

Abstract
Process Economics Program Report No. 204
ECONOMICS OF PETROCHEMICAL COMPLEXES
(February 1991)

Resurgence of the basic petrochemicals industry during the second half of the 1980s has resulted in many grass roots petrochemical complexes being planned for the early to mid-1990s, in a variety of global locations.

In this report we evaluate the economics of new petrochemical complexes in 10 regions of the world, using prevailing market prices during the fourth quarter of 1989. The regions studied are Brazil, Western Canada, China, Indonesia, Japan, Saudi Arabia, South Korea, Taiwan, the U.S. Gulf Coast, and West Germany.

We evaluate production economics for ethylene based on five alternative feedstocks (ethane, propane, butane, wide range naphtha, and atmospheric gas oil). The ethylene derivatives evaluated are high-density polyethylene, linear low-density polyethylene, ethylene glycol, ethylene dichloride, polyvinyl chloride, styrene, polystyrene, linear alpha olefins, and ethanol. Propylene derivatives evaluated are propylene homopolymer, propylene block copolymer, acrylonitrile, propylene glycol, cumene, 2-ethylhexanol, and isopropyl alcohol.

We then convert the production economics for ethylene and for individual ethylene and propylene derivatives to site-specific economics for each of the 10 regions. Lastly, we combine data from the individual steam cracker and olefin derivative studies to create four petrochemical complex configuration and we evaluate the region-specific production economics for each complex configuration.

CONTENTS

1	INTRODUCTION	1-1
2	SUMMARY	2-1
	GEOGRAPHICAL REGIONS INVESTIGATED	2-1
	REGIONAL ETHYLENE ECONOMICS	2-2
	ETHYLENE DERIVATIVE REGIONAL ECONOMICS	2-4
	PROPYLENE DERIVATIVE REGIONAL ECONOMICS	2-7
	INTEGRATED PETROCHEMICAL COMPLEX ECONOMICS	2-7
3	HISTORICAL PERSPECTIVE	3-1
4	INDUSTRY STATUS	4-1
	CURRENT ENVIRONMENT	4-1
	PRICES	4-1
	PROFITABILITY	4-5
	CAPACITY UTILIZATION	4-6
	PETROCHEMICAL CAPACITY GROWTH	4-8
	ISSUES	4-13
5	GEOGRAPHICAL AREAS OF INTEREST	5-1
	REGIONS CONSIDERED	5-1
	EXISTING PETROCHEMICAL CAPABILITY	5-4
	POPULATION TRENDS	5-5
	ECONOMIC GROWTH PROSPECTS	5-6
	STRATEGIC COMPETITIVE FACTORS	5-7
6	GEOGRAPHICAL ECONOMIC INDICES	6-1
	INTRODUCTION	6-1
	INVESTMENT COST	6-1
	REGIONAL LOCATION FACTORS	6-3
	LABOR COSTS	6-3
	PLANT OVERHEAD RATES	6-4
	MAINTENANCE REQUIREMENTS	6-5

CONTENTS (Continued)

6	GEOGRAPHICAL ECONOMIC INDICES (Concluded)	
	LOCAL TAXES AND INSURANCE	6-6
	G&A, SALES, R&D COSTS	6-7
	EXCHANGE RATES	6-7
	SUMMARY	6-8
7	PETROCHEMICAL DERIVATIVES	7-1
	OVERVIEW	7-1
	STEAM CRACKER PRODUCTS	7-1
	STEAM CRACKER BY-PRODUCTS	7-1
	ETHYLENE DERIVATIVES	7-3
	PROPYLENE DERIVATIVES	7-5
8	STEAM CRACKING AND OLEFIN DERIVATIVE TECHNOLOGIES	8-1
	PETROCHEMICAL UNIT CAPACITIES	8-1
	CAPITAL COST ESTIMATES	8-2
	FEEDSTOCK AND UTILITIES COSTS	8-2
	PRODUCTION COSTS	8-3
	PRODUCT PRICING	8-4
	STEAM CRACKING TECHNOLOGY	8-5
	Steam Cracker Yields	8-5
	Regional Cracking Feedstock Options	8-6
	Ethylene Plant Capital Investments	8-7
	Ethylene Plant Operating Costs	8-8
	Production Economics	8-9
	ETHYLENE DERIVATIVES TECHNOLOGY	8-11
	External Resources	8-11
	High-Density Polyethylene	8-12
	Linear Low-Density Polyethylene	8-14
	Ethylene Glycol	8-16
	Ethylene Dichloride	8-18
	Polyvinyl Chloride	8-19

CONTENTS (Continued)

