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APPENDICES

Appendix A Product Distribution and Product Yield Calculation

$$\textbf{Yield}\ (\text{ wt }\%) = \frac{\textbf{Total weight of any products}}{\textbf{Total weight of converted bioethanol}} \times \textbf{100}$$

Table A1 Product distribution and product yields from the single-bed catalytic systems

Catalyst	**HZ5**	**GHZ5**	**ZHZ5**	**Z+HZ5**
Ethanol conversion (wt %)	85.05	83.36	82.80	79.90
Fed ethanol (ml/hr)	3.63	3.65	3.68	3.67
Fed ethanol (g/hr) *	2.81	2.82	2.84	2.83
Converted ethanol (g/hr)	2.39	2.35	2.35	2.26
Product distribution (g/hr)				
Total Oil	0.25	0.43	0.31	0.40
Total Gas	1.34	1.14	1.26	1.12
Others **	1.22	1.25	1.27	1.31
Product yield (wt %)				
Oil yield	10.33	18.27	13.20	17.77
Gas yield	56.21	48.51	53.66	49.53

*Ethanol concentration is 99.5 5 v/v %

**The summation of feed water, reaction water, and unconverted ethanol

Table A2 Product distribution and product yields in the dual-bed catalytic systems

Catalyst	EPC:HZ5	EPC:GHZ5	EPC:ZHZ5	EPC:Z+HZ5
Ethanol conversion (wt %)	83.66	85.61	85.29	88.55
Fed ethanol (ml/hr)	3.58	3.74	3.65	3.67
Fed ethanol (g/hr) *	2.77	2.89	2.82	2.83
Converted ethanol (g/hr)	2.32	2.47	2.40	2.51
Product distribution (g/hr)				
Total Oil	0.37	0.57	0.31	0.53
Total Gas	1.17	1.07	1.29	1.13
Others **	1.22	1.24	1.22	1.17
Product yield (wt %)				
Oil yield	16.11	23.00	12.75	21.09
Gas yield	50.63	43.46	53.76	44.99

*Ethanol concentration is 99.5 5 v/v %

**The summation of feed water, reaction water, and unconverted ethanol

Appendix B Chemical Composition in Gas Products

Table B1 Gas composition as a function of time on stream in the single-bed catalytic system of HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
CH4	33.5	30.2	22.3	26.5	23.5	21.5
CO2	33.1	14.8	12.2	12.8	11.2	10.5
Ethylene	0.00	8.04	9.65	8.15	8.54	9.22
Ethane	19.1	21.7	21.3	24.3	23.8	23.5
C3s	9.49	23.3	30.3	25.9	28.6	31.6
C4s	0.00	1.17	2.43	1.40	2.85	2.64
C5s	0.00	0.00	0.00	0.00	0.00	0.00
C6s	4.80	0.75	1.68	0.96	1.44	0.97
Σ	100	100	100	100	100	100

Table B2 Gas composition as a function of time on stream in the single-bed catalytic system of Ga_2O_3/HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
CH4	39.7	29.5	31.1	26.9	28.8	23.5
CO2	13.8	18.2	22.0	18.9	21.6	17.9
Ethylene	0.00	5.58	4.97	6.42	5.74	7.82
Ethane	33.0	24.7	22.9	21.8	21.0	20.0
C3s	13.5	20.4	17.3	23.7	21.0	28.6
C4s	0.00	0.00	0.00	0.00	0.00	0.00
C5s	0.00	0.00	0.00	0.00	0.00	0.00
C6s	0.00	1.64	1.82	2.28	1.79	2.26
Σ	100	100	100	100	100	100

Table B3 Gas composition as a function of time on stream in the single-bed catalytic system of ZnO/HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
CH4	27.4	22.7	21.5	18.4	21.7	19.4
CO2	30.5	34.4	35.9	30.8	36.0	35.4
Ethylene	0.77	0.99	1.13	13.9	1.50	7.19
Ethane	37.8	33.8	33.1	24.1	32.2	25.0
C3s	3.51	7.04	7.11	9.80	6.89	9.84
C4s	0.00	0.62	0.65	1.86	0.74	1.77
C5s	0.00	0.00	0.00	0.00	0.00	0.00
C6s	0.00	0.38	0.66	1.17	0.96	1.44
Σ	100	100	100	100	100	100

Table B4 Gas composition as a function of time on stream in the single-bed catalytic system of ZnO-Al_2O_3 co-catalyst combined with HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
H2	76.7	13.2	9.72	18.8	15.5	15.4
CH4	29.0	21.9	20.5	21.2	18.4	18.3
CO2	46.2	38.1	39.0	38.0	39.4	39.3
Ethylene	0.00	7.48	6.82	7.38	8.38	7.39
Ethane	24.8	19.1	20.0	20.3	20.3	20.9
C3s	0.00	12.7	12.7	12.0	12.0	12.4
C4s	0.00	0.75	0.74	0.79	0.85	0.86
C5s	0.00	0.00	0.00	0.00	0.00	0.00
C6s	0.00	0.00	0.30	0.36	1.01	0.92
Σ	100	100	100	100	100	100

