2.7 Tables and Figures

Table 2-1
Coal Analysis

	Dry	As Received
Proximate analysis, wt%		
Moisture		5.50
Volatile matter	39.15	37.00
Fixed Carbon	53.44	50.50
Ash	7.41	7.00
Total	100.00	100.00
Higher Heating Value,		13,250
Ultimate Analysis, wt%		
Carbon		72.35
Hydrogen		4.97
Sulfur		3.20
Oxygen		5.56
Nitrogen		1.36
Ash		7.00
Chlorine		0.06
Water		5.50
Total		100.00

Table 2-2
Clean Syngas Composition (dry)

Constituent	Vol%
H_2	31.42
CO	61.74
CO_2	1.46
CH_4	0.03
N_2	4.27
Ar	1.08
H_2S	neg.
Total	100.00

Table 2-3
Case 1 - IGCC/LPMAS
Sample Material Balance

Description	Raw syngas	Raw Syngas Total	Raw Syngas Reduced load	Syngas to HP AGR	Syngas to LP AGR	Syngas to LPMAS	Acid gas	Total reactor product	Unconverted syngas
	mole %	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr
CO	60.735	28135.2	28135.2	28135.2	0.0	28135.2		16585.2	16585.2
H2	30.913	14320.3	14320.3	14320.3	0.0	14320.3		4222.0	4222.0
CO2	2.146	994.1	994.1	994.1	0.0	572.0	422.1	4905.9	4905.9
H2O		0.0	0.0	0.0	0.0	0.0		78.1	78.1
Methanol		0.0	0.0	0.0	0.0	0.0		1369.4	
Ethanol		0.0	0.0	0.0	0.0	0.0		0.0	
Propanol		0.0	0.0	0.0	0.0	0.0		0.0	
N-butanol		0.0	0.0	0.0	0.0	0.0		23.6	
I-butanol		0.0	0.0	0.0	0.0	0.0		1333.5	
N-pentanol			0.0	0.0	0.0			7.9	
I-pentanol			0.0	0.0	0.0			39.8	
N-hexanol			0.0	0.0	0.0			7.0	
I-hexanol			0.0	0.0	0.0			23.0	
1-butylene									
I-butylene									
1-pentylene									
I-pentylene									
1-hexene									
I-hexene									
MTBE									
TAME									
H2S	0.923	427.6	427.6	427.6	0.0	0.0	427.6	0.0	
CH4	0.028	13.0	13.0	13.0	0.0	13.0		13.0	13.0
N2	4.196	1943.8	1943.8	1943.8	0.0	1943.8		1943.8	1943.8
Ar	1.058	490.1	490.1	490.1	0.0	490.1		490.1	490.1
O2		0.0	0.0	0.0	0.0			0.0	
Total, mol/hr	100.00	46324.0	46324.0	46324.0	0.0	45474.3	849.7	31042.1	28238.0
Total, lb/hr		938446	938446	938446	0	905334	33112	905334	753635

Table 2-3
Case 1 - IGCC/LPMAS
Sample Material Balance

Description	Alcohol product	Bypassed syngas	Total syngas to gas turbines	Methanol to ether	C4+ alcohols to dehydr.	Methanol to storage	C2-C3 OH's to fuel	Dehydration product	MTBE, TAME	Unconv Olefins
	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr	lb-mol/hr
CO		0.0	16585.2			0.0				
H2		0.0	4222.0			0.0				
CO2		0.0	4905.9			0.0				
H2O	0.0	0.0	78.1			0.0		1434.8		
Methanol	1369.4	0.0	0.0	1369.4		0.0				
Ethanol	0.0	0.0	0.0			0.0	0.0			
Propanol	0.0	0.0	0.0			0.0	0.0			
N-butanol	23.6	0.0	0.0		23.6	0.0				
I-butanol	1333.5	0.0	0.0		1333.5	0.0				
N-pentanol	7.9				7.9	0.0				
I-pentanol	39.8				39.8	0.0				
N-hexanol	7.0				7.0	0.0				
I-hexanol	23.0				23.0	0.0				
1-butylene								23.6		23.6
i-butylene								1333.5		0.0
1-pentylene								7.9		7.9
i-pentylene								39.8		4.0
1-hexene								7.0		7.0
I-hexene								23.0		23.0
MTBE									1333.5	
TAME									35.8	
H2S		0.0	0.0		0.0	0.0				
CH4		0.0	13.0		0.0	0.0				
N2		0.0	1943.8		0.0	0.0				
Ar		0.0	490.1		0.0	0.0				
O2		0.0	0.0		0.0	0.0				
Total, mol/hr	2804.1	0.0	28238.0	1369.4	1434.8	0.0	0.0	2869.5	1369.4	65.4
Total, lb/hr	151700	0	753635	43874	107825	0	0	107825	121171	4674