8 STEAM CRACKING AND OLEFIN DERIVATIVE TECHNOLOGIES (Concluded)	
ETHYLENE DERIVATIVES TECHNOLOGY (Concluded)	
Styrene	8-21
Polystyrene	8-23
Linear Alpha Olefins	8-24
Ethanol	8-26
PROPYLENE DERIVATIVES TECHNOLOGY	8-27
Polypropylene Homopolymer	8-27
Polypropylene Block Copolymer	8-29
Acrylonitrile	8-30
Propylene Glycol	8-31
Cumene	8-34
2-Ethylhexanol	8-35
Isopropyl Alcohol	8-37
9 PETROCHEMICAL ECONOMICS	9-1
PURPOSE	9-1
METHODOLOGY	9-1
CASE STUDIES	9-2
OLEFIN PLANT ECONOMICS	9-2
Feedstock and By-Product Pricing	9-2
Olefin Plant Investment Requirements	9-4
Production Economics	9-4
Analysis of Production Economics	9-4
Olefin Plant Profitability	9-8
ETHYLENE DERIVATIVE ECONOMICS	9-9
Ethylene Derivative Prices and Feedstock Costs	9-9
Production Economics	9-11
PROPYLENE DERIVATIVE ECONOMICS	9-14
Propylene Derivative Feedstock Costs	9-15
Propylene Derivative Production Economics	9-16

CONTENTS (Concluded)

10 PETROCHEMICAL COMPLEX ECONOMICS	10-1
PETROCHEMICAL COMPLEX CAPACITIES	10-2
PETROCHEMICAL COMPLEX CAPITAL COSTS	10-3
VALUE ADDED	10-4
AVERAGE PRODUCTION ECONOMICS	10-5
REGIONAL PRODUCTION ECONOMICS	10-7
CONCLUSIONS	10-10
APPENDIX A: ETHYLENE DERIVATIVES REGIONAL PRICES DURING FOURTH QUARTER 1989	A-1
APPENDIX B: PETROCHEMICAL FEEDSTOCK PRICES DURING FOURTH QUARTER 1989	B-1
APPENDIX C: PROPYLENE DERIVATIVE REGIONAL PRICES DURING FOURTH QUARTER 1989	C-1
APPENDIX D: CITED REFERENCES	D-1

ILLUSTRATIONS

3.1	FREE WORLD ETHYLENE CONSUMPTION	3-3
3.2	HISTORIC ETHYLENE PRICES	3-4
4.1	1989 CONTRACT ETHYLENE PRICES	4-2
4.2	1989 CONTRACT POLYMER GRADE PROPYLENE PRICES	4-3
4.3	1989 CONTRACT PLASTICS PRICES	4-4
4.4	FREE WORLD OLEFIN CAPACITY UTILIZATION	4-7
4.5	GLOBAL PE CAPACITY/PRODUCTION	4-9
4.6	GLOBAL PP CAPACITY/PRODUCTION	4-10
5.1	REGIONAL OLEFIN PRODUCTION	5-3
7.1	STEAM CRACKING YIELDS	7-2
7.2	MAJOR ETHYLENE DERIVATIVES	7-4
7.3	PRINCIPAL PROPYLENE DERIVATIVES	7-6

TABLES

2.1	PRODUCTION COST AND PRODUCT VALUE FOR ETHYLENE IN FOURTH QUARTER 1989	2-3
2.2	PRODUCTION ECONOMICS FOR ETHYLENE DERIVATIVES	2-5
2.3	PRODUCTION ECONOMICS FOR PROPYLENE DERIVATIVES	2-6
2.4	PRODUCTION ECONOMICS FOR INTEGRATED PETROCHEMICAL COMPLEXES	2-8
4.1	1989 PETROCHEMICAL MARGINS	4-6
4.2	FREE WORLD OLEFIN CAPACITY/PRODUCTION	4-6
4.3	GRASS ROOTS ETHYLENE CAPACITY ANNOUNCEMENTS	4-11
5.1	GEOGRAPHICAL ASSESSMENT	5-2
5.2	1988 REGIONAL HYDROCARBON PRODUCTION	5-5
5.3	GLOBAL POPULATION TRENDS	5-6
5.4	1989 REGIONAL HYDROCARBON PRODUCTION	5-7
5.5	STRATEGIC COMPETITIVE FACTORS	5-8
6.1	ETHYLENE FROM WIDE RANGE NAPHTHA BY HIGH SEVERITY STEAM CRACKING	6-2
6.2	REGIONAL EXCHANGE RATES	6-8
6.3	REGIONAL ECONOMIC INDICES	6-8
7.1	STEAM CRACKING YIELD	7-1
7.2	1988 ETHYLENE DERIVATIVE CONSUMPTION IN THE MAJOR INDUSTRIALIZED REGIONS	7-5
7.3	1988 PROPYLENE DERIVATIVE CONSUMPTION IN THE MAJOR INDUSTRIALIZED REGIONS	7-7
8.1	DESIGN CAPACITIES FOR DERIVATIVE PLANTS	8-2
8.2	GENERAL 1989 RAW MATERIAL AND UTILITY COSTS	8-3
8.3	AVERAGE 1989 PRODUCT PRICES IN INDUSTRIAL REGIONS	8-4
8.4	STEAM CRACKER YIELDS	8-6

