THE REPUBLIC OF INDONESIA SURVEY REPORT

ON

PETROCHEMICAL INDUSTRY DEVELOPMENT

VOL. II OLEFIN COMPLEX

OCTOBER 1974

Prepared for

JAPAN INTERNATIONAL COOPERATION AGENCY

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Abbreviations

AB	Alkylbenzene
ABS	Acrylonitrile-butadiene-styrene for polymer
ABS	Alkyl Benzene Sulfonate
AD	Acetic Acid
AG	Aromatic Gasoline (Pyrolysis Gasoline)
BR	Butadiene Rubber
B-B	Butan, Butadiene Residue
BTX	Benzene, Toluene, Xylene
CHP	Cumene Hydroperoxide
CCW	Circulating Cooling Water
CPP	Cast Polypropylene Film
CR	Chloroprene Rubber
C-X(CHX)	Cyclohexane
DEG	Diethylene Glycol
DMT	Dimethyl Terephthalate
DOP	Dioctyl Phthalate
E	Ethylene
EG(MEG)	Ethylene Glycol
EO	Ethylene Oxide
EP	Electric Power
EPDM	Ethylene-propylene-diene-methylene Linkage
EDC	Ethylene Di-chloride
EVA	Ethylene-vinyl Acetate Copolymer
FG	Fuel Gas
FO	Fuel Oil
FRP	Fiber Reinforced Plastic
FW	Filtered Water
GP	General Purpose (Polystyrene)
HDPE	High Density Polyethylene
HI	High Impact (Polystyrene)
IR	Isoprene Rubber
IIR	Butyl Rubber
LAB	Linear Alkylbenzene

LDPE	Low Density Polyethylene	
LNG	Liquefied Natural Gas	
LPG	Liquefied Petroleum Gas	
MI	Melt Index	
M-xylene (Xylene)	Mixed Xylene	
NBR	Nitril Rubber	
NG	Natural Gas	
NGL	Natural Gas Liquid	
NR	Natural Rubber	
OPP	Oriented Polypropylene Film	
PP	Polypropylene	
PS	Polysterene	
PTA	Pure Terephthalic Acid	
PVC	Polyvinyl Chloride	
PW	Polished Water	
p-Xylene (P-X)	Paraxylene	
SBR	Styrene-butadien Rubber	
SM	Styrene Monomer	
TPA (TA)	Terephthalic Acid	
UV	Ultra-violet	
VCM	Vinyl Chloride Monomer	
DCF	Discounted Cash Flow	
Exchange Rate	1971	1US$=360 Yen
		1US$=415 Rupiah
	After the End of 1973	1US$=300 Yen
		1US$=415 Rupiah
GDP	Gross Domestic Product	
GNP	Gross National Product	
IRR	Internal Rate of Return	
$(DL.)	U.S.$, unless Particularly Remarked	
ROI	Return on Investment	

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PART I. SUMMARY AND RECOMMENDATIONS

Chapter 1. General

1-1 Background and Objectives of the Survey

Indonesia has a potential for establishing petrochemical industry with her population of approximately 130 million and the resources of oil and natural gas both of which can be utilized as the raw materials for the industry.

With these factors taken into account, the Phase I survey was conducted in 1972 with a cooperation extended by UNIDO. As a step subsequent to Phase I, the implementation of Phase II studies were planned and the Government of Indonesia requested for cooperation from Japan. This being the circumstance, the Phase II study is now decided to be conducted with a cooperation of the Government of Japan.

In UNIDO's Phase I study, an emphasis was placed on the forecast on the Indonesian domestic market and further, an assumption was made concerning the market share ratio of the overseas markets to estimate the possible exportation market. The two markets were added and the production extent was assumed. Based on this market, feasibility was presented concerning two proposals, the one pertaining to the on stream in 1980 of an ethylene plant of 300,000 t/y capacity on naphtha basis and another for on stream in 1977 of a 200,000 t/y ethylene plant on natural gas and naphtha combination basis.

In these cases, no specific request was made by the Indonesian Government regarding the raw materials and therefore, the study was conducted in the form of estimating the necessary amount of raw materials on the basis of the assumption of the market scale.

This Phase II report has had a purpose to compile detailed technical and economic data on a more practical standpoint concerning the above-mentioned production project including the selection of the plant sites. However, as a result of the visit to Indonesian sites in January 1974 for this report, the following points have since been confirmed regarding the raw materials so that the production schedule formulated in Phase I has to be reshuffled.

(1) Olefin complex shall be based on natural gas, and it will take several months to clarify the quantity, quality, and the location of the natural gas supply sources.

(2) It is not possible to secure sufficient quantity of naphtha to be allocated to the olefin complex.

At the meeting in August 1974 in Jakarta, the following were informed.

(1) Ethan will be used for olefin complex in connection with LNG project at Arun, North Sumatra.

(2) Ethylene plant with a capacity of 450,000 t/y is planned.

(3) The price of F.O.B. LNG is calculated based on the F.O.B. price of Minas crude oil.

Further, the following changes have drastically taken place since the compilation of the Phase I Report.

(1) Extreme price hike and supply shortage of crude oil.

(2) Price increase and supply shortage of plastics products.

(3) Increase in the construction cost and freight cost.

(4) Consecutive announcement of a number of petrochemical construction projects.

Because of these circumstances, it became necessary to take a new look with a renewed vision at the problems concerning the raw materials and product prices. Also, it became necessary to take into serious account the increment factor concerning the construction cost. Further, the necessity for re-studying the export markets became imperative in view of the successive announcement of petrochemical industrialization projects and also of the shortage in the supply of petrochemical industrial products. Regarding the domestic markets, it seems necessary to formulate a new forecast on the basis of the above-mentioned price changes, etc., however, no such forecast has been formulated in the present study.

The change in the conditions surrounding the raw material supply, the change took place in the structure of export market and also the fluctuation and increment in various general costs as above-mentioned, all contributed to shift the direction of the Phase II study from a mere continuation of the Phase I study to the formulation of surveys on the basis of new basic considerations.

1-2 Scope of Survey and Report

It was planned in the outset that the emphasis will be placed on the selection of sites for the petrochemical industry to be operated on naphtha basis by following up the UNIDO's Phase I study. In such a case, it was also planned that the emphasis will also be placed on the relative surveys pertaining to the plant site conditions such as port facilities, water conditions, ground bearing factors, etc. in addition to the relationship with the site with the major consumption areas. This has been based on the fact that naphtha can be transported to any destination.

However, as has been mentioned earlier, it was decided that the production of aromatics production will be undertaken in Palembang on one hand, and another decision was made that natural gas will be taken as the basis for the production of olefin on the other.

This having been the circumstance,the site selection of olefin plant became necessarily limited to be made amongst the gas reserve areas.

Concerning the utilization of the gas, only the local policies have been revealed so far and no specific location of the reserves has been clarified to this day.

Because of the above fact, the scope of survey and report was changed as follows:

(1) The relative economic evaluation in the form of the effects of

(a) Capacity

(b) Candidate place(on marketing and construction cost)

At the meeting in August 1974, the olefin plant, having a capacity of 450,000 t/y based on ethan in North Sumatra, was informed as Indonesia's intention. Therefore, we have added the effects of this decision and the price of gas based on Minas crude oil. The problems in proceeding with the present survey can be enumerated as follows.

(a) The petrochemical industry of the world in general, the site in particular, is now going through a transient phase so that the forecast on the supply and demand trends is extremely difficult to formulate.

(b) The price factors (for raw materials, products, construction cost, transportation cost, etc.) is now displaying the most unstable status.

Therefore, a number of prerequisite conditions had to be stated in each case for undertaking relative forecast.

This having been the circumstance, observations will be made concerning the effects exerted by the change made in the prerequisite conditions.

(2) The technical data and information for selected alternatives for the details of such points as the material balance, plant layout, plant organization manning scheme and others.

(3) The required information for (1)

(a) The future problems of the petrochemical industries of the world (Annex V)

(b) The international competitiveness (Annex IX)

(c) The forecast on various prices (Annex I)

(4) The description of process of petrochemical industry consisting of

(a) The list of process owner for each stage

(b) The features of the available process

(c) Outline explanation

(5) The utilization of natural gas (Annex X) and preliminary study of methanol production

Chapter 2. Prerequisite Conditions

2-1 Commencement of Commercial Operation

The olefin complex shall accomplish the mechanical completion from January to June 1979 gradually as the nature of each plant and an immediate test operation for each plant shall be undertaken thereafter. The test operation shall be continued for approximately 6 months and the commercial operation shall be commenced in August to December 1979. However it was assumed that whole complex shall commence commercial operation in October 1979.

2-2 Plant Sites

Palembang was selected as a site for a complex for early construction to cover Indonesian domestic demand alone; North Sumatra and East Kalimantan were selected as the candidate sites for the construction of a large-scale complex whose production shall cover the export markets as well. As a result of the comparison amongst these alternatives, it was revealed that higher effects will be exerted by the complex scale and other factors rather than the effects exerted by the difference in the site conditions. This being the circumstance, the North Sumatra site was selected as the subject of studies in elaborating on the complex scale assessments, etc.

2-3 Scale and Scheme of Complex

Studies were made centering around the complex scale of ethylene production capacity range from 200,000 t/y to 450,000 t/y and comparison were also made up to the maximum capacity of 600,000 t/y for the purpose of reference.

An assumption at the making report was made regarding the composition of the raw material gas which was further assumed to be available as much as required. These assumptions were made due to the fact that no finalization has yet been made for the source of the raw material gas supply. On the basis of the assumed raw material gas composition, yield pattern by thermal cracking in olefin plant was estimated. The selection of the products to be turned out was made on the basis of the yield pattern of the olefin-rich cracked gas and also on the results of the forecasts on the petrochemical industrial products demand within Indonesia and outside of Indonesia.

For the establishment of these alternatives, further considerations were made regarding the minimum economical scale of the process plants and the geographic proximity of the sites to the market areas. Table II-1 displays the alternative complex schemes and the capacities of each process plant.

Table II-1 Plant Capacity in Each Case

	Case 1	Case 2	Case 3
Site	Palembang	East Kalimantan	North Sumatra
Subject Markets	Domestic market only	Philippines and domestic demand	General export and domestic market
Olefin Plant	200×10^3MTA	450×10^3MTA	300×10^3MTA
Chlorine	43	86	62
VCM	73	146	104
LDPE	100	210	120
HDPE	30	80	50
PVC	70	140	100
EG	50	100	100
PP	48	103	69

At the meeting in August 1974, Indonesia Authorities has informed that olefin plant will be erected based on Ethan in Arun, North Sumatra and the expected capacity of ethylene plant is 450,000 t/y.

According to the alteration of analysis of raw material, the production scheme should be changed as we have estimated in Tables II-2 and II-3. The main differences of production patterns from one of 450,000 t/y in East Kalmantan are:

Table II-2 Yield Pattern of Ethane Feed Olefin Plant

	Feed	Products	(Weight ratio)
Ethane	1.24	-	
Residue Gas	-	0.155	
Ethylene	-	1.00	
Propylene	-	0.03	
$C_{4,5}$	-	0.025	
Aromatic Gasoline	-	0.03	

Table II-3, Plant Capacities and Domestic Demand Case-4

	1980 MTA	1784 MTA	Plant Capacity MTA
LDPE	90	175	180,000
HDPE	20	28	120,000
PP	40	100	
TOTAL	60	128	
PVC	65.	135	140,000
EG	58.5	75.0	100,000

(a) PP production was not taken up and we assumed that the required quantity of PP is covered by increase of HDPE production, because the propylene yield is so low that the capacity of PP plant is not able to attain the economical minimum scale.

(b) Production scheme was made in proportion of domestic market but not based on Philippine market because North Sumatra has not specific advantage as East Kalimantan.

2-4 Operational Rate

The operational rate during the commercial operation period shall be constantly fixed on a 85% level for the basis to carry out the economic evaluations.

2-5 Hydrocarbon Raw Materials and Fuel

(1) Hydrocarbon raw materials

At the present stage, no clarification has been made regarding the available amount, composition and the source of supply concerning the hydrocarbon raw materials which are the feedstock for the olefin plant. Therefore, an assumption was made that light condensate centering around ethane and propane will be employed and further, it was assumed that necessary quantity will be amply supplied. (Refer to Table II-4 regarding the assumed composition.) Light condensate is assumed to be extracted from LNG liquefying plant and the LNG liquefying costs shall be proportionally alloted in accordance with the properties and, thus alloted costs were added to the natural gas price in order to estimate the feedstock price.

Table II-4 Light Condensate Gas Composition

	Weight ratio
Ethane	1.0
Propane	1.47
C_4 fraction	0.97
C_5+ fraction	0.654

We have also studied the case of ethan which will be separated at LNG plant. Tables II-5(1) and (2) show the prices of hydrocarbon raw materials based on Middle East crude oil and Minas crude oil.

Table II-5(1) Prices of Hydrocarbon Raw Materials Based on Middle East Crude Oil

	Prices @ 1974	Prices @ 1980
Natural Gas (Fuel gas)	63¢/MMKcal	94¢/MMKcal
Condensate Gas	29$/t (=64.5¢/MMKcal)	43,5$/t
Crude Oil	9.35$/bbl (CIF Japan)	14.04$/bbl

Table II-5(2) Prices of Hydrocarbon Raw Materials Based On Minas Crude Oil

	Prices @ 1974 January	Prices @ 1980
Natural Gas (Fuel gas)	100¢/MMBTU	150¢/MMBTU
Condensate Gas	45.5$/t (=102¢/MMBTU)	68.3$/t
Ethan	50.1$/t (=102¢/MMBTU)	75.1$/t
LNG	170¢/MMBTU (FOB)	255¢/MMBTU (FOB)
Minas Crude	10.8$/bbl (FOB)	16.2$/bbl

Note: Prices in 1980 are estimated with 7%/year inflation.

(2) Fuel

Natural gas prior to liquefying and remaining after the separation of the light condensate is used as the fuel. The price of such fuel shall be deemed as being equivalent to the natural gas price at the entrance of the LNG plant.

2-6 Auxiliary Raw Material

Concerning chlorine, it was assumed that industrial salt produced through the Madura Island project is to be carried out to the plant site in which electrolysis shall be undertaken. The price of salt was estimated to be US$8.1/t in Madura Island for 1980 and the price at plant site (in the case of Palembang) was estimated to be US$28.4/t including necessary costs such as transportation cost, etc., from Madura.

Also, electrolysis plant by utilizing low cost electric power from hydro power generation to be undertaken for a aluminum smelting project in Asahan could be considered, and a separate study concerning the feasibility thereof was also made.

2-7 Market and Product Prices

(1) Domestic demand

The demand which has been revealed in UNIDO Phase I study has been applied for domestic market up to 1985 and thereafter yearly increment made by considering the above data, up to the year of 1989, shown in Table II-6. However, as for EG, there is a large gap as is supplementary shown in the table between the above data and the demand estimated on the basis of Synthetic Fiber Raw Material Survey. The latter that is on the Synthetic Fiber Raw Material Survey was taken for the basis of economic evaluations in this report.

Table II-6 Estimated Domestic Demand of Petrochemical Products in Indonesia

(Unit: 10^3 t/y)

	1975	1976	1977	1978	1979	1980	1981	1982
LDPE	36	43	52	63	75	90	106	125
HDPE	11.5	13	14.5	16	18	20	22	24
PVC	23	29	36	44	54	65	78	95
PP	-	2.5	8.5	16.5	26.5	40	51.5	65
EG	15.2	17.5	21	24.8	28.2	32.5	47.5	43.3
(EG) *			27.5	37.8	48.2	58.5	62.5	66.7

	1983	1984	1985	1986	1987	1988	1989
LDPE	148	175	200	228	260	296	338
HDPE	26	28	30	32.7	35.6	38.9	42.3
PVC	113	135	160	190	225	266	315
PP	81	100	120	144	173	207	249
EG	49.8	57.7	66.7	76.7	88.2	101	117
(EG) *	70.9	75.0	79.1	83.2	87.4	91.7	96.3

*Note : * To be estimated based on the result of synthetic fibre material survey*
Figures 1975-1985 is the result from UNIDO phase I.

(2) Export Market

As is shown in Annex VIII, a vast extent of gap between the demand and production capacity will emerge in the ECAFE area due to the decrease in the export surplus capacity in Japan. Therefore, provided that the price-wise international competitiveness is ample, the production surplus, which is the balance between the Indonesian domestic demand and the total production, can be assumed to be totally exportable. However, it must be noted here that re-study must be made concerning the exportability and the export prices concerning the export amount exceeding the adequate level, e.g., a portion which largely exceeds the one-half level of the domestic demand.

(3) Domestic price

As is shown in Annex I and Part III, there are three policies for estimation of exfactory price of petrochemical industrial products for domestic market, i.e., (a) prices based on the import price levels of petrochemical products; (b) prices based on the production cost; and (c) prices based on the relationship between the demand and the price level.

As is shown in Volume VI, the present status of Indonesia displays a high rate of product distribution margins and this factor is expected to be reduced along with the expansion of the consumption amount. Therefore, the prices on the above (c) was not directly utilized for formulating the price forecast. For the most case, estimations were made on the above (a) to obtain exfactory prices which will be viable against the import prices from Japan and Middle East countries. The calculation results obtained through the above (b) were utilized for determining whether or not import duty imposition should be effected. Refer to Table II-7, exfactory prices for domestic market.

Table II-7 Exfactory Price for Domestic Market

(Unit:¢/kg)

	Minimum Exfactory Price, Japan		Exfactory Price Middle East	Standard Price
Products	1974*	1980	1980	1980
LDPE	53	72	75	83.3
HDPE	52	70	73	81.0
VCM	26	37	31	-
PVC	41	58	82.6	79.4
EG	-	50	44	55.3
PP	57	78	70	82.7

Notes: Standard price is used for economic evaluation of project.
Price increase per year is about 5%.
* = Estimation

(4) Export prices

It was assumed that the Philippines will be the representative export market in view of geographic proximity and also the potential of growth into a large-scale consumption market of petrochemical products. Estimations were made to obtain exfactory price for export which will be viable against the CIF Ports of importing countries from Japan or Middle East countries. However, concerning the export prices of Japan, the estimation were made on the assumption that the production will be made by the already existing plants. As far as the export prices of Middle East countries are concerned, an assumption was made that the production will be carried out by newly constructed plants and that the export price does include adequate extent of profit margin. No special exportation practices such as exportation by marginal price levels, etc. has been taken into consideration in this study. However, the actual export prices are prone to drastic changes according to the international economic situations. The economic viability assessment of this project has been made on the basis of 80% level of CIF prices for the Philippines market. Refer to Table II-8, exfactory price for export.

Table II-8 Exfactory Price for Exportation

(Unit: ¢/kg)

Products	CIF Manila from Japan	CIF Manila from Middle East	Exfactory price for export: Competitive Price with Japanese Export	Exfactory price for export: Standard Price
LDPE	84.0	91.1	71.9	67.2
HDPE	81.8	88.9	69.9	65.5
VCM	44.6	64.9	37.1	-
PVC	68.6	100.0	57.9	61.7
EG	57.6	54.1	50.0	40.0
PP	90.6	85.8	77.9	72.5

Note: Standard price is used for economic evaluation of project

Chapter 3. Results of Evaluation

3-1 Comparison of the Candidate Sites

Indonesia consists of a number of islands covering a wide area so that the site conditions for industrialization vastly vary from locality to locality and difference is also conspicuous in the geographic distance from the plant site to the market areas. Therefore, such differences will cause variations in factors such as the (1) product transportation cost and (2) exfactory prices, (3) construction cost and (4) production cost and profitability of each process plant.

The differences by candidate sites in this respect are shown in Tables II-9, II-10 and II-11 and further Figure II-1 shows representative results by taking LDPE as an example concerning the above factor (4). The results imply that generally speaking, the differences in such factors as transportation cost and construction cost will not form any vital element affecting the site selection decisions at this stage where no finalization has been made regarding the raw material.

Table II-9 Comparison of Transportation Cost between Domestic Market and Each Plant Site

(Unit: ¢/kg)

Products	Plastic resin		EG		VCM	
Market / Site	Domestic Jakarta	Export Manila	Domestic Jakarta	Export Manila	Domestic Jakarta	Export Manila
Palembang	1.41	-	0.94	-	-	-
E. Kalimantan	1.85	2.08	1.27	1.55	-	2.55
N. Sumatra	1.95	2.78	1.37	1.99	2.24	3.26

Table II-10 Comparison of Exfactory Price for Each Plant Site

(Unit: ¢/kg, year: 1980)

Products / Markets / Site	LDPE Domestic Jakarta	LDPE Export Manila	HDPE Domestic Jakarta	HDPE Export Manila	PVC Domestic Jakarta	PVC Export Manila
Palembang	112.0	-	133.2	-	87.0	-
E. Kalimantan	111.6	82.6	132.8	98.6	86.6	63.6
N. Sumatra	111.5	81.9	132.7	97.9	86.5	62.9

	PP Domestic Jakarta	PP Export Manila	VCM Domestic Jakarta	VCM Export Manila	EG Domestic Jakarta	EG Export Manila
Palembang	127.9	-	-	-	80.2	-
E. Kalimantan	127.5	94.6	-	39.7	79.9	58.6
N. Sumatra	127.4	93.9	64.0	39.1	88.9	58.1

Note : Import price base
Imported from Japan by Min. price, and included import tax 15%.

Table II-11 The Rate of Construction Cost in Plant Sites

	Palembang	E. Kalimantan	N. Sumatra
Location factor	98.5 %	103.7 %	100 %

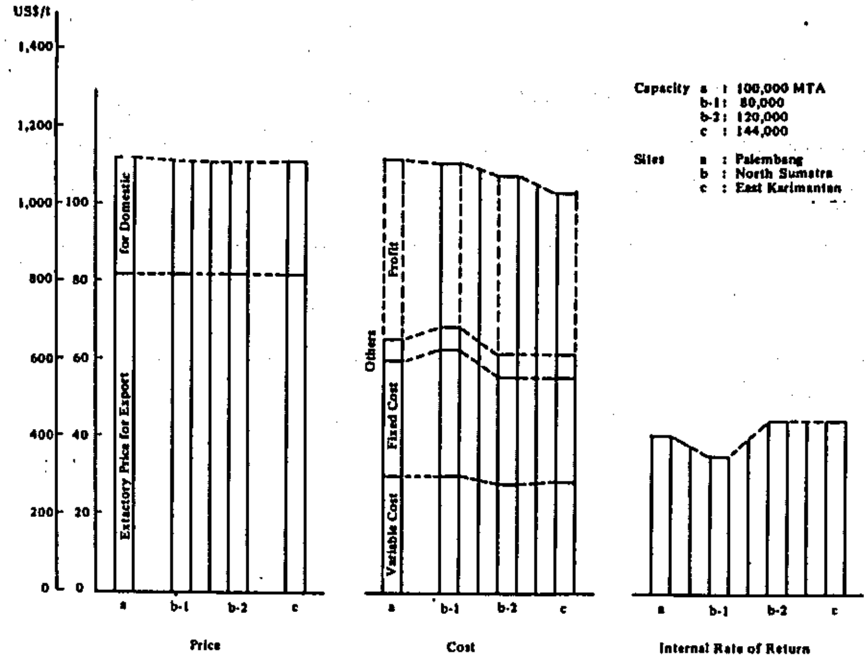


Figure II-1 Comparison of Exfactory Price, Production Cost & Profitability by Plant Sites

3-2 Comparison of Complex Scheme Alternatives

Table II-13 shows a comparison of internal rate of return of the complex of each case as a whole. Also, Table II-12 shows the investment cost required for each one of the cases. Further, for the purpose of reference, Table II-13 includes the results of internal rate of return by scale-up and scale-down sliding of the product pattern applicable to Case 3, the North Sumatra site, directly in proportion to the production capacity of ethylene. As is evident from the tables, all the cases display favorable economy, however, the profitability difference between the schemes is much more greatly affected by the complex scale differences rather than by the site conditions or the makret-combined complex schemes.

Table II-12 Comparison of Alternative Scheme

	Case 1		Case 2		Case 3		Case 4 *2	
Sites	Palembang		East Kalimantan		North Sumatra		North Sumatra	
	Plant Capacity 10^3MTA	Investment Cost $10^6$$	Plant Capacity 10^3MTA	Investment Cost $10^6$$	Plant Capacity 10^3MTA	Investment Cost $10^6$$	Plant Capacity 10^3MTA	Investment Cost $10^6$$
Olefin Plant	205	133	442	243	98	173	453	225
Electrolysis Plant(chlorine)	43	49	86	82	62	62	86	78
VCM	73	50	146	84	104	63	146	81
LDPE	100	163	210	282	120	184	180	244
HDPE	30	45	80	91	50	63	120	114
PVC	70	53	140	89	100	67	140	85
EG	50	57	100	95	100	91	100	92
PP	48	70	103	124	69	89	0	0
Total *1		620		1,089		792		920

Notes: *1 = Excluding the investment cost for utilities

*2 = Ethan feed complex

Production pattern is corresponding to the domestic market in 1984.

Table II-13 Comparison of Alternatives

(Comparison of Internal Profit Rate of the Complex as a Whole) *3

	Case 1	Case 2	Case 3
Ethylene capacity x 10^3 MTA	200	450	300
Site	Palembang	East Kalimantan	North Sumatra
I.R.R. of Whole Complex	20.2%	23.9%	(20.9%) *2 21.8%
I.R.R. of Whole Complex with corresponding capacity*1	17.3%	25.5%	(20.9%) 21.8%

Note: The product price are assumed standard prices.
Refer to Clause pertaining to porduct prices

*1 The North Sumatra case was slided up and down to obtain these results.

*2 ( ) showns the calculation results obtained by detailed financial analyses.
All the other figures were obtained comparative calculations by utilizing models.

*3 Price of natural gas is 63 ¢/MMBTU for the year of 1974.

3-3 Utilization of Surplus Electric Power at Asahan

This plan intends to utilize the low-cost electric power (assumed to be US$0.012/KWH) generated by a hydro-power station at Asahan for the purpose of carrying out electrolysis of salt to produce caustic soda to be supplied to the alumina production and at the same time utilize chlorine for the production of VCM and PVC. The electrolysis plant, VCM and PVC plants which utilize chlorine shall then be constructed in Asahan and the other plants such as olefin plant in the vicinity of the natural gas sources, thereby dividing the complex into two groups. In this writing, studies were made by taking a complex scheme equivalent to Case 3. Table II-14 shows a summary of the results of the economic evaluation. Table II-14 shows two cases, i.e., (1) the same price level was

Table II-14 Financial Comparison of Asahan Electric Power

	Caustic Soda	Profit at 1980	Total Invest-ment cost	R.O.I.* at 1980	I.R.R.
Case 3	301	72.7 10^6\$	721 10^6\$	10.1%	21.8%
ASAHAN Electric Power Use (1)	206	71.2	743	9.6	21.2
ASAHAN Electric Power Use (2)	301	76.9	743	10.3	21.9

Note: * Net profit before tax/investment at 1980.

(1) Caustic Soda Price 20.6 ¢/Kg. based on 15% of the I.R.R. of Electrolysis Plant.

(2) Caustic Soda Price 30.1 ¢/Kg same price as in the Case 3 is taken.

taken for caustic soda and the chlorine and (2) the caustic soda price was taken on the same level as in Case 3. As has shown in the above table the unit price reduction in the electric power cost for electrolysis has been compensated by increment in the construction cost and utility unit cost caused by the disintegration of the complex into two groups.

3-4 Effects of Variation of Several Prerequisite Conditions (i.e. price of raw material and product, construction cost, operational rate)

The sensibility curves for internal rate of return of ethylene and LDPE plant(others are mentioned in Part III), ethylene capacity of 300,000 t/y based on light condensate, illustrate the effects of variation of several prerequisite (Shown in Figures II-9 and II-12(2).

They indicate the importance of operational rate (stream factor) and construction cost beside product price, and this means that this project is capital intensive one.

It is important to prepare the project well so as to minimize the construction cost and increase the operational rate.

3-5 Effect of Escalation Factor

In this economic evaluations, it has been assumed that a 7% per year of escalation factor will affect the prices of raw materials, products, ocean freight, labor cost, construction cost, etc. after the time of sudden rise in oil price.

Concerning the effects of inflation, cases covering a range from 0% to 10% progress factors were also studied. As a result, it was revealed that the internal rate of return changed from 16.8% to 24% in the 300,000 t/y of ethylene basis case set for North Sumatra. The nature of internal rate of return variations under the circumstances of inflation could be seen on this result.

3-6 Effect of the Time of Construction

The time of construction was taken to be 1979, 1978 and 1977. The least advantage was found to be available for the case of completion of construction in the year 1977 at which time the domestic market scale is the smallest. However, if it is deemed that the petrochemical complex constructions are presently stagnating in the world, there is a possibility that merits become available by constructing the complex at an earlier time.

3-7 Economic Viability Concerning a Representative Case

By taking a 300,000 t/y olefin complex assumed to be constructed in the North Sumatra site (Case 3) as a representative case, studies were made regarding financial analyses, foreign exchange balance and national benefit assessment as a whole complex. The obtained results are shown in Table II-15. Also, separate Table II-16 shows the breakdown of the relative investment cost. As a result, it was revealed that the internal rate of return was 20.9% which implies a favorable extent of economic viability. Regarding the foreign exchange saving amounts, the saving amount will attain accumulatively US$2,240 million during a ten-year period from 1979 to 1989. The national benefit will attain US$3,820 million during the same period which is expressed in terms of the internal rate of return at 27.9%, thereby indicating a highly favorable outcome.

