

MARKETS AND PROFITABILITY

Quarterly Business Analysis Supplement 2021

Petrochemicals, Polymers, C1 Chemicals and
Fertilizers

Asia Pacific



This Report was prepared by NexantECA, the Energy and Chemicals Advisory company ("NexantECA"). Except where specifically stated in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge and belief of NexantECA. The information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility. Neither NexantECA, Subscriber nor any person acting on behalf of either shall have any liabilities for any loss or damage arising from or connected to the use of any information contained in this Report. NexantECA does not represent or warrant that any assumed conditions will come to pass.

The Report is for Subscriber's internal use only and shall be kept strictly confidential. The Report should not be otherwise reproduced, distributed or used without first obtaining prior written consent by NexantECA. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Copyright © by NexantECA (BV) Ltd. 2022. All rights reserved.



Contents

1	Executive Summary	1
2	Methodology	2
2.1	Leader Laggard Plant Concept	2
2.2	Cost of Production Definition and Basis	4
2.2.1	Variable Costs	5
2.2.2	Direct Fixed Costs	7
2.2.2.1	Direct Plant Manpower	8
2.2.2.2	Direct Overhead	8
2.2.2.3	Maintenance	8
2.2.3	Allocated Fixed Costs	9
2.2.3.1	General Plant Overheads	9
2.2.3.2	Tax and Insurance	10
2.2.4	Technical Support/Royalty	10
2.2.5	Cash Costs	11
2.2.6	Corporate Overheads	11
2.2.7	Working Capital	11
2.2.8	Energy Taxation	12
2.3	Investment Costs	13
2.3.1	Inside Battery Limits	14
2.3.2	Outside Battery Limits	14
2.3.3	Miscellaneous Owner's Costs/Other Project Costs	15
2.4	Pricing Basis	16
2.5	Profitability Analysis and Basis	18
2.5.1	Variable Cost Margin	18
2.5.2	Cash Cost Margin	18
2.5.3	Integrated Costs and Margins	19
2.5.4	Return on Replacement Capital	20
3	Olefins	21
3.1	Ethylene	21
3.2	Propylene	32
3.3	Butadiene	37
4	Polyolefins	40
4.1	Low Density Polyethylene (LDPE)	40
4.2	Linear Low Density Polyethylene (LLDPE)	43
4.3	High Density Polyethylene (HDPE)	46
4.4	Polypropylene (PP)	49
5	Vinyls	52
5.1	Chlor-alkali / Ethylene Dichloride (EDC) / Vinyl Chloride Monomer (VCM)	52
5.2	Polyvinyl Chloride (PVC)	67
6	Aromatics	70



6.1	Reformate, Benzene, Toluene and Xylenes	70
6.1.1	Valuation of Aromatics	71
6.1.1.1	Gasoline Valuation for Aromatics.....	71
6.1.1.2	Gasoline Component Valuation Equation.....	72
6.1.2	Reformate.....	73
6.1.3	Benzene	76
6.1.3.1	Pyrolysis Gasoline.....	76
6.1.3.2	Toluene Dealkylation Costs	78
6.1.4	Mixed Xylenes	82
6.1.4.1	Mixed Xylenes from Reformate.....	82
6.1.4.2	Mixed Xylenes from Toluene Disproportionation (TDP)	82
7	Styrenics	87
7.1	Styrene	87
7.2	Polystyrene.....	89
8	Butadiene Derivatives.....	91
8.1	Styrene Butadiene Rubber (SBR)	91
8.2	Acrylonitrile Butadiene Styrene (ABS)	93
8.3	Butadiene Rubber (BR)	95
9	Polyester and Intermediates	97
9.1	Mono Ethylene Glycol (MEG).....	97
9.2	<i>para</i> -Xylene	103
9.2.1	Xylene Isomers.....	103
9.2.2	Integrated Xylenes Separation.....	104
9.3	Purified Terephthalic Acid (PTA)	110
9.4	Polyethylene Terephthalate (PET)	113
10	Propylene Derivatives.....	116
10.1	Acrylonitrile	116
10.2	Cumene/Phenol.....	118
10.3	Bisphenol-a (BPA)	121
10.4	Polycarbonate	123
10.5	Propylene Oxide	127
10.6	Oxo-Alcohols: Butanols and 2-Ethylhexanol (2EH)	132
11	Isocyanates	135
11.1	Methylene Diphenyl Diisocyanate (MDI) and Toluene Diisocyanate (TDI)	135
12	Methanol.....	148
12.1	Methanol.....	148
12.2	Methyl Tertiary Butyl Ether.....	150
13	Ammonia & Urea	152
13.1	Ammonia	152
13.2	Urea.....	154