Table B5 Gas composition as a function of time on stream in the dual-bed catalytic system of HZSM-5 catalyst

Component	Composition (mol %)				
	@ 10 min	**@ 70 min**	**@ 130 min**	**@ 250 min**	**@ 310 min**
CH4	31.0	23.1	25.5	21.3	16.9
CO2	1.15	1.57	2.90	3.34	2.98
Ethylene	8.40	7.89	7.58	7.64	7.92
Ethane	28.1	27.4	29.3	28.2	25.0
C3s	29.5	36.4	31.0	35.9	42.0
C4s	1.86	2.43	2.19	2.47	3.94
C5s	0.00	0.06	0.04	0.03	0.14
C6s	0.00	1.07	1.44	1.11	1.13
Σ	100	100	100	100	100

Table B6 Gas composition as a function of time on stream in the dual-bed catalytic system of Ga_2O_3/HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	**@ 70 min**	**@ 130 min**	**@ 190 min**	**@ 250 min**	**@ 310 min**
CH4	45.2	29.5	29.5	24.1	22.3	20.3
CO2	9.94	4.76	6.14	5.28	5.30	4.90
Ethylene	4.17	5.52	5.47	6.24	6.19	6.76
Ethane	31.9	28.7	28.7	26.1	25.5	24.5
C3s	8.76	29.5	28.4	35.9	37.6	40.0
C4s	0.00	0.48	0.44	0.97	1.32	1.81
C5s	0.00	0.00	0.00	0.00	0.00	0.00
C6s	0.00	1.55	1.40	1.46	1.77	1.70
Σ	100	100	100	100	100	100

Table B7 Gas composition as a function of time on stream in the dual-bed catalytic system of ZnO/HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
CH4	24.0	24.0	24.5	25.7	24.1	26.4
CO2	20.3	33.0	33.8	33.7	34.5	33.1
Ethylene	0.82	2.82	1.32	1.48	1.99	2.67
Ethane	51.4	31.1	32.1	31.5	30.2	28.9
C3s	2.36	7.62	6.83	6.34	7.31	7.16
C4s	0.00	0.89	0.67	0.55	0.74	0.91
C5s	1.20	0.00	0.00	0.00	0.00	0.00
C6s	0.00	0.59	0.74	0.74	1.10	0.94
Σ	100	100	100	100	100	100

Table B8 Gas composition as a function of time on stream in the dual-bed catalytic system of ZnO-Al_2O_3 co-catalyst combined with HZSM-5 catalyst

Component	Composition (mol %)					
	@ 10 min	@ 70 min	@ 130 min	@ 190 min	@ 250 min	@ 310 min
CH4	26.1	26.3	25.1	23.3	18.6	20.9
CO2	27.1	23.5	22.3	24.9	23.1	29.3
Ethylene	0.00	7.25	8.28	7.64	11.6	15.6
Ethane	32.0	24.0	24.2	25.4	22.5	26.1
C3s	0.00	18.1	18.8	16.8	20.4	3.25
C4s	0.00	0.49	0.62	0.50	1.61	1.91
C5s	7.06	0.00	0.00	0.00	0.00	0.00
C6s	7.81	0.37	0.59	1.46	2.13	2.92
Σ	100	100	100	100	100	100

Table B9 Gas composition as a function of time on stream in the case of only $MgHPO_4/Al_2O_3$ catalyst packed in the first catalytic bed

Component	**Composition (mol %)**					
	@ 10 min	**@ 70 min**	**@ 130 min**	**@ 190 min**	**@ 250 min**	**@ 310 min**
CH4	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00
Ethylene	100	84.2	83.0	80.9	87	83.6
Ethane	0.00	0.54	0.54	0.52	0.54	0.56
C3	0.00	0.30	0.28	0.27	0.30	0.31
C4	0.00	3.12	2.95	2.94	2.94	3.38
C5	0.00	11.8	13.2	15.4	9.25	12.2
C6	0.00	0.00	0.00	0.00	0.00	0.00
Σ	100	100	100	100	100	100

Appendix C Chemical Composition in Oil Products

Table C1 Oil composition from the single-bed catalytic systems (After 5 hours time on stream)

Component	Composition (wt %)	
	ZHZ5	**Z+HZ5**
NA	3.63	3.60
Benzene	19.22	20.08
Toluene	44.40	44.14
p-Xylene	5.36	4.72
m-Xylene	11.80	10.39
o-Xylene	5.47	4.88
Ethylbenzene	0.65	1.01
C9	1.62	1.85
C10+	7.85	9.33
	100	*100*
BTX/total aromatic	0.89	0.87

Component	Composition (wt %)	
	HZ5	**GHZ5**
Monoaromatic	87.0	90.1
Diaromatic	1.3	1.7
Triaromatic	< 0.1	< 0.1
Non-aromatic	11.7	8.2

Table C2 Oil composition from the dual-bed catalytic systems (After 5 hours time on stream)