Case
Ope

Case	1-1	1-2	1-3	1-4
LPMAS overall syngas conversion	20%	25%	30%	40%
Case Conditions				
Gasification capacity, stpd	3860	4097	4368	503(
No. of gasifier trains	2	2	2	2
No. of LPMAS trains	1	1	1	1
LPMAS fresh feed, MMSCFD	273.7	290.5	309.7	356.6
LPMAS reactor feed, MMSCFD	273.7	290.5	309.7	356.6
LPMAS recycle ratio, recycle mol/feed mol	0.00	0.00	0.00	0.00
No. of LPMAS reactors per train	1.0	1.0	1.0	2.0
LPMAS per pass syngas conversion	20%	25%	30%	40%
Overall CO conversion	11%	14%	17%	24%
Overall H2 conversion	37%	45%	52%	66%
LPMAS reactor inlet molar composition				
CO	61.87%	61.87%	61.87%	61.87%
H2	31.49%	31.49%	31.49%	31.49%
CO2	1.26%	1.26%	1.26%	1.26%
H2O	0.00%	0.00%	0.00%	0.00%
Methanol	0.00%	0.00%	0.00%	0.00%
Isobutanol	0.00%	0.00%	0.00%	0.00%
N2, Ar	5.35%	5.35%	5.35%	5.35%
CH4	0.03%	0.03%	0.03%	0.03%
LPMAS reactor outlet molar composition				
CO	59.23%	58.44%	57.57%	55.60%
H2	25.63%	23.94%	22.11%	18.00%
CO2	5.87%	7.24%	8.73%	12.11%
H2O	0.16%	0.19%	0.22%	0.26%
Methanol	1.42%	1.84%	2.29%	3.31%
Isobutanol	1.39%	1.79%	2.23%	3.22%
Other alcohols	0.11%	0.14%	0.17%	0.24%
N2, Ar	6.16%	6.39%	6.65%	7.22%
CH4	0.03%	0.03%	0.04%	0.04%
Total alcohol production, stpd	495	653	834	1277
Catalyst activity, g MeOH/kg cat hr	84	104	125	166
Catalyst activity, g iBOH/kg cat hr	189	235	281	374
Ether production, bpd	3022	3989	5095	7799
Olefin production, bpd	133	176	225	344
Energy flows, MMBtu/hr, LHV				
Gasifier output	3316	3520	3753	4321
Direct syngas to gas turbine	0	0	0	0
Acid gas	67	71	75	87
Syngas to LPMAS	3250	3449	3677	4235
Unconverted syngas	2582	2568	2552	2511
Alcohol products	534	705	901	1379

1. Case 1-5 is a once-through LPMAS plant, Case 1-6 is a recycle LPMAS plant.
2. Case 1-7 requires 2 gasifier trains, Case 1-8 requires 3 gasifier trains.

Table 2-4
- IGCC/LPMAS
ating Summary

1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12
49%	49%	51%	51%	55%	60%	62%	64%
5842	5842	6000	6001	6559	7169	7520	7947
2	2	2	3	3	3	3	3
1	1	1	1	1	2	3	5
414.2	414.2	425.4	425.5	465.0	508.3	533.2	563.4
414.2	416.7	459.4	459.5	719.8	1214.3	1825.2	3195.6
0.00	0.01	0.08	0.08	0.55	1.39	2.42	4.67
2.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
49%	49%	48%	48%	38%	29%	22%	14%
30%	30%	31%	31%	35%	38%	40%	41%
77%	77%	79%	79%	85%	89%	92%	94%
61.87%	61.87%	61.80%	61.79%	61.50%	61.26%	61.21%	61.17%
31.49%	31.39%	30.25%	30.24%	24.49%	18.30%	14.25%	9.97%
1.26%	1.34%	2.28%	2.27%	6.91%	11.86%	15.00%	18.31%
0.00%	0.00%	0.00%	0.00%	0.02%	0.03%	0.03%	0.04%
0.00%	0.00%	0.03%	0.03%	0.13%	0.21%	0.26%	0.30%
0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%
5.35%	5.37%	5.63%	5.63%	6.92%	8.30%	9.20%	10.15%
0.03%	0.03%	0.01%	0.03%	0.04%	0.04%	0.05%	0.05%
53.43%	53.50%	53.85%	53.90%	56.07%	57.86%	58.96%	59.94%
13.60%	13.62%	13.06%	12.99%	10.84%	8.40%	6.92%	5.28%
15.80%	15.79%	16.36%	16.30%	17.99%	19.88%	20.92%	22.12%
0.25%	0.25%	0.19%	0.24%	0.22%	0.17%	0.15%	0.12%
4.41%	4.37%	4.12%	4.12%	2.85%	1.82%	1.25%	0.74%
4.30%	4.26%	4.01%	4.01%	2.77%	1.77%	1.21%	0.72%
0.33%	0.32%	0.30%	0.30%	0.21%	0.13%	0.09%	0.05%
7.84%	7.85%	8.08%	8.08%	9.00%	9.91%	10.43%	10.97%
0.04%	0.04%	0.02%	0.04%	0.05%	0.05%	0.05%	0.06%
1820	1820	1926	1927	2299	2699	2929	3199
204	203	194	194	148	103	74	46
459	456	438	438	334	232	168	105
11116	11116	11760	11764	14040	16483	17886	19532
490	490	519	519	619	727	789	861
5019	5019	5155	5156	5635	6159	6461	6828
0	0	0	0	0	0	0	0
101	101	103	103	113	124	130	137
4918	4918	5051	5052	5522	6036	6331	6691
2462	2462	2452	2452	2419	2393	2379	2376
1966	1966	2080	2080	2483	2915	3163	3454