Table II-15 Summary of Economic Evaluation of Total Complex

Case	Case 3
Site	North Sumatra
Complex Scale	Ethylene 300,000 t/y
Date of Start up	Sept. 1979, Start-up of commercial operation
Investment cost	Fixed capital 932,530 x 10^3 $
	Working capital 24,870 x 10^3 $
	957,400 x 10^3 $
I.R.R.	20.9 %
Effects of saving foreign currency	Sept. 1979 to Sept. 1989 2,236,494 x 10^3 $
National Benefit	Sept. 1979 to Sept. 1989
	3,822,382 x 10^3 $
	I.R.R. 27.9 %

Table II-16 Investment Details of Olefin Complex (Case-3)

(Unit: 10^3 US$)

ISBL	366,807
Licence and Know-How	30,810
Catalyst & Chemicals	6,654
Spare parts	17,845
Contingency	37,269
Process Plant	459,385
Utilities Facilities	139,746
Storage	36,613
Service Facilities	72,675
Housing, Jetty, Road	78,299
Construction Cost Total	786,718
Land	21,250
Pre-operational Cost	30,252
Interest During Construction	94,300
Fixed Capital Total	932,530
Working Capital Total	24,870
Investment Total	957,400

3-8 Effects of Changes in the Raw Material Hydrocarbon Condition (which was informed in August 1974)

(1) Prices

As the alternatives of price for raw materials and fuel in 1974, 102¢/MMBTU and 100¢/MMBTU were used calculating from LNG price of January 1974, based on Minas crude oil price. The increase of hydrocarbon prices will lead to the critical situation of viability for the complex as a whole, and unfeasible situation for the PVC project. (Tables II-17(1) and (2), details are shown in 6-1, Part III of this volume.

Table II-17(1) The Effects of Changes in the Raw Material Hydrocarbon Prices - IRR of Complex as a whole - North Sumatra Case

Ethylene Capacity / Price of NG @1974	@1980	200,000 MTA*	300,000 MTA	450,000 MTA*
63¢/MMBTU	95¢/MMBTU	17.3%	21.8%	25.5%
100¢/MMBTU	150¢/MMBTU	12.3%	17.0%	20.2%

Note: * The North Sumatra Case (Case 3) was slided up and down.

Table II-17(2) The Effects of Changes in the Raw Material Hydrocarbon Prices - IRR of Each Process Plant - North Sumatra Case

Price of NG		95¢/MMBTU	150¢/MMBTU
Price of Feed Condensate		43.5$/t	68.3$/t
	Capacity	I.R.R.	I.R.R.
Complex as a Whole		21.8%	17.0%
Olefin	298,000 MTA	15	15
Electrolysis	62,000	15	15
VCM	104,000	15	15
LDPE	120,000	24.8	17.8
HDPE	50,000	22.4	15.2
PVC	100,000	21.9	12.3
EG	100,000	28.8	21.6
PP	69,000	29.8	22.7

(2) Ethan Feed Complex

The comparison of the economic viability between the complex feeding C_2, C_3 mixture light condensate assumed in Interim Report and the complex feeding ethan shows the advantage of the former case. This is due to the rise of production cost of ethylene caused by the decrease of by-products credit in the latter case. Therefore, the conclusion on this matter will be greatly influenced by the price structure of raw materials and by-products. It is recommendable to review the economic comparison when the price structure of the raw materials and by-products is established. (cf. Table II-18, details are shown in 6-2, Part III of this volume.)

Table II-18 The Effect of Changes in the Raw Material Composition - C_2, C_3 Mixture - Ethane

(Unit $/t)

Type of Feed / Items	C_2, C_3 Mixture		Ethane	
Case	Sliding up of Case 3		Case 4	
Feed Components	C_2, C_3 mixture		Ethane	
Price of NG (1980)	150 ¢/MMBTU		150 ¢/MMBTU	
Price of Feed (")	68.3 $/t		75.1 $/t	
Price of Ethylene (")	208.9 $/t		257.4 $/t	
	Capacity	I.R.R.	Capacity	I.R.R.
Complex as a whole		20.2 %		18.1 %
Olefine	450,000 MTA	15	453,000 MTA	15
Electrolysis.	92,000	15	86,000	15
VCM	156,000	15	145,600	15
LDPE	180,000	22.3	180,000	18.5
HDPE	75,000	19.5	120,000	26.9
PVC	150,000	21.7	140,000	16.5
EG	150,000	23.6	100,000	19.1
PP	104,000	28.6	-	-

3-9 International Competitiveness

It was deemed precarious to base all the considerations solely on the internal rate of return of the complex in Indonesia especially during the period of general price fluctuation. Therefore, the assessment of the international competitiveness of Indonesian petrochemical industry was made on the basis of the already announced official data and information and also on the basis of assuming a constant and uniform internal rate of return of 15%. The result of such considerations also displayed that Indonesian petrochemical industry will have enough international competitiveness where US¢ 64.5/MMBTU is adopted for the price of raw material in 1974. However, in case where US¢ 102/MMBTU is applied for the price, international competitiveness is not so significant in comparison with the case of Singapore etc.

3-10 Evaluation of Methanol Project

The result of feasibility study of methanol project based on gas price, US¢ 64.5/MMBTU, shows the possibility of installation of methanol plant. (Annex XI)

Chapter 4. Recommendation

As the conclusion of all the above points, the following could be stated.

4-1 Raw Material

As it has been deemed that all the assumed cases pertain to the investment possibilities in view of all plant site, plant capacity, and time of construction, outcome of the project as to whether it will succeed or not rather depend on such factors as the availably of raw material gas and the nature of the relationship with LNG projects. This being the circumstance, it is recommnded that this olefin complex construction be duly incorporated into the already progressing LNG projects or future LNG projects. It is also recommended that once the finalization and decision are made to proceed with this project, another series of detailed studies be conducted including plant site surveys.

4-2 Preparation of Project

As mentioned in 3-4 (effects of variation of several prerequisites), following preparations for the project, i.e. to minimize the construction cost and to rise the operational rate, are most important for the economic and financial viability of the project.

In this report, the reference data for setting up complex are enclosed.

(1) Process licenser list can be used for selection of process and partner for Joint Venture.

(2) The following data - i.e. plant organization, required number of personnel, necessary utility facilities, service facilities and other supporting facilities, can be used to get a picture of complex.

(3) The information of the required schedule mentioned in 5-5 Part III should be considered at planning of project.

4-3 Domestic Market

As mentioned in 2-7 (Market, prerequisite), the forecast of demand described in UNIDO Phase I Study is used in this Study.

But after oil crisis, the market of plastic has remarkably shrinked due to the price increase of product, the decrease of actual procurement ability and the fluctuation of world economy.

Therefore, we recommend the re-study of domestic market and also we strongly recommend to establish the policy to support the growth of plastics processing industry.

4-4 Methanol Project

The pre-feasibility study of methanol plant shows the possibility of this project, so it is recommended to make the detail feasibility study.

PART II. GENERAL CONDITIONS

In this Part II, a summary of necessary data for carrying out various economic evaluations to be conducted in Part III is made.

At present, the petrochemical industry is finding itself in a chaotic environment so that such factors as the raw material prices, product prices, construction costs, transportation costs, etc. are all in a transient and unstable conditions. This being the circumstance, the only reasonable way to take is to compile the relative data by setting rational prerequisite conditions as much as possible in order for the outcome to be compatible even under such a confused circumstance. Due to the fact that the stipulation of all of such prerequisite conditions within the scope of Part II will unnecessarily complicate the description, the conditions are mostly described in Annex attached hereto. This signifies that in this Part II, the basic policies for the compilation of the relative data and the outcome of the compilation are described. By taking into consideration the cases in which the above-mentioned prerequisite conditions vary or become different due to the evolution of the circumstances, description of changes in the economic viability in the event of change in various variable factors will be madein Part III.

In view of the conditions that the raw material to be employed is natural gas as far as the plastics products are concerned and also that the cyclohexane and p-xylene for use as the synthetic fiber raw materials will be made from naphtha and further, the plastics sector and the synthetics fiber raw material sector will be constructed in different sites, while the supply of naphtha itself will not be sufficient to be allocated for the production of olefin, the items of products to be turned out within the scope of this project will be limited to VCM (PVC), LDPE, HDPE, EO/EG, and PP as plastics, while PS, etc. which are to be produced by the combination of the aromatics and olefin will be excluded from the scope of the product item consideration. As far as the synthetic fiber raw materials are concerned, descriptions will be made in a separate report regarding the production of PTA, DMT and caprolactam. Therefore, this report will cover up to the production of cyclohexane and p-xylene.

Chapter 1. Market

1-1 Indonesian Market

Regarding the market inside Indonesia for plastics products, the data stipulated in UNIDO's Phase I are adapted in this report and shown in Table II-19.

Table II-19 Estimated Annual Demand for Indonesian Petrochemical Products

(Unit: tons)

Product	Market	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
<u>Synthetic Resins</u>												
LDPE	Domestic	36,000	43,000	52,000	63,000	75,000	90,000	106,000	125,000	148,000	175,000	200,000
	Overseas	15,000	15,400	18,400	20,000	22,000	21,000	21,000	21,000	21,000	21,000	21,000
	Total	51,000	58,400	70,400	83,000	97,000	111,000	127,000	146,000	169,000	196,000	221,000
HDPE	Domestic	11,500	13,000	14,500	16,000	18,000	20,000	22,000	24,000	26,000	28,000	30,000
	Overseas	4,900	5,700	6,600	7,300	8,000	8,000	8,000	8,000	8,000	8,000	8,000
	Total	16,400	18,700	21,100	23,300	26,000	28,000	30,000	32,000	34,000	36,000	38,000
VCM	Domestic	44,000	50,000	58,000	67,000	78,500	93,000	106,000	124,000	142,000	165,000	190,000
	Overseas	0	0	0	0	0	0	0	0	0	0	0
	Total	44,000	50,000	58,000	67,000	78,500	93,000	106,000	124,000	142,000	165,000	190,000
PVC	Domestic *1	23,000	29,000	36,000	44,000	54,000	65,000	78,000	95,000	113,000	135,000	160,000
	Overseas	4,700	4,400	5,200	6,200	7,200	10,000	10,000	10,000	10,000	10,000	10,000
	Total	27,700	33,400	41,200	50,200	61,200	75,000	88,000	105,000	123,000	145,000	170,000
DOP	Domestic	19,000	22,000	25,000	29,000	34,000	40,000	46,000	54,000	62,000	72,000	83,000
	Overseas	0	0	0	0	0	0	0	0	0	0	0
	Total	19,000	22,000	25,000	29,000	34,000	40,000	46,000	54,000	62,000	72,000	83,000
Polystyrene	Domestic	9,000	11,000	13,500	16,500	20,000	25,000	30,000	35,000	42,000	50,000	60,000
	Overseas	6,500	7,200	7,800	8,500	9,200	10,000	10,000	10,000	10,000	10,000	10,000
	Total	15,500	18,200	21,300	25,000	29,200	35,000	40,000	45,000	52,000	60,000	70,000
PP	Domestic*2	-	2,500	8,500	16,500	26,500	40,000	51,500	65,000	81,000	100,000	120,000
	Overseas	-	2,800	3,000	3,200	3,400	4,000	4,000	4,000	4,000	4,000	4,000
	Total	-	5,300	11,500	19,700	29,900	44,000	55,500	69,000	85,000	104,000	124,000
<u>Synthetic Fibers</u>												
<u>Intermediates</u>												
Caprolactum *3	Domestic	15,100	16,200	19,900	22,300	24,600	26,500	28,600	31,700	34,900	38,000	41,000
	Overseas	0	0	0	0	0	0	0	0	0	0	0
	Total	15,100	16,200	19,900	22,300	24,600	26,500	28,600	31,700	34,900	38,000	41,000
TPA *4	Domestic	36,100	41,600	49,900	58,800	66,900	77,100	89,100	102,700	118,100	136,900	158,200
	Overseas	0	0	0	0	0	0	0	0	0	0	0
	Total	36,100	41,600	49,900	58,800	66,900	77,100	89,100	102,700	118,100	136,900	158,200
EG *4	Domestic	15,200	17,500	21,000	24,800	28,200	32,500	47,500	43,300	49,800	57,700	66,700
	Overseas	0	0	0	0	0	0	0	0	0	0	0
	Total	15,200	17,500	21,000	24,800	28,200	32,500	47,500	43,300	49,800	57,700	66,700
<u>End Products</u>												
Nylon	Domestic	10,000	11,000	14,000	16,000	18,000	20,000	22,000	25,000	28,000	31,000	34,000
	Overseas	4,400	4,500	5,000	5,300	5,500	5,300	5,300	5,300	5,300	5,300	5,300
	Total	14,400	15,500	19,000	21,300	23,500	25,300	27,300	30,300	33,300	36,300	39,300
Polyester	Domestic	34,000	40,000	49,000	59,000	68,000	80,000	94,000	110,000	128,000	150,000	175,000
	Overseas	8,300	8,700	9,400	9,900	10,300	10,300	10,300	10,300	10,300	10,300	10,300
	Total	42,300	48,700	58,400	68,900	78,300	90,300	104,300	120,300	138,300	160,300	185,300

Notes: Net Domestic Market = Total Domestic Demand - Planned Capacity already approved by The Government.
*1 Total Domestic Demand - 15,000 T/Y (Planned by Eastern Polymer)
*2 Total Domestic Demand - 20,000 Y/T (Planned by Pertamina)
*3 Intermediate for nylon.
*4 Intermediate for polyester.

The demand for caprolactum, TPA, and EG were estimated respectively from estimated Nylon and Polyester fiber demands, using ratios of products/raw materials.

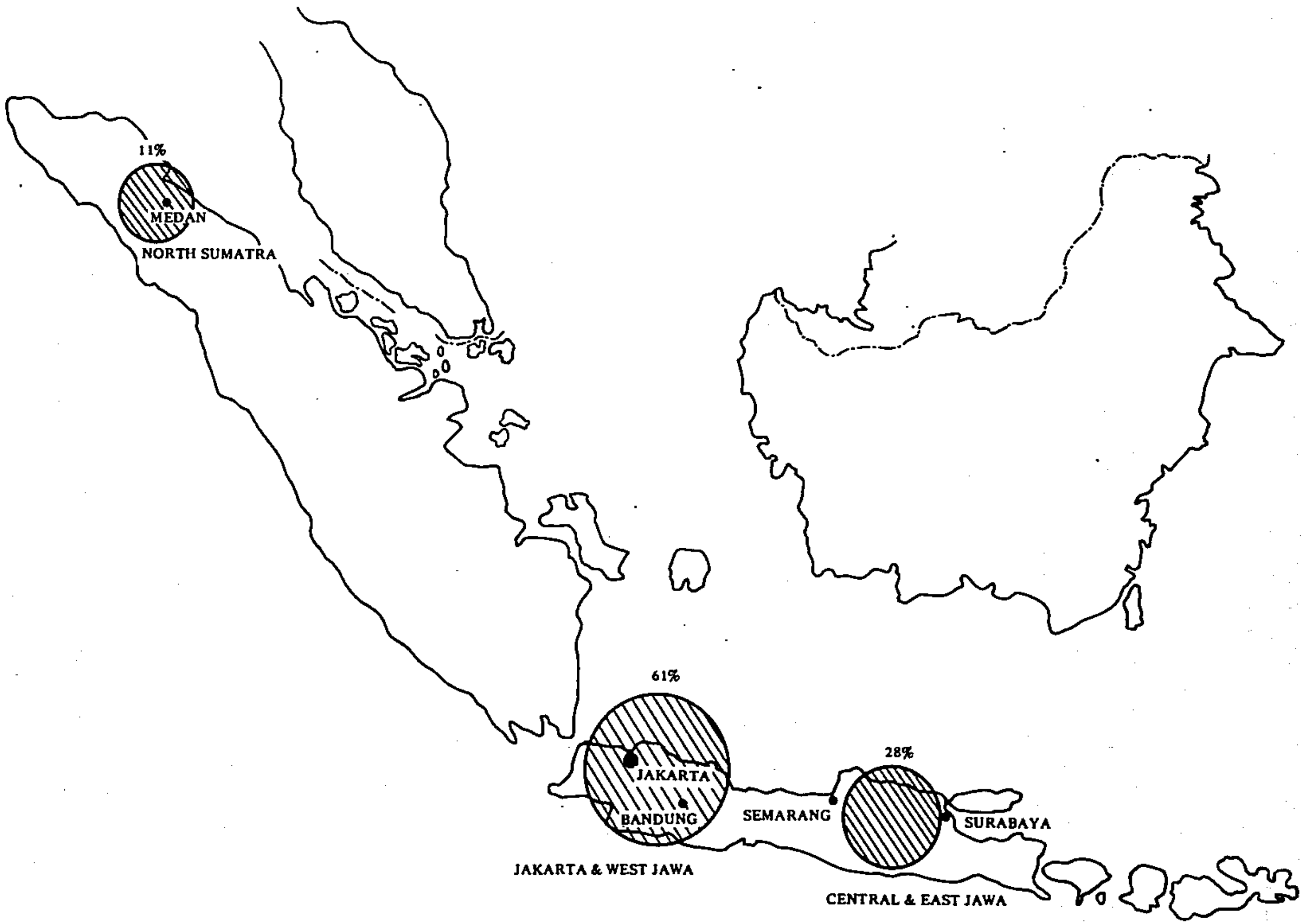


Figure II-2 Market Distribution of Plastic Products in Indonesia

At present the geographic distribution of the market areas is as shown in Figure II-2.

Although market distribution may change in the future, the evaluation will be made on the basis of the present distribution status as shown in the Figure.

1-2 Export Possibility

As is described in Annex VIII, the construction projects concerning petrochemical industry are experiencing and utter confusion at present. In this respect, the trend and behaviour of investment undertaken by the developed countries and the Middle East countries will particularly affect the supply and demand balance of the petrochemical industrial products of the world.

Concerning the Southeast Asian market, it is necessary to closely observe the trends of investments undertaken by Japan, Korea, Singapore, the Philippines and Australia along with the trend of investment carried out by the Middle East countries. Presently announced various projects may not necessarily progress in accordance with the intentions of the countries concerned due to the difficulties in delivering the plant component, in securing staff for operation, the site selection difficulties experienced by the developed countries, etc. However, it seems necessary to carry out a thorough scrutinization in view of the competitiveness factors because of the fact that the operational rate of a capital intensive industry will greatly affect the economic viability of the plant as a whole. Regarding this point, detailed description will be made in Annex IX and the outcome of the scrutinizations is described together with the result of the evaluations concerned in the "General" of Part I.

However, not only in view of the free competition, the following must be considered in order to secure adequated operational rates of the production facilities.

(1) Joint investment with certain countries who have enough market.

(2) Collabolation with companies which have marketing capacities.

Therefore, the following three cases were taken up as the basis for the relative evaluations in this report.

(a) The case in which no exportation is considered so that the domestic market alone is taken as the study subject (Palembang).

(b) The case in which the market of the Philippines is also taken into account as far as East Kalimantan is concerned.

(c) The case in which the complex scale equivalent to that being projected in Singapore will be considered in order to study the relative comparison with Singapore as far as North Sumatra is concerned.

After studying the above-mentioned three cases, the scrutinization of the outcome obtained by varying the capacities and raw material prices was also undertaken concerning Case (b) and (c). Further, the market forecast for plastic materials of the countries described in UNIDO's Phase I study is shown in table II-20 and Figure II-3. For the most part in this report, these data will be employed as and when necessary, however, as far as the data pertaining to the

Philippines are concerned the caliberation was made by carrying out separate calculations by taking into account various factors, due to the fact that this country is particularly important in view of the relationship with Indonesia and also that the forecast data made on the Philippines seem to be excessive and exaggerated.

Table II-20　Market Size in ECAFE Region

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Philippine	LDPE	3,235				19,400	25,000	32,500				92,900	114,300	135,700	157,100	178,000	199,000
	HDPE						8,000	14,000				39,000	45,000	52,000	60,000	68,000	79,000
	PP				11,960	13,500	15,650	n.a.				29,000	32,000	35,000	37,000	40,000	43,000
	PVC			7,881	8,560	9,800	12,740					47,300	61,500	79,950	113,900	135,000	175,700
	PS	458				2,870	4,000	5,500				17,000	20,000	73,000	26,000	29,000	32,000
	TOTAL	3,693		7,881	20,520	45,570	65,390	52,000				225,200	272,800	325,650	384,000	450,000	528,700
Thailand	LDPE	12,000				25,000	30,000	30,000				58,000	66,000	75,000	86,000	96,000	112,000
	HDPE	4,000				7,000	10,000	15,000				28,000	33,000	38,000	44,000	51,000	58,800
	PP	2,000				4,500	5,500	8,000				14,000	17,000	20,000	20,000	26,000	30,000
	PVC	5,000				10,000	12,000	14,000				24,000	28,000	32,000	37,000	42,000	48,000
	PS	2,000				4,500	5,000	6,500				11,000	13,0000	15,000	17,000	20,000	23,000
	TOTAL	25,000				51,000	62,500	73,500				135,000	157,000	180,000	206,000	235,000	271,800
Indonesia	LDPE						18,000		26,000			36,000	43,000	52,000	63,000	74,000	90,000
	HDPE						4,000		9,000			11,500	13,000	14,000	16,000	18,000	20,000
	PP						1,000		8,000			17,500	22,500	28,500	36,500	46,500	60,000
	PVC						16,300		25,000			38,000	44,000	51,000	59,000	69,000	80,000
	PS						3,000		4,700			9,100	11,000	13,500	16,500	20,000	25,000
	TOTAL						42,300		72,700			112,100	133,500	159,000	191,000	228,500	275,000
Malaysia	LDPE						12,800	14,700				25,700	28,300	31,100	34,200	37,600	41,400
	HDPE						3,200	3,700				6,500	7,200	7,900	8,700	9,500	10,500
	PP					1,192	2,183	4,608				7,000	8,000	9,000	11,000	12,000	14,000
	PVC				3,000	2,950	3,000					10,000	12,000	13,000	15,000	18,000	20,000
	PS				·	1,221	1,750					3,500	3,900	4,200	4,700	5,100	5,600
	TOTAL				3,000	5,363	22,933	23,009				52,700	59,400	65,200	73,600	82,200	91,500
Singapore	LDPE					12,900	15,200	17,600				30,800	34,200	37,900	42,200	46,700	51,600
	HDPE						3,400	4,400				7,700	8,500	9,500	10,500	16,700	12,900
	PP					1,500	1,500	4,300				4,000	4,700	5,500	6,500	7,600	9,000
	PVC					7,383		14,341				25,100	27,600	30,400	33,400	36,700	49,400
	PS							3,538				7,400	8,300	9,300	10,400	11,600	13,000
	TOTAL					21,783	20,100	44,179				75,000	83,300	92,600	103,000	114,300	135,900
Japan	LDPE								766,000	821,000	887,000	949,000	1,006,000				
	HDPE								280,000	321,000	365,000	414,000	469,000				
	PP								500,000	545,000	594,000	641,000	186,000				
	PVC											1,310,000	1,380,000	1,450,000	1,520,000	1,600,000	1,680,000
	PS								360,000	416,100	487,300	558,000	638,600				
	TOTAL								1,906,600	2,103,100	2,333,300	3,872,600	4,179,600	1,450,000	1,520,000	1,600,000	1,680,000
Korea	LDPE	4,100	6,637	11,700	17,300	20,250	29,500					80,300	96,000	115,000	133,000	152,000	175,000
	HDPE			2,700	5,500	8,000	12,950					42,500	51,000	61,000	70,000	81,000	93,000
	PP	417	760	2,986	3,856	4,800	9,254					34,000	45,000	53,600	63,400	72,000	78,000
	PVC	8,031	12,103	20,258	29,560	n.a.	36,700					89,000	102,000	118,000	134,000	148,000	163,000
	PS	661	1,500	2,000	2,834	4,673	7,384					23,500	28,200	33,800	40,100	48,700	58,400
	TOTAL	13,209	21,000	39,644	59,050	37,723	95,748					269,300	322,200	381,400	440,500	501,700	567,400
Sri-Lanka	LDPE						2,300	3,700				12,000	13,800	15,900	18,300	21,000	24,100
	HDPE					Neg.	100	200				2,000	2,300	2,600	3,000	3,500	4,000
	PP																
	PVC				1,900	2,500	2,200	3,100				6,400	7,400	8,500	9,800	11,300	13,000
	PS				100	200	700	1,000				2,000	2,300	2,500	3,000	3,500	4,000
	TOTAL				2,000	2,700	5,300	8,000				22,400	25,800	29,600	34,100	39,300	45,100

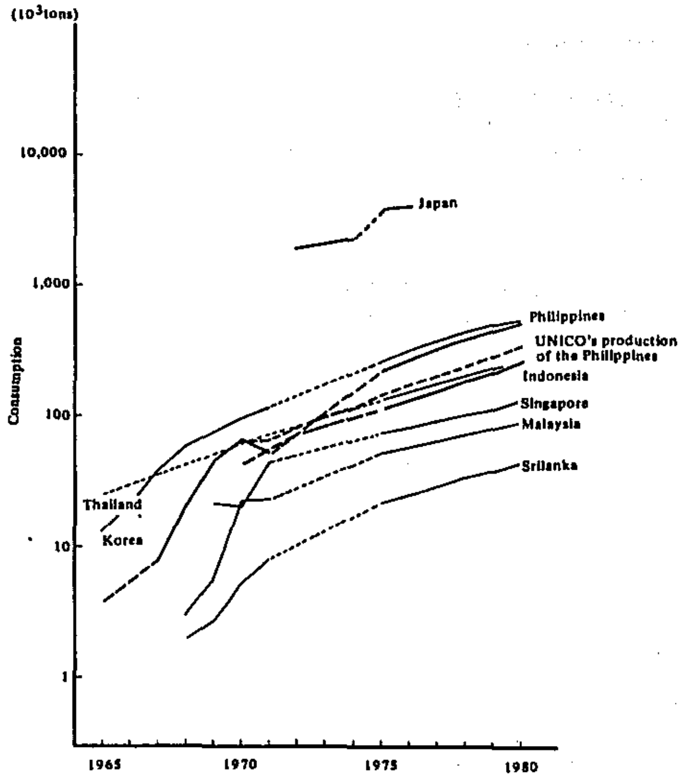


Figure II-3 Predictions of 5 Principal Plastics Total in Some of the ECAFE Countries

Chapter 2. Availability of Raw Materials

2-1 Availability of the Main Raw Materials (Hydrocarbons)

Hydrocarbons as raw materials for petrochemical industry can be classified at the present stage into two categories, i.e., naphtha and natural gas including LPG crude oil or other fractions heavier than naphtha are not employed as raw materials at present.

The following points were confirmed at a discussion meeting with Pertamina in January 1974.

(1) Naphtha has been secured for aromatics complex.

(2) No naphtha can be made available for use as the raw material for olefin complex (for plastics production), so that the natural gas-base production shall be undertaken. Concerning the details of the natural gas (the reserve locations, quantity, quality and price) will be clarified in approximately six months.

Annex VII will further explain the utilization possibility of naphtha and gas in Indonesia. Therefore the following points were employed as the prerequisite conditions for present study at the discussion to be held with the Government of Indonesia after the completion of the site surveys. (Refer to Page 12 of the Interim Report)

2-1-1 Natural gas

(1) Locations of reserves:

East Kalimantan, North Sumatra, Palembang and West Java. (The Departemen Perindustrian commented to the Interim Report that Palembang and West Java will not necessarily be included in the scope of the survey).

(2) Quantity:

Not confirmed (An assumption is tentatively made that the required amount will be available).

(3) Composition of the gas to be supplied to the olefin plant (after being separated from natural gas).

	Weight Ratio
C_2	1.00
C_3	1.47
C_4	0.97
C_5^+	0.654

But at a discussion meeting in August 1974, the followings were informed from Indonesia side.

(1) Ethan which will be separated in LNG plant will be used.

(2) Location is North Sumatra

(3) Quantity of Ethan is enough for the production of ethylene with a capacity of 450,000 t/y.

(4) Price of LNG is FOB US¢195/MMBTU, corresponding to the price of Minas crude oil of FOB US$12.60/bbl in July 1974

(We take FOB US¢100/MMBTU as LNG price corresponding to the price of Minas crude oil of FOB US$10.80/bbl in January 1974 because all other prices including products are calculated based on the price of Middle East crude oil in January 1974.)

2-2 Availability of Sub-raw Materials

As the scope of the production was limited to VCM (PVC), LDPE, HDPE, EO/EG, PP, the required sub-raw material is only chlorine. During the recent on-site surveys it was revealed that 99.5% purity salt is scheduled to be produced at a cost of FOB US$5.00 per ton in Madura Island.

On the other hand, a project for the production of aluminum in the Asahan area for 225,000 ton/year has been finalized. For this project, caustic soda sufficient for processing yearly 500,000 tons of alumina is required, and there is a possibility of procuring chlorine from this factory.

2-3 Availability of Utilities

Every candidate sites must be equipped with its own utility facilities within the complex. An exception is made in Asahan where water power generation facility is scheduled to be constructed for aluminium industry, and electric power of low price will be available for petrochemical industry.

Chapter 3. Scope of Estimate

3-1 Investment

The investment cost covers the following items.

3-1-1 Process plant

The scope of process plant includes the following items.

1. Control room
2. Secondary electric substation (secondary transformers), electric wires
3. Offices in plant site
4. Process control analysis equipment in the plant site
5. Receiving and handling facilities for chemicals and catalyst
6. Cooling tower
7. Fire fighting facility in plant site
8. Primary waste and waste-water treating facilities (including incinerators, etc.)
9. Minor maintenance shop, warehouses for special storage
10. Small sized receiving holding facilities such as feed tanks to be installed normally in production unit for the easeness of operation.