Component	Composition (wt %)			
	EPC:HZ5	**EPC:GHZ5**	**EPC:ZHZ5**	**EPC:Z+HZ5**
NA	3.53	3.68	3.79	3.74
Benzene	20.45	19.92	21.31	23.51
Toluene	41.05	42.06	43.24	44.99
p-Xylene	4.36	4.46	4.92	4.57
m-Xylene	9.55	10.01	10.80	9.91
o-Xylene	4.51	4.67	4.97	4.57
Ethylbenzene	1.92	0.93	0.85	1.10
C9	3.22	1.92	1.70	1.65
C10+	11.42	12.34	8.42	5.95
	100.0	*100.0*	*100.0*	*100.0*
BTX/total aromatic	0.83	0.84	0.89	0.91

APPENDIX D True Boiling Point Curves

Table D1 True boiling point curves: Single-bed catalytic systems

%OFF	Boiling point (°C)			
	HZ5	GHZ5	ZHZ5	Z+HZ5
0	55.6	55.7	60.3	59.9
5	57.4	73.4	78.0	77.2
10	73.5	74.0	78.6	77.6
15	74.2	74.4	79.2	78.0
20	75.1	74.9	105.5	104.7
25	103.2	102.8	105.7	105.0
30	103.4	103.0	105.8	105.1
35	103.5	103.1	105.9	105.3
40	103.6	103.2	106.0	105.4
45	103.7	103.3	106.1	105.5
50	103.8	103.4	106.2	105.6
55	104.0	103.5	106.3	105.7
60	104.7	103.7	107.1	105.9
65	135.7	103.9	138.1	137.2
70	136.2	134.7	138.4	137.6
75	136.7	135.2	138.6	137.9
80	141.9	135.9	143.2	142.5
85	172.4	141.6	158.4	157.4
90	222.6	200.5	224.8	203.3
95	247.4	222.5	445.0	243.4
100	562.9	554.5	547.4	540.4

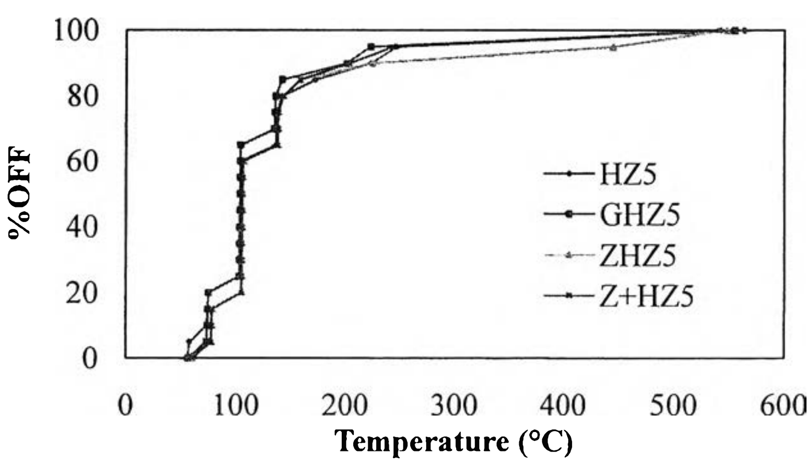


Table D2 Petroleum cuts (Type 1) obtained from single-bed catalytic systems

Boiling point (^oC)	Petroleum Cut	% wt			
		HZ5	GHZ5	ZHZ5	Z+HZ5
<149	Gasoline	81.16	85.63	81.91	89.64
149-232	Kerosene	10.73	9.51	8.26	5.47
232-343	Gas oil	4.62	1.67	2.52	0.84
343-371	LVGO	0.44	0.42	0.64	1.18
>371	HVGO	3.04	2.76	6.68	2.87

Table D3 Petroleum cuts (Type 2) obtained from single-bed catalytic systems

Boiling point (^oC)	Petroleum Cut	% wt			
		HZ5	GHZ5	ZHZ5	Z+HZ5
<200	Full range naphtha	87.75	89.96	88.13	82.18
200-250	Kerosene	7.29	5.46	2.44	11.40
250-300	Light gas oil	0.79	0.75	1.14	3.10
300-370	Heavy gas oil	1.11	1.05	1.59	0.47
>370	Residue	3.06	2.78	6.70	2.85

Table D4 True boiling point curves: Dual-bed catalytic systems

%OFF	Boiling point (°C)			
	EPC:HZ5	EPC:GHZ5	EPC:ZHZ5	EPC:Z+HZ5
0	72.6	58.2	59.3	59.7
5	73.4	73.8	76.4	77.0
10	73.7	74.1	76.8	77.4
15	74.2	74.5	77.2	77.7
20	102.5	77.0	104.0	79.9
25	102.8	103.1	104.4	104.9
30	103.0	103.2	104.5	105.0
35	103.1	103.3	104.6	105.1
40	103.2	103.4	104.7	105.3
45	103.3	103.5	104.8	105.4
50	103.4	103.6	104.9	105.5
55	103.5	103.7	105.0	105.6
60	103.7	103.8	105.2	105.7
65	134.2	131.8	136.5	105.9
70	135.0	135.3	137.0	137.2
75	135.4	135.7	137.2	137.5
80	140.7	136.3	137.8	137.8
85	155.2	141.6	142.7	142.6
90	200.3	200.7	223.9	164.8
95	222.2	222.3	507.2	227.9
100	253.5	246.5	562.7	561.4