Case
Ecor

Case	1-1	1-2	1-3	1-4
LPMAS syngas conversion	20%	25%	30%	40%
Operating Cost Summary, MM$/yr (Ist year)				
Coal feed	7.5	9.5	11.8	17.5
Operations and maintenance labor	2.4	2.7	2.9	3.3
Maintenance, taxes and insurance	9.9	11.9	14.0	18.7
Catalyst and chemical costs	1.1	1.5	1.9	2.9
Slag disposal costs	0.2	0.2	0.3	0.4
Capital Cost Summary, MM$				
Gasification (including coal receiving, air sep.)	261.3	270.8	281.4	306.3
Acid gas removal, TGT, sulfur recovery	16.9	17.5	18.2	19.8
Mixed alcohol synthesis	31.8	34.0	36.5	42.4
Alcohol separation	1.5	1.7	1.9	2.3
Alcohol dehydration	0.7	0.9	1.1	1.5
Ether plant	6.9	8.2	9.5	12.2
Fuel gas saturation	4.8	4.8	4.8	4.9
Gas turbine, auxiliaries and steam cycle	161.9	162.9	164.2	167.1
Offsites	90.8	93.4	96.3	103.2
Total	576.6	594.3	614.0	659.9
Field indirect costs and HO eng. costs	86.5	89.1	92.1	99.0
Contingency	132.6	136.7	141.2	151.8
Total plant costs	795.7	820.1	847.3	910.6
% of Gasification/AGR costs attributable to LPMAS	22.6%	27.1%	31.7%	40.8%
Total Capital Cost Attributable to LPMAS	171.6	204.8	240.9	322.5
Required ether value for 13% ROR, cents/gal	111.2	101.3	93.9	83.4

1. Case 1-5 is a once-through LPMAS plant, Case 1-6 is a recycle LPMAS plant.
2. Case 1-7 requires 2 gasifier trains, Case 1-8 requires 3 gasifier trains.

able 2-5
- IGCC/LPMAS
mic Summary

1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12
49%	49%	51%	51%	55%	60%	62%	64%
24.5	24.5	25.9	25.9	30.7	35.9	39.0	42.6
3.6	3.6	3.7	3.7	3.9	4.1	4.2	4.3
24.0	24.0	25.2	27.8	32.8	40.4	47.1	59.9
4.1	4.1	4.3	4.3	5.2	6.1	6.6	7.2
0.6	0.6	0.6	0.6	0.8	0.9	1.0	1.1
335.1	335.1	340.5	396.5	418.2	441.1	454.0	469.3
21.7	21.7	22.0	22.0	23.2	24.5	25.2	26.0
49.6	50.1	53.7	53.7	72.7	120.4	174.5	291.1
2.8	2.8	2.9	2.9	3.1	3.4	3.5	3.7
2.0	2.0	2.1	2.1	2.5	2.8	3.0	3.2
15.1	15.1	15.6	15.7	17.4	19.2	20.1	21.2
5.0	5.0	5.0	5.0	5.1	5.2	5.3	5.3
170.6	170.6	171.3	171.3	173.8	176.7	178.4	180.7
111.3	111.4	113.4	123.3	132.1	147.1	161.2	188.9
713.3	713.9	726.6	792.5	848.0	940.4	1025.1	1189.5
107.0	107.1	109.0	118.9	127.2	141.1	153.8	178.4
164.1	164.2	167.1	182.3	195.0	216.3	235.8	273.6
984.4	985.2	1002.7	1093.7	1170.3	1297.7	1414.6	1641.6
49.1%	49.1%	50.5%	50.5%	54.8%	58.6%	60.6%	62.8%
413.3	414.0	434.1	480.1	565.6	696.8	813.1	1033.1
76.1	76.2	75.6	81.5	80.3	83.1	87.8	99