The following items are excluded from the scope.

1. Raw materials receiving facilities excepting the above item 10.
2. Product shipping facilities, for example filling and bagging facilities product storage houses railway siding lines, unloading facilities etc (in the case of the polymer plants, the process plant shall include up to the measuring hopper).
3. Common process control laboratory.
4. Emergency electric power supply system.

Breakdown of process plant cost is described as follows:

1. Equipment and materials

Machineries and equipment cost, materials for erection works (piping materials, electric wires, instrument wiring and tubing materials, other materials for construction works, etc.) Materials for structures and civil work are not included in this items.

2. Civil work

Civil work cost (including the materials and construction cost), including buildings, foundations (including piles and piling work) structures. However, the site development or site preparation cost shall not be included.

3. Field erection

Direct field erection cost (installation cost), i.e., all the piping work costs, machinery and equipment installation, electrical and instrumentation work, insulations, painting and coating, filling of internals, catalyst and chemicals, the mechanical-run cost up to start-up (oil-run), excluding the relative material costs. Therefore, this item shall include the direct labour and construction aid and temporary structure costs.

4. Supervision

This item shall include all the costs necessary for carrying out supervision including the field expenses of the contractor (including indirect cost for field office, telephone, automobil rental, etc.).

5. Engineering and contractor's fee

This item shall include the detail design fee of the contractor, the cost for procurement, project management, and other contractor's headquarter expenses (indirect cost).

6. License and know-how

This shall include the paid up royality and basic engineering fee undertaken by the licensor, know-how fee, etc.

7. Catalyst and chemicals

This includes the cost for solvents, coolants and catalysts to be filled into the internals of process equipment.

8. Spare parts

Unless otherwise specified, the cost for spare parts for two-year operation shall be included.

9. Inside battery limit facility

The mechanical plant construction cost, i.e., the scope covering 1 through 5 is deemed as the inside battery limit facility cost (ISBL cost).

3-1-2 Off-site Facilities

The off-site facilities include such storages and shipping facilities as warehouses, tanks, etc. and the common service facilities such as offices, maintenance shops, etc. Although the utilities facilities are common facilities, they will be deemed as being a process plant, rather than the off-site facilities, in view of the fact that the utilities are to be sold to each plant included within the complex.

(1) Storages and shipping facilities

a. Bagging facilities

b. Warehouses

c. Tanks

d. Loading and unloading facilities, wharves, etc.

(2) Common service facilities

a. Administration offices

b. Fire fighting facilities (fire-engines, etc.)

c. Maintenance shop

d. Communications

e. Sewerage

f. Lighting

g. Process control laboratory

h. Company housing facilities

i. Clinics and hospital inside plants

3-1-3 Land Cost

The land cost includes, in addition to the right of land, the site development costs.

3-1-4 Pre-operating expenses

This item includes the loss caused during the test operation, labour cost, initial charges, start-up cost etc. which will be incurred prior to the commencement of commercial operation. It further includes the cost incurred by training and educating of operators, technical assistance expenses, legal expenses for establishing and registering the company, the project management cost of the owner, etc.

3-1-5 Interest during construction

This signifies the interest on the construction cost and the pre-operating expenses incurred after the commencement of the construction works up to the commencement of commercial operation.

3-1-6 Total fixed capital

The total amount of 1-1 up to 1-5.

3-1-7 Working capital

This signifies the fund necessary for the running of the company including such items as the accounts receivable, prepaied expenses, etc. required after the commencement of commercial operation.

3-1-8 Total investment

Total of 1-1 up to 1-7.

Chapter 4. Prerequisite Conditions for Economic Viability Evaluation

4-1 Foreword

Part III describes case studies pertaining to the olefin complex. Further, financial analysis and economic analysis shall be additionally made to a representative case. The economic analysis consists of the assessments of foreign exchange balance and the national benefit by employing the shadow pricing method from the national viewpoint. This Chapter and Chapter 5 describe the standards and the methods of the relative calculations. Further, a utilization of simplified methods has been made for the economic evaluation of case studies by employing simulation models. Further explanation on this point shall be made in Chapter 6. The effects of implementation of this project on the expansion of employment opportunities have not been included within the present study. Up to the present project, the basic nature of the industry is of capital-intensive one and therefore it is considered that the degree of the employment expansion effects will not be very high.

4-2 Escalation Factor

During the course of the profit/loss calculations on an annual basis, an escalation factor of 7% per year increment was assumed concerning the following items in view of the effects of inflation, etc.

1. Product and by-product prices
2. Raw material and sub-raw materials prices
3. Cost of bagging, catalysts and chemicals
4. Cost of labour, plant overhead, technical assistance, maintenance and general administration

4-3 Project Life and Operation Years

Calculations have been made regarding the profit/loss balance over a ten-year period after the commencement of the operation and individualized analysis shall be undertaken. However, it must be noted that the operation commencement target has been set for the olefin complex for 1st October, 1979 . In other words, the calendar year and the operational year of the project after the commencement of operation do not coincide. In order to incorporate necessary adjustment in this respect, the period from 1st October until 30th September of the following year shall be termed the "One Business Year". For instance, the business year 1980 shall run from 1st October, 1979 until 30th September, 1980. The years used in the annual-basis profit/loss calculations shall signify the above-mentioned "Business Year". On the other hand, calendar year basis was adopted for expressing the demand amount and other various cost factors. These items shall be converted in terms of the business year through the following equation.

$$P_i = \frac{3 \text{ month}}{12 \text{ month}} \times C_{i-1} + \frac{9 \text{ month}}{12 \text{ month}} \times C_i$$

Where P_i : Value for the business year "i"

C_i : Value for calendar year "i"

C_{i-1}: Value for calendar year "i-1"

4-4 Cost Items

4-4-1 Variable costs

Variable costs shall include those items the amount of which will vary according to the variation in the production amount including such items as raw materials, utilities, catalyst, chemicals, running royalties, etc.

4-4-2 Depreciation

Process Plant:	10-year fixed amounts
Utility facilities:	15-year fixed amounts
Off-site facilities:	30-year fixed amounts
Pre-operational expenses:	10-year fixed amounts
Interest during construction period:	10-year fixed amounts

It must be noted there that no salvage value shall be counted.

4-4-3 Labour cost and plant overhead costs

The labour cost includes the direct wages and salaries as well as fringe benefit costs for operator necessary for the operation of the plant. The plant overhead cost includes those expenses required for the administration of the plant other than the costs required for directly operating the process plants. In other words, the plant overhead cost includes such cost items as the production technique control cost, accounting, personal administration, general affairs, engineering effected by the engineers on the owners side, maintenance, process control analysis, etc.

Labour cost: 1975 US$/y (all included)

1.	Helper	750
2.	Laborer	900
3.	Operator III	950
4.	Operator II	1,050
5.	Operator I	1,200
6.	Senior Operator	1,300
7.	Foreman	2,800
8.	Section Superintendent	3,800
9.	Unit Superintendent	4,500
10.	Production Manager	5,400
11.	Technical Director	6,400
12.	Works Manager	7,700
13.	Deputy Director General	9,300
14.	Director General	–

Source: Pertamina

The total labour cost is calculated on the basis of the personnel charge indicating the required number of personnel for the operation of the olefin complex as well as on the basis of the labour unit cost as of calendar year 1975 stipulated in page 17 of the Interim Report. The escalation factor shall be multiplied to the calculated results in order to compute the labour cost for each year. Regarding the plant administration cost, 180% of the labour cost of the operating personnel is applied.

Average labour cost for calendar year 1974: US$1,600/y

4-4-4 Maintenance

This item includes the cost for repair works ordered contractors and the cost for procuring equipment and materials for maintenance. The cost for the owner's engineers is included within the scope of the plant overhead cost. The annual maintenance cost shall be calculated on a constant rate against the facility costs.

Process plant (for ISBL alone):	3%
Utility facilities:	3%
Off-site facilities:	0.5%

4-4-5 Fixed asset tax and insurance

As the tax to be imposed on the fixed assets and also, as the insurance costs, 1% of the total fixed assets excluding land cost is calculated and counted as the annual cost. The total fixed asset signifies the asset obtained by subtracting the depreciated value from the initial total fixed asset.

4-4-6 Technical assistance fee

This item includes the cost incurred on the invitation of expatriate skilled engineers for receiving assistance for plant operation. However, this item shall be included within the scope of labour cost in the calculations employing the simulation models. The number of the expatriate engineers shall be 100 for 1980, 48 for 1981 and 32 from 1982 onwards. The necessary costs shall be assumed as US$135,000/year/head for the year 1980 and the annual escalation factor was taken into consideration in this respect.

4-4-7 Bagging and sales expense

The bagging facilities shall be included within the scope of the off-site facilities and in this item, the direct material costs such as the bag cost is counted. All the other sales costs have already been deducted from the exfactory price.

4-4-8 General administration

This item includes the headquarters expenses, business expenses, etc. which are outside the scope of plant expense. For this item, 3% of the total sales amount is counted.

4-4-9 Interests and the repayment method

The capital rate shall be set at 30% on the basis of the discussion made with the Departemen Perindustrian and the remaining 70% shall be accommodated by loans. The local loans shall be applied to accommodate the working capital.

Foreign Loans

Interest:	7.5% (per annum on unpaid balance)
Grace Period:	5 years (3 years after the commencement of operation)
Repayment Method:	7 year equal installment repayment of the principal after the grace period

Local Loans

Interest:	12%(per annum on unpaid balance)
Repayment Method:	3 year equal installment repayment

4-4-10 Taxes and levies

Corporate Income Tax:	45% on profit before tax (tax exemption effective for five years outside Java Island)
Fixed Assets Tax, Insurance Premium:	Refer to above 4-4-5
Foreign Remittance Tax:	The 10% foreign remittance tax on interest and dividends shall be deducted by the Convention for Prevention of Double Taxation.

Chapter 5. Prerequisite Conditions and Methods Concerning Financial and Economic Analyses

5-1 Financial Analysis

These analyses are for evaluating the profitability of the subject project as a private enterprise. As the index for the evaluation of profitability, this report employs the internal rate of return (IRR) by means of the Discounted Cash Flow Method (DCF method). The calculation formula is as follows:

$$I_o = \sum_{i=1}^{n} \frac{C_i}{(1 + r)^i}$$

Where: I_o *1) : Initial total investment amount

C *2) : Net cash flow

r : Internal rate of return (IRR)

i : Business year

n : Subject period for evaluation, 10 years in the present case.

Notes: *1): Total fixed assets + Working capital:

(Total assets = Total cost of facilities procured + Pre-operating expenses + Interest during construction)

*2): Profit after tax + Depreciation + Interests payable; otherwise referred to as Return (Internal rate of return against investment)

5-2 Annual Balance of Foreign Currency

As one of the methods for examining the extent of the contribution to the national benefit by the implementation of the present project, a study will be conducted by taking a period of 10 years regarding the effects exerted on the foreign exchange balance. When the implementation of this project is actually carried out, the foreign currency saving and loss of opportunities for foreign currency earning due to import substitution and export substitution as well as the foreign exchange earning made indirectly shall also be taken into consideration in addition to the actual inflows and outflows of foreign exchange.

5-2-1 Foreign currency inflows

(1) Earning of foreign exchange by exportation

Although it is assumed that the products shall be primarily supplied to the domestic market, an assumption is made that all the surplus products shall be allocated for exportation during the stage at which the growth of the domestic market will not be substantially made. The following enumerates the items of products which have the export potential:

PVC

LDPE

HDPE

EG

PP

Note: In computing the foreign exchange earning by exportation, the evaluation should be made on the FOB price basis, however, as will be described in Part III the exfactory prices of the products for export has tentatively been deemed as the FOB prices, in view of the fact that difference between the FOB price and the exfactory price is quite small.

(2) Foreign currency saving by import substitution

Although the products shipped directly to the domestic market will actually earn no foreign currency, it would have been necessary to import them if the subject project were not implemented. Therefore, the extent of such a saving should be included within the scope of the foreign currency earning. The products applicable to this category are as follows:

PVC

LDPE

HDPE

EG

PP

Notes: 1. When computing the foreign currency saving by means of import substitution, the evaluation should be made on the basis of the import price (CIF price) at Indonesia (Jakarta), however, the exfactory prices for domestic market were tentatively deemed as being the CIF prices in view of the fact that, as will be mentioned in Part III, the difference between the CIF price and the exfactory price is quite small.

2. Concerning the products to be turned out from the olefin complex, no import duty protection has been incorporated. Therefore, there is no need for price adjustment in this respect.

(3) Indirect foreign currency saving

Deduction from the production cost has been carried out concerning the by-products by means of carrying out price conversion in terms of fuel or, by evaluating the by-products in terms of the product prices.

In view of the small extent of the amount of by-products turned out, there are a number of instances in which any significant foreign exchange earning or saving by import substitution can not be achieved. However, even in the case of these by-products, the creation and growth of domestic markets are also expected along with the development of industrialization. Also, from the national point of view, those by-products which can be used as fuel, will serve for the saving of fuel oil and natural gas. Therefore, such an effective utilization of by-products will eventually contribute to the earning or saving of foreign currency. The applicable items of products in this respect are as follows:

Hydrogen, Methane
LPG, C_4 fraction,
Aromatic gasoline
Caustic soda

5-2-2 Foreign currency outflow

(1) Loss of export opportunity of raw materials and auxiliary raw materials.

The raw materials which are available inside Indonesia and intended to be used as raw materials, auxiliary raw materials and fuel for the subject project have the export potential in the form of raw materials, auxiliary raw materials or fuel, if the subject project implementation is not to be made. Therefore, these materials should be deemed as having been deprived of export opportunities due to the utilization in the subject project and therefore shall be evaluated in terms of foreign currency outflow. The items applicable to this category are as follows:

Olefin complex:

Raw material natural gas
Salt
Fuel natural gas

Note: Of the necessary raw materials, those items the procurement of which must depend on importation from overseas should be counted as belonging to the foreign exchange outflow category. However, as far as the subject project is concerned, no such imported raw materials exist.

(2) Imported materials

This includes the materials necessary for the operation of the plant and are required to be imported from overseas, i.e., such items as catalyst, chemicals and spare parts. Therefore, these items have been deemed as belonging to the foreign currency outflow category. The total amount of the maintenance cost was counted as being the importation amount of the spare part. Naturally, the total amount of the maintenance will not necessarily be allocated for the importation of the spare parts, however, the necessary number of personnel for securing the normal maintenance has been incorporated in the plant administration cost item and further, it is considered that a number of cases of repair to be ordered outside the plant will pertain to the outflow of foreign exchange.

(3) Foreign currency payable

Within this category, the technical assistance fee to be paid to expatriate engineers in foreign currency, the repayment amount of foreign loans and the interests thereof, shall be included. The repayment in foreign currency is the repayments to be made to the foreign loans, however, the foreign loans alone will not be sufficient for fulfilling the facility procurement. The shortage portion shall be paid in terms of foreign exchange from the capital. Such a shortage portion was counted as a part of the foreign currency outflow for the initial year.

5-3 National Benefit Employing Shadow Prices

The actually prevailing market price will be employed as the basis for the financial analysis, however, shadow price which reflects the scarcity shall be employed when analysing the extent of national benefit. The shadow price employes the following rates regarding the foreign currency and the labour cost items.

Foreign currency: 125% of the actually prevailing exchange rate (Rp. 519/US$ as against Rp.415/US$)

Unskilled labour wages: 45% of the actual rate (including plant overhead cost)

As the index for the evaluation of the national benefit, the internal rate of return (IRR) on the basis of the Discounted Cash Flow Method (DCF method) was selected. The relative calculation formula is as follows:

$$Io' = \sum_{i=1}^{n} \frac{C'i}{(1 + r')^{i}}$$

Where: Io' : Initial investment total amount obtained by multiplying 1.25 to the required foreign currency portion.

C'*1: Return calculated by utilizing shadow price

r'*2: Internal rate of return

i : Business year

n : Subject period for evaluation, 10 years in the present case.

Notes: *1: At the time of analysing the national benefit, the land cost shall be deleted from the initial total investment amount employed for the case of financial analyses.

*2: Unlike the return in the case of financial analysis, the corporate income tax and the fixed asset tax will be deleted from the cost at the time of calculating the national benefit.

Chapter 6. Economic Calculations of Complex by Employing Models

Studies were conducted by employing computer models which represent complexes during the stage at which economic evaluation for the comparison of petrochemical complex alternative schemes and sensitivity analysis of economic viability by the change of variable factors of the projects. Separate and detailed financial and economic analyses were made regarding the whole complex of the selected representative scheme. By utilizing the employed models, it is possible to carry out calculations of the material and utility balance, outlines of construction cost, production cost, profit, IRR, etc., among the process plants and also covering the whole complex for the preliminary economic evaluation. The studies employing models were made concerning the selection of the products, production scale and process routes.

6-1 Characteristics of the Employed Models

The employed models have been made on the basis of the general process simulation and optimization program (GPSOP), so that they have the following characteristics.

1) Computation of material and utility balance

2) Arbitrary specification of design parameter, such as consumption rate of raw material, of complex is easily possible. For instance, it is possible to calculate the amount of feed to obtain specified amount of products or, conversely to decide the amount of products giving the available amount of raw material. It is further possible to compute the IRR by pre-setting the product prices and also to calculate the raw material prices or product prices by specifying IRR (Refer to Figure II-4)

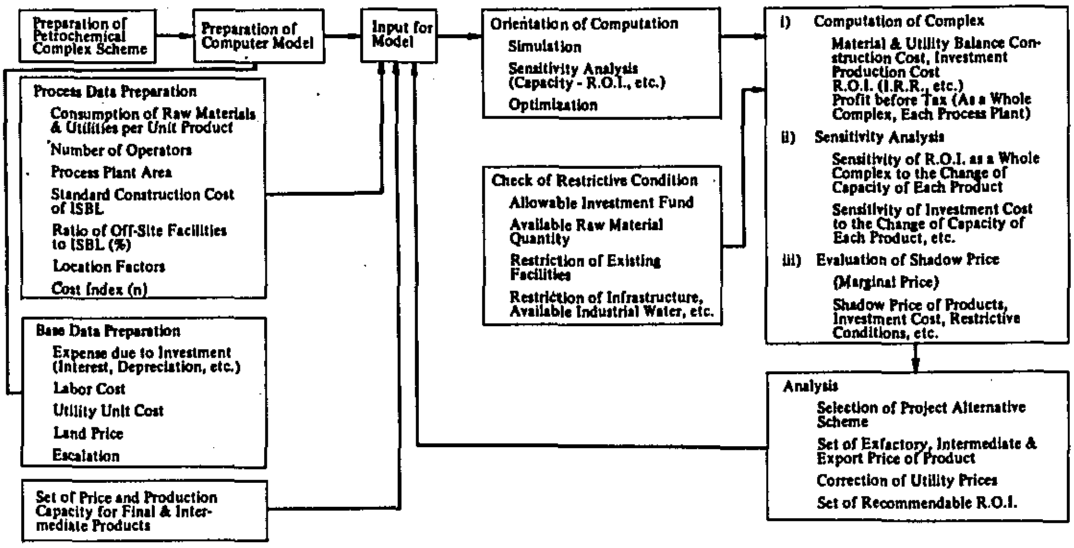


Figure II-4 Economic Evaluation of Petrochemical Complex by Employing Computor Model

6-2 Procedures for Economic Evaluation and Comparison of Complex Alternatives by Employing the Models

In the economic evaluation and comparison of the complex by utilizing models, the studies of the outline of the economic viability of each one of the process plants shall also be conducted in addition to those covering the whole complex. As is shown in Figure II-5, basic cases were assumed as the preparatory procedure for forming the models and on the basis of these cases, the scrutinizations and conceptional design will be made on the process plant, utility facilities and common service facilities in order to calculate the utility unit price and the allocation rates of the investment cost of common facilities to each one of the process plants. By carrying out such procedures, the preparations for economic evaluation of each process plant was accomplished. These preparatory procedures are the

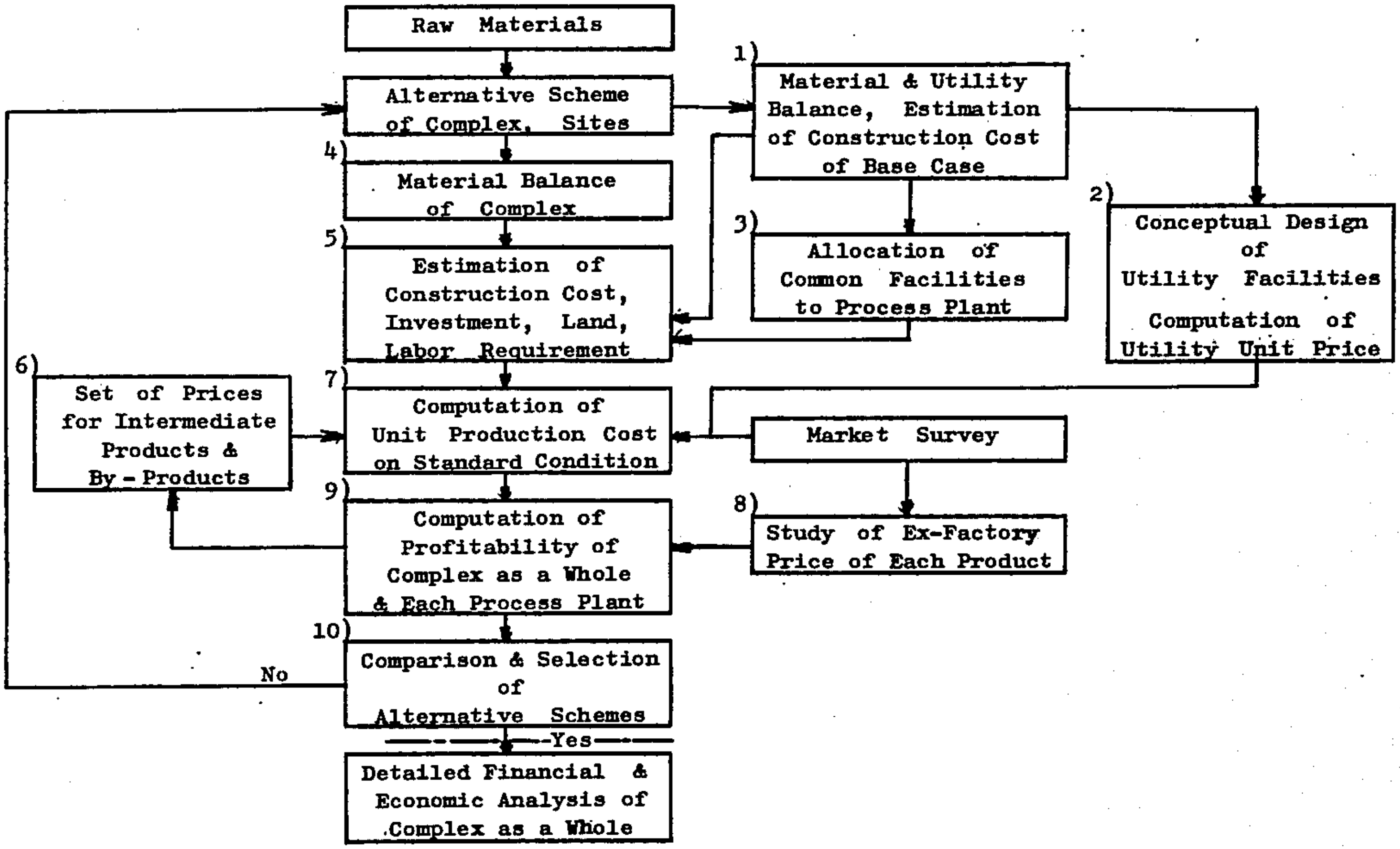


Figure II-5 Procedure of Selection & Study of Complex Schemes by Employing Computor Model

Steps (1) through (3). The economic calculations by means of computer models employing simplified methods are undertaken in accordance with the procedures from (4) through (7) and (9). On the basis of the results obtained by such economic calculations, Step (10), the comparison and selection of the alternatives, were made. By taking thus selected representative alternative case, detailed financial and economic analyses covering the whole complex were conducted independently from the above-mentioned models.

6-2-1 Calculation of material balance, utility balance and construction cost of the basic case

From the alternatives of the complex schemes which have already been separately studied, the selection will be made for singling out the most suitable basic case. Calculations of material balance and utility balance of the basic case complex were made. And estimation was carried out for the construction cost of common service facilities for all the process plants, the required number of operators, the required areas for installation, etc.

6-2-2 Facilities and unit prices of utilities

An conceptional design of utility facilities to cover consumption of utilities of the whole process plants, offices, maintenance shops and other off-site facilities as well as of the utility facilities themselves shall be made to calculate the fuel consumption and construction cost. To the obtained result, the proportionally allocated common off-site facility costs explained in following 6-1-3 shall be added to obtain the total construction cost and investment for utility facilities. The pre-operating expenses and working capital required were estimated to be 1% and 5% respectively of the utility plant construction costs. The utility facilities were deemed to undertake sale of utilities on unit price basis to the process plants so that the utility unit price calculation was made on the basis of the mutual allocation method. For instance, it was assumed that cost of the extractive low pressure steam is evaluated on the basis that cost of the electric power incurred during reducting from high pressure steam is deducted from the cost of high pressure steam. The annual profit before tax was assumed to be 4% of the investment. All the other procedures are in accordance with the calculation basis employed for the standard cost calculations.

6-2-3 Allocation of common facility investment cost

The common facility investment cost excluding utility investment cost was re-allocated to the investment cost of process plants and the utility plants in proportion to the number of operators, areas required and necessary facility cost of each one of the process plants by taking into consideration the specific characteristics of each common facility.

6-2-4 Material balance in the complex

By employing the simulation models, the balance of the raw materials, auxiliary raw materials, products by-products of each one of the process plants was obtained to meet the requirements of the study, such as the specified operating conditions, product amount and feed amount.

6-2-5 Calculations of construction cost and investment

Regarding the construction cost of the process plants, the discrepancy due to operation years and site conditions were calibrated by incorporating the adjustments made by the escalation factors and location factors into the standard construction cost. Regarding the costs of off-site facilities, the proportional allocation rates as against the ISBL of the basic case described in 6-2-3 were employed. Long-term loan interest rates for 1/2 of the construction period were applied to the interests during the construction. Regarding the pre-operating expenses and the working capital, 10% of the facility cost within the battery limit, and one month supply of raw materials and sales of product were respectively counted. Further,in the model calculation procedure, utility facilities are not included within the scope of the investment amount for the complex.

6-2-6 The estimation of intermediate product prices and by-product prices

Establishment of intermediate product prices shall be made in such a manner that the profit rate of the raw material plant and the derivatives plants thereof shall become balanced. The by-product prices shall be based on market prices as long as the market is available. Otherwise they shall be calculated based on equivalent factors to the main products.

6-2-7 Calculation of standard unit production cost of products

On the basis of the above-mentioned construction cost, raw material cost, utility unit price, etc., calculations of the standard unit production cost of each product were made at specified year in accordance with the following conditions.

- Maintenance cost: In accordance with the characteristics of the process plants, the specified rate (%/year) of cost of the inside-battery-limit facilities shall be counted.
- Taxes and insurance premium: 1%/year of the fixed assets
- Depreciation: 10-year streight-line depreciation of the total amount of the fixed capital.
- Interest: 12% per year for working capital,

  7.5%/y x 70% x 1/2 = 5.25%/y x 1/2 = 2.625%/y for fixed capital
- Labour cost: Average unit cost of the local labours x number of persons + average unit cost of skilled expatriate x number of expatriates(technical assistance fee)
- Plant overhead cost: Labour cost x 180%
- Distribution cost: Bagging cost alone was counted as far as plastic resins were concerned. The bagging facility cost were counted within the scope of the off-site facility cost.
- General administration cost: 3%/year of sales amount

6-2-8 Demand and exfactory prices of products

The domestic demand was calculated on the basis of the results obtained by UNIDO Phase I Study and the Synthetic Fiber Raw Material Survey. During the course of the calculations by employing the models, approximation was made regarding the domestic demand by employing the growth rate thereof for the sake of simplicity. The export is the total amount of surplus, i.e., the balance between the production amount and the domestic demand. As far as the product prices are concerned, the domestic market-destined and export-destined market separately estimated have been employed.

6-2-9 Economic viability study

Along with the evaluations of the economic viability of the complex as a whole (excluding utility facilities) calculations were made regarding those of individual process plants. Adjustments were made to the profit rates of each process plant by controlling the level of the intermediate product price (Generally speaking, the intermediate product prices were calculated in such a manner that the internal rate of return of the relative process plant becomes 15%). For the calculations of the internal rate of return for the complex as a whole and for each one of the process plant, the same calculation basis as employed for unit production cost calculations were employed. Whenever the inflation factor should be taken into consideration, such a condition was duly incorporated in the course of the study. Therefore, it was assumed that the effects of the inflation will be exerted on such items as raw material price, product price including the intermediate product price, maintenance cost, utility price, labour cost, bagging cost, plant overhead cost, and general administration cost. The depreciation and interest shall be deemed to be unaffected by inflation. Also, repayments of the loans were assumed to be made in equal installments of the total principal and interest, in other words, the principal and interests were calculated in terms of the add-on method equally for all the years. Tax holiday was taken for five years and further, it was assumed that 45% company tax and working capital will not be depreciated. However, the working capital shall be included within the scope of the total investment amount.

PART III VARIOUS ECONOMIC EVALUATIONS

Chapter 1. Prices

1-1 Product Prices

1-1-1 Exfactory prices for domestic market

(1) Exfactory prices based on the imported prices

Annex I, Table AI-2-16 shows the exfactory prices which were obtained on the assumption that they are competitive with the imported prices. According to the table, it seems that, except for PVC and VCM, the relevant prices to the minimum exfactory prices of Japan are similar to the prices obtained on the basis of the export prices from Middle East.