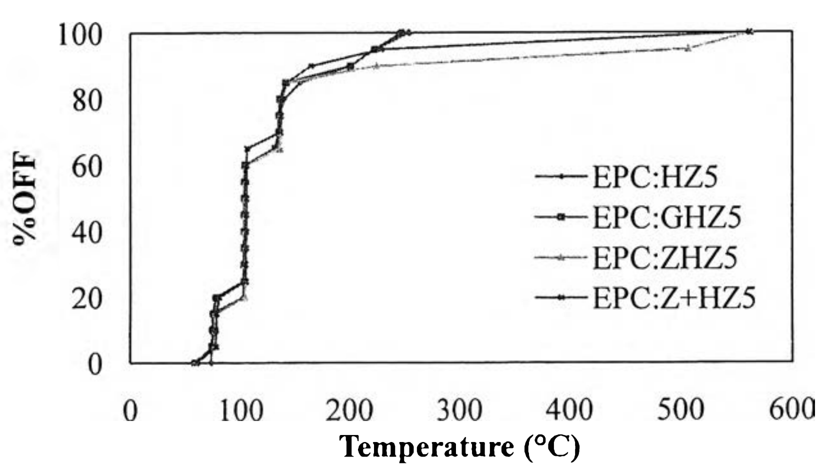


Table D5 Petroleum cuts (Type 1) obtained from dual-bed catalytic systems

Boiling point (°C)	Petroleum Cut	% wt			
		HZ5	**GHZ5**	**ZHZ5**	**Z+HZ5**
<149	Gasoline	82.86	85.63	88.53	92.79
149-232	Kerosene	13.70	11.38	1.93	2.54
232-343	Gas oil	3.43	3.00	0.88	0.75
343-371	LVGO	0.00	0.00	1.24	1.05
>371	HVGO	0.00	0.00	7.42	2.87

Table D6 Petroleum cuts (Type 2) obtained from dual-bed catalytic systems

Boiling point (°C)	Petroleum Cut	% wt			
		HZ5	**GHZ5**	**ZHZ5**	**Z+HZ5**
<200	Full range naphtha	89.97	89.94	85.39	86.44
200-250	Kerosene	9.47	10.06	4.76	8.62
250-300	Light gas oil	0.56	0.00	1.96	1.66
300-370	Heavy gas oil	0.00	0.00	0.49	0.42
>370	Residue	0.00	0.00	7.40	2.85

Appendix E Economic Evaluation Data

Table E1 Product distribution for economic evaluation (172.2 ton per day of ethanol feed)

Component	% Yield	Weight		
		TPD	TPH	TPY
Gas	37.2	64.1	2.7	21,356.2
Oil	19.7	33.9	1.4	11,300.2
Water	28.7	49.4	2.1	16,477.9
Unconverted ethanol	14.4	24.8	1.0	8,265.6
Total	100	172.2	7.2	57,400.0

Table E2 Basic Assumption of Economic Evaluation

Plant Capacity		
Natural gas	21,356	Ton/year
Liquid hydrocarbons	11,300	Ton/year
Working time	8,000	hours/year
Natural gas	2.7	ton/hr
	64.1	ton/day
Liquid hydrocarbons	1.4	ton/hr
	33.9	ton/day
Raw material capacity	172.2	ton/day
	57,400	ton/year
	218,251	Ltrs/day
All Capex is paid at zero year		
Economic life, years	20	
Corporate taxes, %	30	
Depreciation, years	20	
Labor and maintenance is 3.1% of investment cost		
Utility costs are 20% deducted from that of Chematur plant		
Exchanger rate is 30 Baht/US$		

Table E3 Summary of plant information

Total Capital Cost	
Total investment (Million $)	75.74
Total investment (Mil. Baht)	2,272.2
Operating Cost	
Raw material cost (Mil. Baht/year)	1,249.85
Labor cost and Maintenance cost (Mil. Baht/year)	70.44
Utilities cost (Mil. Baht/year)	138.77
Total Operating cost	1,459.06
Revenue	
Liquid hydrocarbons Capacity (tons/year)	11,300
Contract Price of liquid hydrocarbons (Baht/ton)	25,600
NG Heating Value (MilBTU/year)	992,993
Contract Price of NG (Baht/MilBTU)	442.3
Gross sale (Mil. Baht/year)	728.45
Margin	
Margin (Mil. Baht/year)	-730.61

Table E4 Product prices

Item	Raw material and product	Eng. unit	Price	Price ($/T)	Basis
1	Ethanol	Baht/lt	17.2	-	Ethanol price (99.5%) from Thaioil ethanol
		Baht/kg	22.0	-	Ethanol density 0.78 kg/lt
2	Liquid hydrocarbon	Baht/kg	25.6	824.7	Naphtha to Mogas pool
3	Natural gas	Baht/ton	16,974.0	-	Marginal economic monitoring 2012
		Baht/Mil BTU	442.3	-	
4	Mixed-xylene (PX content 18-20%)	Baht/ton	37,326	1,244.2	MEM corp plan'12
5	Paraxylene (PX 99.7%)	Baht/ton	46,626	1,554.2	
6	Benzene	Baht/ton	35,451	1,181.7	
7	Toluene	Baht/ton	32,976	1,099.2	
8	C9	Baht/ton	29,130	971	
9	C10	Baht/ton	25,791	859.7	

