2. PROJECT SUMMARY

DOE Contract Number DE-AC22-91PC90027 required the development of a conceptual Baseline design and several alternative designs for the indirect liquefaction of Illinois No. 6 coal from the Burning Star Mine and a Wyoming Powder River Basin coal. In 1995, this contract was modified to consider the Fischer-Tropsch conversion of natural gas to liquid transportation fuels. In 1996 a second natural gas conversion case was added to develop a once-through, slurry-bed, Fischer-Tropsch (F-T) plant design with power co-production using technology from Syncrude Technology, Incorporated. ASPEN Plus process flowsheet simulation (PFS) models were developed for all of the coal liquefaction cases. A slightly less comphrensive ASPEN Plus PFS model was developed for the first natural gas case. In addition, a LOTUS spreadsheet discounted, cash-flow economics model also was developed.

During this contract, the following eight conceptual designs were developed.

1. Baseline design for Illinois No. 6 coal using conventional petroleum refining technology for product upgrading

2. An second Illinois No. 6 coal case with an alternate product upgrading scheme based on upgrading the vapor stream from the slurry-bed F-T reactor with ZSM-5 catalyst

3. A design using Wyoming Powder River Basin coal with conventional petroleum refining technology for product upgrading

4. A second Wyoming Powder River Basin coal design with an alternate product upgrading scheme based on upgrading the vapor stream from the slurry-bed F-T reactor with ZSM-5 catalyst

5. An third Illinois No. 6 coal case with an alternate product upgrading scheme using wax fluid catalytic cracking with a beta zeolite catalyst instead of mild hydrocracking

6. A fourth Illinois No. 6 coal case with an alternate product upgrading scheme using wax fluid catalytic cracking with equilibrium USY catalyst instead of mild hydrocracking

7. A design for the F-T liquefaction of natural gas using conventional petroleum refining technology for product upgrading

8. A design for the once through F-T liquefaction of natural gas with power co-production using the slurry-bed F-T technology of Syncrude Technology, Incorporated with minimal product upgrading.

After the designs for the first three cases were developed, the ASPEN/SP process simulation model was converted to ASPEN Plus and revised to include more components in the F-T wax product to improve the vapor-liquid calculations around the slurry-bed F-T reactor (TR-6).* Consequently, the results for the first three cases were revised using this new, improved model, and these revised results will be presented in this report. These results are only slightly different than those described in the corresponding Topical Report (TR-1, TR-2 andTR-3).

Cases 4 through 7 were developed by creating ASPEN Plus PFS models for the new plants based on conceptual designs, and combining these new models with the existing ASPEN Plus plant models to calculate the material balances and costs for these cases. A complete ASPEN Plus model for Case 8, the once-through, natural gas case using STI technology, was not developed. An ASPEN Plus model PFS model only was developed for the F-T synthesis reactor and downstream units.

* Designates a specific reference in Appendix A: CN refers to Conference Notes, LR refers to Letter Report, QR refers to Quarterly Report, and TR refers to Topical Report.

2.1 Case 1 -- Baseline Design Case

Figure 2.1 is a block flow diagram showing the overall process configuration of the Baseline design. The Baseline design case (for Illinois No. 6 coal using conventional petroleum refining technology for product upgrading) consists of three ISBL (Inside Battery Limits) process areas and offsites plants. The three ISBL process areas are:

1. Area 100 -- Syngas Production
2. Area 200 -- Fischer-Tropsch Synthesis Loop
3. Area 300 -- Product Upgrading and Refining

Simplified block flow diagrams of the above ISBL plants are shown in Figure 2.2 to 2.4 respectively. Table 2.1 lists the various plants inside each of the three ISBL process areas and the offsites plants for the Baseline design case. Detailed descriptions of these plants are contained in Topical Report, Volume I, *Process Design - Illinois No. 6 Coal Case with Conventional Refining* (reference TR-1).

This plant, as well as all the other Illinois No. 6 coal cases, is located at a generic southern Illinois mine-mouth site.

Table 2.2 shows the overall material balance and installed plant cost for the Baseline design case. This is the Management Summary Report generated by the ASPEN Plus process flowsheet simulation (PFS) model for the Baseline design case. These results are essentially identical to those of the actual design. This report is shown here because it concisely presents the overall plant summary for the Baseline case on a single page.

The plant produces 48,629 bbls/day of gasoline and distillate blending stocks and 1922 bbls/day of LPG from 18,575 tons/day of moisture free Illinois No. 6 coal and 3110 bbls/day of normal butane. The plant also consumes about 54.3 MW of purchased electric power. This power consumption is in addition to the 66.6 MW of power that are produced in Plant 31 from the byproduct steam and fuel gas.

The lower half of Table 2.2 shows the ISBL field cost and total installed cost of each plant as well as the number of dedicated operators required to run it.* The total installed cost of each plant consists of the ISBL field cost, an apportioned allotment for the OSBL plants, an amount for home office, engineering and fees, and a contingency allotment. As shown at the bottom of the second cost column, the total cost of the Baseline case in mid-1993 dollars at the southern Illinois site is 2964 MM$. The annual catalyst and chemicals cost is 31.1 MM$.

Three hundred and seventy five operators are required to run the ISBL plants in this design. An additional 713 operating and maintenance personnel are required for

* For computer modeling purposes, Plant 202 has been divided into two sections. Plant 202A is the amine adsorption section, and Plant 202B is the amine regeneration section.

Figure 2.1

INDIRECT COAL LIQUEFACTION BASELINE DESIGN
OVERALL PROCESS CONFIGURATION

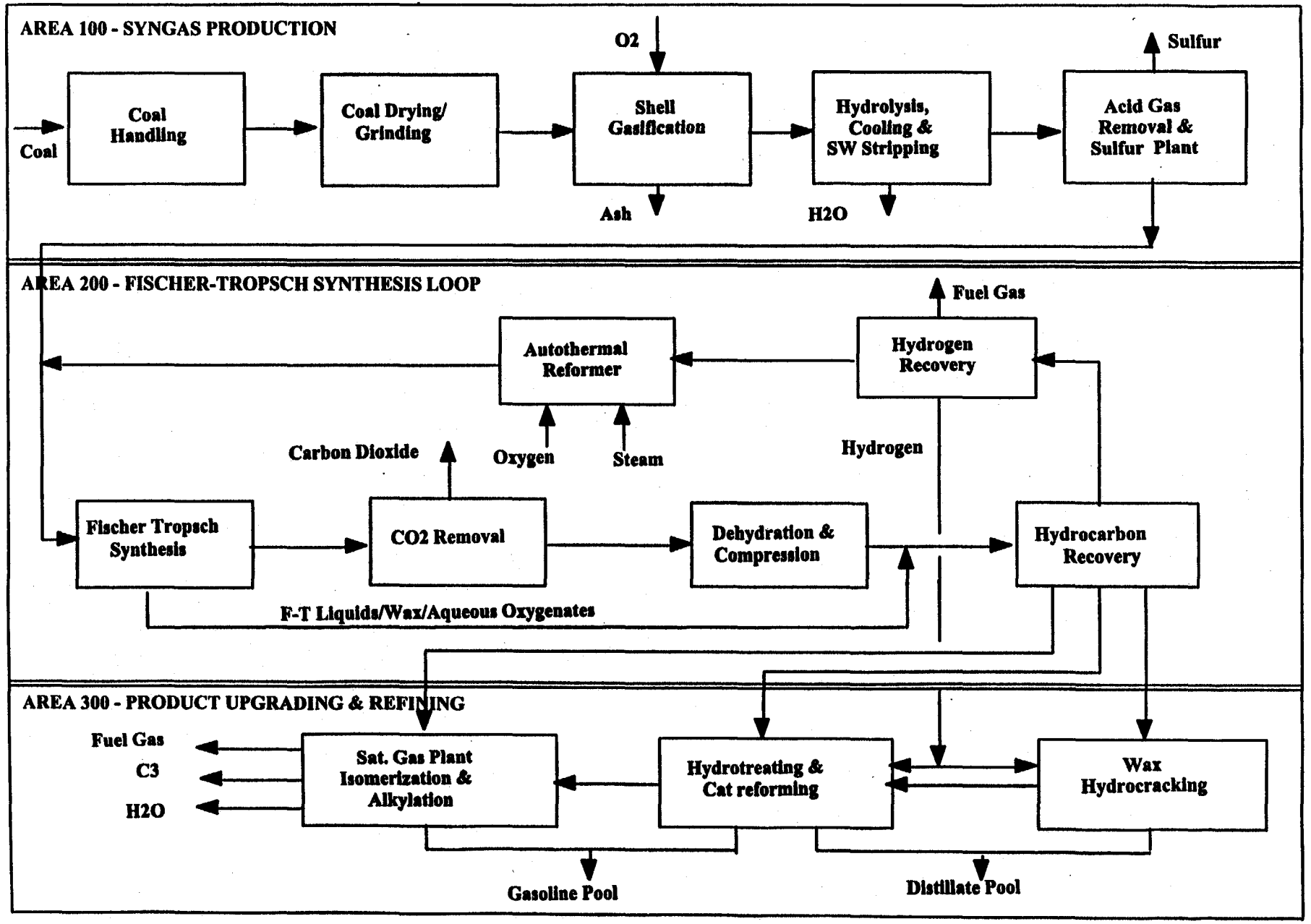

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Figure 2.2

Block Flow Diagram - Baseline Design Area 100 (Syngas Production)