(2) Exfactory prices based on the production costs.

Table II-21 shows the calculation results obtained by the method described in Annex I, Chapter 2, 2-5.

(3) Exfactory prices based on the relationship between demand and market price

A general discussion regarding this point was made in Annex I, Chapter 2, 2-6. However, in view of the fact that the level of production is low during the initial stage of operation of a petrochemical complex in Indonesia, it is doubtful at this stage as to whether strict product-wise relationship between the demand and the market price can be made. Also, under the present circumstance, there is a considerably large difference between market price and the CIF or the landed cost, thereby implying the complexity of the distribution system in the country. Nevertheless, it is expected that improvements in the distribution system will be achieved along with the expansion in the demand. Therefore, there is a possibility that exfactory product prices for domestic market can be set at a comparatively high level depending on the improvement of distribution costs. In the light of the above reasons, a price estimation on the basis of consideration has been deleted from this report.

(4) The assumption of the standard exfactory prices for economic evaluation

As a result of comparative scrutinizations of the imported prices, production cost, etc. the exfactory prices for domestic market from the petrochemical complexes in Indonesia for economic evaluation of the projects were established as shown in Table II-22 for the year 1980.

Except for PVC, the lowest price of the results of various calculations on a number of assumptions was adopted for the able II-22. As far as PVC is concerned, the calculation results were obtained on the basis of Japanese maximum exfactory prices without imposing import duty and by incorporating the prices on Middle East-basis and production-cost-basis. This has been undertaken due to the fact that the Japanese PVC prices seem to show a tendency of being excessibly low.

Table II-21 Estimated Exfactory Price in Indonesia Based on Production Cost and I.R.R.

(Unit: ¢/y year=1980)

Calculation base		LDPE	HDPE	PP	PVC	VCM	EG
Inflation 7%/y	I.R.R. %	15	15	15	15	15	15
I.R.R. 15%	Unit Cost	60.2	59.2	56.3	69.4	42.6	35.2
	Price	69.0	66.4	63.5	74.3	46.6	40.4
Inflation 7%/y	I.R.R. %	20	20	20	20	15	15
I.R.R. 15% (monomer)	Unit Cost	60.6	59.4	56.5	69.5	42.6	35.2
20% (plastic resin)	Price	75.9	72.0	69.3	77.3	46.6	40.4
Inflation none	I.R.R. %	15	15	15	15	15	15
I.R.R. 15%	Unit Cost	61.7	62.9	58.5	75.2	45.1	36.9
	Price	78.2	74.3	71.2	83.4	51.7	46.0
Inflation none	I.R.R. %	20	20	20	20	15	15
I.R.R. 15% (monomer)	Unit Cost	63.2	62.0	58.8	75.3	45.1	36.9
20% (plastic resin)	Price	85.7	80.5	77.5	86.8	51.7	46.0

Note: Case 3 North Sumatra was calculated as the following capacity,
Ethylene 300 x 10^3 MTA, LDPE 120,000, HDPE 50,000, PP 70,000
PVc 100,000, VCM 104,000, EG 100,000 MTA, the rate of operation 85%

Table II-22 Exfactory Price for Domestic Market

(Unit: US$/t)

	Exfactory Price (for Domestic Market)	Base of Assumption
LDPE	833	Japan, Min., Import Tax 0
HDPE	810	- " -
PVC	794	Japan, Max., Import Tax 0
PP	827	Middle East Import Tax 0
EG	553	- " -

Further, concerning plastics, the necessary technical servicings for sales promotion, application development research cost, etc. will be necessary in addition to the production cost, the additional cost requirement was assumed to be average US$50/t which has been subtracted from the exfactory prices of the plastics.

1-1-2 Exfactory prices for export

Basically, the export price (CIF price) is determined by the international competitiveness of the subject item. In other words, it is considered that, if a certain product has export competitiveness on the basis of CIF port of importing countries and, if the exporting country of such a product is capable of maintaining the lowest possible level of the CIF price, all the minimum prices CIF of other exporting countries will have to be on the same level. This assumption can be amply supported by the actual status of the international market in the past.

In accordance with the international competitiveness already conducted in the other chapters of this report, Japan and Middle East countries were selected as the subjects of this study as having export competitiveness, and, as the representative destination for exportation, the Philippines was selected as the subject. The method of price calculation was explained in 2-4, Chapter 2 of Annex I and the calculation results are summarized in Table AI-2-15 of 2-4 of the same Chapter.

The export prices from Middle East countries are affected by the political administrative policies of the exporting countries themselves. Also, it is possible for these countries to conduct exportation on a low price level in order to secure future markets commensurate with the abundant raw material availability. If it is assumed that over-supply will soften the international market by the effect of the petrochemical industrialization rush which will take place in the developing countries from 1978 onwards, this problem will present a much more serious circumstance.

In view of the above reasons, it seems dangerous for the project evaluation to set the export price on a high level. Table II-23 pre-supposes that 80 % of the CIF prices which have been calculated on the basis of the Japanese prices was established at the standard exfactory prices for export at 1980 for the economic evaluation. This assumption was made in view of avoiding the inclusion of the above danger during the course of this study. As far as PVC is concerned, the rate was taken at 90% for the same reason as has already been mentioned above.

Table II-23 Exfactory Price for Exportation

(Unit: US$/t)

	Ex-factory price (for Exporting)	Base of Assumption
LDPE	672	80% of Japan CIF, Min.
HDPE	655	"
PVC	617	90% of Japan CIF, Min.
PP	725	80% of Japan CIF, Min.
EG	400	"

1-2 Raw Material Prices

The level of prices of raw material and fuel gas can be estimated in different ways. In this writing, two ways are applied. The one is to estimate based on the calorific price of clean fuel oil produced by the desulfurization of Middle East crude oil. The other is to estimate based on the calorific market price of Indonesian LNG (FOB).

In this Chapter 1 - 5 of Part III, the prices estimated by the former case is adopted for economic evaluation. And as alternative prices of raw material and fuel gas, the later method was applied to check the effects of changes in the raw material hydrocarbon conditions in Chapter 6.

1-2-1 Prices of supplied condensate gas and fuel gas based on the desulfurized Middle East fuel oil.

It is assumed that the hydrocarbon raw materials to be supplied to the olefin complex consists of the C_2^+ condensate gas containing mainly ethane and propane which are produced during the production of LNG by means of liquefying natural gas. For the assumption of the condensate gas prices, the proportional allocation portion of the LNG liquefying cost to be alloted to C_2^+ fraction was added to the natural gas price at the fence of the LNG plant. The proportional allocation of the liquefying cost was undertaken by taking into consideration the physical property differences in view of the easiness in liquefying of the methane-rich fractions and of the C_2^+ fractions. The former are the main components of natural gas and also, are of the low boiling point. The proportional allocation ratio was estimated on the basis of the required driving shaft horse power for each one of the fractions to be liquefied. In some cases, the separation cost of C_2^+ fraction from the methane-rich fraction shall be added. However, this factor can be neglected depending on how to pre-suppose the economically adequate recovery rate of the C_2^+ fraction. In this study, the same amount as the proportional allocation portion of the liquefying cost was incorporated in this respect in the present calculations. The natural gas price at the fence of the LNG plant was computed by subtracting the gas cost, the storage cost, transportation cost and other costs for the fuel gasifying at the boiler-entrance in the consuming country.

Also, the LNG price is estimated based on an assumption that the LNG price is equivalent on the calorific value basis to the clean fuel price consumed for electrical power generation in a large consumption market (Japan). The clean fuel price was in turn calculated by adding the desulfurization cost to the Middle East fuel oil, the consumption of which is large.

(1) The basic clean fuel price:

The Middle East fuel oil (sulfur content = 3.0 wt%) price is US¢151/MMBTU, which corresponds to the Middle East crude oil price of US$9.36/bbl CIF for the month of January 1974.

Price of high sulfur content fuel Oil:	US¢151/MMBTU	(crude oil price US$9.36/bbl CIF)
Desulfurization cost:	US¢ 40*/MMBTU	
Clean fuel price before burner:	US¢191/MMBTU	

As assumption is made that the above figure is the before-burner price level of LNG for the year 1974.

Note: The cost of desulfurization varies depending on the applied process & the extent of desulfurization. The cost for the removal of 90% of sulfur contained in exhaust gas will be 8 - 16 ¢/MMBTU by utilizing calcium carbonate absorber. The cost required for the direct desulfurization of heavy oil from 3 wt% of sulfur to 0.3 wt will attain 40 -80 ¢/MMBTU.

(2) Transportation, storage and regasifying cost of LNG:

Transportation cost:	US¢43/MMBTU
Storage and regasifying cost:	US¢18/MMBTU

(3) Natural gas liquefying cost: US¢67/MMBTU

(4) Natural gas price at the fence of liquefying plant:

On the basis of the above (1) through (3), the following will ensue.

(Natural gas price; plant entrance) = (LNG price; before burner) - (Transportation, storage and regasifying cost) - (Natural gas liquefying cost) = 191 - (43 + 18) - 67 = US¢63/MMBTU.

(5) C_2^+ condensate price

The following table shows the required driving shaft power for requefying methane-rich fractions and C_2^+ condensates on the basis of per calorific value. The assumption of C_2^+ condensate components is shown 2-1-1 in Part III.

	Drive shaft horse power required for liquefying	Liquefying temperature conditions
Methane-rich fractions:	16.4KWH/MMBTU	32°C to - 163°C
C_2^+ condensates:	1.41KWH/MMBTU	32°C to - 89°C

The production rate of the C_2^+ condensate and methane-rich fractions to be shipped in the form of LNG separated at the LNG plant is assumed as shown in the following table. By alloting the liquefying cost to the C_2^+ condensate in proportion to the required driving shaft horse power, the C_2^+ condensate price is calculated as follows:

	Weight basis	Calorific value basis
Methane-rich fraction (LNG):	5000×10^3MTA	231×10^6MMBTU/Year
C_2^+ condensates:	660×10^3MTA	29.0×10^6MMBTU/Year

(C_2^+ condensate) = (Natural gas price) + (Liquefying cost proportional allocation portion)

However, the calculated value of the liquefying cost proportional allocation portion equals:

$$Cav \times \frac{q_1 \times Q_1}{q_1 \times Q_1 + q_2 \times Q_2}$$

where:

Cav: Average liquefying cost = LNG liquefying cost = US¢67/MMBTU

q: Driving shaft horse power per unit quantity

Q: Production amount

i: Suffixes: i=1 C_2^+ condensate gas

i=2 Methane-rich gas

On the basis of the above, the proportional allocation portion of the liquefying cost will be calculated as follows.

$$67 \times \frac{1.41 \times 29}{1.41 \times 29 + 16.4 \times 231} = 67 \times \frac{40900}{40900 + 3790000}$$

= US¢0.7/MMBTU

The proportional allocation portion of the liquefying cost including the separation cost from the methane-rich gas was multiplied approximately by 2, thereby establishing a figure of US¢1.5/MMBTU. Therefore, the price of the C_2^+ condensate which is the olefin complex feedstock for the year 1974 will be calculated as follows.

(C_2^+ condensate Price) = (Natural gas price) + (Liquefying cost proportional allocation portion) = US¢63/MMBTU + US¢1.5/MMBTU

= US¢64.5/MMBTU

= US$2.56/MMKcal : @1974

In view of the fact that the calorific value of the assumed C_2^+ condensate gas is 11,327 Kcal/kg, the per ton price shall be as follows:

(C_2^+condensate Price) = 2.56 x 11,327 x 10^{3-6} = US$29.0/t
@1974

Also, it will be assumed that the fuel gas price shall be the natural gas price at the fense of the LNG liquefying plant. This was effected due to the fact that in the case of the olefin complex which employs the gas fractions as the raw materials will possess a large amount of residual mathane-rich gas.

(Fuel gas Price) = US¢63/MMBTU = US$2.5/MMKcal
@1974

Thus, the hydrocarbon raw materials and fuel prices for the olefin complex for the year 1980 will be as follows by taking into consideration the 7% per year escalation factor.

(C_2^+condensate price) = US$43.5/t @1980

(Fuel gas price) = US$ 3.75/MMKcal: @1980

1-2-2 The availability and price of auxiliary raw materials

As the scope of the production was limited to VCM (PVC), LDPE, HDPE, EO/EG, PP the required sub-raw material is only chlorine. During the recent on-site surveys it was revealed that 99.5% purity salt is scheduled to be produced at a cost of FOB US$5.00 per ton in Madura Island. It is therefore assumed that salt will be produced at a cost of US$8.10 per ton in 1980 when the inflational trend is taken into consideration. The following charges will be added to the salt cost.

Unloading cost	US$0.50/t
Margin, etc.	US$0.80/t
Freight to Palembang	US$15.80/t (1)

Freight to East Kalimantan	US$14.2/t	(2)
Freight to North Sumatra	US$19.0/t	(3)

As the result, the total cost landed at the above ports are as follows:

Palembang	US$25.20/t
East Kalimantan	US$23.6/t
North Sumatra	US$28.4/t

On the other hand, a project for the production of aluminum in the Asahan area for 225,000 t/y has been finalized. For this project, caustic soda sufficient for processing yearly 500,000 tons of alumina is required.

1-3 Intermediate Products

The intermediate products at the olefin complex are chlorine, VCM, ethylene and propylene. The intermediate products prices were calculated in such a manner that the internal rate of return (IRR) will become 15% at the intermediate products plants.

1-4 By-Products

The by-products turned out from the olefin complex will be as follows and the respective prices of the by-products for the year 1980 has been established as under-mentioned through calculations, the details of which shall be explained in the latter part of this writing.

Olefin plant	Price (US$/t)	Price basis
Hydrogen (purity, 90 to 95%)	107.5	Fuel gas basis
Residue gas (methane rich gas)	44.8	"
C_3 LPG (propane)	135.0	LPG export basis
C_4 fractions (butadienes are included)	135.0	"
Aromatic gasoline	131.0	Approximately Naphtha price basis
Fuel oil	102.0	Fuel oil basis

Electrolysis plant		
Caustic soda:	-	Same price as chlorine
Hydrogen (purity 100%)	107.5	Fuel gas basis

For the above, the fuel price was taken at the price of natural gas at the fence of the plant, i.e., US$3.75/MMKcal
Hydrogen price US$3.75/MMKcal x 28.67 MMKcal/t = US$107.5/t

Residue gas US$3.75/MMKcal x 11.95 MMKcal/t = US$44.8/t

C_3, C_4, and LPG: The CIF price of LPG in Japan in 1974 was US$110/t. Including storage, ocean freight, insurance premium and margin, it is considered that the Indonesia-Japan cost will be US$20/t approximately. Therefore, the exfactory price in Indonesia should be US$110/t - US$20/t = US$90/t. When the 7% per year escalation is taken into consideration up to 1980, the following will ensue.
$90 \times (1.07)^6$ = US$135/t.

Aromatic gasoline: The price shall be forecast on the basis of and by referring to the naphtha price. Due to the fact that aromatic gasoline contains a higher extent of aromatics than the straight-run naphtha, the price level shall be set slightly higher accordingly. The naphtha price was calculated on the basis of exportable price for large market (Japan).

(FOB price in Indonesia) US$195.8/MMBTU at 1974

Therefore, the Indonesian naphtha price shall be as follows.

195.8 x 1/0.252 ¢/MMKcal x 10,500 Kcal/kg

= US$81.6/t : @1974

In view of the above, the price of aromatic gasoline will be as follows.

$81.6 \times (1.07)^6$ = US$122.4/t: @1980

On the other hand, the price of reformate is US$147.6/t @1978 according to the aromatics complex study. In other words, the following will ensue.

$147.6 \times (1.07)^2$ = US$168.3/t @1980

On the other hand, the aromatic gasoline which has been by-produced from an olefin plant has received a much severer extent of thermal history and further contains a large amount of ethyl benzene, so that it has a lower value as a raw material for aromatics production than the reformates. In view of the above facts, the price level of aromatic gasoline was set at US$131/t; @1980.

Fuel Oil: If an assumption is made that the price per volume is taken as equal as Minas crude oil, the fuel oil price of the ethylene bottom becomes as follows when the SP.Gr is 1.0.

US$10.8/bbl = US$67.92/Kl ; @1974

$67.92 \times (1.07)^6$/Kl = US$101.9/Kl

= US$101.9/t -- US$102/t

1-5 Utility Prices

Case 3 was taken as the basic case and the conceptional design of the utility facilities was undertaken. Further, estimation of construction cost etc. were made in order to carry out the utility cost calculation. The results of the study are shown in Table II-24. The bases for the cost calculations were described Chapter 6, in Part II. Further, in the case of electrolysis, VCM and PVC complexes which utilize the electrical power from Asahan, the results will be extremely different from those of the basic case so that separate calculations were conducted. The obtained results were shown in Table II-25. The fuel prices were taken at the natural gas prices at plant fence, i.e., US$3.75/MMKcal which has already been described in the Raw Material Prices in 1-2 of Part III.

Table II-24 Utilities Price - North Sumatra -

Case 3

Stream Factor : 85%

Items		
Electric	$/KWH	0.0491
Sea Water	$/m^3	0.0316
River Water	$/m^3	0.120
Filtered Water	$/m^3	0.248
Deminelized Water	$/m^3	0.556
Polished Water	$/m^3	0.803
Instrument Air	$/m^3	0.0255
Oxygen	$/m^3	0.0488
Plant Air	$/m^3	0.0277
110 ^{k} Steam	$/ton	5.89
Fuel	$/MMKcal	(3.91)
20^k - 10^k Steam	$/t	3.22
Inert Gas	$/Nm^3	0.0497
Steam Condensate	$/Nm^3	0.513
Fuel Gas	$/MMKcal	3.75

Table II-25 Utilities Price for PVC, VCM and Electrolysis Plant in Asahan and Other Plants in North Sumatra

Stream Factor : 85%

Items		ASAHAN	North Sumatra
Electric Power	\$/KWH	0.012	0.0552
110^k Steam	\$/t	-	7.84
10^k -20^k Steam	\$/t	-	4.03
15^k Steam	\$/t	10.7	-
Sea Water	\$/t	-	0.0410
River Water	\$/t	0.11	0.106
Filtered Water	\$/t	0.307	0.272
Deminerized Water	\$/t	0.69	0.522
Polished Water	\$/t	-	0.784
Instrument Air	$\$/Nm^3$	0.032	0.0370
Oxygen	$\$/Nm^3$	0.052	0.0532
Plant Air	$\$/Nm^3$	0.030	0.0344
Inert Gas	$\$/Nm^3$	0.057	0.0516
Steam Condensate	\$/t	-	0.0850
Fuel	\$/MMKcal	10.3 *1)	3.75 *2)

Notes: *1) Fuel oil

*2) Fuel gas - NG price is 63¢/MMBTU in 1974, 300,000MTA.

Chapter 2. Various Alternatives

2-1 Basic Policy for Formulating Various Alternatives for an Olefin Complex on Natural Gas Basis

2-1-1 Raw materials

(1) Hydrocarbons

Migas, Pertamina, and other authorities in Indonesia, have indicated their basic policy concerning the selection of the hydrocarbons for the feed of the olefinic petrochemical complex that the available naphtha will not be found in the near future, therefore hydrocarbons extracted from natural gas shall be considered as the basic raw materials for the future olefinic petrochemical projects.

Therefore, the study on olefinic petrochemical industry on the basis of natural gas was conducted in compliance with the above-mentioned basic Indonesian policy. However, at the present stage, the composition, the quantity and the locations of the available raw material natural gas are completely unknown. In this connection, it has been voiced that the clarification of these points will be made sometime during the second half of 1974. This being the circumstance, this report made an assumption on the gas compostion which is to be utilized as a raw material for olefinic petrochemical industry by referring to various natural gas which has so far been produced in Indonesia. For the purpose of proceeding with this study, it has therefore been assumed as follows. Of the condensating liquid after separating methane from the natural gas, the light gas condensate mainly composed of C_2 through C_4 (C_2^+) is considered in this report to be employed as raw materials. Further, the following assumption concerning the composition thereof shall be made.

	Weight Ratio
C_2	1.00
C_3	1.47
C_4	0.97
C_5^+	0.654

However, the composition of natural gas varies vastly from place to place of production in general. Therefore, as and when various data regarding the natural gas for use in the petrochemical industry are clarified on the side of Indonesia in the future, further detailed studies shall be conducted anew.

(2) Chlorine

The two chlorine sources for VCM will be possible in Indonesia, i.e., the own production of chlorine by electrolysis of salt in Indonesia and importation of chroline in the form of EDC. Nevertheless, in this report, studies will be conducted on the basis of the former case, i.e., production by the establishment of the own electrolysis facilities. In this case, further two cases can be considered as possibilities, i.e., the case in which the electrolysis facilities be installed within the complex and another case in which the utilization of surplus electricity from Asahan project is conducted. The comperative studies of these two cases will be made in this bulletin.

2-1-2 Sites

Unlike the naphtha-base olefinic petrochemical complex, site for the natural gas basis complex shall be basically selected in the vicinity of the gas sources in view of the transportation problems of the raw material gas. However, at the present stage, no clarification has been made concerning the gas sources to be utilized for petrochemical industry as has been mentioned earlier. Therefore in this report, the following three sites are tentatively taken up as the candidate locations by taken into consideration the production conditions of the gas achieved so far, the relationship with the market as well as the substantiation of existing infrastructures.

(1) Palembang

The infrastructures installed at the existing oil refineries (in both areas of Plaju and South Gexong) are the best substantiated in the industrial sites of all of Indonesia and except for the raw materials supply problems, Palembang is the most suited location as the site at the present stage. However, in view of the capacity of Sungai Musi River for ocean vessels, there is a certain limitation in the way of future development potential and the expansion in the scale of petrochemical complex. This being the circumstance, problems still remain pertaining to the suitability for constructing large scale complex. (If a transportation base is constructed at the mouth of Sungai Musi River, the potential for future development will be greater). Therefore, as far as Palembang is concerned, the location seems to be suitable for early construction of olefinic petrochemical complex for the first time in Indonesia by utilizing the existing infrastructures with a scope corresponding with the domestic demand level.

(2) North Sumatra

It is strongly possible that North Sumatra will be the supply sources of gas raw material for the future olefinic petrochemical industries, in view of the natural gas production and also of the present development being undertaken in this area. Together with the future possibility of natural gas supply for feed of petrochemical industries, the strong intention of the government of Indonesia for the further advancement of social development of exterior area, North Sumatra is one of the most potential sites available in Indonesia. However, North Sumatra is located on the west-most tip of the Indonesian country and therefore the location must be considered in terms of overseas site geographically in view of the locational relationship with the Java Island, which is the largest market, and also in view of the possible competition with Singapore. Therefore, it is necessary to establish a petrochemical complex having sufficient scale and international competitiveness after taking into consideration the overseas market covering the range from Middle East up to the Far East, in general, the Southeast Asian markets in particular.

(3) East Kalimantan

East Kalimantan can be considered as being one of the potential site in the same sense as North Sumatra, in view of the compliance with the strong intention of the government of Indonesia concerning the development of the outer territories and also of the possibility of becoming one of the supply sources of natural gas for use in the future petrochemical industry. Further, East Kalimantan is located approximately in the middle of the Java Island and the

Philippines. On the assumption that the mutual cooperation of Indonesia and the Philippines, it is possible to contemplate the construction of plants with an ample scale for enabling international competition within the framework of the international market consisting of the two countries. Naturally, if the above mutual cooperation of the two countries can be assumed as the basis prerequisite condition, the burden of export efforts aiming at numberous and unspecified overseas market will be vastly decreased while realizing the operation within the framework of international scale marketing. Therefore, the merit in this case is highly obvious.

2-1-3 Selection of the products

The selection of the products (derivatives) will be limited within a certain scope when considering the fact that this petrochemical industrial complex is to be based on the utilization of natural gas (C_2^+) and also in view of the scale of the market for the various products (derivatives) as well as the control and operation of the constructed factory.

In other words, as far as the ethylene derivatives, polyethylene (low and high density polyethylenes) and polyvinyl chloride having the most general application fields and possessing comparatively large market will be taken up as the products. And further, ethylene glycol will be included within the product scope in view of the forthcoming necessity for the same in connection with the synthetic fiber raw material project in Palembang which is preceding this project. Further, as far as polyvinyl chloride is concerned, several projects are already being planned on the basis of the importation of VCM, for a quantity of 63,000 t/y. In this study, VCM produced in the olefin complex is assumed to be either totally converted into polyvinyl chloride or, partially supplied to the existing polyvinyl chloride manufacturing plants in the form of VCM.

Regarding the other ethylene derivatives, such as acetic aldehyde, etc., it would not be appropriate to incorporate production of such derivatives into the initial stage of the petrochemical complex, in view of the fact that the related industries utilizing such derivatives are still on an underdeveloped stage. As to propylene derivative, polypropylene will be taken up as the product for the same reason as stated for the case of polyethylene, i.e., in view of the potential for a comparatively large market as the general use of resin. Phenol and acrylonitrile can also be nominated as the potential propylene derivatives in addition to the above items. However, the economic scale for phenol production is minimum 100,000 t/y and the substantiation of the related industries such as the adhesive material production, etc., must be required in order to consume such an extent of production. It seems absolutely impossible to consume all the produced phenol from such a plant within the framework of Indonesian and the surrounding overseas markets in 1980, when the completion of this complex is scheduled. Further, the consumption of acetone which will be produced by approximately 60% in the form of by-product of the phenol production is also difficult to attain.

Although the minimum economic scale production of acrylonitrile is 60,000 t/y approximately, the growth of acrylic fiber in areas such as Indonesia which is located in the tropic zone cannot be expected to attain a high level in the future. Polyester and nylon will rather take the lead in the market and then it seems that the demand for acrylic fibers will grow gradually as and when the demand for high-class items such as carpet, etc. begin to emerge. The SOHIO Process which is globally employed at present requires propylene as well as ammonia as the main raw materials. For Indonesia, ammonia will be allocated for the production of fertilizer so that no surplus can be expected for allocation to the production of acrylonitrile. Also, the hydrogen cyanide and aceto-nitryl which are both by-produced through the SOHIO Process must also be utilized effectively for such a purpose, the development of related industries as galvanizing industry, MMA, etc. must be present. Therefore, as the propylene derivative, polypropylene alone will be taken up as the subject. It seems that the production of phenol, acrylonitrile and other items is still inadequate in view of the prematurity of the surrounding conditions.

2-1-4 Capacities

The capacities for olefin plant and for the production of various derivatives will be established on the basis of the following:

(1) Complex scale for domestic market

A forecast assumption is made concerning the scale of production commensurate to the Indonesian domestic market for the year 1980 concerning the above-mentioned items, i.e., LDPE, HDPE, PVC, EG, and PP. Further, the ethylene production scale will be established in accordance with the above established scale (Case-1).

This corresponds to the petrochemical complex to be established in Palembang described in the above 1-2.

(2) International competitive complex scale

In view of stiff competition within the framework of exportation, a basis will be set that the production scale of each derivative will be commensurate with the exportable quantity to the surrounding Southeast Asian market, plus the extent of Indonesia domestic market and further, the establishment of the production scale for each item shall be made in such a manner that the production scale for each derivative will attain the economical scale. This corresponds to the case of North Sumatra described in the above 1-2 (Case-3)

(3) Complex scale for domestic and Philippine market

On the assumption of mutual cooperation with the Philippines, the demand in Indonesia in 1980 and that of the Philippines in the same year are taken as the basis for establishing the production capacities for each item. This corresponds to the case of East Kalimantan described in the above 1-2 (Case-2)

2-2 Alternative Flow Schemes for an Olefin Plant on Natural Gas Basis

In compiling various flow schemes, an assumption was made regarding the raw material gas composition as stipulated in 2-1. The composition at the outlet of the thermal cracker of olefin plant are assumed as follows taking into accounts the maximization of olefin productions.

Yield Pattern of Olefin Plant

	Weight Ratio
H_2	0.105
C_1	0.348
C_2	1.000
C_3	0.293
C_3-LPG	0.094
C_4-Mix	0.216
C_5-200°C	0.143
200°C -	0.022

2-2-1 Case-1

Figure II-6 shows the flow scheme made on the basis of the production scale commensurate with the Indonesian domestic market for the year 1980. Concerning PVC, a figure 65,000 t/y for 1980 Indonesian market scale was taken as the basis and the capacity of 70,000 t/y is selected.

