	Miscellaneous (Control House, Pipe Rack)	21.0
	Sub-Total	588.0
Offsite Units		
121	Oxygen Production	110.1
122, 123, 125 & 126	Boiler, Main Superheater, Stackgas Precipitator and Clean-Up	122.1
124	Superheater	3.6
127	Instrument and Plant Air	0.6
128	Coal Handling	63.3
129	Ash Handling	5.6
131	BFW Preparation	16.6
132	CW Make-Up Preparation	0.5
133	CW Towers	20.0
134	Power Generation	10.3
135	Waste Water Treatment	25.4
136	Blow-Down Facilities	2.6
137	Storage	22.5
138	Interconnecting Piping	20.4
141	Refrigeration	20.8
154	Gasoline Blending	1.7
	Miscellaneous (Water Ponds, Misc. Tankage)	3.4
	Sub-Total	449.5
Infrastructure (See Paragraph 1.6.)		46.4
Total		1,083.9

TABLE 6.1.4
UNIT INVESTMENT BREAKDOWN - BASE CASE II

Unit No.	Description	Field Construction Cost, MM $
Process Units		
201	Gasification, Shift, Cooling	
to	Purification & Recovery -	
209	Same as Base Case I	414.9
210	Hydrocarbon Recovery	19.4
211	H_2 Recovery	8.8
212	Methanation	12.0
213	CO_2 Removal	9.2
214	SNG Drying & Compression	3.1
250	F-T Synthesis	76.4
251	Naphtha Hydrotreating	3.7
252	F-T Product Fractionation	14.5
253	F-T Product Hydrogenation	6.6
254	Hydrotreated Product Fractionation	3.8
255	Catalytic Reforming	7.3
256	C_5/C_6 Isomerization	5.3
257	Catalytic Polymerization	4.1
258	HF Alkylation	2.2
259	Poly Gasoline Hydrogenation	2.4
260	Light Ends Recovery	2.2
261	H_2 Purification	2.7
262	Alcohol Recovery	11.0
	Miscellaneous (Control House, Pipe Rack)	26.6
	Sub-Total	636.2
Offsite Units		
221	Oxygen Production	110.1
222,223,	Boiler, Main Superheater,	
225 & 226	Stackgas Precipitator and Clean-Up	146.6
224	Superheater	1.6
227	Instrument and Plant Air	0.6
228	Coal Handling	65.6
229	Ash Handling	5.8
231	BFW Preparation	20.6
232	CW Make-Up Preparation	0.5
233	CW Towers	23.3
234	Power Generation	10.6
235	Waste Water Treatment	26.3
236	Blow-Down Facilities	2.7
237	Storage	8.6
238	Interconnecting Piping	20.4
241	Refrigeration	27.1
270	Gasoline Blending	2.0
271	F-T Catalyst Preparation	27.7
	Miscellaneous (Water Ponds, Misc. Tankage)	3.4
	Sub-Total	503.5
Infrastructure (See Paragraph 1.6.)		46.4
Total		1,186.1

Abbreviated investment breakdowns are given in Table 6.1.5. For comparison, the base case breakdowns are also included. The effect on plant investment brought about by the technical sensitivity change is readily apparent: for example, (1) the lower gasoline production sector investment for the fluid-bed, versus fixed-bed, operation in the Mobil methanol conversion technology, (2) the increased investments required when shifting to a gasoline-only plant production mode of operation, and (3) the potential of the Mobil direct route technology to have a plant investment comparable to one for the Mobil methanol conversion technology.

New Unit investment costs (as defined in Tables 6.1.3 and 6.1.4) for the sensitivity cases are:

Sensitivity Case	Unit	Plant Construction Cost, MM $
I-A	115 - Methanol Distillation	6.6
I-B	116 - Autothermal Reforming	36.5
I-C	150 - Methanol Conversion (Fluid-Bed)	20.5
	152 - Fractionation	11.3
II-A	250 - Direct Conversion	72.4
	252 - Fractionation	5.8

TABLE 6.1.5
INVESTMENTS FOR SENSITIVITY CASES

Case	Base I	Sensitivity I-A	Sensitivity I-B	Sensitivity I-C	Base II	Sens. II-A
Depreciable Capital, MM $						
Process Units						
Gasification et al	430	430	467	430	430	430
Gasoline Production	132	70*	206	105	180	119
SNG Production	26	26	0	26	26	26
Sub-Total	588	526	673	561	636	575
Offsite Units						
Oxygen Facilities	110	110	145	110	110	110
Steam Facilities	126	116	148	120	148	139
Water Facilities	68	61	71	65	76	73
Catalyst Preparation	0	0	0	0	28	0
Other	146	132	159	148	142	143
Sub-Total	450	419	523	443	504	465
Infrastructure	46	46	46	46	46	46
Sub-Total, Field Const.	1,084	991	1,242	1,050	1,186	1,086
Engineering & Design	139	126	160	135	152	139
Sub-Total, Contractor Cost	1,223	1,117	1,402	1,185	1,338	1,225
Other Project Costs	248	227	284	240	270	248
Estimating Allowance	220	202	252	214	242	220
Royalties	17	17	19	17	13	13
Total	1,708	1,563	1,957	1,656	1,863	1,706
Expense Capital, MM $						
Sales Tax	16	16	19	16	19	16
Catalyst & Chemicals	6	6	8	6	3	3
Environmental Studies, etc.	2	2	2	2	2	2
Total	24	24	29	24	24	21

*Methanol production