Figure 2-1
Case 1 - IGCC/LPMAS
Block Flow Diagram

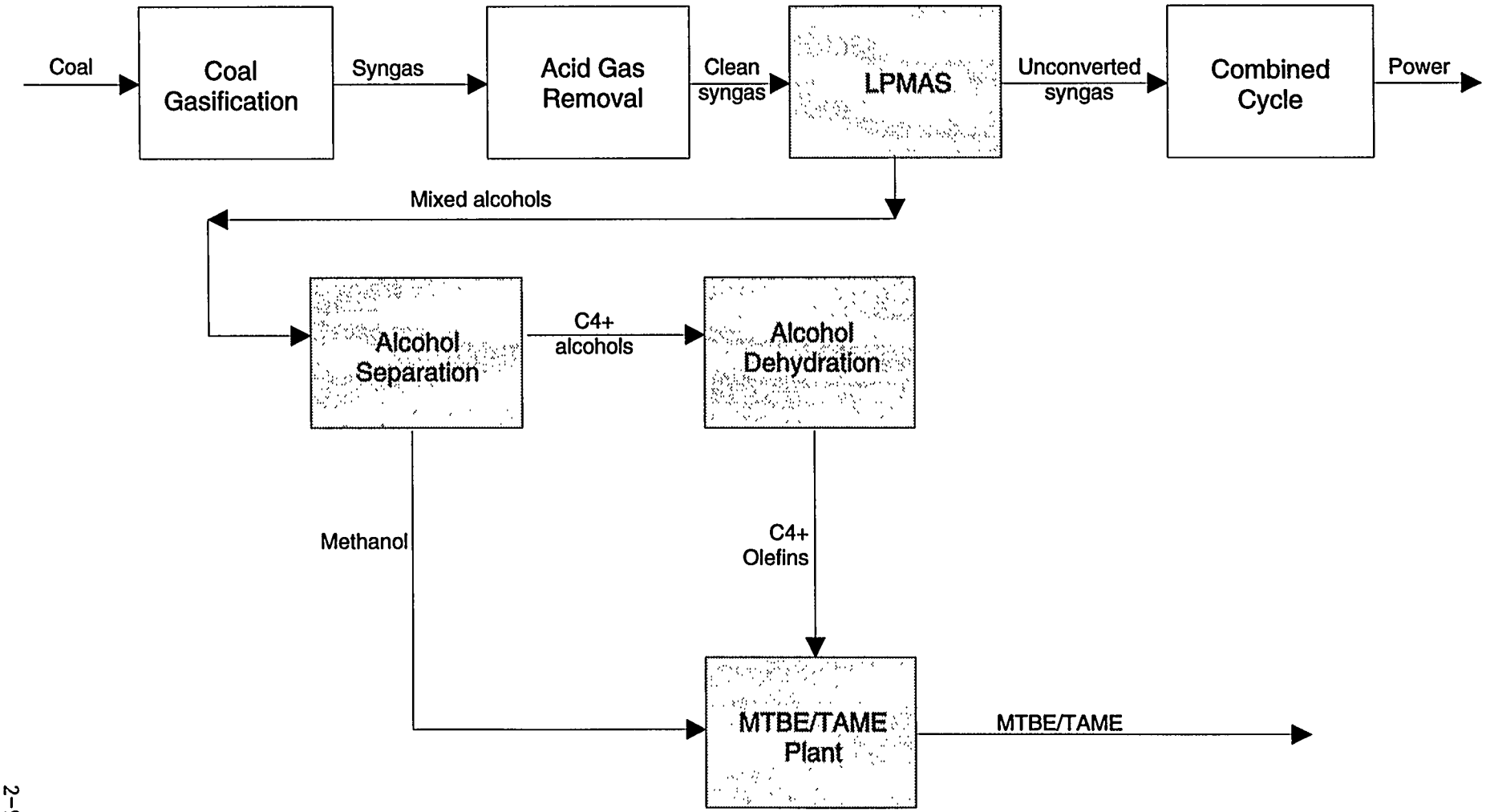

Figure 2-2
Case 1 - IGCC/LPMAS
Gasification Feed Rates