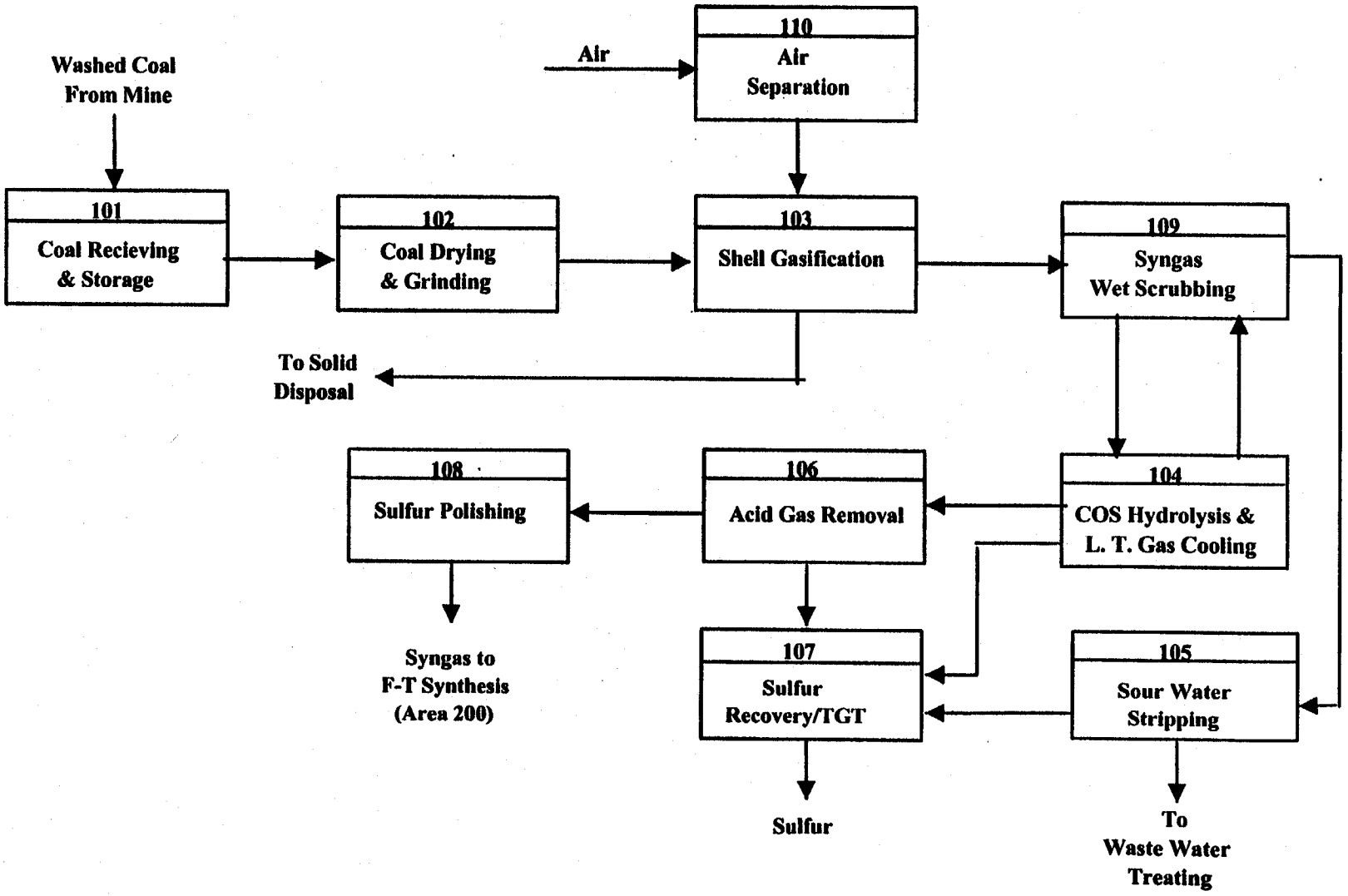

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Figure 2.3

Block Flow Diagram - Area 200 (F-T Synthesis Loop)

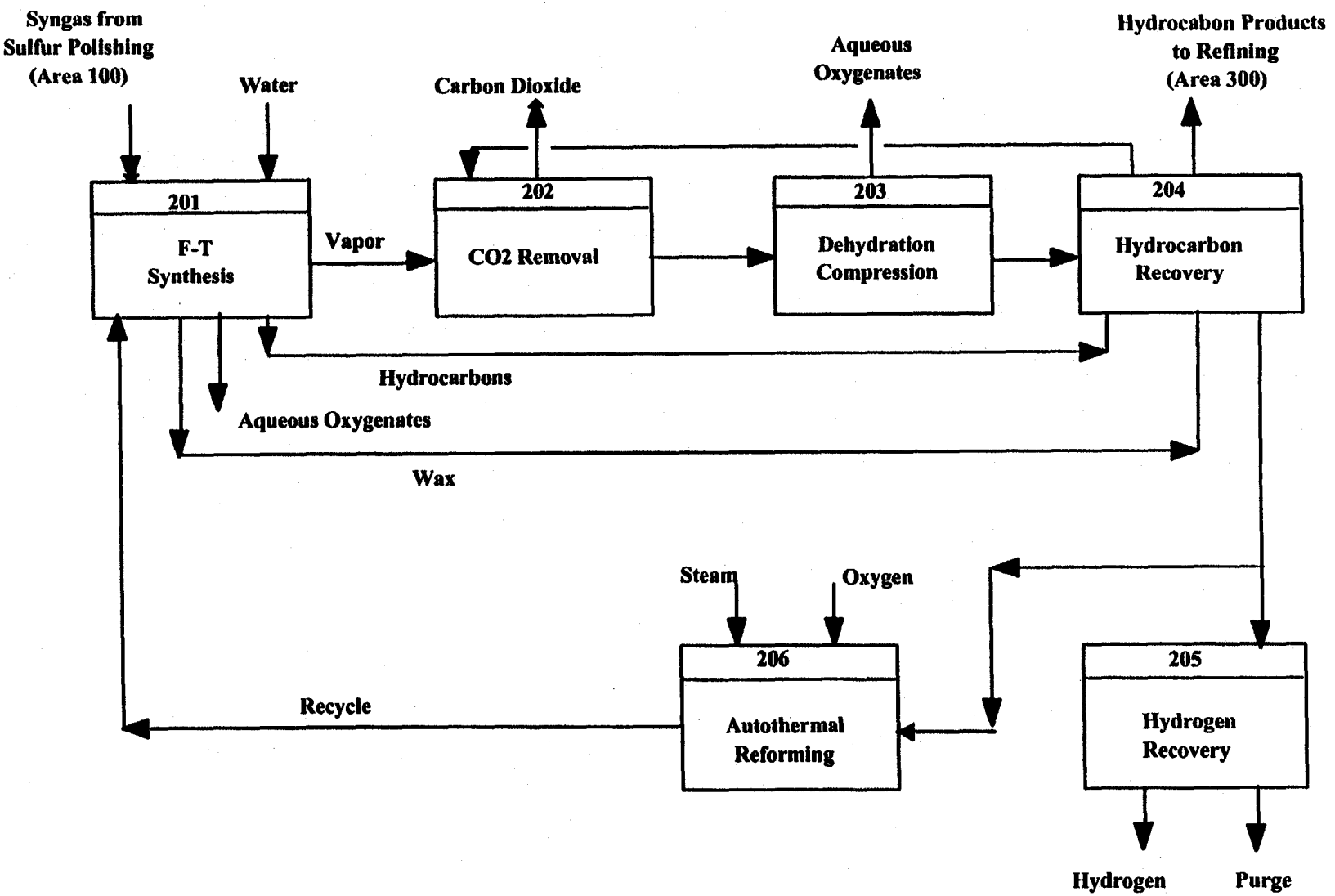

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Figure 2.4

Block Flow Diagram - Area 300 (Product Upgrading and Refining)

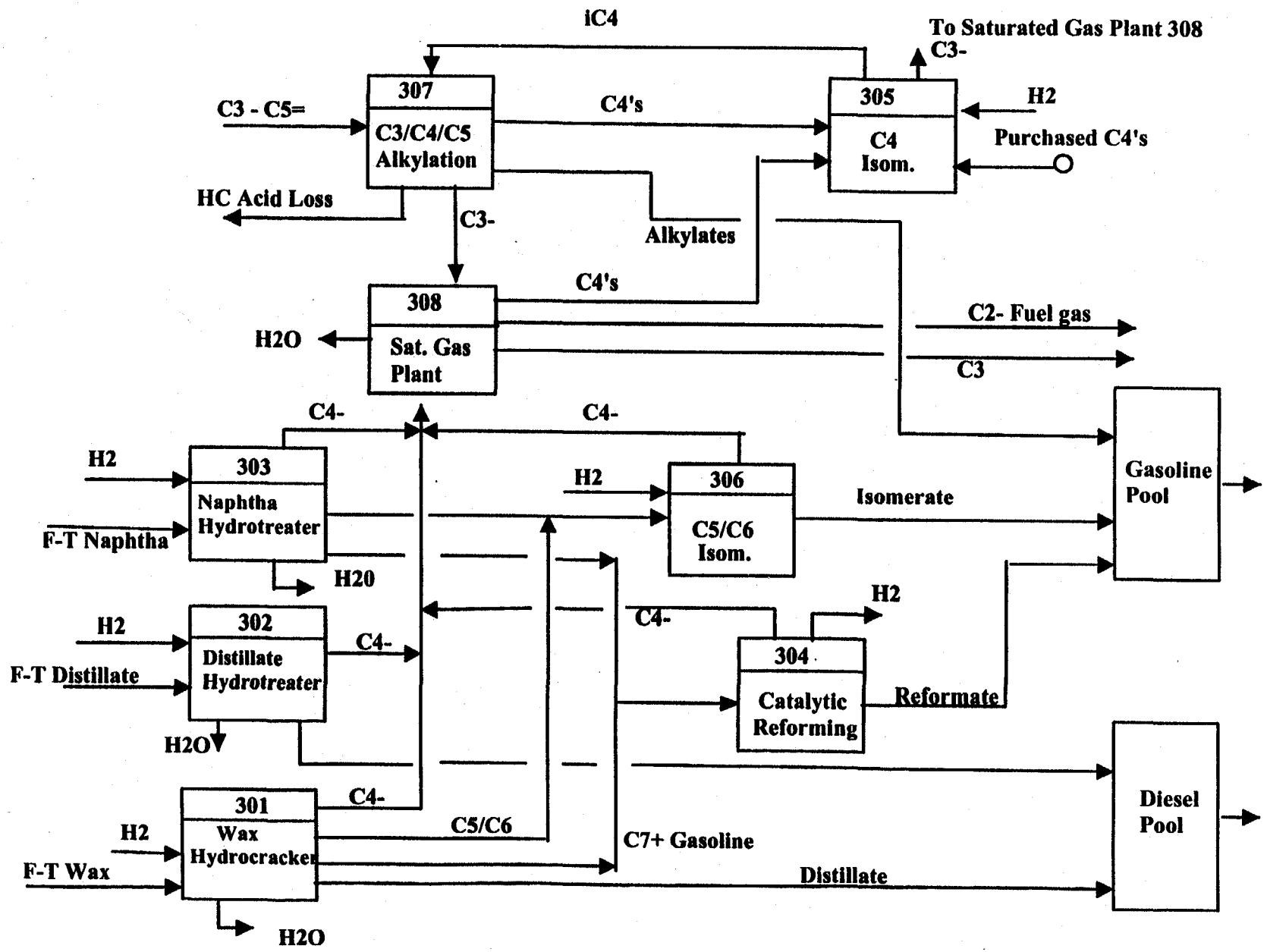

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Table 2.1

Process Plants of the Baseline Design Case

Area 100 -- Syngas Production

101	Coal Receiving and Storage
102	Coal Drying and Grinding
103	Shell Gasification
104	Syngas Treating and Cooling
105	Sour Water Stripper
106	Acid gas Removal
107	Sulfur Recovery and Tailgas Treating
108	Sulfur Polishing
109	Syngas Wet Scrubbing
110	Air Separation