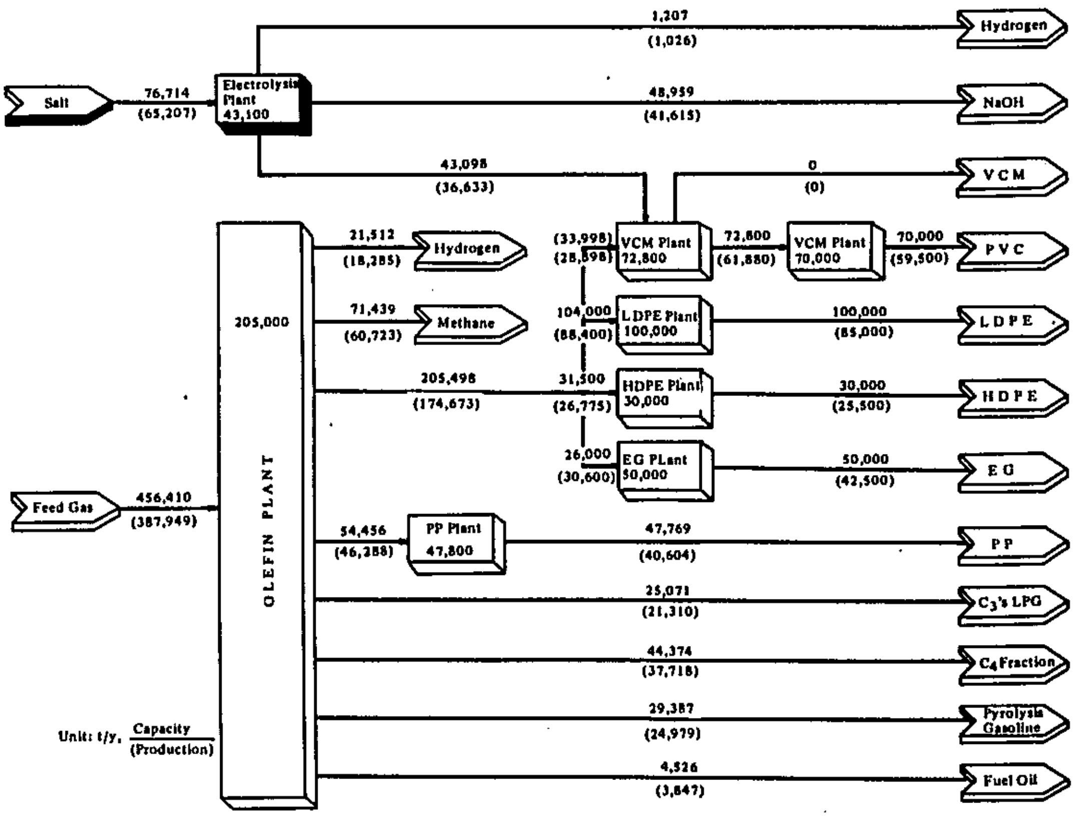


Figure II-6 Process Flow and Balance for Case-1

For LDPE, a 100,000 t/y unit is assumed on the basis of the 90,000 t/y market scale in Indonesia for the year 1980. Concerning HDPE, the Indonesian market in 1980 is forecast at 20,000 t/y, however, the minimum economic scale or production is taken as 30,000 t/y. As to EG, a capacity of 50,000 t/y is selected as the minimum economic scale and at the same time, as the approximately corresponding capacity to the polyester fiber demand in Indonesia in the year 1980. A capacity of 48,000 t/y was taken for PP on an assumption that the total amount of propylene will be covered into PP, such an amount of propylene being corresponding to the ethylene amount required for the production of the above-mentioned various ethylene derivatives. This also coincides with the residual Indonesian market scale attainable in 1980 excluding existing 20,000 t/y PP plant in Palembang, i.e., 40,000 t/y.

As a result of the above assumption, the ethylene production scale will therefore be set at approximately 200,000 t/y.

2-2-2 Case-2

This is a case in which the Indonesian and the Philippines market for the year 1980 are combined and are taken as the basis of the capacity selection. (Figure II-7)

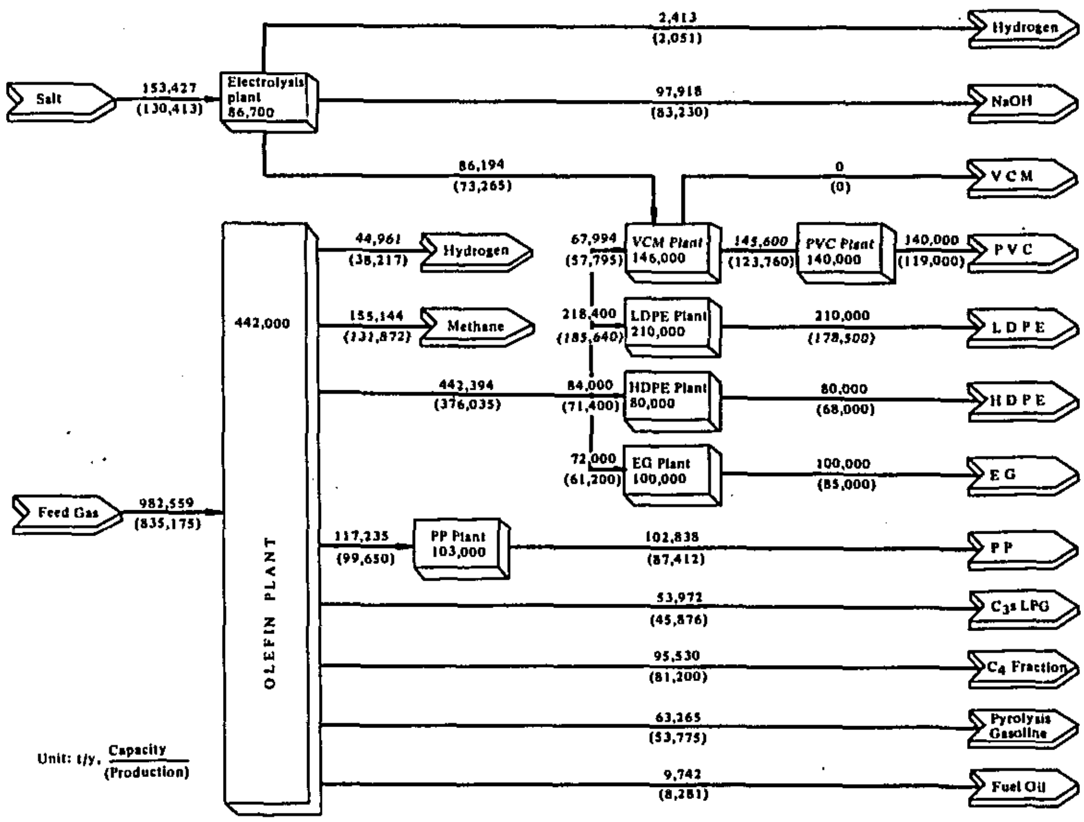


Figure II-7 Process Flow and Balance for Case-2

Table II-26, shows the estimated demand in Indonesia and Philippines considering the fact that the HDPE amount in the above-mentioned UNIDO Phase I will be proportionately small, the PVC capacity will be set at 140,000 t/y and LDPE for 200,000 t/y, and HDPE at 80,000 t/y.

Table II-26 Estimated Domestic Market in Indonesia

	Indonesia UNIDO	The Philippines UNICO
	Phase I	Calibrated Values
PVC	65,000 t/y	121,400 t/y
LDPE	90,000	140,300 (LDPE + HDPE)
HDPE	20,000 (40,000)	
PP	40,000	56,500

Also, by assuming that the production amount of polyester raw material (PTA and DMT) in Indonesia in 1980 will be 200,000 t/y, the EG production amount of approximately 80,000 t/y will be necessary to meet such a situation. On the other hand, due to the fact that the minimum capacity of reactor is 50,000 t/y, a capacity figure of 100,000 t/y was established on the basis of installing two lines. Therefore, the exportation of 10,000 t/y to 20,000 t/y will be taken as the available extent.

The propylene which meets the ethylene required for turning out the above-mentioned ethylene derivatives is considered in this writing to be totally converted polypropylene and therfore, the PP production capacity was set at 100,000 t/y. This figure coincides with the market scale of both Indonesia and the Philippines in the year 1980 attaining a level of 96,500 t/y.

Here, the chlorine necessary for the production of PVC shall be produced by installing an electrolysis plant in the petrochemical complex site (the raw material salt shall either be imported or domestically supplied) and of the by-produced caustic soda, approximately 50,000 t/y which is necessary for carrying out the Asahan aluminium project shall be transported to Bintan Island while the remaining portion being allocated for export. Figure II-7 shows the flow sheet applicable to such a case. (Case-2)

2-2-3 Case-3

Figure II-8 shows a flow sheet of this case in which the Indonesian domestic market and the surrounding Southeast Asian markets for exportation are both taken into consideration for the year 1980. This also takes into account the competition to be waged with Singapore. In this scheme, average 1/3 of the product items shall be allocated for exportation. In this respect, the comparative studies of economics will be undertaken for the cases of either increase or decrease in the export amount and the detailed scrutinization on this subject will be undertaken in the latter part of this writing.

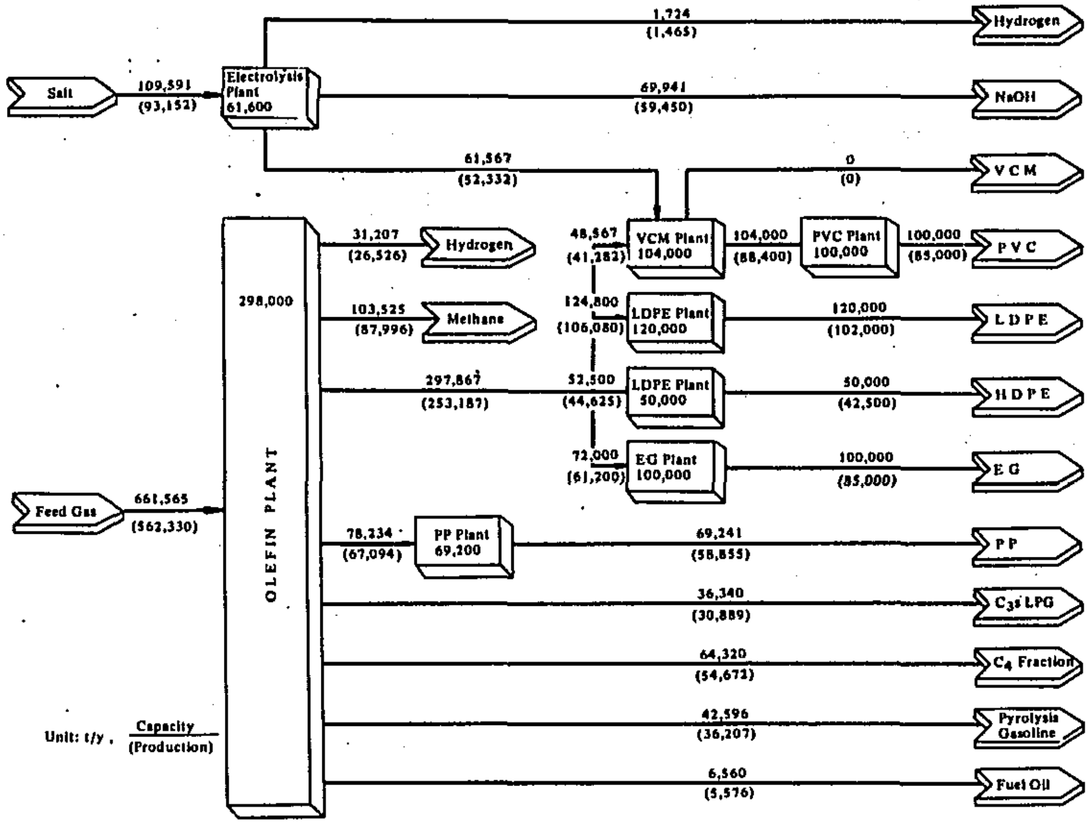


Figure II-8 Process Flow and Balance for Case-3

Chapter 3. Economic Evaluation of Alternatives for Olefin Complex

The competitive cost calculations and the analysis of foreseeable valuable factors regarding the alternatives were conducted by forming models by utilizing the process simulator (GPSOP: Generalized Chemical Process Simulation and Optimization Program). Further detailed financial analysis were conducted for representative alternative selected therefrom. The outline of the economic evaluation by utilizing the models has been described in Part II, Chapter 6. It must be noted here that the operational rate (stream factor) was assumed at 85% during the course of economic evaluation calculations. (Refer to Part I, 3-1-4).

3-1 Comparison of the Site Conditions

The most advantageous raw material to be employed for the production of olefin derivatives in view both of economy and technology is the light condensate centering around ethane and propane which have been separated from natural gas. For this reason, the site selection of a petrochemical complex is limited to three areas as follows where supply possibility of the raw material gas is available at present. Further, in relation to the project for aluminium smelting operation, Asahan is selected as a candidate site for the construction of the electrolysis plant, however, studies on this point shall be made separately from this writing.

a. Palembang

b. East Kalimantan

c. North Sumatra

In view of the capacity of the supply amount of the raw material, Palembang will be the site for constructing a plant with the capacity of which will be, at the most, sufficiently cover the Indonesian domestic market only, while East Kalimantan and North Sumatra seem to be suitable for constructing an ethylene center of 300 x 10^3 MTA to 450 x 10^3 MTA production capacity to also cover a considerable extent of export.

3-1-1 Difference in the exfactory product prices

Indonesia consists of a number of islands and total coverage of area of the country is wide. In many cases, distance between one of localities to another is comparable to a distance from one country to another in other part of the world. Therefore, depending upon the selection of the production site, the distance between the site to the domestic markets as well as export markets will be largely different (Refer to Table II-27 . Therefore, the transportation cost will vary greatly different (Refer to Table II-28) so that, if an assumption is made that the market price should be fixed on the same level, the exfactory price will differ depending on the site selected (Refer to Table II-29). As is described in ANNEX II,

Table II-27 Distance between Market and Plant Site

(Unit: nautical mile)

	Domestic (100%)				Export
	Jakarta	Surabaya	Medan	Average	To: Manila
	60%	20%	10%	100%	30%
Palembang	350	626	658	466	1503
E. Karimantan	764	478	1441	746	800
N. Sumatra	1002	1315	188	1013	1722

the transportation cost was calculated on the basis of the future cost. This has been effected in view of the fact that at the present stage, the fluctuation of ocean freight market is quite conspicuous due to the skyrocketing of crude oil prices, etc., thereby making it impossible to effect any realistic forecast by basing only on the past ocean freight trend. On the basis of the results shows in Table II-29, it has been revealed that difference in the exfactory prices between and the among the candidate sites can be neglected at the present stage without seriously affecting the course of the present study.

3-1-2 Difference in the construction cost

The difference in the construction cost is shown in ANNEX III. The order of construction cost advantage is Palembang, North Sumatra, then East Kalimantan. Palembang is in the highest advantage where the substantiation of site conditions has already been undertaken by forming an already industrialized area. However, within the framework of what is excluded from the scope of the infrastructure, the difference is not great amongst the three sites because of the fact that, new investment shall be required even in the case of Palembang for the construction of new off-site facilities, etc.

3-1-3 Difference in production cost and profitability

The profitability will be affected more seriously by the difference in the production scale rather than by that in the site conditions. If an identical production scale is assumed, the construction cost difference will affect more seriously the profitability than the difference in the product prices. (i.e. transportation cost difference) Therefore, the advantage is available in the order of Palembang, North Sumatra and East Kalimantan. However, at the present stage where no clarification has been made concerning the raw material supply amount, it is difficult to pinpoint any significant difference which can be taken as a basis for site selection.

3-2 Comparison of Alternative Schemes - Plant Site and Market

As has been described in Part II, the prepared and predesignated alternative schemes have been established on an assumption that the main raw materials will be amply suppliable and further, the site selected and the destination markets are integrally combined. In other words, Case-1 presupposes the construction of an ethylene plant of 200 x 10^3 MTA capacity in Palembang to cover the domestic market by forming an olefin complex; Case-2 presupposes a Kalimantan complex of 450 x 10^3 MTA ethylene production capacity which corresponds to covering the Indonesia domestic market as well as the Philippines export market; and Case-3 targets a complex which will have a production capacity of 300 x 10^3 MTA of ethylene which corresponds to the domestic markets and 1/3 of the export amount for the year 1980 in North Sumatra. When comparative study is conducted between these three alternative cases and also the internal rate of return of the whole complex which has respectively corresponding ethylene production capacity, the results as shown in

Table II-28 Comparison of Transportation Cost between Domestic Market and Each Plant Site in 1980

(Unit: $/Kg)

Products	Plastic Resin		E G		V C M	
Market	Domestic	Export	Domestic	Export	Domestic	Export
Site	Jakarta	Manila	Jakarta	Manila	Jakarta	Manila
Palembang	1.41	-	0.94	-	-	-
E. Kalimantan	1.85	2.08*	1.27	1.55	-	2.55
N. Sumatra	1.95	2.78*	1.37	1.99	2.24	3.26

* excluding PVC

Table II-29 Comparison of Exfactory Price for Each Plant Site

(Unit: $/Kg)

Products	LDPE		HDPE		PVC	
	Domestic	Export	Domestic	Export	Domestic	Export
Site	Jakarta	Manila	Jakarta	Manila	Jakarta	Manila
Palembang	112.0	-	133.2	-	87.0	-
E. Kalimantan	111.6	82.6	132.8	98.6	86.6	63.6
N. Sumatra	111.5	81.9	132.7	97.9	86.5	62.9

Products	P P		V C M		E G	
	Domestic	Export	Domestic	Export	Domestic	Export
Site	Jakarta	Manila	Jakarta	Manila	Jakarta	Manila
Palembang	127.9	-	-		80.2	-
E. Kalimantan	127.5	94.6	-	39.7	79.9	58.6
N. Sumatra	127.4	93.9	64.0	39.1	88.9	58.1

Table II-30 can be obtained.

Further, Table II-30 additionally shows the internal rate of return of the complexes in which the product pattern of the North Sumatra site Case-3 has been scaled up and scaled down by sliding along the ethylene production capacity. On the basis of the above results, it has been revealed that the effects of the difference in the complex scale are much greater than that of the difference in the plant site/market location combination factor. Summary of eco- II-9 concerning the effects of scale (scale merits). Summary of nomic viabilityiof Case 1, 2 and 3 is shown in Tables II-31(1) through II-31 (3).

Table II-30 Comaprison of Alternative Scheme

	Case 1	Case 2	Case 3
Ethylene Capacity x 10^3 MTA	200	450	300
Site	Palembang	E. Kalimantan	N. Sumatra
I.R.R. of Total Complex	20.2%	23.9%	21.8% (20.9)*2
I.R.R. of equivalent*1 scale complex	17.3%	25.5%	21.8% (20.9)*2

Note :

*1 Capacity of each process plant scaled up and/or down by Case 3.

*2 ( ) to be a result of detailed financial analysis.

Table II-31(1) Summary of Investment Unit, Production Cost & Profitability of each Process Plant & Total Complex - Case 1

Purpose of Study: Palembang

Cal Number : @ R-11
Case Number : No. 1
Ethylene Production Capacity: 200,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity		MTA		205,000	43,100	72,800	100,000
Investment		10^6 $	620.1	132.9	49.0	50.1	163.0
I.R.R.		%	20.2	15.0	15.0	15.0	21.3
Break Down of Unit Production Cost @ 1980	Variable Cost			19.6	-8.2	304.0	293.0
	Fixed Cost			128.5	251.5	150.8	314.9
	Distri. & Admini.			5.7	9.6	15.4	40.5
	Total Production Cost			153.8	252.9	470.2	648.4
Average Sales Price $/t				191.4	319.2	514	833

			H D P E	P V C	E G	P P
Plant Capacity		MTA	30,000	70,000	50,000	47,800
Investment		10^6 $	44.8	53.2	57.2	69.9
I.R.R.		%	16.4	9.0	20.9	23.1
Break Down of Unit Production Cost @ 1980	Variable Cost		298.7	555.6	176.2	274.2
	Fixed Cost		355.0	181.3	234.8	322.8
	Distri. & Admini.		38.8	39.3	18.1	40.3
	Total Production Cost		692.5	776.2	429.1	637.2
Average Sales Price $/t			777	794	553	825

Table II-31(2) Summary of Investment Unit, Production Cost & Profitability of each Process Plant & Total Complex - Case 2

Purpose of Study: East Karimantan

Cal Number : @ R-12-(2)
Case Number : No. 2
Ethylene Production Capacity: 450,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		442,000	86,200	146,000	210,000
Investment	10^6 $	1,088.9	242.5	81.8	83.7	281.6
I.R.R.	%	23.9	15.0	15.0	15.0	28.7
Break Down of Unit Production Cost @ 1980	Variable Cost		25.4	28.3	270.7	264.7
	Fixed Cost		101.7	191.7	114.5	245.4
	Distri. & Admini.		4.9	8.5	13.1	38.1
	Total Production Cost		132.0	228.6	398.3	548.2
Average Sales Price $/t			164	285	435	753

		H D P E	P V C	E G	P P
Plant Capacity	MTA	80,000	140,000	100,000	103,000
Investment	10^6 $	90.6	89.2	95.3	124.2
I.R.R.	%	25.6	26.4	28.0	33.1
Break Down of Unit Production Cost @ 1980	Variable Cost	270.1	473.4	156.6	249.3
	Fixed Cost	233.1	134.6	182.8	240.6
	Distri. & Admini.	36.5	36.9	16.7	38.7
	Total Production Cost	539.7	645.0	356.1	528.6
Average Sales Price $/t		701	714	505	772

Table II-31(3) Summary of Investment Unit, Production Cost & Profitability of each Process Plant & Total Complex - Case 3

Purpose of Study: North Sumatra
Price of NG : 63 ¢/MMBTU @1974
Cal Number : @ R-0
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	791.7	172.5	62.0	63.4	184.3
I.R.R.	%	21.8	15.0	15.0	15.0	24.8
Break Down of Unit Production Cost @ 1980	Variable Cost		23.3	18.7	285	275
	Fixed Cost		112	213	128	293
	Distri. & Admini.		5.22	9.0	14.0	39.9
	Total Production Cost		140	241	426	608
Average Sales Price $/t			174	301	466	814

		H D P E	P V C	E G	P P.
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.5	66.9	91.0	89.1
I.R.R.	%	22.4	21.7	28.8	29.8
Break Down of Unit Production Cost @ 1980	Variable Cost	280	505	164	258
	Fixed Cost	277	151	176	272
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	594	694	356	569
Average Sales Price $/t		728	752	505	794

Case-3 was selected as the representative complex and the results of the cost calculation for this case are shown in Table II-32 (1) through (8).

Table II-32(1) Breakdown of Production Cost & Investment of Ethylene Production

MODEL NAME = OLEFINE1 UNIT NO = 2

PROCESS	ETHYLENE	
PRODUCT	ETHYLENE	
PLANT CAPACITY		297868. (TON/Y)
ANNUAL PRODUCTION		253188.
TIME OF CONSTRUCTION		1979.09
STREAM FACTOR		0.850
INVESTMENT		
PROCESS PLANT		91694273. (DL.)
OFF-SITE		44841403.
LAND		3630140.
PRE-OPER. EXPENSE		8492690.
INTEREST DUR. CONST.		15609143.
* FIXED CAPITAL		164267649.
* WORKING CAPITAL		8225648.
TOTAL INVESTMENT		172493297.

PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
CON'SATE	2.2210 (TON/TON)	43.20	562330.	24292660.	95.95
BY-PRO.	-0.8340	78.63	-211159.	-16603403.	-65.58
LPG	-0.1220	135.00	-30889.	-4170003.	-16.47
PROPYLEN	-0.2650	139.21	-67095.	-9340048.	-36.89
OTHER	0.9670 (DL. /TON)			244833.	0.97
RAW MATERIAL & BYPRODUCTS				-5575961.	-22.02
EP	52.800 (KWH/TON)	0.0491	13368316.	656384.	2.59
STEAM	1.056 (TON/TON)	3.2200	267366.	860920.	3.40
FUEL	4.356 (MMKCAL/TON)	3.7500	1102886.	4135823.	16.33
F.W	0.264 (TON/TON)	0.2480	66842.	16577.	0.07
S.W	594.000 (TON/TON)	0.0316	150393553.	4752436.	18.77
OTHER	4.130			1045666.	4.13
UTILITIES				11467805.	45.29
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				5891844.	23.27
MAINTENANCE				2749593.	10.86
TAX & INSURANCE				1297683.	5.13
DEPRECIATION				14865851.	58.71
INTEREST				4889364.	19.31
LABOR	LOCAL 100. (MD)	EXPART 10. (MD)		1590893.	6.28
PLANT OVER-HEAD				2863608.	11.31
* FIXED COST TOTAL				28256992.	111.60
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				1321705.	5.22
TOTAL PRODUCTION COST				35470541.	140.10

PROFIT & LOSS	8586291.	33.91
* SALES FOR DOMESTIC MARKET	44056832.	174.01
* SALES FOR EXPORT	0.	0.0
SALES TOTAL	44056832.	174.01
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)	0.050	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT)	0.150	
TOTAL SALES OF EXPORT (10 YEAR)	0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)	0.	

Table II-32(2) Breakdown of Production Cost & Investment of Chlorine Production

MODEL NAME = OLEFINE1 UNIT NO = 1

PROCESS	ELECTROLYSIS OF SALT				
PRODUCT	CHLORINE				
PLANT CAPACITY				61568. (TON/Y)	
ANNUAL PRODUCTION				52333.	
TIME OF CONSTRUCTION				19•9.09	
STREAM FACTOR				0.850	
INVESTMENT					
PROCESS PLANT				33029103. (DL.)	
OFF-SITE				14731885.	
LAND				2540076.	
PRE-OPER. EXPENSE				3006507.	
INTEREST DUR. CONST.				5597295.	
• FIXED CAPITAL				58904866.	
• WORKING CAPITAL				3070612.	
TOTAL INVESTMENT				61975478.	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
SALT	1.7800 (TON/TON)	28.40	93152.	2645528.	50.55
HYDROGEN	-0.0280	107.50	-1465.	-157522.	-3.01
NAOH	-1.1360	300.47	-59450.	-17862893.	-341.33
OTHER	8.7330 (DL. /TON)			457022.	8.73
RAW MATERIAL & BYPRODUCTS				-14917865.	-285.06
EP	3320.000 (KWH/TON)	0.0491	173744896.	8530874.	163.01
STEAM	43.000 (TON/TON)	3.2200	2250310.	7245999.	138.46
FUEL	0.0 (MMKCAL/TON)	3.7500	0.	0.	0.0
F.W	0.0 (TON/TON)	0.2480	0.	0.	0.0
S.W	0.0 (TON/TON)	0.0316	0.	0.	0.0
OTHER	2.310			120889.	2.31
UTILITIES				15897763.	303.78
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
• VARIABCE COST TOTAL				979898.	18.72
MAINTENANCE				817920.	15.63
TAX & INSURANCE				447970.	8.56
DEPRECIATION				5330757.	101.86
INTEREST				1767797.	33.78
LABOR	LOCAL 63. (MD)	EXPART 6. (MD)		1001911.	19.14
PLANT OVER-HEAD				1803440.	34.46
• FIXED COST TOTAL				11169795.	213.44
• DISTRIBUTION				0.	0.0
• ADMINISTRATION				471731.	9.01
TOTAL PRODUCTION COST				12621424.	241.18
PROFIT & LOSS				3102954.	59.29
• SALES FOR DOMESTIC MARKET				15724378.	300.47
• SALES FOR EXPORT				0.	0.0
SALES TOTAL				15724378.	300.47
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.050	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.150	
TOTAL SALES OF EXPORT	(10 YEAR)			0.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)			0.	

Table II-32(3) Breakdown of Production Cost & Investment of VCM Production

MODEL NAME = OLEFINE1 UNIT NO = 3

PROCESS	OXY-CLORINATION	
PRODUCT	VINYL-CLORIDE MONOMER	
PLANT CAPACITY		104000. (TON/Y)
ANNUAL PRODUCTION		88400.
TIME OF CONSTRUCTION		19•9.09
STREAM FACTOR		0.850

INVESTMENT	
PROCESS PLANT	32556582. (DL.)
OFF-SITE	14650536.
LAND	2448000.
PRE-OPER. EXPENSE	2872654.
INTEREST DUR. CONST.	5515416.
• FIXED CAPITAL	58043189.
• WORKING CAPITAL	5349653.
TOTAL INVESTMENT	63392842.

PRODUCTION COST	UNIT CONS./PHOD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
ETHYLENE	0.4670 (TON/TON)	174.01	41283.	7183559.	81.26
CLORINE	0.5920	300.47	52333.	15724378.	177.88
OTHER	1.4670 (DL. /TON)			129683.	1.47
RAW MATERIAL & BYPRODUCTS				23037619.	260.61
EP	215.000 (KWH/TON)	0.0491	19006000.	933195.	10.56
STEAM	1.500 (TON/TON)	3.2200	132600.	426972.	4.83
FUEL	1.100 (MMKCAL/TON)	3.7500	97240.	364650.	4.12
F.W	0.570 (TON/TON)	0.2480	50388.	12496.	0.14
S.W	0.0 (TON/TON)	0.0316	0.	0.	0.0
OTHER	4.510			398684.	4.51
UTILITIES				2135997.	24.16
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
• VARIABCE COST TOTAL				25173616.	284.77
MAINTENANCE				640458.	7.25
TAX & INSURANCE				433771.	4.91
DEPRECIATION				5252777.	59.42
INTEREST				2020812.	22.86
LABOR	LOCAL 66. (MD)	EXPART 7. (MD)		1049730.	11.87
PLANT OVER-HEAD				1889514.	21.37
• FIXED COST TOTAL				11287063.	127.68
• DISTRIBUTION				0.	0.0
• ADMINISTRATION				1234747.	13.97
TOTAL PRODUCTION COST				37695425.	426.42

PROFIT & LOSS	3462795.	39.17
• SALES FOR DOMESTIC MARKET	41158220.	465.59
• SALES FOR EXPORT	0.	0.0
SALES TOTAL	41158220.	465.59
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)	0.055	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT	0.150	
TOTAL SALES OF EXPORT (10 YEAR)	0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)	0.	