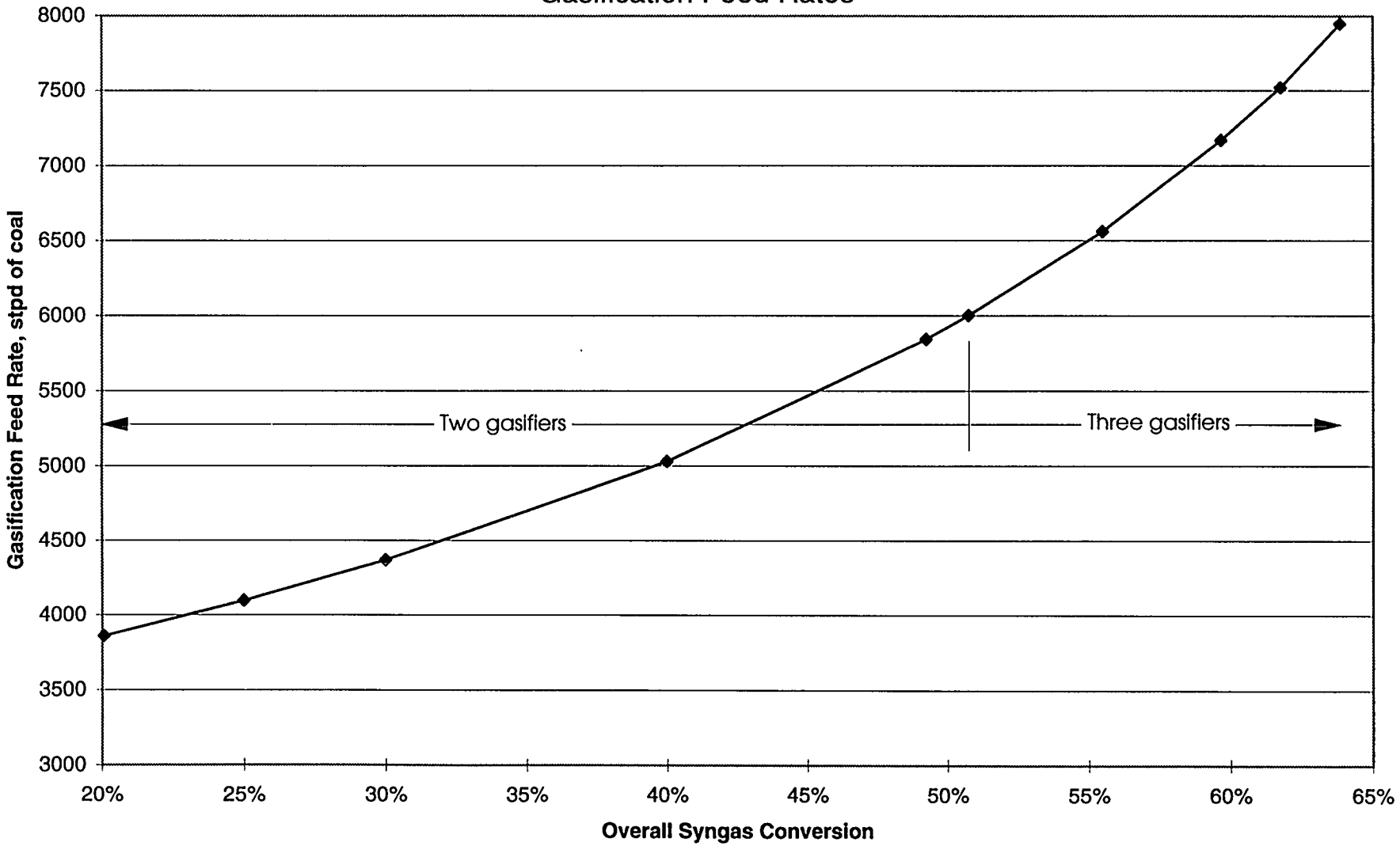

Figure 2-3
Case 1 - IGCC/LPMAS
LPMAS Capacity/Alcohol Production

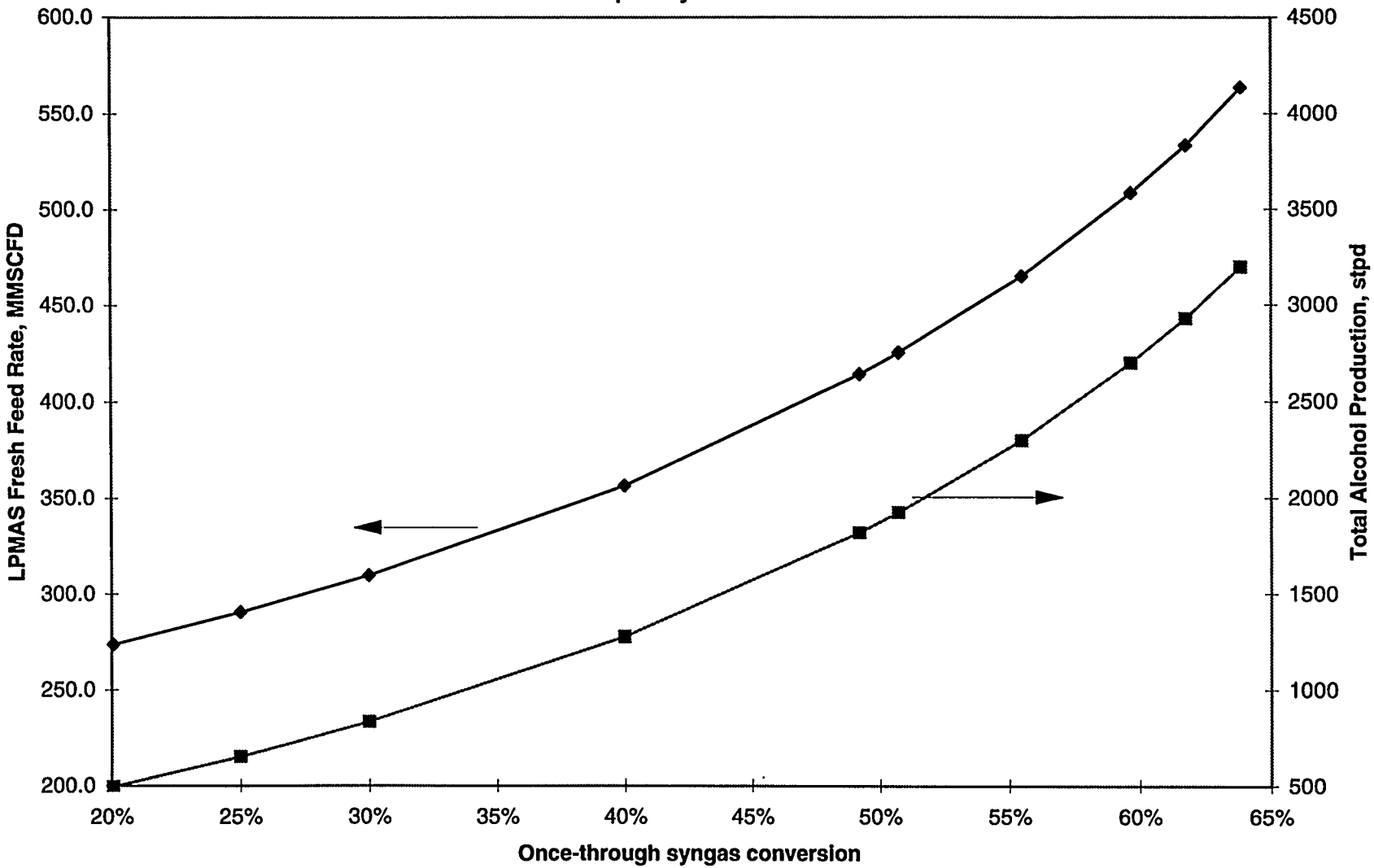

Figure 2-4
Case 1 - IGCC\LPMAS