Area 200 -- Fischer-Tropsch Synthesis Loop

201	Fischer-Tropsch Synthesis
202	Carbon Dioxide Removal
203	Recycle Gas Compression and Dehydration
204	Hydrocarbons Recovery
205	Hydrogen Recovery
206	Autothermal Reformer

Area 300 -- Product Upgrading and Refining

301	Wax Hydrocracking
302	Distillate Hydrotreating
303	Naphtha Hydrotreating
304	Catalytic Reforming
305	C4 Isomerization
306	C5/C6 Isomerization
307	Alkylation
308	Saturated Gas Plant and Product Blending

Offsites Plants

19	Relief and Blowdown
20	Tankage
21	Interconnecting Piping
22	Product Shipping
23	Tank Car/tank Truck Loading
24	Coal Ash Disposal
25	Catalyst and Chemical Handling'
30	Electrical Distribution System
31	Steam and Power Generation
32	Raw, Cooling and Potable Water
33	Fire Protection system
34	Sewage and Effluent Water Treatment
35	Instrument and Plant Air Facilities
36	Purge and Flush Oil System
37	Solid Waste Management
40	General Site Preparation
41	Buildings
42	Telecommunications System
43	Distributed Control System and Software

Table 2.2
Baseline Design Case

MANAGEMENT SUMMARY REPORT

MAJOR INPUT AND OUTPUT STREAMS

INPUT	MLBS/HR	TONS/DAY	
ROM COAL*	1547.933	18575.	
METHANOL	0.000	0.	
NATURAL GAS, MM SCF/HR			0.000
ELECTRIC POWER, MEGA-WH/SD			1303.792
RAW WATER MAKE-UP, MM GAL/SD			14.460

OUTPUT	MLBS/HR	TONS/DAY	BBL/DAY
PROPANE	14.231	171.	1922.
BUTANES	-26.423	-317.	-3110.
GASOLINE	251.753	3021.	23943.
DIESEL	278.556	3343.	24686.
REFUSE*	0.000	0.	
SLAG*	187.033	2244.	
SULFUR	46.689	560.	
TOTAL	751.839	9022.	47441.

* THESE STREAM FLOW RATES ARE ON A DRY BASIS.
NEGATIVE PRODUCT FLOWS DESIGNATE PURCHASED MATERIAL.

ISBL FIELD AND TOTAL INSTALLED COSTS (INCLUDING OSBL COSTS)

	NUMBER OF PLANTS		PLANT COST, MM$,		DEDICATED
PLANT	OPERATING	SPARES	ISBL	TOTAL	OPERATORS
101	1	0	41.997	63.539	12
102	5	1	101.271	153.217	17
103	8	1	702.888	1063.426	183
104	8	0	37.968	57.443	8
105	1	0	3.213	4.861	0
106	4	0	18.654	28.223	9
107	2	1	43.367	65.612	13
108	8	0	23.731	35.904	0
109	8	0	7.543	11.412	8
110	8	0	326.754	494.358	8
201	8	0	220.197	333.145	43
202A	8	0	16.788	25.400	0
202B	8	0	124.698	188.661	8
203	4	0	17.830	26.975	4
204	4	0	53.662	81.188	4
205	4	0	44.361	67.115	4
206	4	0	21.921	33.166	4
301	1	0	43.564	65.909	10
302	1	0	13.994	21.172	4
303	1	0	6.595	9.977	4
304	1	0	31.365	47.453	10
305	1	0	6.731	10.184	4
306	1	0	7.275	11.006	4
307	1	0	37.061	56.071	10
308	1	0	5.549	8.395	4
TOTAL			1958.977	2963.809	375

CATALYST AND CHEMICALS, MM$/YEAR 31.074

DEDICATED PLANT OPERATORS	375
EXTRA OPERATORS, FOREMEN AND MAINTENANCE WORKERS	713
TOTAL	1088

operating the OSBL facilities, extra and spare operators, maintenance, and laboratory personnel making a total labor requirement of 1088 people without management supervision.

Both the primary liquid hydrocarbon products are nitrogen, sulfur and oxygen free. The gasoline blending component has a 90.9 RON and a 86.1 MON. It has a low Reid vapor pressure of 5.0 psi, contains a small amount of benzene (0.3 wt%), contains an insignificant amount of olefins (0.02 wt%), and contains a significant amount of aromatics (28.1 wt%). The diesel blending component has an exceptionally high cetane index of about 74 and a pour point of about -28 °F. This is a superior diesel fuel blending component.

2.2 Case 2 -- Illinois No. 6 Coal with Alternate ZSM-5 Product Upgrading Case

The first alternative case involves upgrading the vapor stream leaving the slurry bed F-T reactor by passing it through a reactor containing Mobil's ZSM-5 oligomerization catalyst. The ZSM-5 catalyst converts the entering straight chain paraffins, olefins and oxygenates to a mixture of isoparaffins, isoolefins, naphthenes and aromatics. All of the oxygen atoms in the oxygenates are converted to water. This case is documented in Topical Report, Volume II, *Process Design - Illinois No. 6 Coal Case with ZSM-5 Upgrading* (reference TR-2).

As in the Baseline design case, the ISBL processing area is divided into three main processing areas and an offsites area. Simplified ISBL block flow diagrams for this alternate ZSM-5 product upgrading case are shown in Figures 2.5, 2.6 and 2.7 respectively for the three main processing area of 100, 200 and 300. Since this case also processes the same Illinois No. 6 coal as the Baseline case, Area 100 is identical to that of the Baseline case.

Area 200, the Fischer-Tropsch Synthesis Loop for the alternative ZSM-5 upgrading case, consists of seven plants. Area 200 is configured very similar to the Baseline design case except that Plant 207, the ZSM-5 Upgrading Plant, has been added essentially in the middle of Plant 201 to process the vapors leaving the F-T slurry bed reactors. Plant 207, the ZSM-5 Upgrading Plant, takes the vapor stream leaving the F-T slurry bed reactor and passes it through a reactor containing Mobil's ZSM-5 oligomerization catalyst.

In addition, some design changes were made to the distribution of the liquid hydrocarbon products leaving Plant 204. The naphtha now goes directly to the gasoline pool, and all the C11 and heavier hydrocarbons go to the wax hydrocracker since the naphtha and distillate hydrotreaters have been eliminated from Area 300.

Area 300, the Product Upgrading and Refining Area, now consists of only four plants for this ZSM-5 upgrading case. These are Plants 301, 305, 307 and 308. Plants 302, 303, 304 and 305 have been eliminated. Besides the F-T wax, the feed to Plant 301, the Wax Hydrocracking Plant, now includes all the C11+ F-T products (distillate and wax) which are hydrocracked to produce more valuable products which are essentially oxygen free because all the oxygen in the feed is converted to water. The distillate product goes to the distillate blending pool. The C5+ naphtha product goes directly to the gasoline pool. The C4- light ends are sent to Plant 308, the Saturated Gas Plant, for further propane recovery. Plant 305, Plant 307, and Plant 308 function exactly the same as their counterparts in the Baseline design case.

The offsites area for this case is essentially the same as that for the Baseline case.

Table 2.3 shows the overall plant summary and the installed plant cost for the alternative ZSM-5 upgrading case with Illinois No. 6 coal. Again, this is the Management Summary Report generated by the ASPEN Plus process flowsheet

Figure 2.5

Block Flow Diagram - ZSM-5 Case Area 100 (Syngas Production)