Table II-32(4) Breakdown of Production Cost & Investment of PVC Production

MODEL NAME = OLEFINE1 UNIT NO = 5

Item	Unit Cons./Prod	Unit Price	Anual Quantity	Anual Cost	Unit Cost
PROCESS	POLY VINYL CLORIDE				
PRODUCT	POLY VINYL CLORIDE				
PLANT CAPACITY				100000. (TON/Y)	
ANNUAL PRODUCTION				85000.	
TIME OF CONSTRUCTION				19e9.09	
STREAM FACTOR				0.850	
INVESTMENT					
PROCESS PLANT				26841773. (DL.)	
OFF-SITE				20845196.	
LAND				2718000.	
PRE-OPER. EXPENSE				2217574.	
INTEREST DUR. CONST.				5525367.	
* FIXED CAPITAL				58147910.	
* WORKING CAPITAL				8787352.	
TOTAL INVESTMENT				66935262.	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
VCM	1.0400 (TON/TON)	465.59	88400.	41158220.	484.21
OTHER	4.0000 (DL. /TON)			340000.	4.00
RAW MATERIAL & BYPRODUCTS				41498220.	488.21
EP	180.000 (KWH/TON)	0.0491	15300000.	751230.	8.84
STEAM	0.900 (TON/TON)	3.2200	76500.	246330.	2.90
FUEL	0.0 (MMKCAL/TON)	3.7500	0.	0.	0.0
F.W	4.500 (TON/TON)	0.2480	382500.	94860.	1.12
S.W	0.0 (TON/TON)	0.0316	0.	0.	0.0
OTHER	3.980			338300.	3.98
UTILITIES				1430720.	16.83
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				42928940.	505.05
MAINTENANCE				537318.	6.32
TAX & INSURANCE				430209.	5.06
DEPRECIATION				5262254.	61.91
INTEREST				2435824.	28.66
LABOR	LOCAL 94. (MD)	EXPART 9. (MD)		1495070.	17.59
PLANT OVER-HEAD				2691126.	31.66
* FIXED COST TOTAL				12851802.	151.20
* DISTRIBUTION				1319268.	15.52
* ADMINISTRATION				1918500.	22.57
TOTAL PRODUCTION COST				59018510.	694.34
PROFIT & LOSS				4931490.	58.02
SALES FOR DOMESTIC MARKET				51610000.	607.18
SALES FOR EXPORT				12340000.	145.18
ALES TOTAL				63950000.	752.35
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.074	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.217	
TOTAL SALES OF EXPORT (10 YEAR)				20689824.	
TOTAL QUANTITY OF EXPORT (10 YEAR)				33372.	

Table II-32(5) Breakdown of Production Cost & Investment of LDPE Production

MODEL NAME = OLEFINE1 UNIT NO = 6

PROCESS	HIGH PRES.POLYMERIZATION					
PRODUCT	LOW DENSITY POLYETHYLENE					
PLANT CAPACITY					120000. (TON/Y)	
ANNUAL PRODUCTION					102000.	
TIME OF CONSTRUCTION					1979.09	
STREAM FACTOR					0.850	
INVESTMENT						
PROCESS PLANT					106379154. (DL.)	
OFF-SITE					38261086.	
LAND					5085000.	
PRE-OPER. EXPENSE					9331972.	
INTEREST DUR. CONST.					16701007.	
* FIXED CAPITAL					175758219.	
* WORKING CAPITAL					8531405.	
TOTAL INVESTMENT					184289624.	
PRODUCTION COST	UNIT CONS./PROD		UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
ETHYLENE	1.0400	(TON/TON)	174.01	106080.	18458823.	180.97
OTHER	8.6670	(DL. /TON)			884034.	8.67
RAW MATERIAL & BYPRODUCTS					19342857.	189.64
EP	1500.000	(KWH/TON)	0.0491	153000000.	7512300.	73.65
STEAM	1.000	(TON/TON)	3.2200	102000.	328440.	3.22
FUEL	0.0	(MMKCAL/TON)	3.7500	0.	0.	0.0
F.W	1.000	(TON/TON)	0.2480	102000.	25296.	0.25
S.W	0.0	(TON/TON)	0.0316	0.	0.	0.0
OTHER	8.120				828240.	8.12
UTILITIES					8694276.	85.24
RUNNING ROYALTY	0.0	(DL. /TON)			0.	0.0
* VARIABCE COST TOTAL					28037133.	274.87
MAINTENANCE					2971767.	29.13
TAX & INSURANCE					1315808.	12.90
DEPRECIATION					15905721.	155.94
INTEREST					5199020.	50.97
LABOR	LOCAL 101. (MD)		EXPART 10. (MD)		1606405.	15.75
PLANT OVER-HEAD					2891529.	28.35
* FIXED COST TOTAL					29890250.	293.04
* DISTRIBUTION					1583122.	15.52
* ADMINISTRATION					2491020.	24.42
TOTAL PRODUCTION COST					62001525.	607.86
PROFIT & LOSS					21032475.	206.20
* SALES FOR DOMESTIC MARKET					74970000.	735.00
* SALES FOR EXPORT					8064000.	79.06
SALES TOTAL					83034000.	814.06
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)					0.114	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT					0.248	
TOTAL SALES OF EXPORT	(10 YEAR)				10578369.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)				16010.	

Table II-32(6) Breakdown of Production Cost & Investment of HDPE Production

MODEL NAME = OLEFINE1 UNIT NO = 7

PROCESS	LOW PRES. POLYMERIZATION					
PRODUCT	HIGH DENSITY POLYETHYLEN					
PLANT CAPACITY					50000. (TON/Y)	
ANNUAL PRODUCTION					42500.	
TIME OF CONSTRUCTION					19*9.09	
STREAM FACTOR					0.850	
INVESTMENT						
PROCESS PLANT					29846477. (DL.)	
OFF-SITE					17681522.	
LAND					3627000.	
PRE-OPER. EXPENSE					2389395.	
INTEREST DUR. CONST.					5622161.	
* FIXED CAPITAL					59166555.	
* WORKING CAPITAL					3325565.	
TOTAL INVESTMENT					62492120.	
PRODUCTION COST	UNIT CONS./PROD		UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
ETHYLENE	1.0500	(TON/TON)	174.01	44625.	7765130.	182.71
OTHER	28.3330	(DL. /TON)			1204152.	28.33
RAW MATERIAL & BYPRODUCTS					8969282.	211.04
EP	775.000	(KWH/TON)	0.0491	32937500.	1617231.	38.05
STEAM	7.000	(TON/TON)	3.2200	297500.	957950.	22.54
FUEL	0.0	(MMKCAL/TON)	3.7500	0.	0.	0.0
F.W	2.000	(TON/TON)	0.2480	85000.	21080.	0.50
S.W	0.0	(TON/TON)	0.0316	0.	0.	0.0
OTHER	8.260				351050.	8.26
UTILITIES					2947311.	69.35
RUNNING ROYALTY	0.0	(DL. /TON)			0.	0.0
* VARIABCE COST TOTAL					11916594.	280.39
MAINTENANCE					796385.	18.74
TAX & INSURANCE					415755.	9.78
DEPRECIATION					5354439.	125.99
INTEREST					1804608.	42.46
LABOR	LOCAL 76. (MD)		EXPART 8. (MD)		1208780.	28.44
PLANT OVER-HEAD					2175804.	51.20
* FIXED COST TOTAL					11755772.	276.61
* DISTRIBUTION					659634.	15.52
* ADMINISTRATION					928125.	21.84
TOTAL PRODUCTION COST					25260124.	594.36
PROFIT & LOSS					5677376.	133.59
* SALES FOR DOMESTIC MARKET					16200000.	381.18
* SALES FOR EXPORT					14737500.	346.76
SALES TOTAL					30937500.	727.94
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)					0.091	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT					0.224	
TOTAL SALES OF EXPORT (10 YEAR)					100976275.	
TOTAL QUANTITY OF EXPORT (10 YEAR)					127630.	

Table II-32(7) Breakdown of Production Cost & Investment of EG Production

MODEL NAME = OLEFINE1   UNIT NO = 8

PROCESS	OXIDATION	
PRODUCT	ETHYLENE GLYCOL	
PLANT CAPACITY		100000. (TON/Y)
ANNUAL PRODUCTION		85000.
TIME OF CONSTRUCTION		19*9.09
STREAM FACTOR		0.850
INVESTMENT		
PROCESS PLANT		56304587. (DL.)
OFF-SITE		15179293.
LAND		2178000.
PRE-OPER. EXPENSE		4599786.
INTEREST DUR. CONST.		8217475.
* FIXED CAPITAL		86479141.
* WORKING CAPITAL		4476094.
TOTAL INVESTMENT		90955235.

PRODUCTION COST	UNIT CONS./PROD		UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
ETHYLENE	0.7200	(TON/TON)	174.01	61200.	10649321.	125.29
OTHER	1.3330	(DL. /TON)			113305.	1.33
RAW MATERIAL & EYPRODUCTS					10762626.	126.62
EP	500.000	(KWH/TON)	0.0491	42500000.	2086750.	24.55
STEAM	2.700	(TON/TON)	3.2200	229500.	738990.	8.69
FUEL	0.0	(MMKCAL/TON)	3.7500	0.	0.	0.0
F.*	0.0	(TON/TON)	0.2480	0.	0.	0.0
S.W	0.0	(TON/TON)	0.0316	0.	0.	0.0
OTHER	3.820				324700.	3.82
UTILITIES					3150440.	37.06
RUNNING ROYALTY	0.0	(DL. /TON)			0.	0.0
* VARIABCE COST TOTAL					13913066.	163.68
MAINTENANCE					1448243.	17.04
TAX & INSURANCE					611772.	7.20
DEPRECIATION					7826167.	92.07
INTEREST					2591500.	30.49
LABOR	LOCAL 55. (MD)		EXPART	5. (MD)	874775.	10.29
PLANT OVER-HEAD					1574595.	18.52
* FIXED COST TOTAL					14927051.	175.61
* DISTRIBUTION					127194.	1.50
* ADMINISTRATION					1288515.	15.16
TOTAL PRODUCTION COST					30255826.	355.95

PROFIT & LOSS		12694674.	149.35
* SALES FOR DOMESTIC MARKET		32350500.	380.59
* SALES FOR EXPORT		10600000.	124.71
SALES TOTAL		42950500.	505.30
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)		0.140	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT		0.288	
TOTAL SALES OF EXPORT	(10 YEAR)	50303596.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)	111062.	

Table II-32(8) Breakdown of Production Cost & Investment of PP Production

MODEL NAME = OLEFINE1 UNIT NO = 9

PROCESS	POLYPROPYLENE				
PRODUCT	POLYPROPYLENE				
PLANT CAPACITY				69241, (TON/Y)	
ANNUAL PRODUCTION				58855,	
TIME OF CONSTRUCTION				1949,09	
STREAM FACTOR				0.850	
INVESTMENT					
PROCESS PLANT				45257053, (DL.)	
OFF-SITE				22849521,	
LAND				4495572,	
PRE-OPER. EXPENSE				3745823,	
INTEREST DUR, CONST.				8016537,	
* FIXED CAPITAL				84364507,	
* WORKING CAPITAL				4780432,	
TOTAL INVESTMENT				89144939,	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
PROPYLEN	1.1400 (TON/TON)	139.21	67095.	9340048.	158.70
OTHER	21.6670 (DL. /TON)			1275213.	21.67
RAW MATERIAL & BYPRODUCTS				10615261.	180.36
EP	950.000 (KWH/TON)	0.0491	55912306.	2745294.	46.64
STEAM	5.500 (TON/TON)	3.2200	323703.	1042323.	17.71
FUEL	0.0 (MMKCAL/TON)	3.7500	0.	0.	0.0
F.W	5.000 (TON/TON)	0.2480	294275.	72980.	1.24
S.W	0.0 (TON/TON)	0.0316	0.	0.	0.0
OTHER	12.330			725683.	12.33
UTILITIES				4586280.	77.92
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				15201541.	258.29
MAINTENANCE				1226570.	20.84
TAX & INSURANCE				603078.	10.25
DEPRECIATION				7634797.	129.72
INTEREST				2577786.	43.80
LABOR	LOCAL 89. (MD)	EXPART 9. (MD)		1412463.	24.00
PLANT OVER-HEAD				2542433.	43.20
* FIXED COST TOTAL				15997126.	271.81
* DISTRIBUTION				913478.	15.52
* ADMINISTRATION				1402498.	23.83
TOTAL PRODUCTION COST				33514643.	569.44
PROFIT & LOSS				13235275.	224.88
* SALES FOR DOMESTIC MARKET				33080000.	562.06
* SALES FOR EXPORT				13669918.	232.26
SALES TOTAL				46749918.	794.32
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.148	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.298	
TOTAL SALES OF EXPORT (10 YEAR)				23485936.	
TOTAL QUANTITY OF EXPORT (10 YEAR)				32177.	

3-3 Comparison of Alternatives - Utilization of Asahan Electricity

The government of Indonesia and foreign companies are now undertaking a project for aluminium smelting plant by utilizing hydro-electric power to be generated in Asahan. In this case, it is reported that the importation of caustic soda is to be conducted for the production of alumina scheduled to be carried out in Bintan Island. The utilization of Asahan electricity described in this writing pertains to the use of low-cost surplus electricity from the Asahan hydro-electric power station for the production and supply of whole or part of caustic soda for alumina production on the basis of salt electrolysis and, at the same time, the produced chlorine is to be used for the production of VCM and PVC after transporting to Asahan the ethylene produced in the olefin complex. In view of the difficulty in the bulk transportation of chlorine by tankers because of the danger involved in the accidents, no study will be made on a scheme in which chlorine is to be transported to the olefin complex. In this report, studies in this respect will be carried out by taking a basic case, i.e., Case-3 (an olefin complex of 300,000 MTA ethylene capacity to be constructed in North Sumatra). Table II-33 shows the electricity consumption by the plants engaging in the electrolysis and chlorine production. The increase in the electricity consumption of such an extent as shown in the table can be supplied utilizing the surplus capacity in the power plant project or by expediting the implementation period of the power project itself.

Table II-33 Electric Power Consumption of Process Plant

		Electrolysis	VCM	PVC	Total
Capacity	Chlorine	61,600MTA	104,000MTA	100,000MTA	
	Caustic Soda	70,000			
Rate of Operation		85 %	85 %	85 %	
Production	Chlorine	52,300MTA	85,000MTA		
	Caustic Soda	59,500	··		
Electric Power Consumption		21,700KW	2,000	4,000	27,700*

Note : *The rate of operation to be at 85%

The power generation cost in accordance with the feasibility study conducted jointly by the Indonesian and Japanese Governments revealed a level of approximately US$0.003/KWH; however, due to the recent inflation, the construction cost increased by approximately two-fold. Therefore, the electricity cost assumed here is on a level of 0.003 x 2 = US$0.006/KWH, accordingly, the price of electric power to be supplied to the electrolysis plant or to the petrochemical industrial facilities is assumed to be US$0.012/KWH at the entrance of each plant. The site for the electrolysis plant is assumed to be in the area adjacent to the aluminium smelting plant approximately 100 Km south of Medan. The price of caustic soda was assumed to be on the same level as that of chlorine and the adjustment of the prices was made in such a manner that the internal rate of return will attain 15%. The following paragraphes will describe an outline of economic evaluations made by the comparison models established as explained above. The results of economic calculation shows, the reduction of the unit price of electric power for the petrochemical complex is compensated by the cost increase in the investment costs caused by the separation of the chlorine production line from the complex, particularly by the facility cost increase in the common facility sections, and by the increment in the unit of utilities other than electricity. (Refer to Table II-34 Comparison of Case-3 and the Asahan Site (2).) The rate of return for the petrochemical complex as a whole will be reduced if a lower level evaluation is made to the caustic soda price corresponding to the low-cost electrical power cost in the Asahan site (1) case. In this case, no significant change will take place in the production cost of VCM and PVC; however, it can be considered that the possibility for evaluating caustic soda which is one of the basic raw materials will yield a certain extent of advantage in carrying out adjustment in the aluminium smelting project, etc. It is nevertheless probable that other difficulties will be caused by the separation of the complex in this manner, in such aspects as the increased complexity in administration and planning, double investment, necessity for surplus personnel and in other intangible aspects. Therefore, when the finalization on the raw material gas is made, this subject should be studied anew by also taking into consideration the problems of the ideal enterprise formation.

Table II-34 Financial Comparison of Asahan Electric Power (Olefin Total Complex)

	Profit at 1980	Total Investment	R.O.I* at 1980	I.R.R.
Case 3	72.7	721 MM$	10.1%	21.8%
Profitable Electric Power of ASAHAN (1)	71.2	743	9.6%	21.2%
Profitable ASAHAN Power (2)	76.9	743	10.3%	21.9%

Note: Case (1) Caustic Soda price is 20.6¢kg, and I.R.R. of electrolysis is 15%.
(2) Caustic Soda price is 30.1¢/Kg which is the same price at case 3.

Table II-36 shows the economic viability of the Case-1 in which the caustic soda and chlorine prices have been reduced according to the electrical power cost. Table II-35 further shows the results of comparison with Case-3 regarding such factors as production cost and prices for chlorine, VCM and PVC. The breakdown of the production cost in this case is shown in Table II-37 (1) through (3).

Table II-36 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex

Purpose of Study: ASAHAN Scheme

Cal Number : @ R-10
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity		MTA		298,000	61,600	104,000	120,000
Investment		10^6 $	816.3	172.5	69.1	74.0	184.3
I.R.R.		%	8.7	5.0	4.8	5.3	11.0
Break Down of Unit Production Cost @ 1980	Variable Cost			26.65	-94.3	256	282
	Fixed Cost			112	231	143	293
	Distri. & Admini.			5.33	6.17	13.7	39.9
	Total Production Cost			144	143	413	615
Average Sales Price $/t				178	206	457	814

			H D P E	P V C	E G	P P
Plant Capacity		MTA	50,000	100,000	100,000	69,000
Investment		10^6 $	62.5	73.7	91.0	89.2
I.R.R.		%	21.6	20.5	28.2	29.1
Break Down of Unit Production Cost @ 1980	Variable Cost		290	496	169	267
	Fixed Cost		277	161	176	272
	Distri. & Admini.		37.4	38.1	16.7	39.4
	Total Production Cost		604	695	361	578
Average Sales Price $/t			728	752	505	794

Table II-37(1) Breakdown of Production Cost & Investment of Chlorine Production in Asahan

MODEL NAME = OLEFINE2 UNIT NO = 1

PROCESS	ELECTROLYSIS OF SALT	
PRODUCT	CHLORINE	
PLANT CAPACITY		61568. (TON/Y)
ANNUAL PRODUCTION		52333.
TIME OF CONSTRUCTION		1979.09
STREAM FACTOR		0.850
INVESTMENT		
PROCESS PLANT		33029103. (DL.)
OFF-SITE		21977567.
LAND		2540076.
PRE-OPER. EXPENSE		3006507.
INTEREST DUR. CONST.		6358092.
* FIXED CAPITAL		66911345.
* WORKING CAPITAL		2188108.
TOTAL INVESTMENT		69099453.

PRODUCTION COST	UNIT CONS./PROD		UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
SALT	1.7800	(TON/TON)	28.40	93152.	4645528.	50.55
HYDROGEN	-0.0280		107.50	-1465.	-157522.	-3.01
NAOH	-1.1360		205.73	-59450.	-12230734.	-233.71
OTHER	8.7330	(DL. /TON)			457022.	8.73
RAW MATERIAL & BYPRODUCTS					-9285706.	-177.44
EP	3320.000	(KWH/TON)	0.0120	173745560.	2084947.	39.84
STEAM	4.300	(TON/TON)	10.7000	225032.	2407841.	46.01
FUEL	0.0	(MMKCAL/TON)	10.3000	0.	0.	0.0
F.*	0.0	(TON/TON)	0.3070	0.	0.	0.0
S.*	0.0	(TON/TON)	0.0410	0.	0.	0.0
OTHER	2.310				120889.	2.31
UTILITIES					4348668.	83.10
RUNNING ROYALTY	0.0	(DL. /TON)			0.	0.0
* VARIABCE COST TOTAL					-4623359.	-88.35
MAINTENANCE					850526.	16.25
TAX & INSURANCE					520426.	9.94
DEPRECIATION					6055325.	115.71
INTEREST					1852096.	35.39
LABOR	LOCAL 63. (MD)		EXPART 6. (MD)		1001911.	19.14
PLANT OVER-HEAD					1803440.	34.46
* FIXED COST TOTAL					12083724.	230.90
* DISTRIBUTION					0.	0.0.
* ADMINISTRATION					322995.	6.17
TOTAL PRODUCTION COST					7734691.	147.79

PROFIT & LOSS		3031800.	57.94
* SALES FOR DOMESTIC MARKET		10766491.	205.73
* SALES FOR EXPORT		0.	0.0
SALES TOTAL		10766491.	205.73
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)		0.044	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT		0.150	
TOTAL SALES OF EXPORT	(10 YEAR)	0.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)	0.	

Table II-37(2) Breakdown of Production Cost & Investment of VCM Production in Asahan

MODEL NAME = OLEFINE2 UNIT NO = 3

PROCESS	OXY-CLORINATION	
PRODUCT	VINYL-CLORIDE MONOMER	
PLANT CAPACITY		104000. (TON/Y)
ANNUAL PRODUCTION		88400.
TIME OF CONSTRUCTION		19*9.09
STREAM FACTOR		0.850
INVESTMENT		
PROCESS PLANT		34866315. (DL.)
OFF-SITE		22004719.
LAND		2448000.
PRE-OPER. EXPENSE		3103627.
INTEREST DUR. CONST.		6554379.
* FIXED CAPITAL		68977040.
* WORKING CAPITAL		5008146.
TOTAL INVESTMENT		73985186.

PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
ETHYLENE	0.4670 (TON/TON)	214.00	41283.	8834519.	99.94
CLORINE	0.5920	205.73	52333.	10766491.	121.79
OTHER	1.4670 (DL. /TON)			129683.	1.47
RAW MATERIAL & BYPRODUCTS				19730693.	223.20
EP	215.000 (KWH/TON)	0.0120	19006000.	228072.	2.58
STEAM	1.500 (TON/TON)	10.7000	132600.	1418820.	16.05
FUEL	1.100 (MMKCAL/TON)	10.3000	97240.	1001572.	11.33
F.*	0.570 (TON/TON)	0.3070	50388.	15028.	0.17
S.*	0.0 (TON/TON)	0.0410	0.	0.	0.0
OTHER	4.510			398684.	4.51
UTILITIES				2876072.	32.53
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				22723585.	256.83
MAINTENANCE				719747.	8.14
TAX & INSURANCE				530410.	6.00
DEPRECIATION				6242266.	70.61
INTEREST				2239572.	25.33
LABOR	LOCAL 66. (MD)	EXPART 7. (MD)		1049730.	11.87
PLANT OVER-HEAD				1889514.	21.37
* FIXED COST TOTAL				14671239.	143.34
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				1211012.	13.70
TOTAL PRODUCTION COST				36695119.	414.88

PROFIT & LOSS	3671934.	41.53
* SALES FOR DOMESTIC MARKET	40367053.	456.64
* SALES FOR EXPORT	0.	0.0
SALES TOTAL	40367053.	456.64
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)	0.050	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT	0.150	
TOTAL SALES OF EXPORT (10 YEAR)	0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)	0.	

Table II-37(3) Breakdown of Production Cost & Investment of PVC Production in Asahan

MODEL NAME = OLEFINE2 UNIT NO = 5

PROCESS	POLY VINYL CLORIDE				
PRODUCT	POLY VINYL CLORIDE				
PLANT CAPACITY				100000. (TON/Y)	
ANNUAL PRODUCTION				85000.	
TIME OF CONSTRUCTION				19*9,09	
STREAM FACTOR				0.850	
INVESTMENT					
PROCESS PLANT				26841773. (DL.)	
OFF-SITE				27010052.	
LAND				2718000.	
PRE-OPER. EXPENSE				2217574.	
INTEREST DUR. CONST.				6172677.	
* FIXED CAPITAL				64960076.	
* WORKING CAPITAL				8721421.	
TOTAL INVESTMENT				73681497.	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
VCM	1.0400 (TON/TON)	456.64	88400.	40367053.	474.91
OTHER	4.0000 (DL. /TON)			340000.	4.00
RAW MATERIAL & BYPRODUCTS				40707053.	478.91
EP	180.000 (KWH/TON)	0.0120	15300000.	183600.	2.16
STEAM	0.900 (TON/TON)	10.7000	76500.	818550.	9.63
FUEL	0.0 (MMKCAL/TON)	10.3000	0.	0.	0.0
F.W	4.500 (TON/TON)	0.3070	382500.	117300.	1.38
S.W	0.0 (TON/TON)	0.0410	0.	0.	0.0
OTHER	3.980			338300.	3.98
UTILITIES				1424504.	16.76
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				42202203.	496.50
MAINTENANCE				565060.	6.65
TAX & INSURANCE				491858.	5.79
DEPRECIATION				5878740.	69.16
INTEREST				2589740.	30.47
LABOR	LOCAL 94. (MD)	EXPART 9. (MD)		1495070.	17.59
PLANT OVER-HEAD				2691126.	31.66
* FIXED COST TOTAL				13711594.	161.31
* DISTRIBUTION				1319268.	15.52
* ADMINISTRATION				1918500.	22.57
TOTAL PRODUCTION COST				59164164.	695.46
PROFIT & LOSS				4785836.	56.30
* SALES FOR DOMESTIC MARKET				51610000.	607.18
* SALES FOR EXPORT				12340000.	145.18
SALES TOTAL				63950000.	752.35
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.065	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.205	
TOTAL SALES OF EXPORT	(10 YEAR)			20689824.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)			33372.	

Table II-35 Comaprison of Production Cost & Price between Asahan Scheme & Case 3

(¢/Kg)

		Chlorine Caustic Soda	VCM	PVC
Case 3	Unit Cost	24.1	42.6	69.4
	Unit Price	30.1	46.6	75.2
Use ASAHAN Electric Power	Unit Cost	14.3	41.3	69.5
	Unit Price	20.6	45.7	75.2

3-4 Variation in Economic Viability Due to Changes in Variable Factors

Case-3 was selected as the most representative complex scheme and on the basis of this case, the variation in economic viability due to variable factor change was studied. During the course of the study, the simulation calculations were conducted covering the whole complex by employing the models which were used for the comparative studies of various alternatives described in Chapter 2. Regarding the calculations pertaining to the economic viability aspects such as internal rate of return, simplified prerequisite conditions as explained in Part II Chapter 6 were established in order to facilitate the calculations in view of the fact that such economic viability calculations necessarily involve the steps of the comparison and selection. The reason for having selected Case-3 as the representative case is that there is practically no substantial difference between and amongst the alternatives, as has already been mentioned during the comparative studies of various alternatives, at the stage when no finalization is made concerning the raw material problems. Another reason is that an olefin plant of 300,000 t/y capacity is of a representative scale as a plant on the international standard.

3-4-1 Effects of variable factors to the internal rate of return of the whole complex

The internal rate of return was employed as the representative criterion for carrying out the evaluation of economy of the whole complex and the following items were selected as the variable factors in this respect.

- i) Plant capacity
- ii) Cost of raw material
- iii) Steam factor (Operational rate)
- iv) Construction cost
- v) Product prices
- vi) Date of commercial operation start
- vii) Inflation

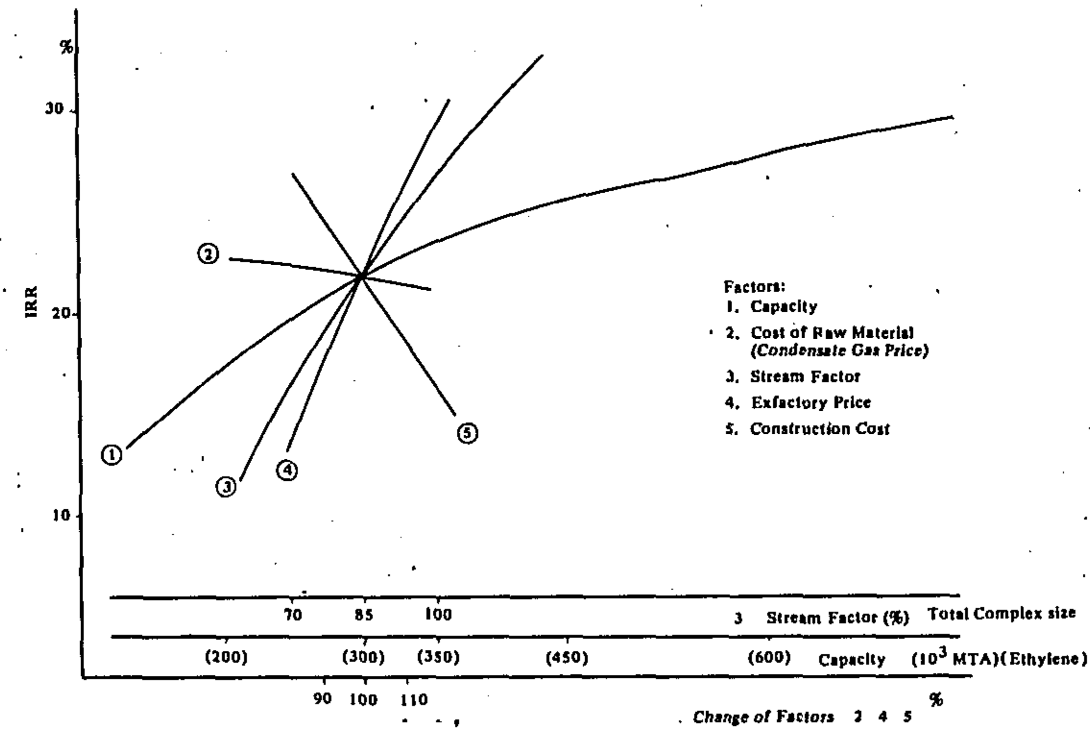


Figure II-9 Sensitivity of Internal Rate of Return of Total Complex to Various Factor Changes

(1) Effects of plant capacity, raw material prices, stream factors, construction cost and product prices

A summary of the results of economic calculations for the whole complex are shown in Table II-38 (1) through (17). As shown in these tables, the most serious effect will be exerted to the whole complex by the change in the product prices, followed by the stream factor and construction cost the degree of effects of which seem to be on an approximately the same level. The scale merit which changes in accordance with the size of the complex will, as has been already mentioned, cause increment in the low-price export portion along with the increase in the production capacity so that the scale merit degree will further be decreased. However, the reasons for a monotonous and unilateral increase in the rate of return along with the increment in the scale of complex seem to be as follows.