Table E5 Heating value and revenues of gaseous products

Composition of natural gas	% composition	TPY	Heating Value	Heating Value	Revenue
		(Ton/Year)	*(Btu/lb)*	*(MilBTU/Year)*	*(Mil.Baht/ year)*
Methane	9.4	1,999.6	23,811	1.0E+05	4.6E+01
Ethylene	5.4	1,162.0	21,884	5.6E+04	2.5E+01
Ethane	21.1	4,512.2	22,198	2.2E+05	9.7E+01
C3	50.7	10,820.3	21,016	5.0E+05	2.2E+02
C4	3.0	643.7	21,210	3.0E+04	1.3E+01
C5+	4.2	896.2	20,526	4.0E+04	1.8E+01
CO_2	6.2	1,322.2	14,150	4.1E+04	1.8E+01
Total	100.0	21,356.2		992,993.5	439.2

Table E6 Revenues of liquid hydrocarbon products (based on naphtha price)

Product	Capacity (ton/year)	Revenue (Mil. Baht/year)
Liquid hydrocarbon (Naphtha)	11,300	289.3

Table E7 Summary of project economic evaluation

Profitability indicators:	Value	
IRR after tax	-	% per year
NPV after tax	- 6,201.17	Mil.Bahts
Profitability index (NPV/Fixed cost)	-	-
Simple payback period before tax	-	Months

Table E8 Economic evaluation: Ethanol price sensitivity

EtOH price (Bth/l)	Margin (Baht/year)	IRR (%)	NPV (Mil.Bahts)	PI (-)	PB (Months)	operating cost (Mil. Baht/year)
17.1785	-730.5	#NUM!	-6200.5	-2.7	-37.3	1459.1
15	-572.0	#NUM!	-5287.4	-2.3	-47.7	1300.5
13	-426.5	#NUM!	-4449.1	-2.0	-63.9	1155.0
11	-281.0	#NUM!	-3610.8	-1.6	-97.0	1009.5
9	-135.5	#NUM!	-2772.4	-1.2	-201.2	864.0
7	10.0	-8.2	-1934.1	-0.9	2729.6	718.5
5	155.5	2.3	-1095.8	-0.5	175.4	573.0
3	301.0	8.8	-257.5	-0.1	90.6	427.5
2	373.7	11.6	161.7	0.1	73.0	354.7
1	446.5	14.2	580.9	0.3	61.1	282.0
0.8	461.0	14.7	664.7	0.3	59.1	267.4
0.7	468.3	14.9	706.6	0.3	58.2	260.1
0.6	475.6	15.2	748.5	0.3	57.3	252.9
0.4	490.1	15.7	832.3	0.4	55.6	238.3

Table E9 Economic evaluation: Product prices sensitivity

Product Price Increasing (%)	Liquid HCs price (Bath/ton)	NG (Bath/MilBTU)
0	25600	442.3
20	30720	530.7
40	35840	619.2
60	40960	707.6
80	46080	796.1
100	51200	884.5
120	56320	973.0
140	61440	1061.4
160	66560	1149.9
161	66816	1154.3
162	67072	1158.7
163	67328	1163.1
164	67584	1167.6
165	67840	1172.0

Table E10 Economic evaluation: Product prices sensitivity (Cont.)