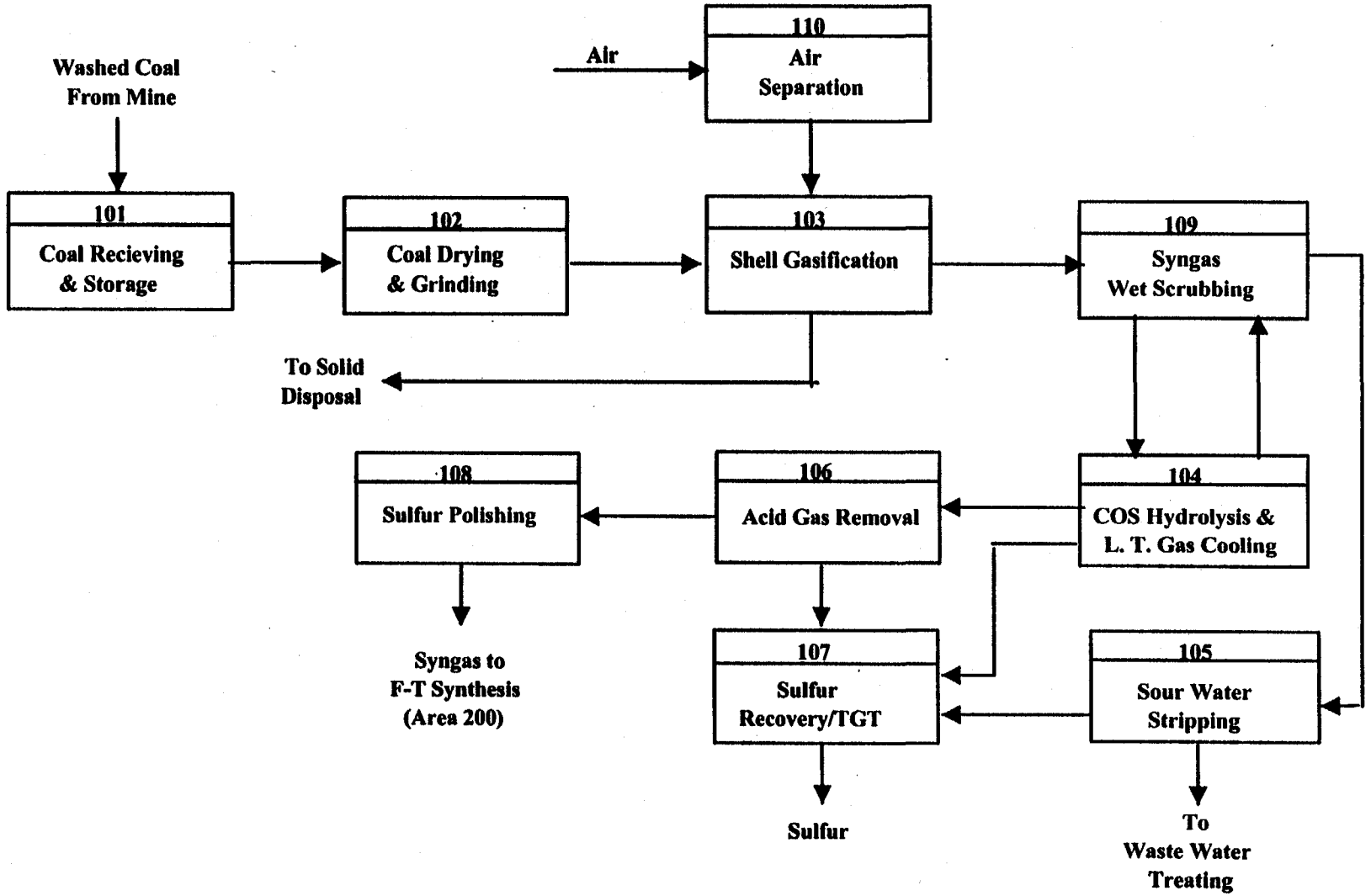

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Figure 2.6

Block Flow Diagram - ZSM-5 Case Area 200 (F-T Synthesis Loop)

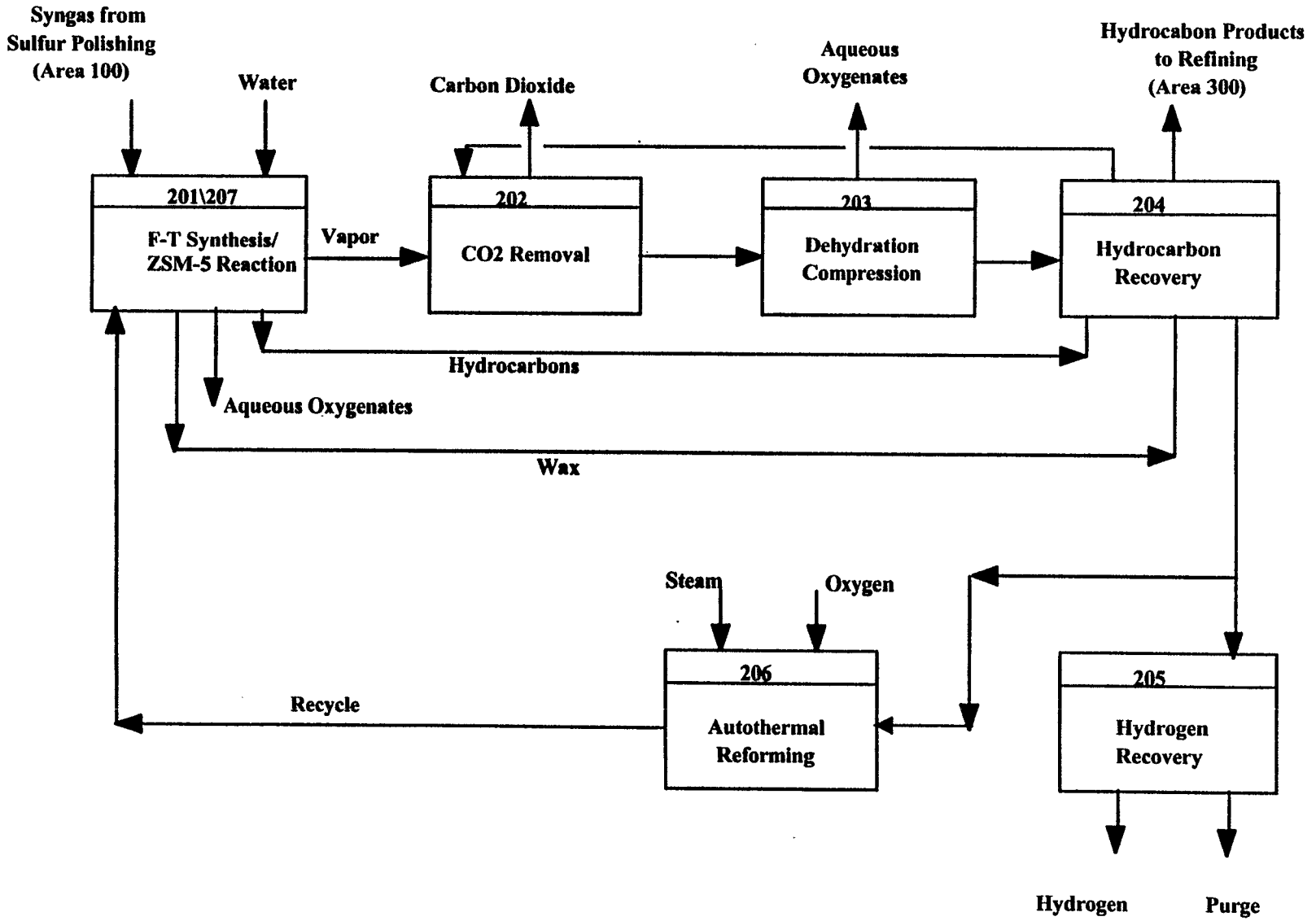

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Figure 2.7

Block Flow Diagram - ZSM-5 Case Area 300 (Product Upgrading and Refining)

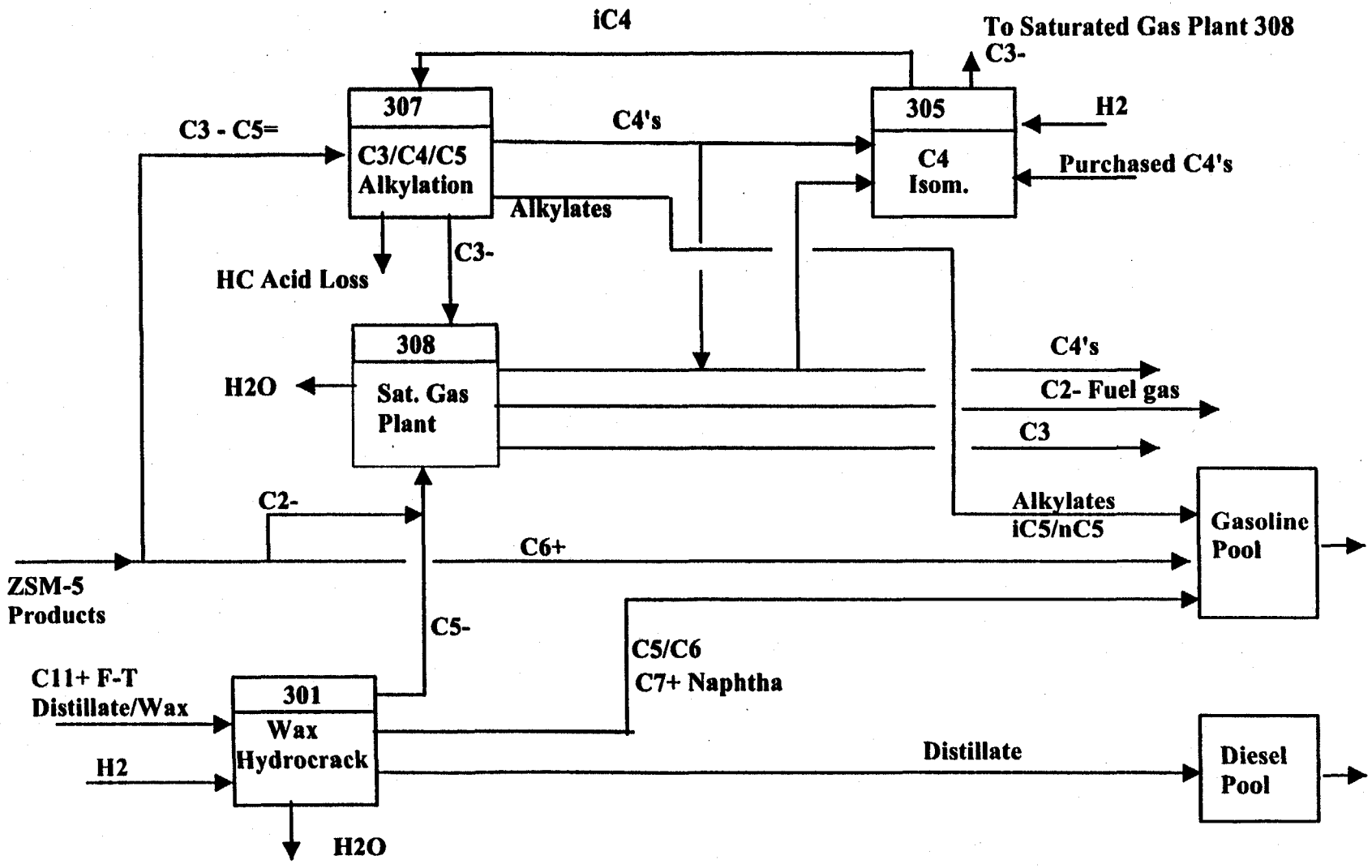

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Table 2.3

ZSM-5 Alternate Upgrading Case with Illinois No. 6 Coal

MANAGEMENT SUMMARY REPORT

MAJOR INPUT AND OUTPUT STREAMS

INPUT	MLBS/HR	TONS/DAY	
ROM COAL*	1547.933	18575.	
METHANOL	0.000	0.	
NATURAL GAS, MM SCF/HR			0.000
ELECTRIC POWER, MEGA-WH/SD			1262.004
RAW WATER MAKE-UP, MM GAL/SD			14.436

OUTPUT	MLBS/HR	TONS/DAY	BBL/DAY
PROPANE	19.420	233.	2623.
BUTANES	8.481	102.	998.
GASOLINE	325.338	3904.	31255.
DIESEL	180.165	2162.	15858.
REFUSE*	0.000	0.	
SLAG*	187.033	2244.	
SULFUR	46.689	560.	
TOTAL	767.126	9206.	50734.