Ether Production

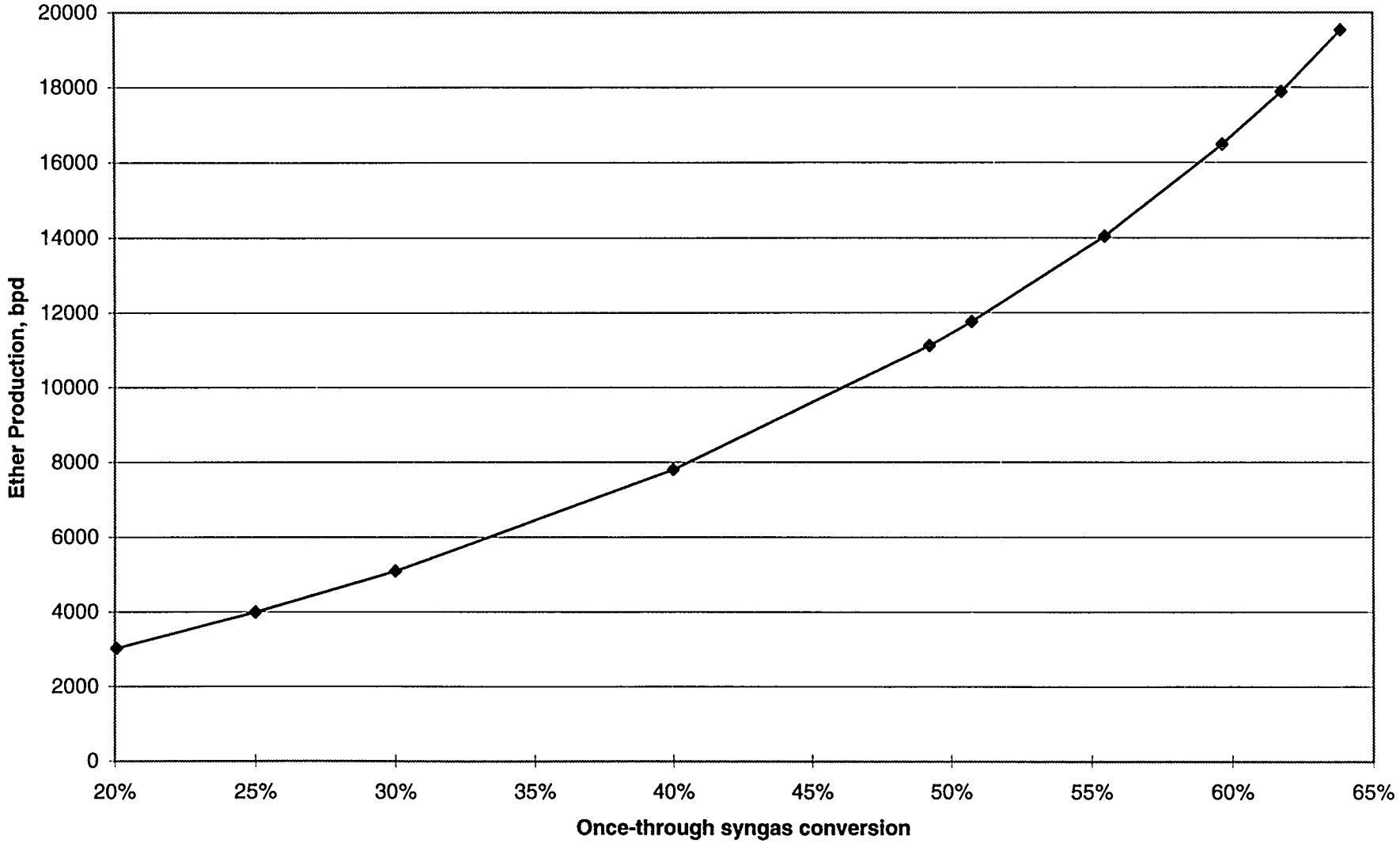

Figure 2-5
Case 1 LPMAS
Block Flow Diagram

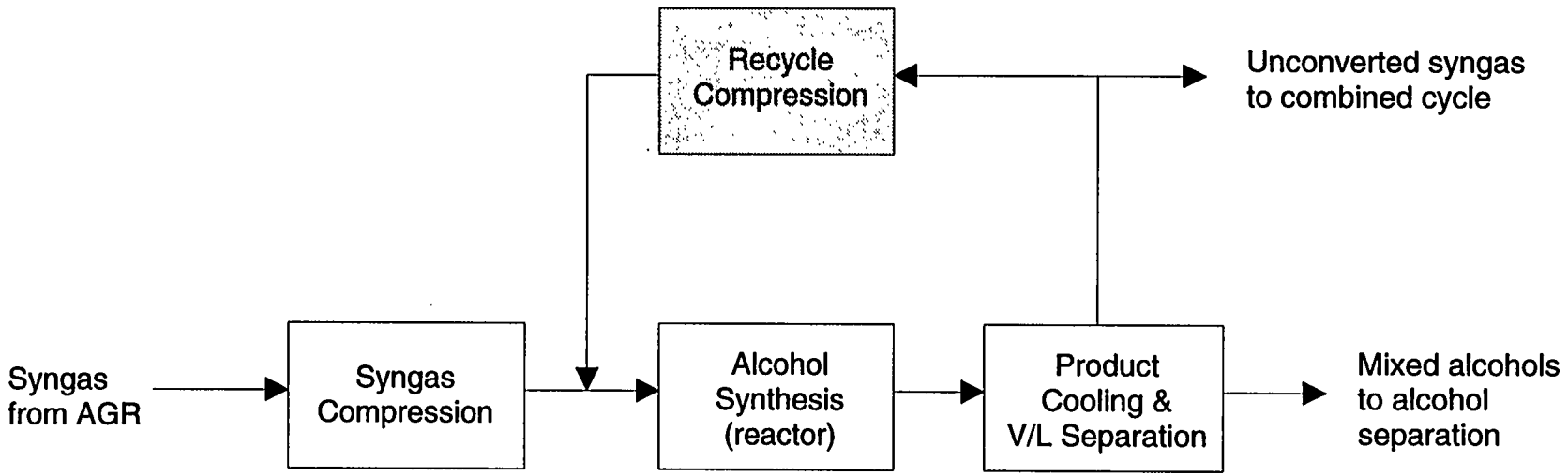

Figure 2-6
Case 1 - IGCC/LPMAS