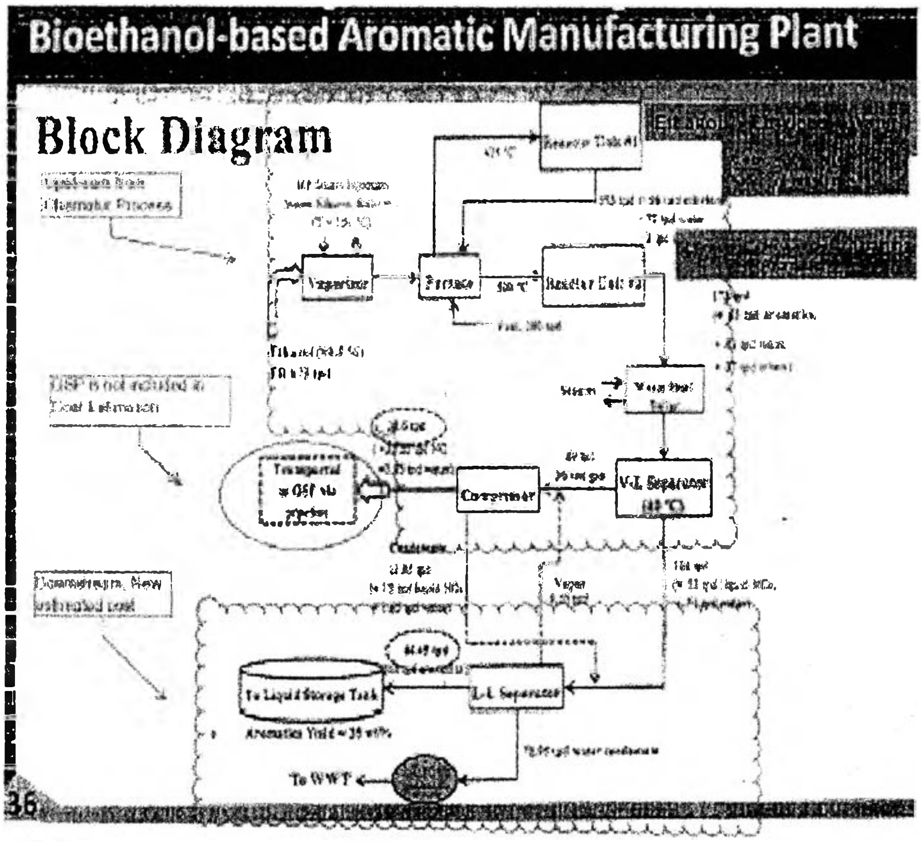
Product Price Increasing	Margin	IRR	NPV	PI	PB
(%)					(Months)
0	-730.6	#NUM!	-6201.2	-2.7	-37.3
20	-584.9	#NUM!	-5361.8	-2.4	-46.6
40	-439.2	#NUM!	-4522.3	-2.0	-62.1
60	-293.5	#NUM!	-3682.9	-1.6	-92.9
80	-147.8	#NUM!	-2843.5	-1.3	-184.4
100	-2.2	-9.8	-2004.1	-0.9	-12623.2
120	143.5	1.7	-1164.7	-0.5	190.0
140	289.2	8.3	-325.3	-0.1	94.3
160	434.9	13.8	514.1	0.2	62.7
161	442.2	14.0	556.1	0.2	61.7
162	449.5	14.3	598.1	0.3	60.7
163	456.8	14.5	640.0	0.3	59.7
164	464.0	14.8	682.0	0.3	58.8
165	471.3	15.1	724.0	0.3	57.8

Table E11 Economic evaluation: Investment cost

Investment Variation (%)	Investment Cost (Mil $)	Margin	IRR	NPV	PI	PB
0	75.7	-730.5	#NUM!	-6200.5	-2.7	-37.3
-5	72.0	-727.0	#NUM!	-6080.7	-2.8	-35.6
-10	68.2	-723.5	#NUM!	-5960.8	-2.9	-33.9
-20	60.6	-716.4	#NUM!	-5721.0	-3.1	-30.4
-30	53.0	-709.4	#NUM!	-5481.3	-3.4	-26.9
-40	45.4	-702.3	#NUM!	-5241.5	-3.8	-23.3
-50	37.9	-695.3	#NUM!	-5001.8	-4.4	-19.6
-60	30.3	-688.2	#NUM!	-4762.0	-5.2	-15.8
-70	22.7	-681.2	#NUM!	-4522.3	-6.6	-12.0
-80	15.1	-674.1	#NUM!	-4282.5	-9.4	-8.1
-90	7.6	-667.1	#NUM!	-4042.8	-17.8	-4.1
-100	0.0	-660.1	#NUM!	-3803.0	#DIV/0!	0.0

Ethanol to Aromatic Plant Cost Estimation

According with the process overview for Ethanol to Aromatic Plant, Upstream process (adiabatic reactor system, quench tower and compressor) has been duplicated with Chematur Plant.



Thus, estimated cost is breakdown as following:

1. Overall Chematur Plant with Deduction cost of Drying and Purification Systems of Chematur Plant
2. Additional estimated cost of Separator System with Tank facilities and piping system.

Note:

- Estimation accuracy +/-50%
- ISBL+OSBL are included
- Instrumentation and Electrical are included
- __Assumption: Gas Separator Plant (GSP) is already existed, only piping system are included.__