Figures

Figure 1	Schematic Cost Curve	3
Figure 2	Production Cost Elements	4
Figure 3	<i>para</i> -Xylene Economics.....	104
Figure 4	MDI and Intermediate Production Costs	136
Figure 5	TDI and Intermediate Production Economics.....	138

Tables

Table 1	Cost of Production for Ethylene Process: Standard Steam Cracker – (Naphtha Feedstock)	23
Table 2	Cost of Production for Ethylene Process: Basic Steam Cracker – (Naphtha Feedstock)	24
Table 3	Cost of Production for Ethylene Process: Steam Cracker – (Naphtha/Propane Feedstock)	25
Table 4	Cost of Production for Ethylene Process: Steam Cracker – (US Import Ethane Feedstock)	26
Table 5	Cost of Production for Ethylene Process: Coal to Olefins (50:50 Ethylene:Propylene)	27
Table 6	Cost of Production for Ethylene Process: Methanol to Olefins (50:50 Ethylene:Propylene)	28
Table 7	Cost of Production for Ethylene Process: Standard Steam Cracker - (Naphtha Feedstock)	29
Table 8	Cost of Production for Ethylene Process: Basic Steam Cracker – (Naphtha Feedstock)	30
Table 9	Influence of Naphtha Cracker Severity on Yield Slate	31
Table 10	Cost of Production for Propylene Process: Propane Dehydrogenation	33
Table 11	Cost of Production for Propylene Process: Coal to Olefins and Olefins Cracking (60:40 Propylene : Ethylene)	34
Table 12	Cost of Production for Propylene Process: Methanol to Olefins and Olefins Cracking (60:40 Propylene : Ethylene)	35
Table 13	Cost of Production for Propylene Process: Propane Dehydrogenation	36
Table 14	Cost of Production for Butadiene Process: Extraction from Mixed C ₄	38
Table 15	Cost of Production for Butadiene Process: Extraction from Mixed C ₄	39
Table 16	Cost of Production for LDPE Liner Grade Process: Tubular Reactor	41
Table 17	Cost of Production for LDPE Liner Grade Process: Autoclave Reactor	42
Table 18	Cost of Production for LLDPE Butene Grade Process: Gas Phase	44
Table 19	Cost of Production for LLDPE Butene Grade Process: Gas Phase	45
Table 20	Cost of Production for HDPE IM Process: Slurry	47
Table 21	Cost of Production for HDPE IM Pellets Process: Slurry	48
Table 22	Cost of Production for Polypropylene Process: Bulk	50
Table 23	Cost of Production for Polypropylene Process: Bulk	51
Table 24	Cost of Production for Chlorine Process: Membrane (Net Basis)	55
Table 25	Cost of Production for Chlorine Process: Membrane Cell (Net Basis)	56
Table 26	Cost of Production for Chlor-alkali Process: Membrane Cell (ECU Basis)	57
Table 27	Cost of Production for Chlor-Akali Process: Membrane Cell (ECU Basis)	58



Table 28	Cost of Production for Ethylene Dichloride Process: Direct Chlorination of Ethylene (Net Chlorine)	59
Table 29	Cost of Production for Ethylene Dichloride Process: Direct Chlorination of Ethylene (Net Chlorine)	60
Table 30	Cost of Production for Vinyl Chloride Process: Balanced Oxy-Chlorination (ECU Chlorine)	61
Table 31	Cost of Production for Vinyl Chloride Process: Coal to VCM via acetylene.....	62
Table 32	Cost of Production for Acetylene Process: Calcium Carbide Hydrolysis (Coal to Acetylene).....	63
Table 33	Cost of Production for Calcium Carbide Process: Lime Kiln (Coal to Calcium Carbide).....	64
Table 34	Cost of Production for Coke Process: Coking Oven (Coal to Coke)	65
Table 35	Cost of Production for Vinyl Chloride Process: Balanced Oxychlorination of Ethylene (ECU Chlorine)	66
Table 36	Cost of Production for PVC Pipe Grade Resin Process: Suspension Polymerisation	68
Table 37	Cost of Production for PVC Pipe Grade Resin Process: Suspension Polymerisation	69
Table 38	Typical BTX Compositions from Pygas and Reformate	70
Table 39	Cost of Production for Reformate Process: CCR Reforming	74
Table 40	Cost of Production for Reformate Process: CCR Reforming	75
Table 41	Pyrolysis Gasoline and Aromatics Yields in Steam Crackers	77
Table 42	Effect of Severity on Pyrolysis Gasoline and Aromatics Yields.....	77
Table 43	Cost of Production for Benzene Process: Extractive Distillation of Pygas	79
Table 44	Cost of Production for Benzene Process: Extractive Distillation of Pygas	80
Table 45	Cost of Production for Benzene Process: Toluene Hydrodealkylation	81
Table 46	Cost of Production for Mixed Xylenes Process: Reformate Extraction	83
Table 47	Cost of Production for Mixed Xylenes Process: Toluene Disproportionation.....	84
Table 48	Cost of Production for Mixed Xylenes Process: Reformate Extraction	85
Table 49	Cost of Production for Mixed Xylenes Process: Toluene Disproportionation.....	86
Table 50	Cost of Production for Styrene Process: Liquid Phase Alkylation.....	88
Table 51	Cost of Production for Polystyrene Process: Mass (Purchased Styrene)	90
Table 52	Cost of Production for SBR Process: Emulsion (Purchased Butadiene & Styrene)	92
Table 53	Cost of Production for ABS Process: Emulsion (Purchased Acrylonitrile, Butadiene & Styrene).....	94
Table 54	Cost of Production for Butadiene Rubber Process: Ni Catalyst (Purchased Butadiene)	96
Table 55	Cost of Production for Ethylene Glycol Process: Ethylene Oxidation/Hydration.....	98
Table 56	Cost of Production for Ethylene Glycol Process: Coal to MEG (Via DMO and Syngas)	99
Table 57	Cost of Production Syngas (2:1) Process: Coal gasification.....	100
Table 58	Cost of Production for Carbon Monoxide and Hydrogen Process: Cryogenic Separation of 2:1 Syngas	101
Table 59	Cost of Production for Ethylene Glycol Process: Ethylene Oxidation/Hydration.....	102
Table 60	Xylene Isomer Distribution in Feedstocks and Products	103
Table 61	Cost of Production for Para-Xylene Process: Adsorption/Isomerisation	106
Table 62	Cost of Production for Para-Xylene Process: <i>Integrated Reformer/BTX Extraction/TDP</i>	107