LPMAS Reactor Feed Rate

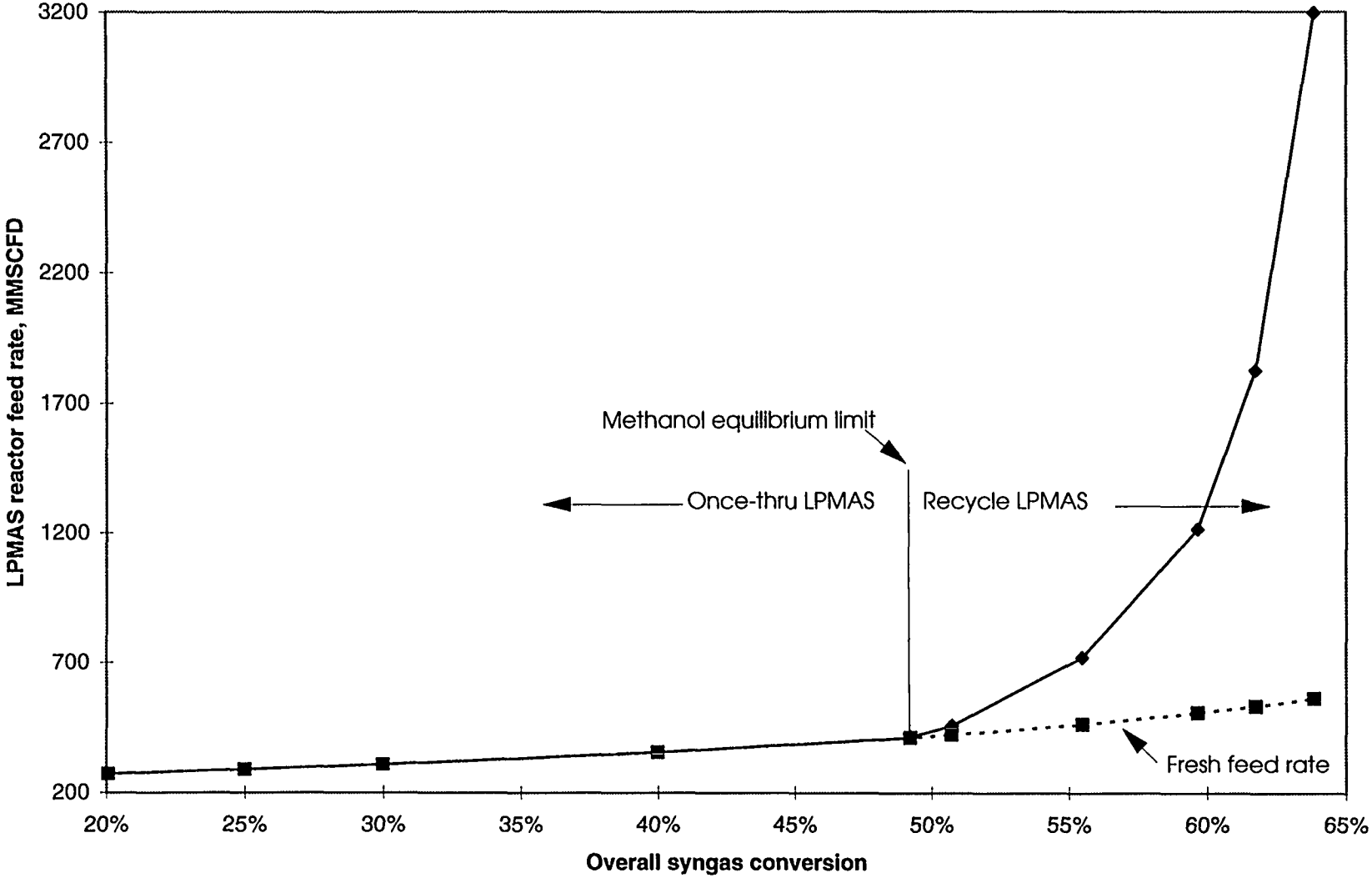

Figure 2-7
Case 1 - IGCC/LPMAS
Required Ether Price

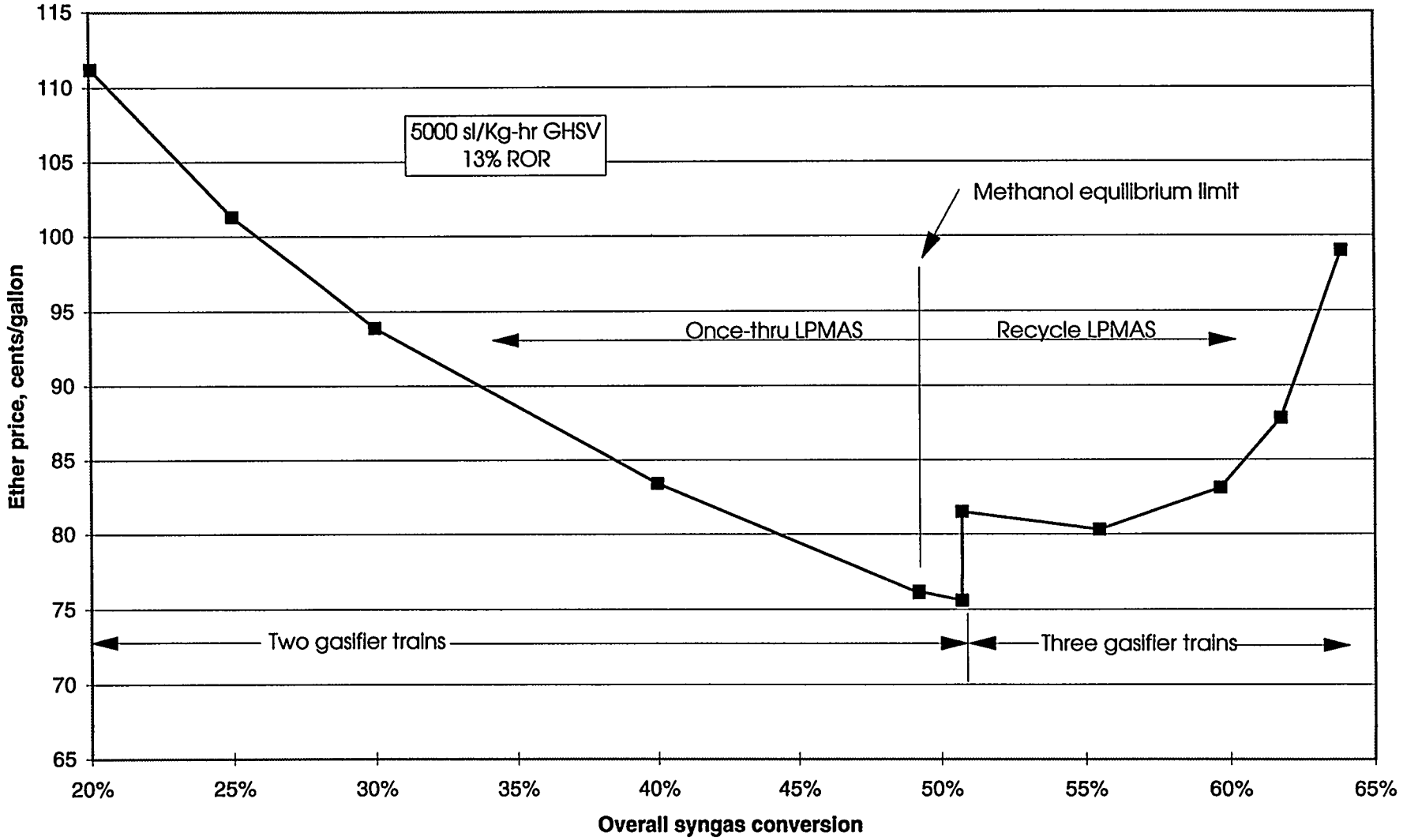