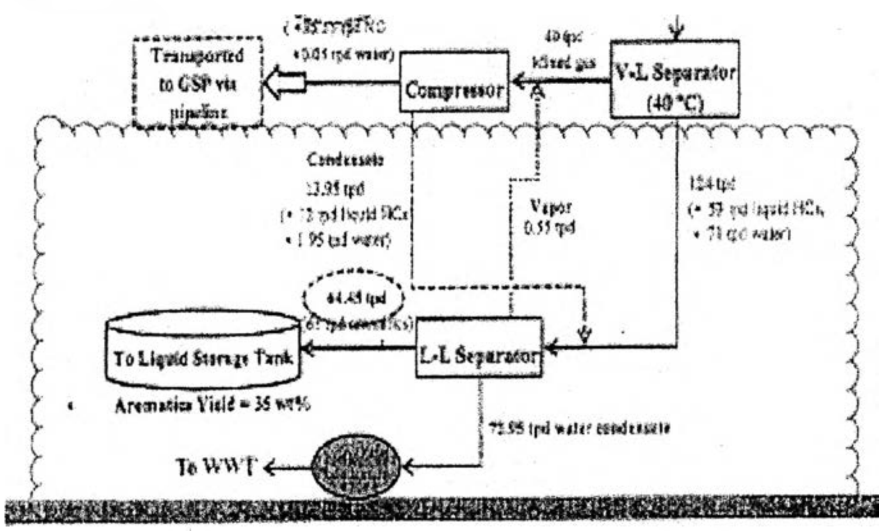
__Estimation Part__

With reference to Ethanol to Light Olefin Plant as previous submission, We estimated that $70.5 m. only for Adiabatic Reactor and compressor Systems as per Attachment 1 of Ethanol to Light Olefin Cost Estimation. So, remaining additional portion of separation system with tank facilities and piping system is $6.07 m. (See detail in Attachment 1).

Overall CAPEX Estimation = $70.5 m + $5.24 m. = $ 75.74 m.

Figure E1 Cost estimation of ethanol to aromatic plant.

Attachment 1. Additional estimated cost of Separator System with Tank facilities and piping system.



Cost breakdown:

Equipment Group	Deduction Cost m.THB ($ m.)
Drum	12 m. THB ($0.4 m.)
Tank (450,000 gallons ~1,700 m3)	50 m. THB ($1.67 m.)
Pump and Piping System	50 m. THB ($1.67 m.)
Other Facilities (incl. OSBL) ~40%	44.8 m. THB ($1.5 m.)
Total	156.8 m. THB ($5.24 m.)

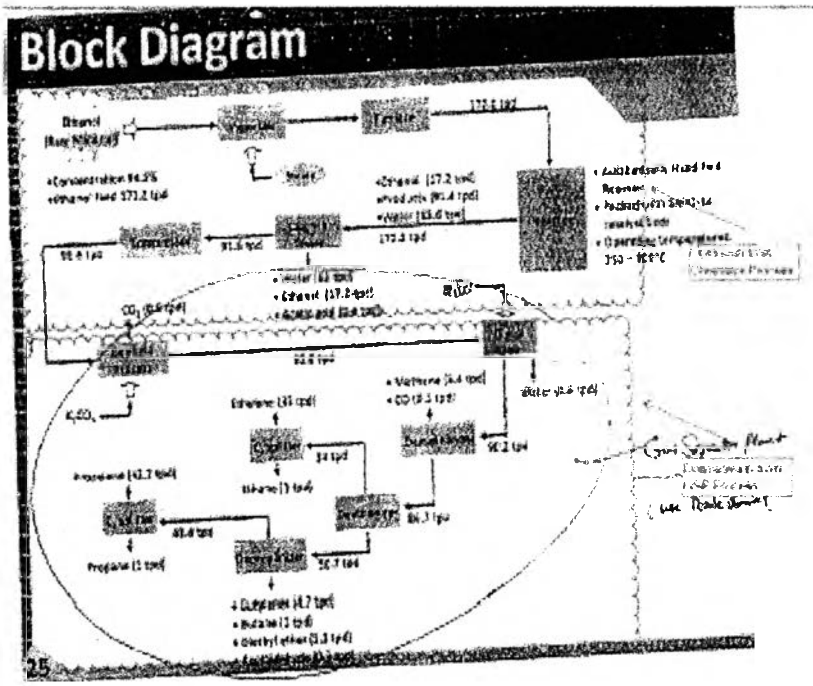
Note:

- Exchange rate - 30 THB/$.
- Equipments cost are from in house data information
- Piping, Civil, instrumentation and electrical are included.

Figure E2 Cost estimation of ethanol to aromatic plant (Cont.).

Ethanol to Light Olefin Plant Cost Estimation

According with the process overview for Ethanol to Light Olefin Plant, Upstream process (adiabatic reactor system, quench tower and compressor) has been duplicated with Chematur Plant



Thus, estimated cost is break down as following

1. Overall Chematur Plant
2. Deduction cost of Drying and Purification Systems of Chematur Plant
3. Additional estimated cost of scale down from Gas Separation Plant (GSP)

Note.

- Estimation accuracy +/-50%
- ISBL+OSBL are included
- Instrumentation and Electrical are included

Estimation Part

With reference to Chematur Plant (Ethanol to Ethylene) as previous submission on table below.