(a) The assumed export price is on a higher side because of an assumption that, for the estimation of the export prices, such an excessive competition as was wages in the past on the marginal cost level will no longer be present.

(b) The growth of Indonesian domestic demand is high and therefore there are a number of opportunities for sales of the products to the relatively advantageous domestic market.

The effects of raw material condensate price to be fed to the olefin complex had to be limited by the fact that the required feed amount is low in view of the fact that the assumed raw material composition was light condensate, thereby realizing a high extent of ethylene yield for the olefin plant. And also, that because of the difficulties in transportation of light gases such as ethane the prices of them can not be expected higher than liquid fuel such as naphtha. If the price of fuel gas should also vary in proportion to the raw material condensate price change, the effects of gas price exerted on the whole complex will be augmented by approximately 60%.

(2) Effects of date of commercial operation start

In order to study the extent of charge in the economic viability of the olefin complex project by bringing forward the date of commercial operation start, calculations were conducted on an assumption that the start-up would be made earlier by one year and also by two years that the basis schedule. The results are shown in Tables II-38 (13) through (14). The results are also illustrated in Figure II-10.

All the plant construction cost, labour cost and the product prices are assumed to be affected by 7%/y influation factor. All the remaining products after fulfilling the domestic market are assumed, same as the basic case to be totally allocated for exportation. On the basis of the above two tables and results shown in Figure II-10, it is revealed that the domestic demand during the initial stage of production will be decreased if the start up time is brought forward and also an increment will be made in the disadvantageous export portion under low price, thereby decreasing the internal rate of return.

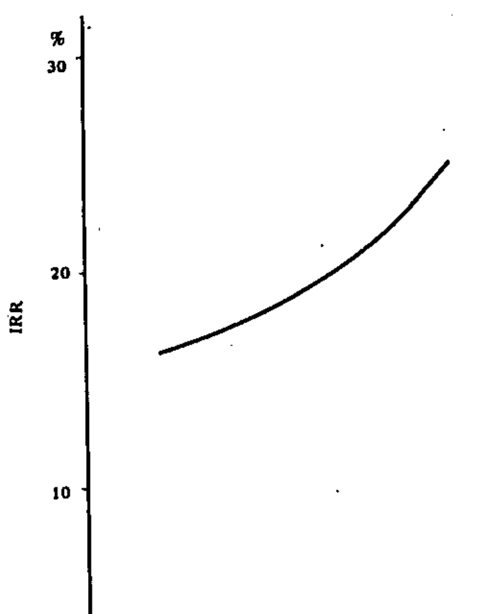


Figure II-10 Sensitivity of Internal Rate of Return of Total Complex to Start Up Time Changes

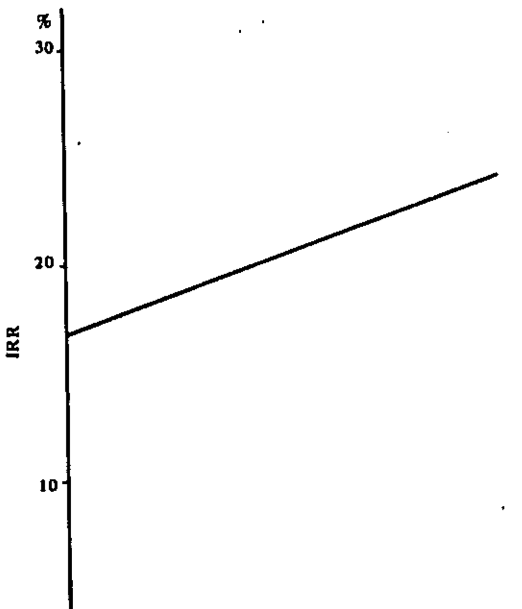


Figure II-11 Sensitivity of Internal Rate of Return of Total Complex to Various Factor Changes

(3) Effects of inflation

A summary of economic calculation results for the whole complex is shown in Tables II-38 (15) through (17). Also, Figure II-11 illustrates the effects of inflation exerted on the internal rate of return of the whole complex.

The effects of inflation appear to be advantageous in view of the economic viability evaluation because of the fact that the depreciation cost and the interest burden will be comparatively reduced as against the product or raw material prices. However, the event where inflation progresses excessively, the recovery of capital by means of depreciation will become impossible. Therefore, separate considerations should be made to cope with such a possibility.

3-4-2 Effects of variable factors to the economic viability of each process plant

(1) The economic viability of each process plant within a petrochemical complex will be affected not only by the plant itself but also by the intermediate raw material plants, olefin plant, etc. Therefore, in order to proceed with a study on each process plant, it is necessary to adequately establish the additional assumption for the economic condition of the intermediate raw material

Table II-38(1) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Capacity - 200,000 MTA

Purpose of Study: Capacity Change

Cal Number : @ R-3
Case Number : No. 3
Ethylene Production Capacity: 200,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		199,000	41,000	69,300	80,000
Investment	10^6 $	602.6	129.5	47.4	48.5	140.8
I.R.R.	%	17.3	15.0	15.0	15.0	18.2
Break Down of Unit Production Cost @ 1980	Variable Cost		19.2	-9.55	308	295
	Fixed Cost		130	258	154	347
	Distri. & Admini.		5.79	9.76	15.7	40.5
	Total Production Cost		155	258	479	682
Average Sales Price $/t			193	325	523	833

		H D P E	P V C	E G	P P
Plant Capacity	MTA	33,300	66,700	66,700	46,000
Investment	10^6 $	47.7	50.9	69.7	68.1
I.R.R.	%	17.4	6.8	24.6	22.5
Break Down of Unit Production Cost @ 1980	Variable Cost	300	565	177	276
	Fixed Cost	336	185	209	328
	Distri. & Admini.	38.5	39.3	18.1	40.3
	Total Production Cost	675	789	404	643
Average Sales Price $/t		764	794	553	827

Table II-38(2) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Capacity - 350,000 MTA

Purpose of Study: Capacity Change

Cal Number : @ R-5
Case Number : No. 3
Ethylene Production Capacity: 350,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity		MTA		350,000	72,400	122,000	141,000
Investment		10^6 $	882.9	193.5	69.0	70.6	205.1
I.R.R.		%	23.4	15.0	15.0	15.0	27.0
Break Down of Unit Production Cost @ 1980	Variable Cost			24.7	28.5	277	268
	Fixed Cost			105	198	119	274
	Distri. & Admini.			5.02	8.76	13.4	39.3
	Total Production Cost			135	236	408	581
Average Sales Price $/t				167	292	446	793

			H D P E	P V C	E G	P P
Plant Capacity		MTA	59,000	118,000	118,000	81,500
Investment		10^6 $/t	69.6	74.6	101.2	99.3
I.R.R.		%	24.4	25.9	29.8	32.5
Break Down of Unit Production Cost @ 1980	Variable Cost		273	484	159	252
	Fixed Cost		256	140	164	253
	Distri. & Admini.		37.0	37.5	16.2	39.0
	Total Production Cost		567	661	339	544
Average Sales Price $/t			717	732	490	784

Table II-38(3) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Capacity - 450,000 MTA

Purpose of Study: Capacity Change

Cal Number : @ R-4
Case Number : No. 3
Ethylene Production Capacity: 450,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		447,000	92,400	156,000	180,000
Investment	10^6 $	990.2	229.9	81.1	82.9	240.9
I.R.R.	%	25.5	15.0	15.0	15.0	29.9
Break Down of Unit Production Cost @ 1980	Variable Cost		26.7	41.6	265	258
	Fixed Cost		96.2	178	106	249
	Distri. & Admini.		4.74	8.41	12.6	38.5
	Total Production Cost		128	228	384	545
Average Sales Price $/t			158	280	419	766

		H D P E	P V C	E G	P P
Plant Capacity	MTA	75,000	150,000	150,000	104,000
Investment	10^6 $	81.9	87.9	118.8	66.8
I.R.R.	%	27.5	31.2	31.6	36.4
Break Down of Unit Production Cost @ 1980	Variable Cost	264	456	152	244
	Fixed Cost	230	125	149	227
	Distri. & Admini.	36.6	36.7	15.6	38.7
	Total Production Cost	530	617	316	510
Average Sales Price $/t		704	707	470	771

Table II-38(4) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Capacity - 600,000 MTA

Purpose of Study: Capacity Change

Cal Number : @ R-5
Case Number : No. 3
Ethylene Production Capacity: 600,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity		MTA		596,000	123,000	208,000	240,000
Investment		10^6 $	1,263.5	282.0	98.1	100.4	291.5
I.R.R.		%	28.0	15.0	15.0	15.0	33.0
Break Down of Unit Production Cost @ 1980	Variable Cost			28.7	55.3	254	248
	Fixed Cost			86.9	157	93.8	222
	Distri. & Admini.			4.45	8.05	11.7	38.8
	Total Production Cost			120	221	359	508
Average Sales Price $/t				148	268	391	743

			H D P E	P V C	E G	P P
Plant Capacity		MTA	100,000	200,000	200,000	138,000
Investment		10^6 $	99.2	106.9	143.8	141.6
I.R.R.		%	31.7	36.5	34.3	41.0
Break Down of Unit Production Cost @ 1980	Variable Cost		253	427	145	235
	Fixed Cost		202	109	132	201
	Distri. & Admini.		36.3	36.1	15.1	38.3
	Total Production Cost		492	573	293	474
Average Sales Price $/t			691	685	453	760

Table II-38(5) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material 10% up

Purpose of Study: Cost Change of Hydrocarbon and Raw Material, 10% up
Cal Number : @ R-1
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	62,000	104,000	120,000
Investment	10^6 $	792.3	172.9	61.9	63.4	184.4
I.R.R.	%	21.4	15.0	15.0	15.0	24.1
Break Down of Unit Production Cost @ 1980	Variable Cost		31.1	18.7	288.8	283.8
	Fixed Cost		111.8	213.4	127.8	293.1
	Distri. & Admini.		5.5	9.0	14.1	39.9
	Total Production Cost		148.3	241.2	430.6	616.8
Average Sales Price $/t			183	300	470	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,000
Investment	10^6 $	62.5	67.0	91.0	89.2
I.R.R.	%	21.6	21.0	28.1	29.1
Break Down of Unit Production Cost @ 1980	Variable Cost	289.4	509.4	169.8	266.1
	Fixed Cost	276.7	151.2	175.7	271.9
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	603.4	698.9	362.2	577.3
Average Sales Price $/t		728	752	505	794

Table II-38(6) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material 10% down

Purpose of Study: Cost Change of Hydrocarbon and Raw Material, 10% down
Cal Number : @ R-2
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	62,000	104,000	120,000
Investment	10^6 $	792	172.1	63.0	63.3	184.2
I.R.R.	%	22.1	15.0	15.0	15.0	25.4
Break Down of Unit Production Cost @ 1980	Variable Cost		15.5	18.7	280.8	266.0
	Fixed Cost		111.4	213.4	127.6	293
	Distri. & Admini.		5.0	9.0	13.8	39.9
	Total Production Cost		131.9	241.2	422.2	598.9
Average Sales Price $/t			165	300	461	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,000
Investment	10^6 $	62.5	66.9	90.9	89.1
I.R.R.	%	23.2	22.4	29.6	30.5
Break Down of Unit Production Cost @ 1980	Variable Cost	271.4	500.6	157.5	250.0
	Fixed Cost	276.5	151.2	175.6	271.7
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	585.3	689.8	349.8	561.6
Average Sales Price $/t		728	752	505	794

Table II-38(7) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Product Price 10% up

Purpose of Study: Change of Exfactory Price 10% up

Cal Number : @ R-8
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	793.8	172.5	62.0	63.4	185.0
I.R.R.	%	26.1	15.0	15.0	15.0	30.2
Break Down of Unit Production Cost @ 1980	Variable Cost		23.3	18.7	284.8	274.9
	Fixed Cost		111.6	213.4	127.7	293.9
	Distri. & Admini.		5.2	9.0	14.0	42.4
	Total Production Cost		140.1	241.2	426.4	611.1
Average Sales Price $/t			174	301	466	895

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.7	67.4	91.3	89.5
I.R.R.	%	28.4	33.0	34.4	35.9
Break Down of Unit Production Cost @ 1980	Variable Cost	280.4	505.1	163.7	258.3
	Fixed Cost	277.3	152	176.1	272.6
	Distri. & Admini.	39.5	40.4	18.2	41.7
	Total Production Cost	597.3	697	358.0	572.6
Average Sales Price $/t		801	828	556	873.8

Table II-38(8) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Product Price 10% down

Purpose of Study: Change of Exfactory Price 10% down

Cal Number : @ R-9
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	789.4	172.5	62.0	63.4	183.6
I.R.R.	%	17.5	15.0	15.0	15.0	19.0
Break Down of Unit Production Cost @ 1980	Variable Cost		23.3	18.7	284.8	274.9
	Fixed Cost		111.6	213.4	127.7	292.2
	Distri. & Admini.		5.2	9.0	14.0	37.5
	Total Production Cost		140.1	241.2	426.4	604.6
Average Sales Price $/t			174	301	466	733

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.2	66.4	90.6	88.7
I.R.R.	%	16.1	9.0	23.1	23.4
Break Down of Unit Production Cost @ 1980	Variable Cost	280.4	505.1	163.7	258.3
	Fixed Cost	275.9	150.5	175.1	271.0
	Distri. & Admini.	35.2	35.8	15.1	37.0
	Total Production Cost	591.4	691.3	353.9	566.3
Average Sales Price $/t		655	677	455	715

Table II-38(9) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Rate of Operation 70%

Purpose of Study: Change of Stream Factor 70%

Cal Number : @ R-7
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	786	171.6	61.6	63.0	183.1
I.R.R.	%	16.3	15.0	15.0	15.0	16.9
Break Down of Unit Production Cost @ 1980	Variable Cost		17.9	-11.6	312.4	301.2
	Fixed Cost		135.0	258.2	154.4	354.1
	Distri. & Admini.		6.0	9.8	15.9	40.5
	Total Production Cost		158.9	256.5	482.6	695.8
Average Sales Price $/t			199	327	529	833

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.0	65.9	90.4	88.4
I.R.R.	%	15.2	6.1	22.1	21.2
Break Down of Unit Production Cost @ 1980	Variable Cost	306.9	571.3	181.9	281.4
	Fixed Cost	334.3	181.9	212.3	328.3
	Distri. & Admini.	37.8	39.0	17.3	39.8
	Total Production Cost	679.1	792.1	411.5	649.5
Average Sales Price $/t		744	781	528	809.2

Table II-38(10) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Rate of Operation 100%

Purpose of Study: Change of Stream Factor 100%

Cal Number : @ R-6
Case Number : No. 3
Ethylene Production Capacity: 300,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity		MTA		298,000	61,600	104,000	120,000
Investment		10^6 $	797	173.4	62.3	63.8	185.4
I.R.R.		%	26.8	15.0	15.0	15.0	31.6
Break Down of Unit Production Cost @ 1980	Variable Cost			27.0	39.9	265.5	256.5
	Fixed Cost			95.2	182.1	109.0	250.2
	Distri. & Admini.			4.7	8.5	12.6	39.3
	Total Production Cost			127.0	230.5	387.1	546.0
Average Sales Price $/t				156	282	421	793

			H D P E	P V C	E G	P P
Plant Capacity		MTA	50,000	100,000	100,000	69,200
Investment		10^6 $	62.9	67.9	91.5	89.8
I.R.R.		%	29.0	33.6	34.8	37.6
Break Down of Unit Production Cost @ 1980	Variable Cost		261.8	458.7	150.9	242.2
	Fixed Cost		236.2	129.7	149.9	232.2
	Distri. & Admini.		37.0	37.5	16.2	39.0
	Total Production Cost		535.1	625.9	317.1	513.4
Average Sales Price $/t			717	732	490	784

Table II-38(11) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Construction Cost 10% up

Purpose of Study: Change of Construction Cost 10% up

Cal Number : @ R-18
Case Number : No. 3-V-(1)
Ethylene Production Capacity: 298,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	857.7	188.7	61.5	69.1	201.4
I.R.R.	%	18.9	15.0	15.0	15.0	21.2
Break Down of Unit Production Cost @ 1980	Variable Cost		21.1	8.03	295	285
	Fixed Cost		121	228	136	316
	Distri. & Admini.		5.52	9.30	14.7	39.9
	Total Production Cost		147	246	446	642
Average Sales Price $/t			184	310	488	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	68.0	72.6	99.4	97.0
I.R.R.	%	19.1	15.8	25.0	26.1
Break Down of Unit Production Cost @ 1980	Variable Cost	291	259	171	267
	Fixed Cost	294	160	189	290
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	623	727	377	597
Average Sales Price	$/t	728	752	505	794

Table II-38(12) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Construction Cost 10% down

Purpose of Study: Change of Construction Cost 10% Down

Cal Number : @ R-19
Case Number : No. 3-V-(2)
Ethylene Production Capacity: 298,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	719.2	156.2	56.3	57.6	167.2
I.R.R.	%	24.8	15.0	15.0	15.0	28.9
Break Down of Unit Production Cost @ 1980	Variable Cost		25.4	29.4	274.5	264.4
	Fixed Cost		102.7	198.6	118.9	269.7
	Distri. & Admini.		4.9	8.7	13.3	39.9
	Total Production Cost		133.0	236.7	406.8	574.0
Average Sales Price $/t			164	291	443	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	56.9	61.3	82.5	81.2
I.R.R.	%	26.3	28.4	33.3	34.2
Break Down of Unit Production Cost @ 1980	Variable Cost	269.8	481.3	156.4	249.1
	Fixed Cost	258.8	142.4	161.8	253.2
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	566.0	661.8	334.9	541.7
Average Sales Price $/t		728	752	505	794

Table II-38(13) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Time of Construction 1977

Purpose of Study: Change of Year of Start-up, 1977 October
Cal Number : @ R-17
Case Number : No. 3-IVO(2)
Ethylene Production Capacity: 298,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	701.0	152.2	54.8	56.4	162.7
I.R.R.	%	17.1	15.0	15.0	15.0	23.1
Break Down of Unit Production Cost @ 1980	Variable Cost		23.2	17.8	285	275
	Fixed Cost		100	195	117	264
	Distri. & Admini.		5.23	9.04	14.1	39.9
	Total Production Cost		129	222	417	579
Average Sales Price $/t			174	301	469	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	55.5	60.0	80.3	79.1
I.R.R.	%	20.7	16.4	27.2	27.7
Break Down of Unit Production Cost @ 1980	Variable Cost	281	508	164	259
	Fixed Cost	254	140	158	248
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	572	687	339	546
Average Sales Price $/t		728	752	505	794

Table II-38(14) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Time of Construction 1978

Purpose of Study: Change of Year of Start-up, 1978 October
Cal Number : @ R-16
Case Number : No. 3
Ethylene Production Capacity: 298,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	744.7	162.0	58.3	59.8	173.1
I.R.R.	%	18.9	15.0	15.0	15.0	24.0
Break Down of Unit Production Cost @ 1980	Variable Cost		23.3	18.3	285	275
	Fixed Cost		106	204	122	278
	Distri. & Admini.		5.22	9.03	14.0	39.9
	Total Production Cost		134	231	421	593
Average Sales Price $/t			174	301	467	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	58.9	63.3	85.4	83.9
I.R.R.	%	21.6	19.2	28.0	28.8
Break Down of Unit Production Cost @ 1980	Variable Cost	281	507	164	258
	Fixed Cost	265	146	167	260
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	583	690	347	557
Average Sales Price $/t		728	752	505	794

Table II-38(15) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. No Cost Escalation

Purpose of Study: Effect of Inflation 0%/year

Cal Number : @ R-13
Case Number : No. 3-3-(1)
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	793.7	173.1	62.2	63.9	184.5
I.R.R.	%	16.8	15.0	15:0	15.0	18.1
Break Down of Unit Production Cost @ 1980	Variable Cost		18.8	-4.55	307	297
	Fixed Cost		112	214	128	293
	Distri. & Admini.		5.85	9.63	15.5	39.9
	Total Production Cost		137	219	451	630
Average Sales Price $/t			195	321	517	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.5	67.3	91.0	89.2
I.R.R.	%	15.4	7.5	21.8	23.0
Break Down of Unit Production Cost @ 1980	Variable Cost	302	559	179	277
	Fixed Cost	277	152	176	272
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	617	749	371	589
Average Sales Price $/t		728	752	505	794

Table II-38(16) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. 3.5% Escalation

Purpose of Study: Effect of Inflation, 3.5%/year

Cal Number : @ R-14
Case Number : No. 3-3-(2)
Ethylene Production Capacity: 298,000 MTA

			Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA			298,000	61,600	104,000	120,000
Investment	10^6 $		742.6	172.7	62.1	63.6	184.4
I.R.R.	%		19.3	15.0	15.0	15.0	21.4
Break Down of Unit Production Cost @ 1980	Variable Cost			21.1	7.39	295	286
	Fixed Cost			111	214	128	293
	Distri. & Admini.			5.53	9.31	14.7	39.9
	Total Production Cost			138	230	438	619
Average Sales Price	$/t			184	310	491	814

		H D P E	P V C	E G	P P.
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.5	17.1	91.0	89.2
I.R.R.	%	18.9	14.7	25.3	26.4
Break Down of Unit Production Cost @ 1980	Variable Cost	291	531	171	268
	Fixed Cost	277	151	176	272
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	605	720	363	579
Average Sales Price $/t		728	752	505	794

Table II-38(17) Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. 10% Escalation

Purpose of Study: Effect of Inflation 10%/year

Cal Number : @ R-15
Case Number : No. 3-3-(3)
Ethylene Production Capacity: 300,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		298,000	61,600	104,000	120,000
Investment	10^6 $	790.8	172.3	61.9	63.2	184.2
I.R.R.	%	24.0	15.0	15.0	15.0	27.6
Break Down of Unit Production Cost @ 1980	Variable Cost		25.0	27.9	276	266
	Fixed Cost		112	213	127	293
	Distri. & Admini.		4.97	8.77	13.4	39.9
	Total Production Cost		142	250	417	599
Average Sales Price $/t			166	292	445	814

		H D P E	P V C	E G	P P
Plant Capacity	MTA	50,000	100,000	100,000	69,200
Investment	10^6 $	62.4	66.8	90.9	89.1
I.R.R.	%	25.4	27.5	31.8	32.7
Break Down of Unit Production Cost @ 1980	Variable Cost	272	484	158	251
	Fixed Cost	277	151	176	272
	Distri. & Admini.	37.4	38.1	16.7	39.4
	Total Production Cost	586	673	350	562
Average Sales Price $/t		728	752	505	794

producing plant. In this writing, the prices of the intermediate raw materials were estimated so that the internal rate of return of a plant which produces such intermediate raw materials will constantly be on a level of 15%. Therefore, the profitability of olefin derivative plants, e.g., the LDPE plant, is brought about increase in the raw material light condensate price will take place as a result of the olefin price increment caused by the raw material condensate cost change. Also, the change in capacity or stream factor of the intermediate raw material plant was assumed to vary in proportion to the change in that of the derivative plants. In other words, if the capacity of a derivative plant becomes doubled, it should be reasonably considered that the capacity of the intermediate raw material plant which undertakes the raw material supply will become approximately doubled accordingly. Also, if any change should take place in the stream factor of a derivative plant, it is considered that the raw material plant will also change accordingly. Therefore, the variation in the internal rate of return of each one of the process plants incorporates both the change in the economic conditions of the plant itself caused by the variable factors and the variation in the economical conditions of the plants which supply the intermediate raw materials to the process plant. The same assumption was made concerning the construction cost. Therefore, it is evident that the internal rate of return of the olefin plant, electrysis plant, vinyl-chloride monomer plant will constantly be on a 15% level. Regarding the other plants, the extent of the effects of variable factors to the internal rate of return is considered to be on the same level as the effects caused to the whole complex and, extremely, analogous results were obtained in all of the exfactory price, stream factor, change in the construction cost, the capacity and raw material cost. The obtained results are illustrated in Figures II-12 (1) through (6).

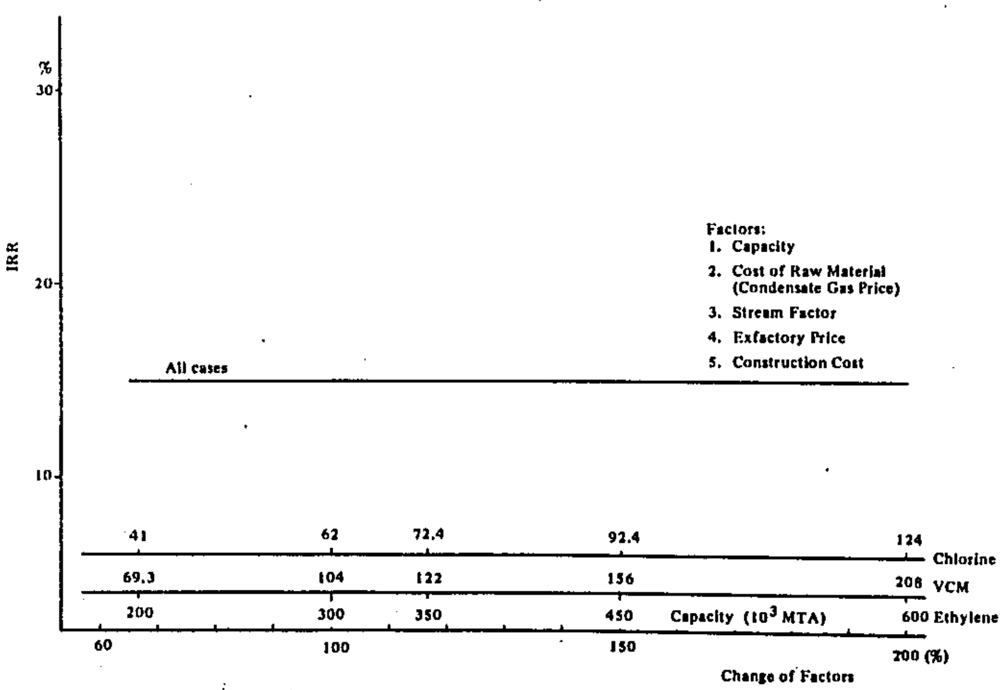


Figure II-12(1) Sensitivity of Internal Rate of Return of Ethylene, Electrolysis and VCM to Various Factor Changes

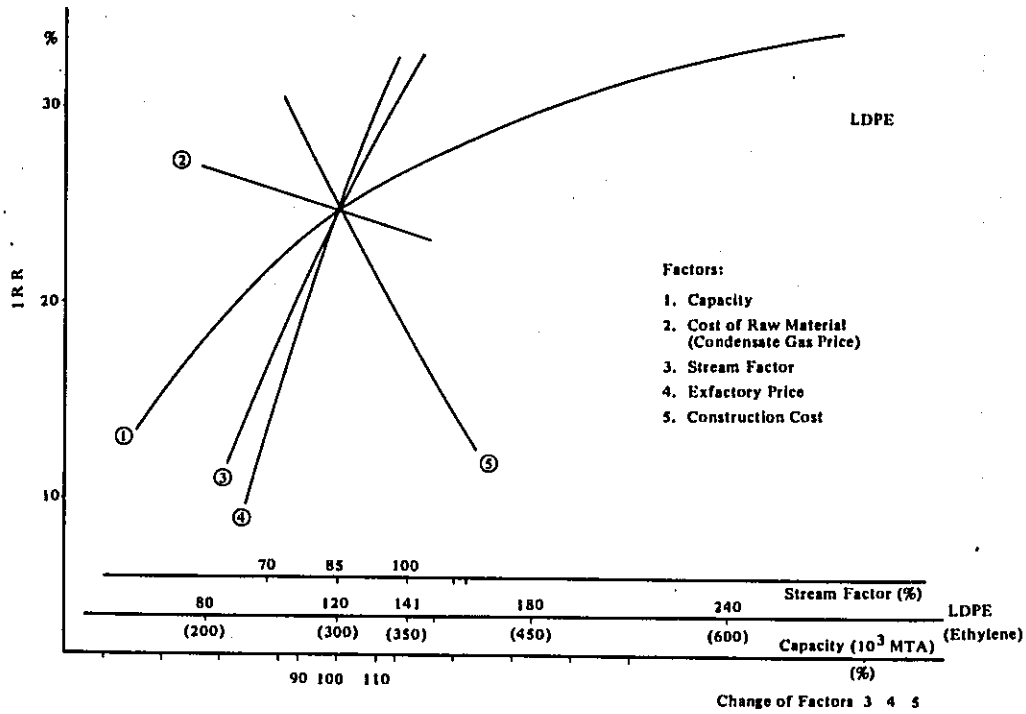


Figure II-12(2) Sensitivity of Internal Rate of Return of LDPE to Various Factor Changes