Figure 2-8
Case 1 - IGCC/LPMAS
Required Catalyst Productivity

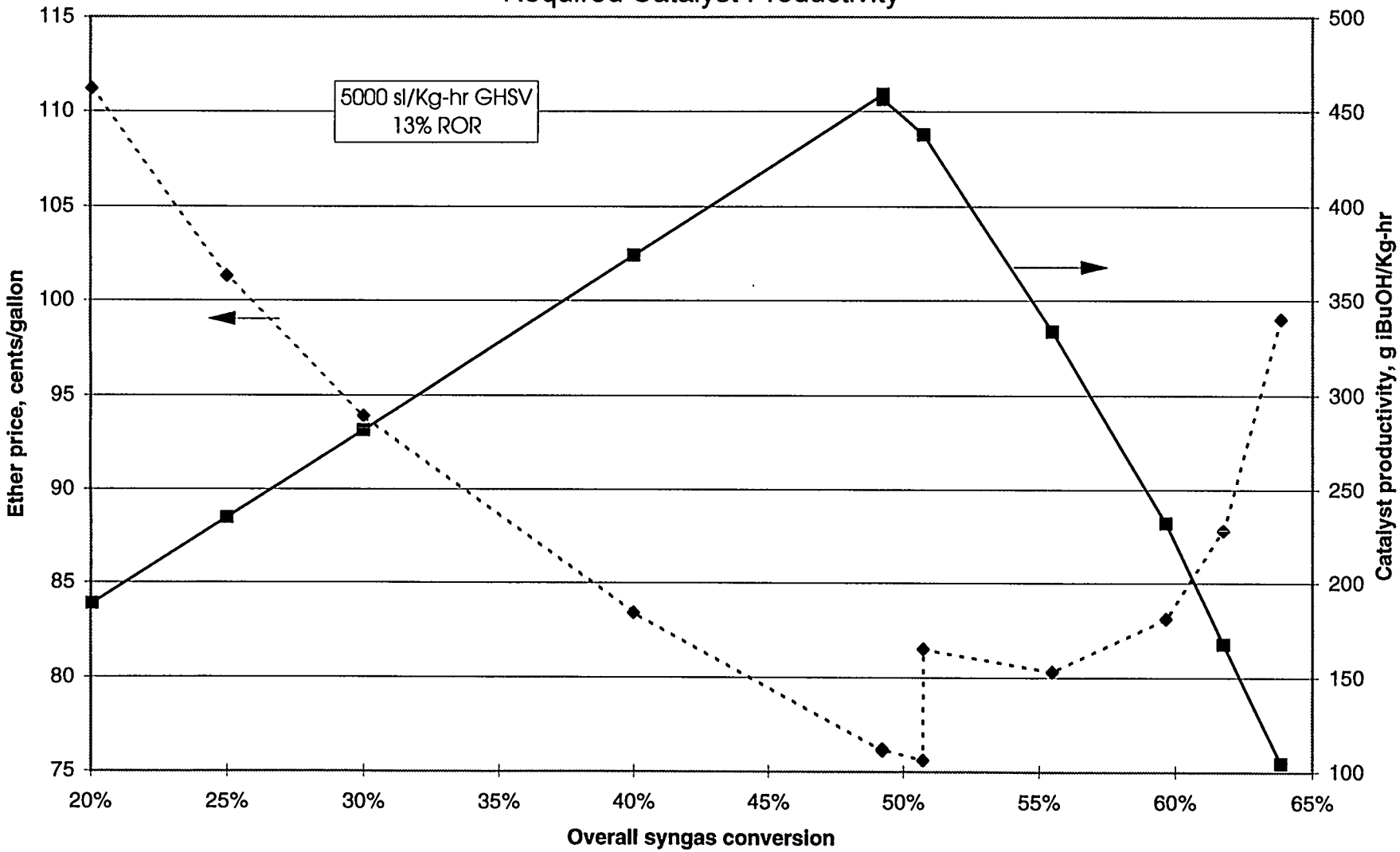

Figure 2-9
Case 1 -IGCC/LPMAS
Effect of LPMAS Reactor Space Velocity