* THESE STREAM FLOW RATES ARE ON A DRY BASIS.
NEGATIVE PRODUCT FLOWS DESIGNATE PURCHASED MATERIAL.

ISBL FIELD AND TOTAL INSTALLED COSTS (INCLUDING OSBL COSTS)

	NUMBER OF PLANTS		PLANT COST, MM$,		DEDICATED
PLANT	OPERATING	SPARES	ISBL	TOTAL	OPERATORS
101	1	0	41.997	63.814	12
102	5	1	101.271	153.879	17
103	8	1	702.888	1068.024	183
104	8	0	37.968	57.692	8
105	1	0	3.213	4.882	0
106	4	0	18.654	28.345	9
107	2	1	43.367	65.895	13
108	8	0	23.731	36.059	0
109	8	0	7.543	11.461	8
110	8	0	326.410	495.973	8
201	8	0	215.817	327.930	43
202A	8	0	16.845	25.596	0
202B	8	0	124.712	189.498	8
203	4	0	17.881	27.170	4
204	4	0	53.318	81.016	4
205	4	0	33.795	51.350	4
206	4	0	21.239	32.272	4
207	8	0	23.320	35.434	0
301	1	0	42.604	64.736	10
305	1	0	3.186	4.841	4
307	1	0	41.845	63.583	10
308	1	0	5.080	7.719	4
TOTAL			1906.685	2897.168	353

CATALYST AND CHEMICALS, MM$/YEAR	31.442

DEDICATED PLANT OPERATORS	353
EXTRA OPERATORS, FOREMEN AND MAINTENANCE WORKERS	671
TOTAL	1024

simulation (PFS) model for this case. This report is shown here because it concisely presents the principal results for the alternative ZSM-5 upgrading case with Illinois No. 6 coal on a single page.

The plant produces 47,113 bbls/day of gasoline and distillate blending stocks, 998 bbls/day of mixed butanes, and 2623 bbls/day of LPG from 18,575 tons/day of moisture free Illinois No. 6 coal. The plant also consumes about 52.6 MW of purchased electric power. This power consumption is in addition to the 67.2 MW of power that are produced in Plant 31 from the byproduct steam and fuel gas.

The lower half of Table 2.3 shows the ISBL field cost and total installed cost of each plant as well as the number of dedicated operators required to run it. The total installed cost of each plant consists of the ISBL field cost, an apportioned allotment for the OSBL plants, an amount for home office, engineering and fees, and a contingency allotment. As shown at the bottom of the second cost column, the total cost of the Baseline case in mid-1993 dollars at the southern Illinois site is 2897 MM$. The annual catalyst and chemicals cost is 31.4 MM$.

An estimated three hundred and fifty three operators are required to run the ISBL plants in this design. An additional 671 operating and maintenance personnel are required for operating the OSBL facilities, extra and spare operators, maintenance, and laboratory personnel making a total labor requirement estimate of 1024 people without management supervision.

Both the primary liquid hydrocarbon products are nitrogen, sulfur and oxygen free. The gasoline blending component is of lower quality than the Baseline design case. It has a 75.5 RON, a 72.4 MON, and a Reid vapor pressure of 6.0 psi. It contains some benzene (0.6 wt%), contains some olefins (6.5 wt%), and contains some aromatics (16.3 wt%). The diesel blending component has an exceptionally high cetane index of about 73 and a pour point of about -19 °F. This is a excellent diesel fuel blending component.

2.3 Case 3 -- Wyoming Powder River Basin Coal with Conventional Refining Case

This second alternative case involves using a Western coal from the Powder River Basin area of Wyoming instead of the Illinois No. 6 coal which was used in the Baseline design case. This is a mine-mouth plant located near Gillette, Wyoming. This case is documented in Topical Report, Volume III, *Process Design - Western Coal Case with Conventional Refining* (reference TR-3).

As in the Baseline design case, the ISBL processing area is divided into three main processing areas. Simplified ISBL block flow diagrams for this alternate Western coal case are shown in Figures 2.8, 2.9 and 2.10 respectively for the three main processing area of 100, 200 and 300. Because this case uses Wyoming Powder River Basin coal instead of Illinois No. 6 coal, Area 100 is significantly different than that of the Baseline design case. In addition, the offsites area has been modified from that of the Baseline case to include a zero-discharge water treatment system to minimize fresh water consumption by maximizing water reuse because of the high water costs in Wyoming.

The Western coal Area 100 consists of nine plants; Plants 101, 102, 103 and 105 through 110. Plant 104, the Syngas Treating and Cooling Plant, has been eliminated and Plant 106 has been redesigned because the Wyoming coal has a much lower sulfur content than Illinois No. 6 coal.

Because of the high CO_2/H_2S ratio in the syngas, Plant 106 was redesigned to use a physical absorption process rather than a chemical one for selective removal of H_2S. It was changed to use a Rectisol wash system, licensed either by Linde AG or Lurgi Corporation, instead of the UOP Amine Guard FS process which was used for he Illinois No. 6 coal cases.

Area 200, the Fischer-Tropsch Synthesis Loop, and Area 300, the Product Upgrading and Refining Area, are identical to those of the Baseline design case.

Table 2.4 shows the overall plant summary and the installed plant cost for the Western coal with conventional refining case. Again, this is the Management Summary Report generated by the ASPEN Plus process flowsheet simulation (PFS) model for this case.

The plant produces 48,222 bbls/day of gasoline and distillate blending stocks and 1907 bbls/day of LPG from 19,789 tons/day of moisture free Wyoming Powder River Basin coal and 3101 bbls/day of butanes. The plant also consumes about 88.0 MW of purchased electric power. This power consumption is in addition to the 64.5 MW of power that are produced in Plant 31 from the byproduct steam and fuel gas.

The lower half of Table 2.4 shows the ISBL field cost and total installed cost of each plant as well as the estimated number of dedicated operators required to run it. The

Figure 2.8

Block Flow Diagram - Western Coal Case Area 100 (Syngas Production)

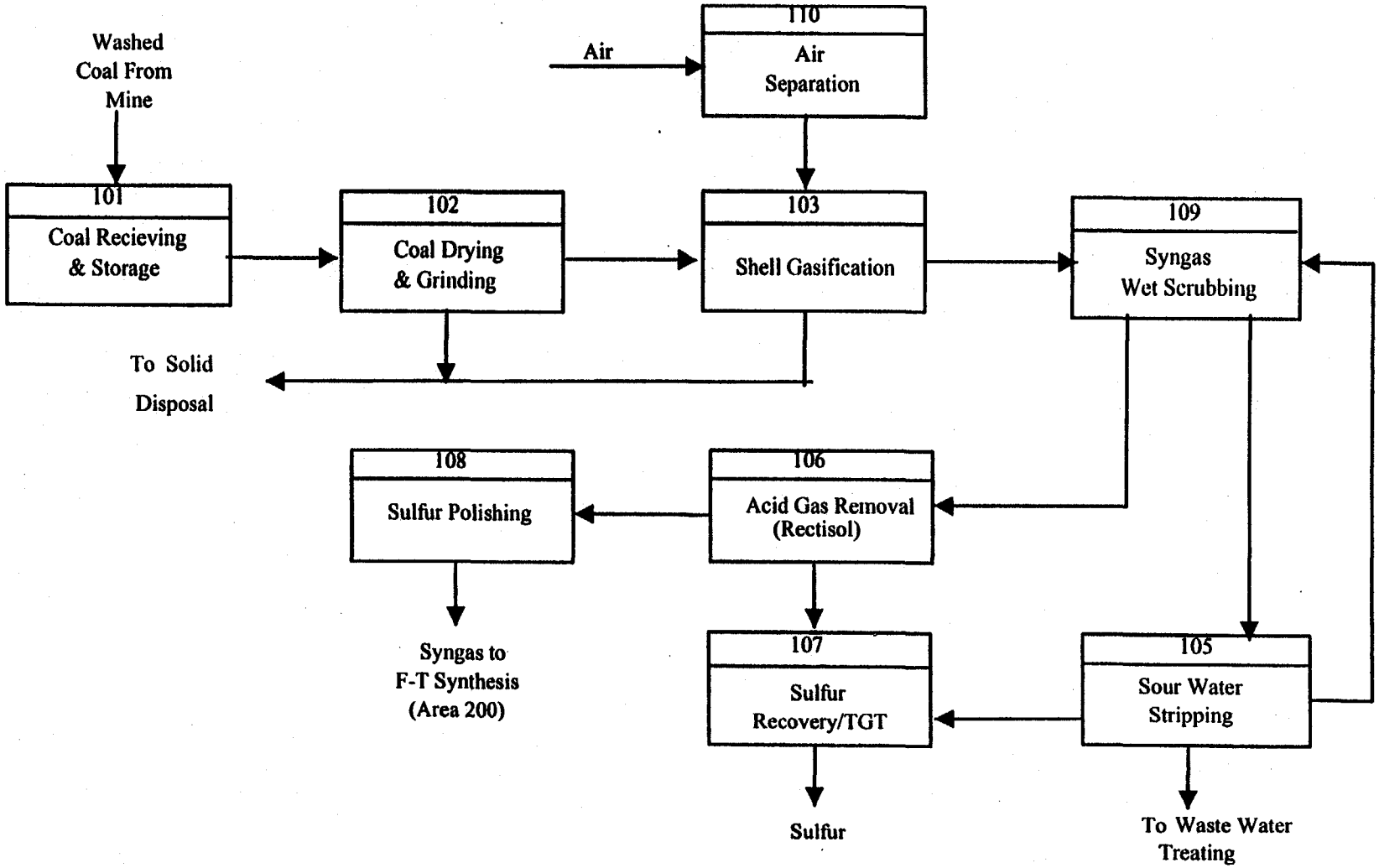

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Figure 2.9

Block Flow Diagram - Area 200 (F-T Synthesis Loop)