TABLES (Continued)

8.5	1989 ETHYLENE PLANT INVESTMENT COSTS	8-7
8.6	ETHYLENE PLANT ENERGY COMPARISON	8-9
8.7	ETHYLENE PLANT UTILITY REQUIREMENTS	8-9
8.8	ETHYLENE PRODUCTION ECONOMICS SUMMARY	8-10
8.9	EXTERNAL RESOURCES FOR ETHYLENE DERIVATIVES	8-12
8.10	CHARACTERISTICS OF HDPE PROCESSES	8-13
8.11	PRODUCTION ECONOMICS FOR HIGH-DENSITY POLYETHYLENE	8-14
8.12	PRODUCTION ECONOMICS FOR LINEAR LOW-DENSITY POLYETHYLENE	8-15
8.13	PRODUCTION ECONOMICS FOR ETHYLENE GLYCOL	8-17
8.14	PRODUCTION ECONOMICS FOR ETHYLENE DICHLORIDE	8-19
8.15	PRODUCTION ECONOMICS FOR POLYVINYL CHLORIDE	8-21
8.16	PRODUCTION ECONOMICS FOR STYRENE	8-22
8.17	PRODUCTION ECONOMICS FOR POLYSTYRENE	8-24
8.18	PRODUCTION ECONOMICS FOR LINEAR ALPHA OLEFINS	8-25
8.19	PRODUCTION ECONOMICS FOR SYNTHETIC ETHANOL	8-27
8.20	PRODUCTION ECONOMICS FOR POLYPROPYLENE HOMOPOLYMER	8-28
8.21	PRODUCTION ECONOMICS FOR POLYPROPYLENE BLOCK COPOLYMER	8-30
8.22	PRODUCTION ECONOMICS FOR ACRYLONITRILE	8-31
8.23	PRODUCTION ECONOMICS FOR PROPYLENE GLYCOL	8-33
8.24	PRODUCTION ECONOMICS FOR CUMENE	8-35
8.25	PRODUCTION ECONOMICS FOR 2-ETHYLHEXANOL	8-36
8.26	PRODUCTION ECONOMICS FOR ISOPROPANOL	8-38
9.1	FOURTH QUARTER 1989 REGIONAL FEEDSTOCK AND BY-PRODUCT PRICES	9-3

TABLES (Concluded)

9.2	1989 TOTAL FIXED CAPITAL COST FOR ETHYLENE PLANTS	9-5
9.3	PRODUCTION COST AND PRODUCT VALUE FOR MANUFACTURING ETHYLENE IN FOURTH QUARTER 1989	9-6
9.4	FEEDSTOCK RANKING OF ETHYLENE PRODUCTION COSTS DURING FOURTH QUARTER 1989	9-7
9.5	REGIONAL ECONOMICS FOR MANUFACTURING ETHYLENE DURING FOURTH QUARTER 1989	9-10
9.6	ETHYLENE DERIVATIVE PRODUCTION ECONOMICS	9-12
9.7	COMPETITIVE ETHYLENE DERIVATIVES FOR EACH REGION	9-13
9.8	PRODUCTION ECONOMICS FOR PROPYLENE DERIVATIVES	9-17
9.9	COMPETITIVE PROPYLENE DERIVATIVES FOR EACH REGION	9-18
10.1	PETROCHEMICAL COMPLEX CONFIGURATIONS	10-2
10.2	PETROCHEMICAL COMPLEX CAPITAL COSTS	10-3
10.3	VALUE ADDED OF PETROCHEMICAL COMPLEXES	10-5
10.4	AVERAGE PRODUCTION ECONOMICS FOR PETROCHEMICAL COMPLEXES	10-6
10.5	PRODUCTION ECONOMICS FOR INTEGRATED PETROCHEMICAL COMPLEXES FOURTH QUARTER 1989 PRICING BASIS	10-8