Table 63	Cost of Production for <i>Para-Xylene</i> Process: Adsorption/Isomerisation	108
Table 64	Cost of Production for <i>Para-Xylene</i> Process: <i>Integrated Reformer/BTX Extraction/TDP</i>	109
Table 65	Cost of Production for PTA Process: Fibre Grade -PX Oxidation	111
Table 66	Cost of Production for PTA Process: Fibre Grade -PX Oxidation	112
Table 67	Cost of Production for PET Bottle Grade Process: PTA Polycondensation and Solid Stating.....	114
Table 68	Cost of Production for PET Bottle Grade Process: PTA Polycondensation and Solid Stating.....	115
Table 69	Cost of Production for Acrylonitrile Process: Propylene Ammonoxidation	117
Table 70	Cost of Production for Phenol Process: Integrated Cumene/Phenol	119
Table 71	Cost of Production for Phenol Process: Integrated Cumene/Phenol	120
Table 72	Cost of Production for BPA Process: Ion Exchange Resin	122
Table 73	Cost of Production for Polycarbonate Process: Interfacial.....	124
Table 74	Cost of Production for Polycarbonate Process: Melt Phase (non-phosgene).....	125
Table 75	Cost of Production for 1:1 syngas Process: Fuel Oil Partial Oxidation	126
Table 76	Cost of Production for Propylene Oxide Process: Propylene Oxide Styrene Monomer (POSM).....	129
Table 77	Cost of Production for Propylene Oxide Process: Hydrogen Peroxide Propylene Oxide (HPPO).....	130
Table 78	Cost of Production for Hydrogen Peroxide Process: Anthraquinone Auto Oxidation (70% solution on 100% basis)	131
Table 79	Cost of Production for <i>n</i> -butanol Process: Oxo Selector 30.....	133
Table 80	Cost of Production for 2EH Process: Oxo Selector 30.....	134
Table 81	Cost of Production for MDI Process: Aniline Condensation and MDA Phosgenation.....	139
Table 82	Cost of Production for Aniline Process: MNB Hydrogenation	140
Table 83	Cost of Production for MNB Process: Benzene Nitration	141
Table 84	Cost of Production for TDI Process: DNT Hydrogenation and Phosgenation.....	142
Table 85	Cost of Production for DNT Process: Toluene Nitration.....	143
Table 86	Cost of Production for Nitric Acid Process: Ammonia Oxidation (60% Acid)	144
Table 87	Cost of Production for Sulphuric Acid Process: Contact Process (98% Acid)	145
Table 88	Cost of Production for Hydrogen and Carbon Monoxide (HYCO) Process: Coal gasification, PSA & Cryogenic separation.....	146
Table 89	Cost of Production for Formaldehyde (38%) Process: Methanol Oxidation.....	147
Table 90	Cost of Production for Methanol Process: Coal Gasification at Mine Mouth	149
Table 91	Cost of Production for MTBE Process: Butylene ex Steam Cracker Raffinat-1.....	151
Table 92	Cost of Production for Ammonia Process: Ammonia from Coal	153
Table 93	Cost of Production for Urea Process: Integrated Coal Mine Mouth	155