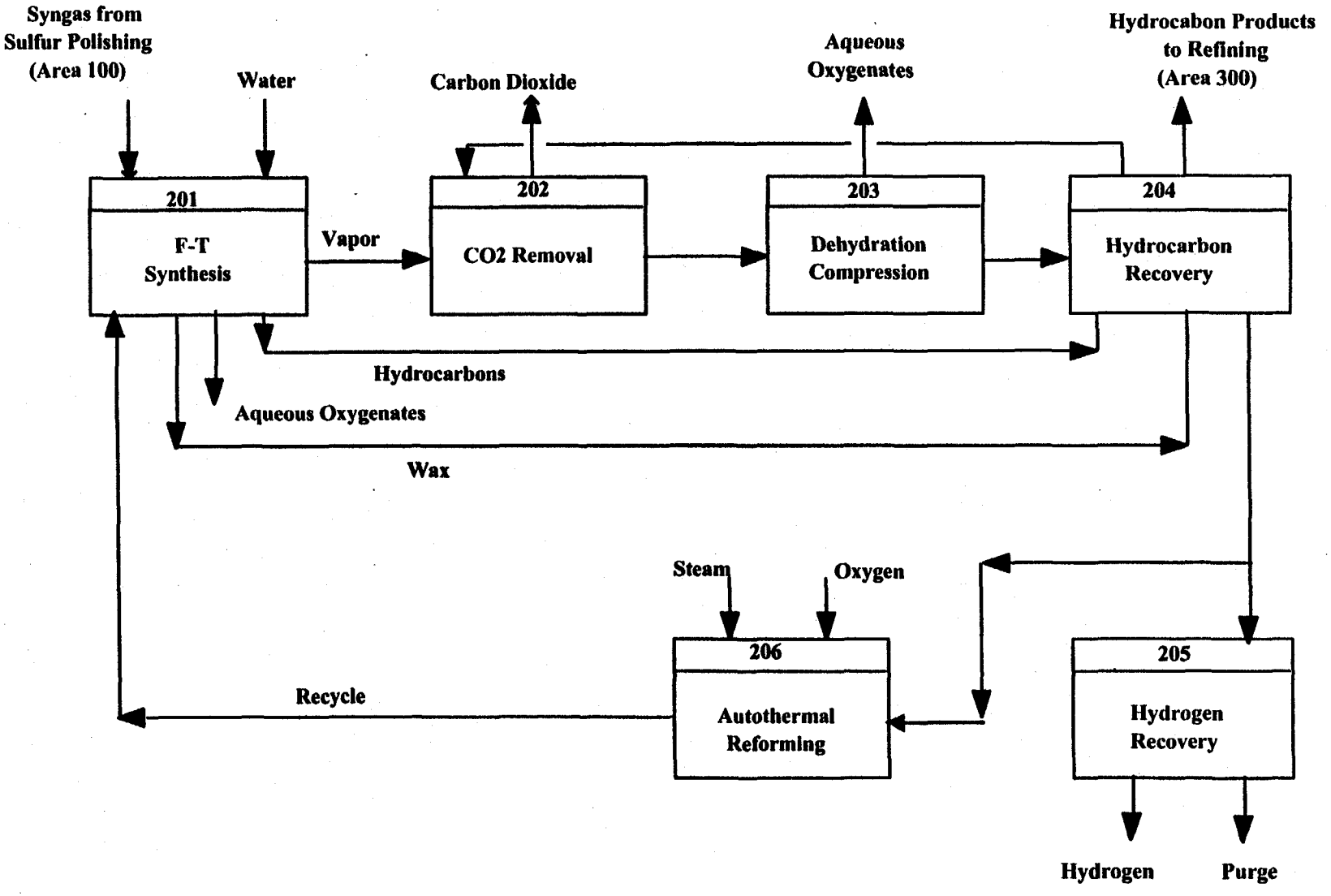

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Figure 2.10

Block Flow Diagram - Area 300 (Product Upgrading and Refining)

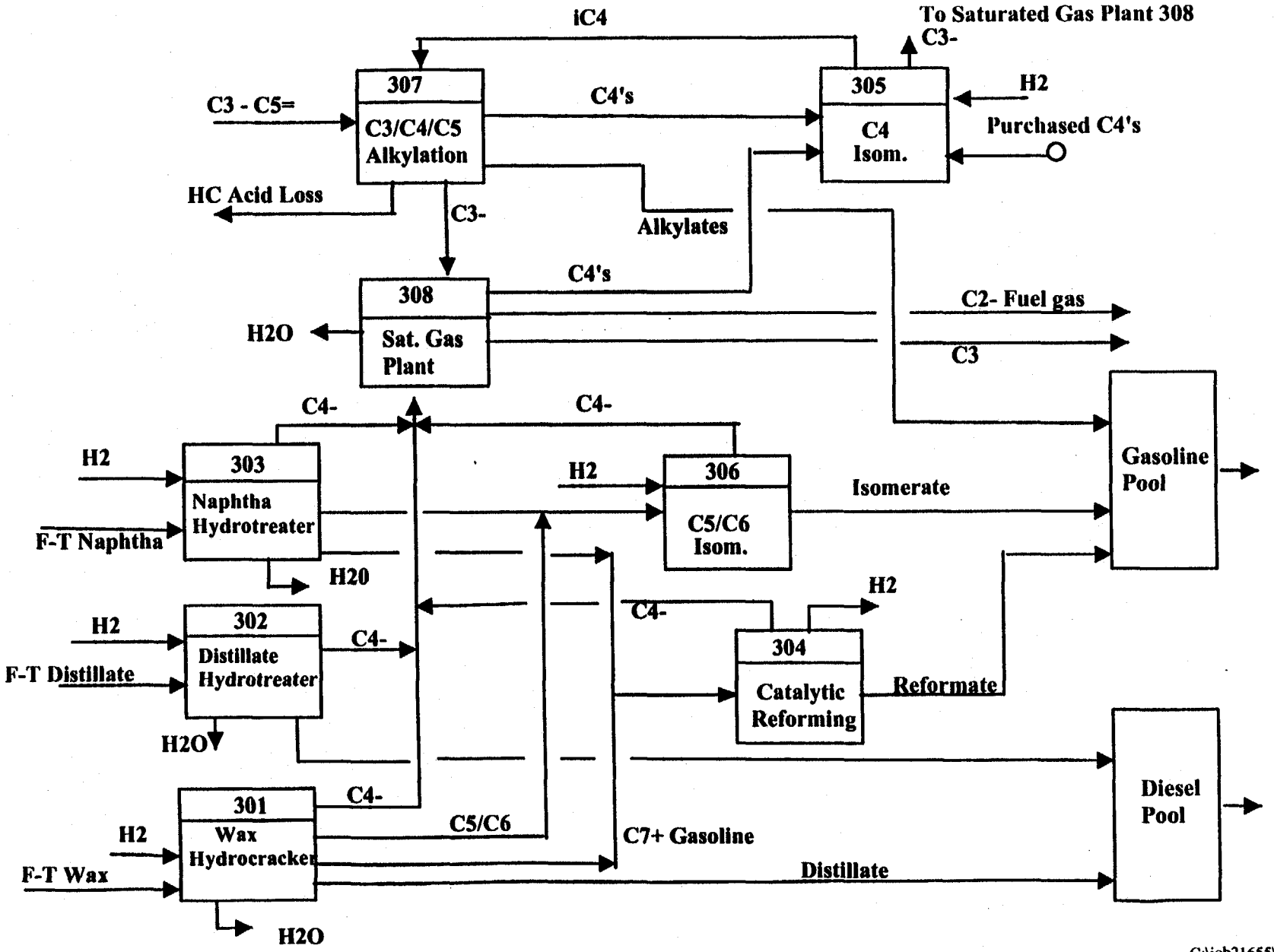

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Table 2.4

Wyoming Powder River Basin Coal with Conventional Refining Case

MANAGEMENT SUMMARY REPORT

MAJOR INPUT AND OUTPUT STREAMS

INPUT	MLBS/HR	TONS/DAY	
ROM COAL*	1649.072	19789.	
METHANOL	0.000	0.	
NATURAL GAS, MM SCF/HR			0.000
ELECTRIC POWER, MEGA-WH/SD			2111.658
RAW WATER MAKE-UP, MM GAL/SD			9.803

OUTPUT	MLBS/HR	TONS/DAY	BBL/DAY
PROPANE	14.122	169.	1907.
BUTANES	-26.348	-316.	-3101.
GASOLINE	249.784	2997.	23756.
DIESEL	276.074	3313.	24466.
REFUSE*	0.000	0.	
SLAG*	145.584	1747.	
SULFUR	9.029	108.	
TOTAL	668.246	8019.	47028.

* THESE STREAM FLOW RATES ARE ON A DRY BASIS.
NEGATIVE PRODUCT FLOWS DESIGNATE PURCHASED MATERIAL.