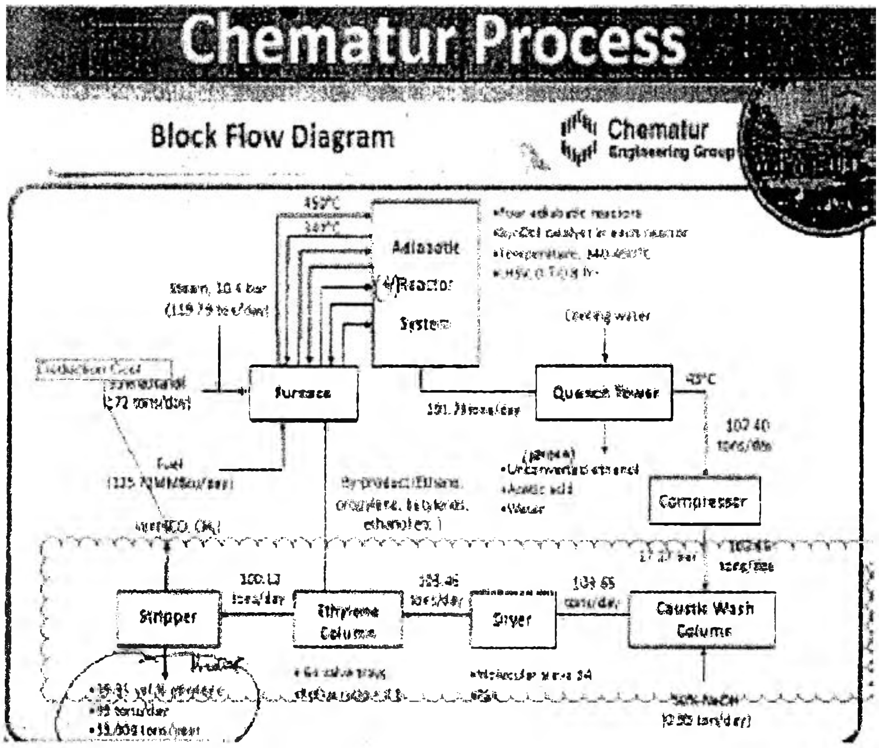
Plant	Capacity	Estimated CAPEX
Chematur	33,000 tons/year	$ 94 m

We estimated 25% cost deduction for Drying and Purification Systems (See detail in Attachment 1). So, remaining portion of Adiabatic Reactor, Quench Tower and Compressor Systems that will be applied for cost estimation of Ethanol to Light Olefin Plant is $70.5 m plus the additional portion of Gas Separation Plant $80 m. (See detail in Attachment 2)

Overall CAPEX Estimation = $70.5 m. + $80 m. = $150.5 m.

Figure E3 Cost estimation of ethanol to light olefin plant.

Attachment 1 : Deduction cost of Drying and Purification Systems



Deduction Cost breakdown

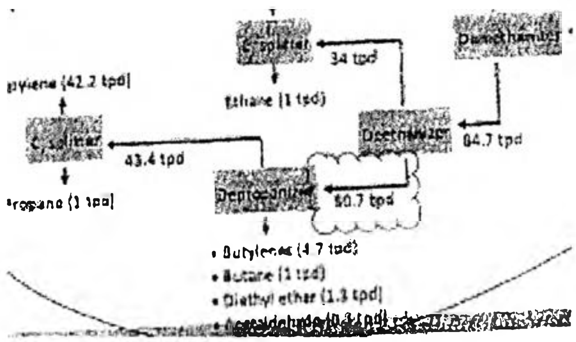
Equipment Group	Deduction Cost m.THB ($ m.)
PSA	200 m. THB ($6.67 m.)
Column and internal	80 m. THB ($ 2.67 m.)
Exchanges	50 m. THB ($1.67 m.)
Drum	15 m. THB ($0.5 m.)
Pump + Piping System	150 m. THB ($5 m.)
Other Facilities (incl. OSBL) +40%	210 m. THB ($7 m.)
Total	705 m. THB ($23.5 m.)

Note:

- Exchange rate – 30 THB/$.
- Equipments cost are from in-house data information.
- Piping, Civil, instrumentation and electrical are inclusion of deduction.

Figure E4 Cost estimation of ethanol to light olefin plant (Cont.).

Attachment 2. Estimated cost of scale down from Gas Separation Plant Unit V (PTT)



Regarding with mass flow capacity 50.7 tpd of C3/C4 as above scheme, comparing with LPG production of GSP Unit 5 from (PTT)

Plant Capacity (MMscfd)	Methane (MMscfd)	Ethane (Tons/Year)	Propane (Tons/Year)	LPG (Tons/Year)	Natural Gasoline (Tons/Year)	Reference Year	Overall Project Investment
Unit 5 530	337	520,000	151,000	495,000	177,000	2005	14,000m THB ($467 m)

Reference http://www.pttplc.com/Files/Document/Pdf/Gas/Gas_en5.pdf

Basis of scaled down estimated cost as same as conversion of Petro gas to Chematur Plant

$$Cost \propto Size^{0.6}$$

Inflation cost shall be added by 3%/year as compound basis from 2005 till 2012

$$Cost\ (Present) = Cost\ (1 + Inflation\ rate)^{Year}$$

Scaled down estimation cost including with inflation cost = $80 m. (2,400 m. THB)

Figure E5 Cost estimation of ethanol to light olefin plant (Cont.).

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	Company name:	APEX plastic company, Thailand Co Ltd.

Presentations:

1. Saewong, S., Wungtanagorn C., and Jitkanka, S. (2012, April 24) Dual-bed ($MgHPO_4/Al_2O_3:Ga_2O_3$/HZSM-5) Catalytic System for Liquid Hydrocarbon Production from Bioethanol. Poster presented at the 3rd Research Symposium on Petroleum, Petrochemicals, and Advanced Materials and the 18th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Queen Sirikit National Convention Centre, Bangkok, Thailand.