ISBL FIELD AND TOTAL INSTALLED COSTS (INCLUDING OSBL COSTS)

	NUMBER OF PLANTS		PLANT COST, MM$,		DEDICATED
PLANT	OPERATING	SPARES	ISBL	TOTAL	OPERATORS
101	1	0	47.690	73.888	12
102	6	1	128.980	199.835	20
103	9	1	735.660	1139.792	205
105	1	0	5.370	8.320	0
106	4	0	166.003	257.196	25
107	2	1	14.980	23.209	13
108	8	0	21.610	33.481	0
109	9	0	6.620	10.257	9
110	9	0	306.553	474.957	9
201	8	0	204.990	317.600	43
202A	8	0	17.305	26.811	0
202B	8	0	111.229	172.332	8
203	4	0	15.887	24.615	4
204	4	0	47.857	74.148	4
205	4	0	42.205	65.390	4
206	4	0	18.960	29.375	4
301	1	0	40.464	62.692	10
302	1	0	13.101	20.299	4
303	1	0	6.081	9.422	4
304	1	0	29.434	45.604	10
305	1	0	6.164	9.550	4
306	1	0	6.691	10.367	4
307	1	0	33.483	51.877	10
308	1	0	5.180	8.025	4
TOTAL			2032.497	3149.041	410

CATALYST AND CHEMICALS, MM$/YEAR		21.321
DEDICATED PLANT OPERATORS	410	
EXTRA OPERATORS, FOREMEN AND MAINTENANCE WORKERS	780	
TOTAL	1190	

total installed cost of each plant consists of the ISBL field cost, an apportioned allotment for the OSBL plants, an amount for home office, engineering and fees, and a contingency allotment. As shown at the bottom of the second cost column, the total cost of the
Western coal with conventional refining case in mid-1993 dollars at the Gillette, Wyoming site is 3149 MM$. The annual catalyst and chemicals cost is 21.3 MM$.

Four hundred and ten operators are required to run the ISBL plants in this design. An additional 780 operating and maintenance personnel are required for operating the OSBL facilities, extra and spare operators, maintenance, and laboratory personnel making a total labor requirement of 1190 people without management supervision.

The product properties for this case (Wyoming Powder River Basin coal with conventional refining case) are essentially the same as those for the Baseline design case. Again, both the primary liquid hydrocarbon products are nitrogen, sulfur and oxygen free. The naphtha has a 90.9 RON, a 86.1 MON, and a Reid vapor pressure of 5.0 psi, and it contains a small amount of benzene (0.3 wt%), contains an insignificant amount of olefins (0.02 wt%), and contains a significant amount of aromatics (28.1 wt%). The diesel blending component also has about the same properties as that from the Baseline case. It has an exceptionally high cetane index of about 74 and a pour point of about -28 °F. This is a superior diesel fuel blending component.

2.4 Case 4 -- Wyoming Powder River Basin Coal with Alternate ZSM-5 Product Upgrading Case

The Wyoming Powder River Basin Coal with Alternate ZSM-5 Product Upgrading Case is a combination of the two previous cases. This case uses the Case 2 ZSM-5 alternate upgrading scheme for processing the products produced by F-T synthesis from a syngas generated from Wyoming Powder River Basin coal in Case 3. As in the previous case, this is a mine-mouth plant located near Gillette, Wyoming. This case is documented in Quarterly Reports of April-September 1995 and October-December 1995.

As in all the previous cases, the ISBL processing area is divided into three main processing areas. Simplified ISBL block flow diagrams for this alternate Western coal with ZSM-5 product upgrading case are shown in Figures 2.11, 2.12 and 2.13 respectively for the three main processing area of 100, 200 and 300. Area 100, the Syngas Production Area, is the same as that used in Case 3, and Areas 200 and 300, the Fischer-Tropsch Synthesis Loop and Product Upgrading and Refining Area, are the same as that of Case 2. The offsites are the same as that of Case 3. Again, this plant is a zero discharge plant which minimizes fresh water consumption by maximizing water reuse because of the high water costs in Wyoming.

Table 2.5 shows the overall plant summary and the installed plant cost for the alternative ZSM-5 upgrading case with Wyoming Powder River Basin coal. Again, this is the Management Summary Report generated by the ASPEN Plus process flowsheet simulation (PFS) model for this case.

The plant produces 46,798 bbls/day of gasoline and distillate blending stocks, 980 bbls/day of mixed butanes, and 2613 bbls/day of LPG from 19,789 tons/day of moisture free Wyoming Powder River Basin coal. The plant also consumes about 91.6 MW of purchased electric power. This power consumption is in addition to the 59.6 MW of power that are produced in Plant 31 from the byproduct steam and fuel gas.

The lower half of Table 2.5 shows the ISBL field cost and total installed cost of each plant as well as the number of dedicated operators required to run it. The total installed cost of each plant consists of the ISBL field cost, an apportioned allotment for the OSBL plants, an amount for home office, engineering and fees, and a contingency allotment. As shown at the bottom of the second cost column, the total cost of the Western coal with conventional refining case in mid-1993 dollars at the Gillette, Wyoming site is 3075 MM$. The annual catalyst and chemicals cost is 21.5 MM$.

Three hundred and eighty eight operators are required to run the ISBL plants in this design. An additional 738 operating and maintenance personnel are required for operating the OSBL facilities, extra and spare operators, maintenance, and laboratory

Figure 2.11

Block Flow Diagram - Western Coal\ZSM-5 Case Area 100 (Syngas Production)

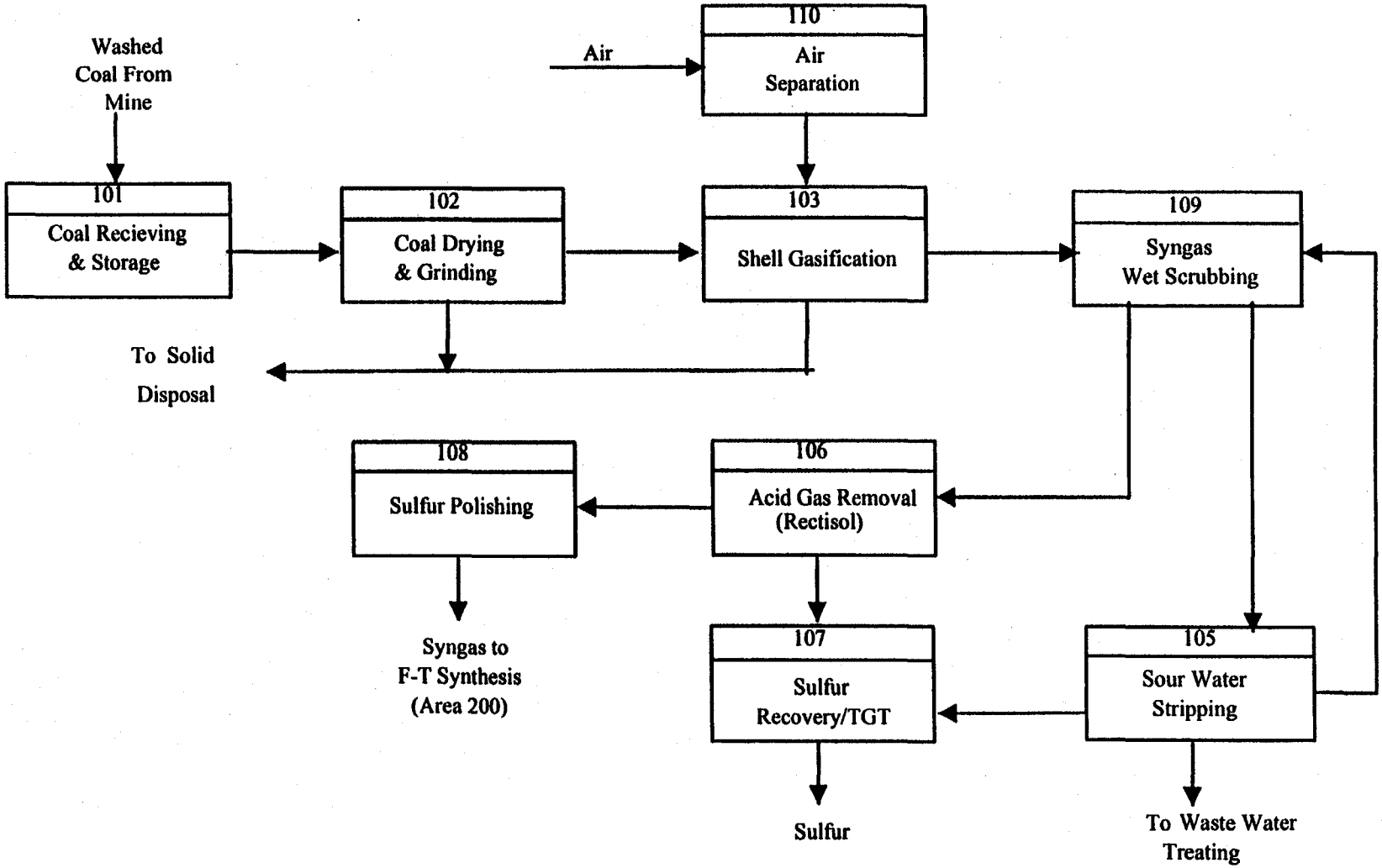

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Figure 2.12

Block Flow Diagram - Western Coal\ZSM-5 Case Area 200 (F-T Synthesis Loop)

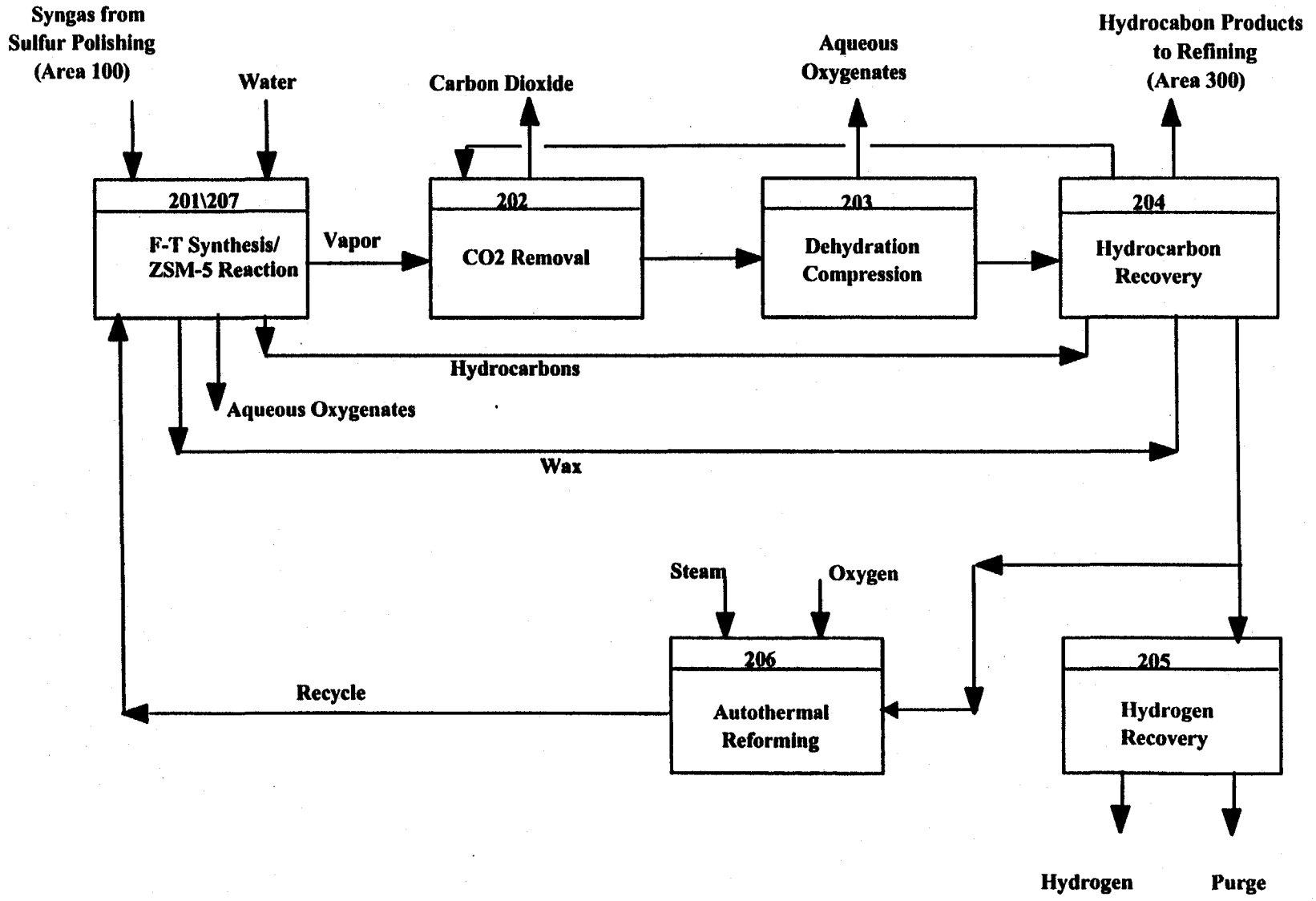

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Figure 2.13

Block Flow Diagram - Western Coal\ZSM-5 Case Area 300 (Product Upgrading and Refining)

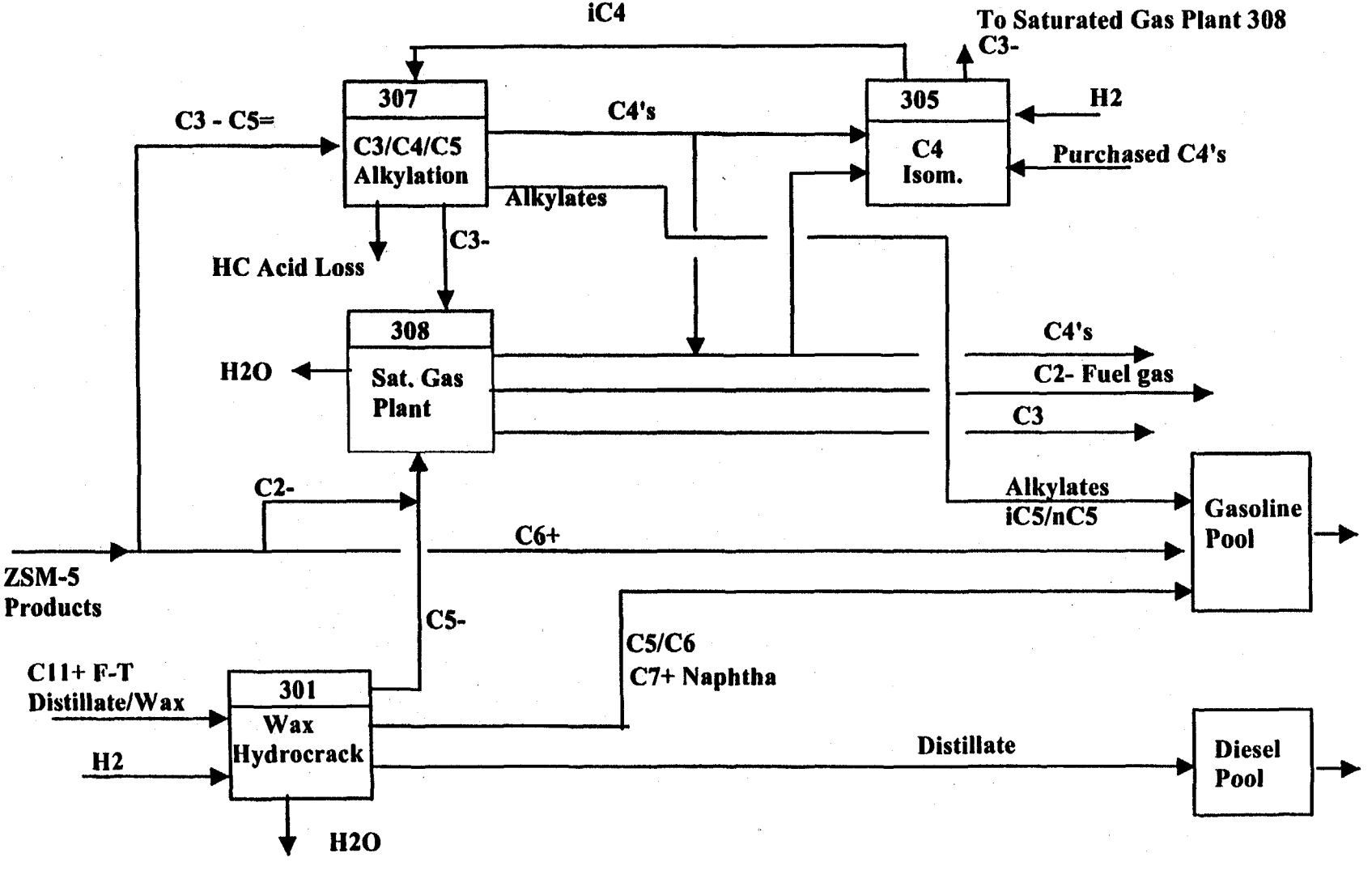

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Table 2.5

Wyoming Powder River Basin Coal
with Alternate ZSM-5 Product Upgrading Case

MANAGEMENT SUMMARY REPORT

MAJOR INPUT AND OUTPUT STREAMS

INPUT	MLBS/HR	TONS/DAY	
ROM COAL*	1649.072	19789.	
METHANOL	0.000	0.	
NATURAL GAS, MM SCF/HR			0.000
ELECTRIC POWER, MEGA-WH/SD			2198.419
RAW WATER MAKE-UP, MM GAL/SD			9.573

OUTPUT	MLBS/HR	TONS/DAY	BBL/DAY
PROPANE	19.349	232.	2613.
BUTANES	8.325	100.	980.
GASOLINE	322.930	3875.	31026.
DIESEL	179.193	2150.	15772.
REFUSE*	0.000	0.	
SLAG*	145.584	1747.	
SULFUR	9.029	108.	
TOTAL	684.411	8213.	50391.

* THESE STREAM FLOW RATES ARE ON A DRY BASIS.
NEGATIVE PRODUCT FLOWS DESIGNATE PURCHASED MATERIAL.

ISBL FIELD AND TOTAL INSTALLED COSTS (INCLUDING OSBL COSTS)

	NUMBER OF PLANTS		PLANT COST, MM$,		DEDICATED
PLANT	OPERATING	SPARES	ISBL	TOTAL	OPERATORS
101	1	0	47.690	74.153	12
102	6	1	128.980	200.551	20
103	9	1	735.660	1143.878	205
105	1	0	5.370	8.350	0
106	4	0	166.003	258.118	25
107	2	1	14.980	23.292	13
108	8	0	21.610	33.601	0
109	9	0	6.620	10.293	9
110	9	0	305.677	475.297	9
201	8	0	199.928	310.869	43
202A	8	0	17.114	26.611	0
202B	8	0	111.713	173.702	8
203	4	0	15.203	23.640	4
204	4	0	45.629	70.949	4
205	4	0	32.002	49.759	4
206	4	0	17.064	26.532	4
207	8	0	21.254	33.048	0
301	1	0	39.649	61.650	10
305	1	0	2.927	4.551	4
307	1	0	37.781	58.745	10
308	1	0	4.763	7.405	4
TOTAL			1977.617	3074.995	388

CATALYST AND CHEMICALS, MM$/YEAR		21.523
DEDICATED PLANT OPERATORS	388	
EXTRA OPERATORS, FOREMEN AND MAINTENANCE WORKERS	738	
TOTAL	1126	

personnel making a total labor requirement of 1126 people without management supervision.

The properties of the products from this Wyoming Powder River Basin coal with ZSM-5 upgrading case are about the same as those from the alternative ZSM-5 upgrading case with Illinois No. 6 coal. Again., both the primary liquid hydrocarbon products are nitrogen, sulfur and oxygen free. The gasoline blending component has a 75.5 RON and a 72.4 MON; both of which are significantly lower than those from the conventional refining cases. In addition, the gasoline has a Reid vapor pressure of 6.0 psi, contains some benzene (0.6 wt%), contains some olefins (6.5 wt%), and contains some aromatics (16.3 wt%). The diesel blending component has an exceptionally high cetane index of about 73 and a pour point of about -19 °F. This is a excellent diesel fuel blending component.