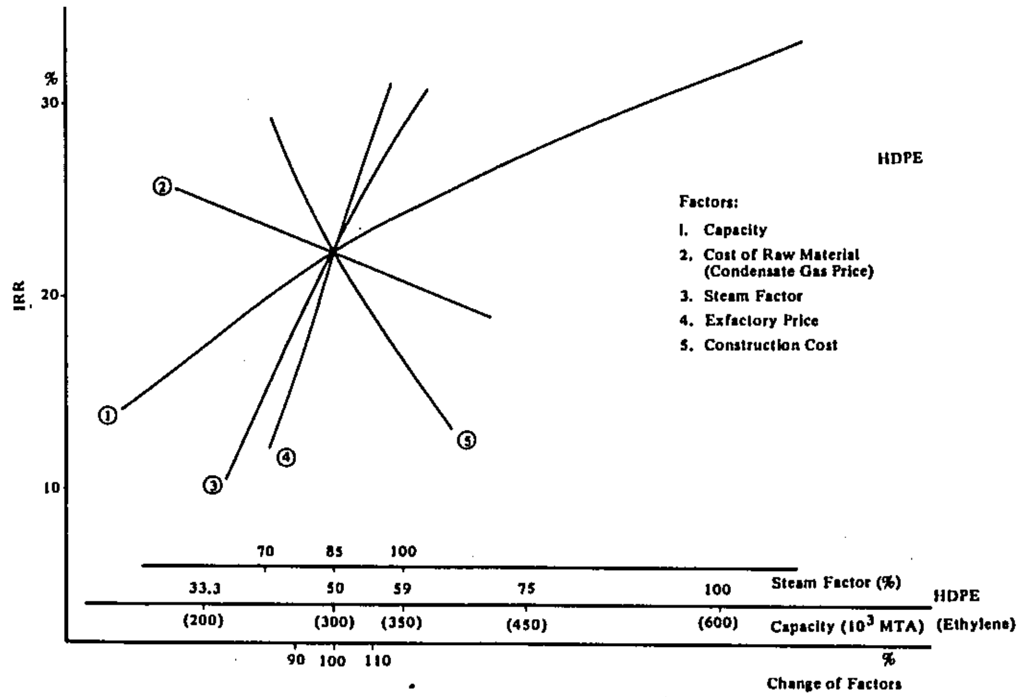


Figure II-12(3) Sensitivity of Internal Rate of Return of HDPE to Various Factor Changes

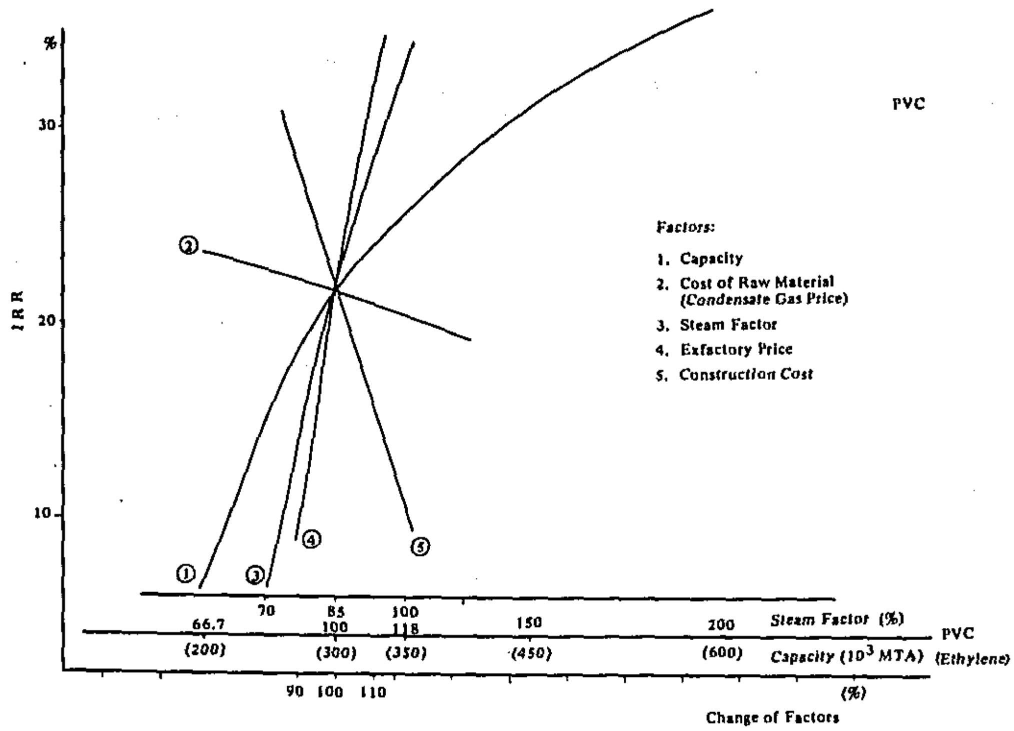


Figure II-12(4) Sensitivity of Internal Rate of Return of PVC to Various Factor Changes

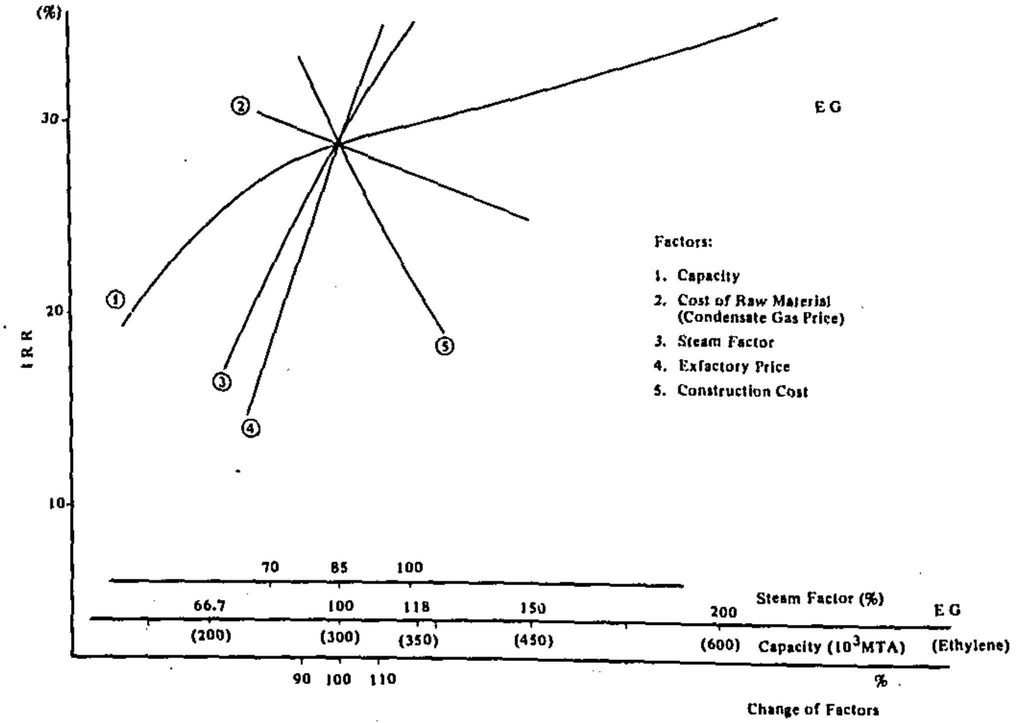


Figure II-12(5) Sensitivity of Internal Rate of Return of EG to Various Factor Changes

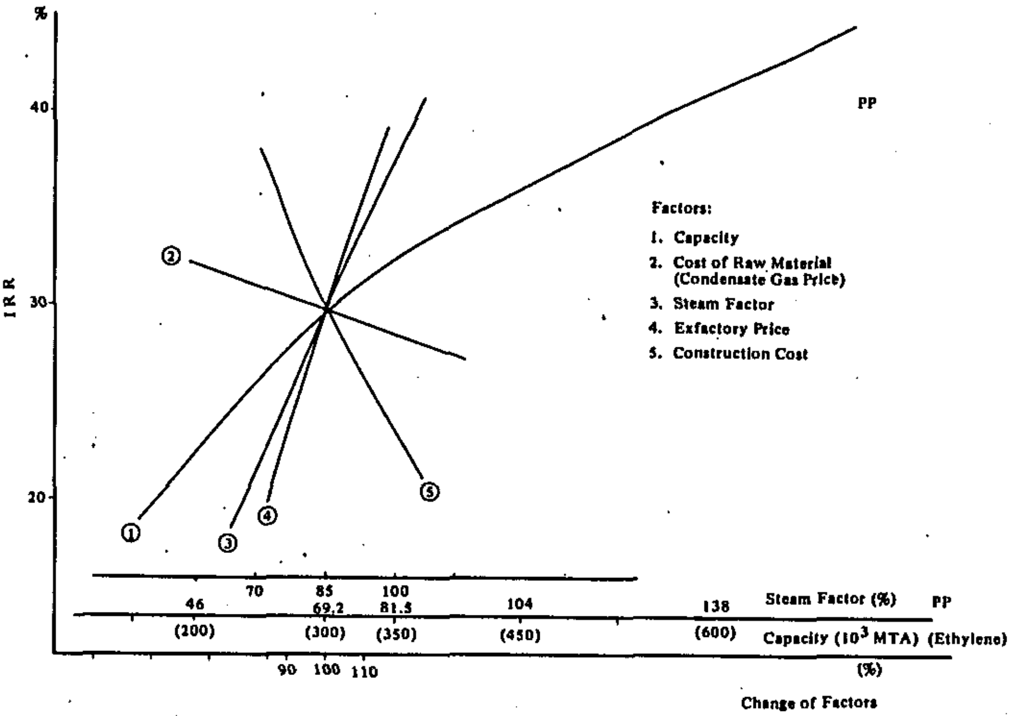


Figure II-12(6) Sensitivity of Internal Rate of Return of PP to Various Factor Changes

(2) Effects on production cost and exfactory prices

studies were made in the same manner as in the above 1), regarding such factors as capacity, stream factor, raw material light condensate price and construction cost by also taking into consideration the effects of the intermediate raw material plant. Also, at the same time, concerning some of the important factors in each plant, studies were made regarding the effects of the factors to the price and production cost by individual. The obtained results are shown in Figures II-13 (1) through (8).

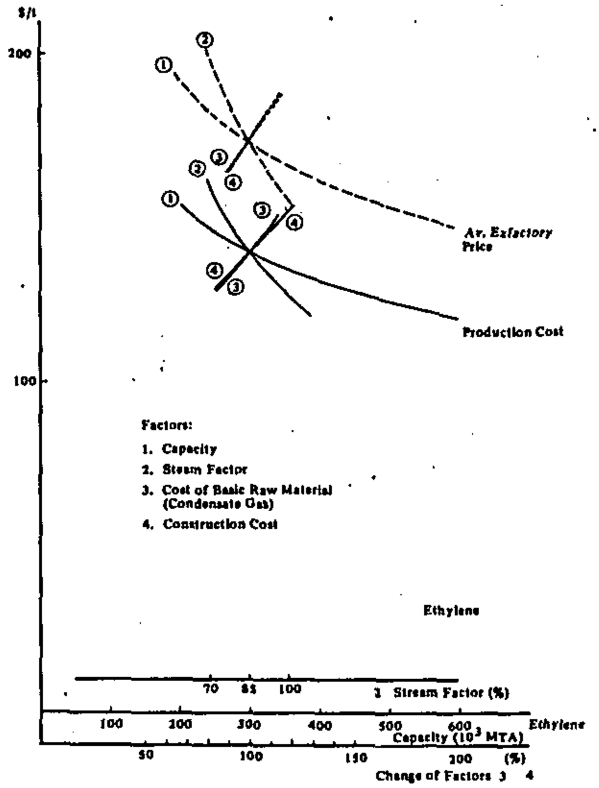
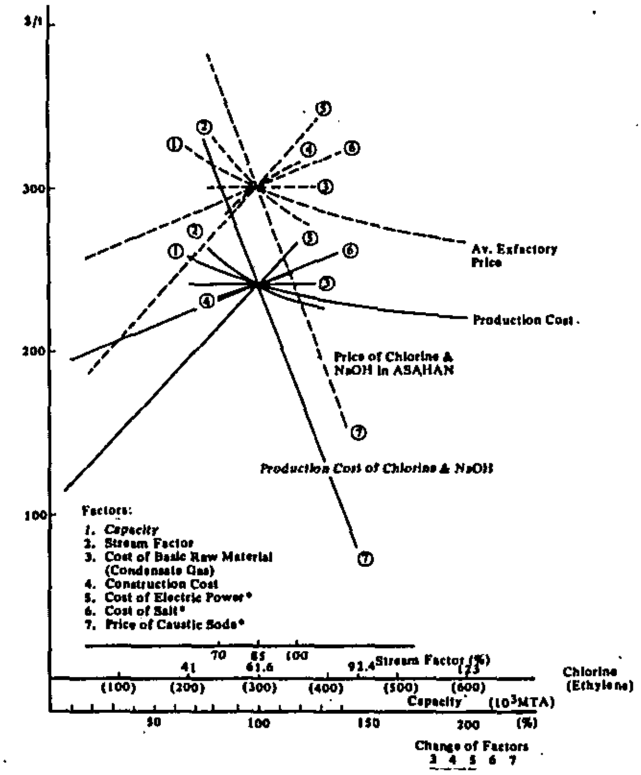


Figure II-13(1) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Changes - *Ethylene*



Note: Price of electric power 4.91 ¢/KWH
Price of Salt 28.4 $/t
Price of NaOH is calculated equal to chlorine.
Production Ratio of NaOH to chlorine is 1.136.

Figure II-13(2) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Changes - Chlorine, NaOH

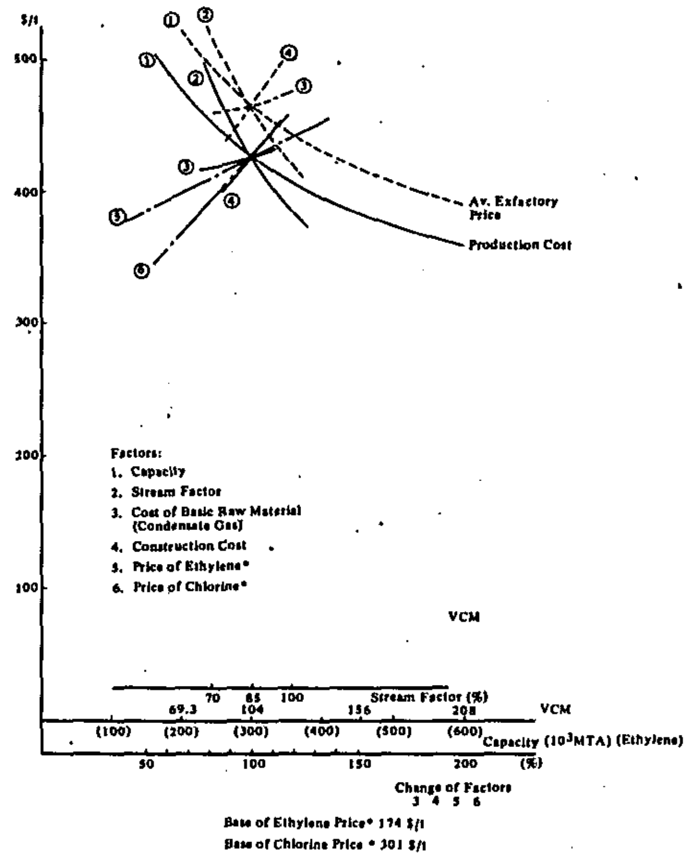


Figure II-13(3) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change - VCM

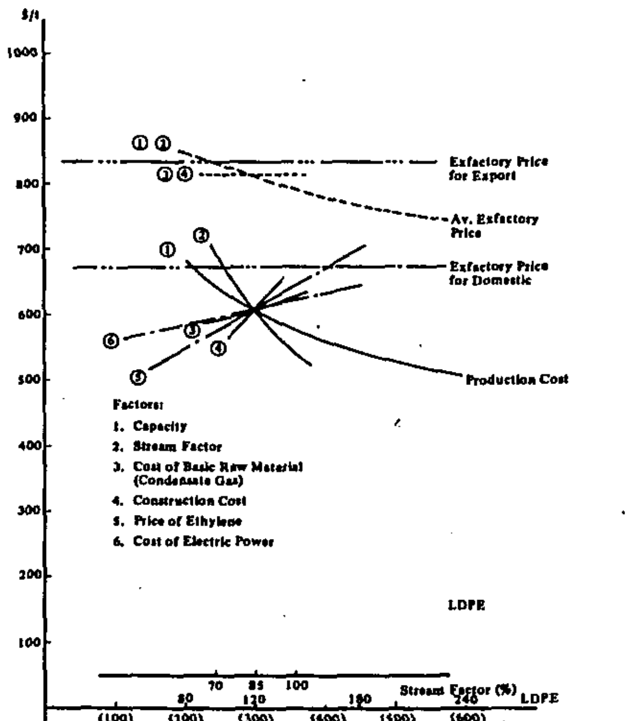


Figure II-13(4) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change - LDPE

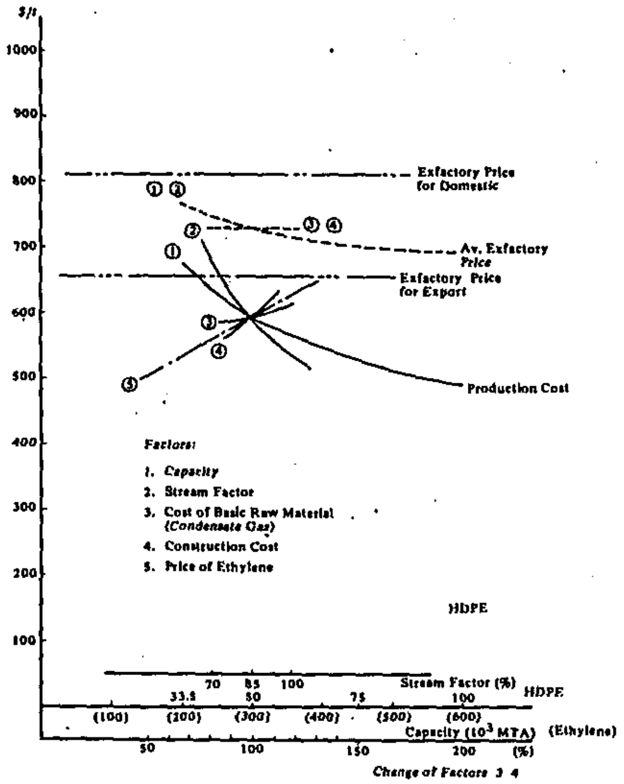


Figure II-13(5) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change -HDPE

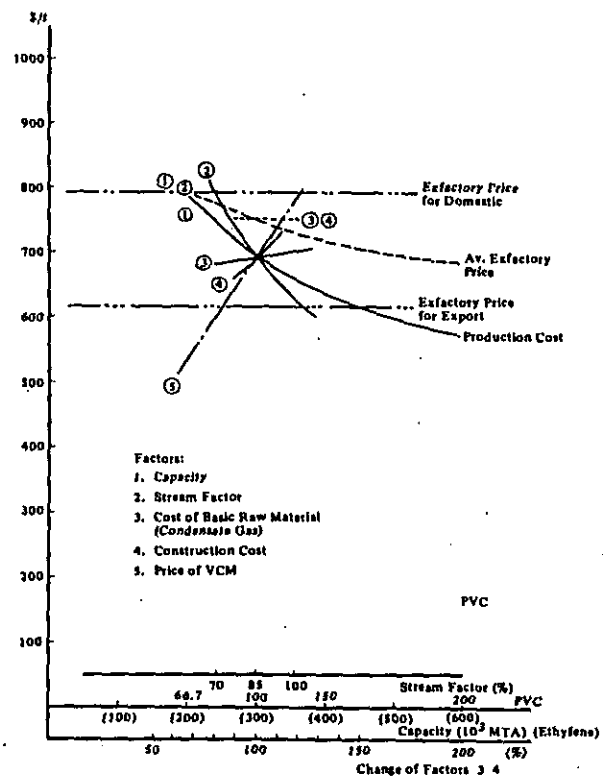


Figure II-13(6) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change - PVC

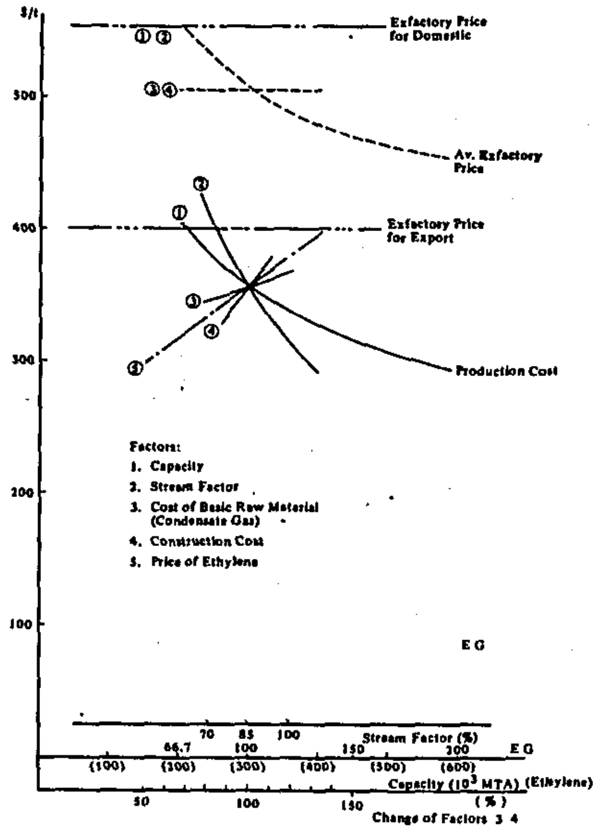


Figure II-13(7) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change - EG

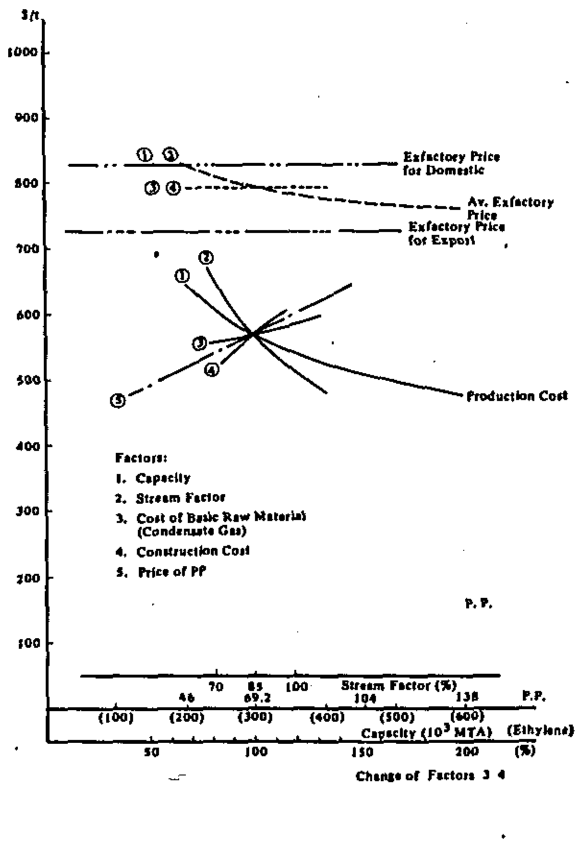


Figure II-13(8) Sensitivity of Production Cost & Average Exfactory Price to Various Factor Change - PP

Chapter 4. Economic Viability Analysis Regarding the Representative Case

In Chapter 3, comperative studies were made to each one of the established cases. In this chapter, Case-3 shall be taken up as the representative case and calculations shall be made concerning this case in accordance with the conditions and method established in Part II, Chapter 4 and Chapter 5 respectively regarding the financial analysis, foreign exchange balance and national benefit by employing the shadow pricing covering the whole complex. Further, concerning the financial analysis, the flactuation in the internal rate of return was studied in accordance with the flactuations made in the product prices, raw material prices, etc.

4-1 Financial Analysis and Economic Analysis

For evaluating the economic viability, the data for the calender year 1980 was modified as follows to establish the data for the business year 1980 in accordance with the calculation fomulas described in 4-3, Part II. Regarding the price level for business year 1981 onwards, the 7% per year escalation factor was multiplied to obtain the figures.

4-1-1 Demand, production and sales amount

Illustration regarding these points is made in Table II-39

4-1-2 Product prices and raw material prices (for business year 1980)

For domestic market (exfactory price)	($/t)
PVC	781
LDPE	819
HDPE	797
EG	524
PP	813

Export Price (exfactory price)	($/t)
PVC	607
LDPE	661
HDPE	644
EG	393
PP	713

Raw material gas price ($/t)	42.5
Salt price ($/t)	28.6
Fuel gas price ($/$10^6$ Kcal)	3.7

Table II-39 Amount of Demand, Export and Production

(Unit: t/y)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PVC	Production 85,000 t/y										
	Domestic	62,250	74,750	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
	Export	22,750	10,250	0	0	0	0	0	0	0	0
LDPE	Production 102,000 t/y										
	Domestic	86,250	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000
	Export	15,750	0	0	0	0	0	0	0	0	0
HDPE	Production 42,500 t/y										
	Domestic	19,500	21,500	23,500	25,500	27,500	29,500	32,025	34,875	38,075	41,450
	Export	23,000	21,000	19,000	17,000	15,000	13,000	10,475	7,625	4,425	1,050
EG	Production 85,000 t/y										
	Domestic	31,425	36,250	41,850	48,175	55,725	64,450	74,425	85,000	85,000	85,000
	Export	53,575	48,750	43,150	36,825	29,275	20,550	10,575	0	0	0
PP	Production 59,500										
	Domestic	36,625	48,625	59,500	59,500	59,500	59,500	59,500	59,500	59,500	59,500
	Export	22,875	10,875	0	0	0	0	0	0	0	0

4-1-3 By-product deduction price (for business year 1980)

(Unit: $/t)

Hydrogen	106
Methane	44.2
LPG and C_4 fraction	133
Aromatic gasoline	120
Fuel	107
Caustic soda	141

4-1-4 Financial analysis

Table II-40 through II-42 show the yearly profit/loss balance and Table II-43 shows the calculation of the internal rate of return. It is revealed that IRR=20.86%.

4-1-5 Yearly balance of foreign exchange

Table II-44 shows the calculation results of the foreign exchange balance obtained by selecting the foreign currency position alone from the yearly balance obtained through financial analysis, the foreign currency portion selection having been conducted in accordance with the method described in Part II, 5-2. Regarding the olefin, there is no item to be adjusted in view of the yearly foreign exchange balance concerning the various data described in 4-1-1 through 4-1-3.

4-1-6 National benefit assessed by employing the shadow pricing method

The results of national benefit calculations conducted in accordance with the method described in Part II, 5-3 are shown in Tables II-45 and II-46. It is revealed that IRR=27.9%. The results of conversion of the initial investment total amount employed in this chapter are as follows:

(Unit: 10^3 US$)

	(1) Foreign currency Portion	(2) Shadow Price	(3) Local Currency Portion	(4) Total on Shadow Price
Investment Cost	(565,420)	706,780	221,310	928,090
Pre-operation Cost	(24,100)	30,120	6,150	36,270
Inrerest During Constraction	(69,000)	86,250	25,300	111,550
Working Capital	-	-	24,870	24,870
Total Investment Cost	(658,520)	823,150	277,630	1,100,780

Notes: (2) = (1) x 1.25

(4) = (2) + (3)

Table II-40 Sales Amount of Olefin Complex (Case-3)

(Unit: 10^3 US$)

Fiscal year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
I. Sales										
(1) Export										
PVC	13,809	6,652	0	0	0	0	0	0	0	0
LDPE	10,411	0	0	0	0	0	0	0	0	0
HDPE	14,812	20,769	14,003	13,413	12,660	11,739	10,119	7,884	4,894	1,242
EG	21,055	20,524	19,417	17,713	15,077	11,323	6,239	0	0	0
PP	16,310	8,298	0	0	0	0	0	0	0	0
	76,397	56,243	33,420	31,126	27,737	23,062	16,358	7,884	4,894	1,242
(2) Domestic										
PVC	48,617	62,491	75,990	81,345	87,040	93,075	99,620	106,590	114,070	122,060
LDPE	70,639	89,352	95,676	102,306	109,548	117,198	125,358	134,130	143,514	153,612
HDPE	15,541	18,339	21,432	24,888	28,737	32,981	38,302	44,640	52,125	60,724
EG	16,467	20,336	25,110	30,928	38,283	47,371	58,498	71,485	76,500	81,855
PP	29,776	42,304	55,394	59,262	63,427	67,830	72,590	77,707	83,121	88,952
	181,040	232,822	273,603	298,729	327,035	358,454	394,368	434,552	469,330	507,204
(3) Sales Total	257,437	289,065	307,023	329,855	354,772	381,516	410,726	442,436	474,224	508,446

Table II-41 Production Cost of Olefin Complex (Case-3)

(Unit: 10^3 US$)

Fiscal Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
II. Production Cost										
(1) Variable Costs										
Raw Material & Fuel										
Light condensate	23,864	25,548	27,289	29,254	31,276	33,465	35,824	38,294	40,989	43,853
Salt	2,635	2,819	3,022	3,234	3,455	3,695	3,962	4,238	4,533	4,847
Fuel gas	14,465	15,476	16,558	17,719	18,958	20,283	21,703	23,224	24,851	26,588
	40,964	43,843	46,869	50,207	53,686	57,443	61,489	65,756	70,373	75,288
Packing *expenses*	5,867	6,278	6,717	7,188	7,691	8,229	8,805	9,421	10,081	10,787
Catalyst & Chemicals	6,888	7,370	7,886	8,438	9,029	9,661	10,337	11,061	11,835	12,664
By-products Deduction										
Hydrogen	-2,966	-3,190	-3,414	-3,638	-3,890	-4,170	-4,449	-4,785	-5,121	-5,457
Methane	-3,888	-4,160	-4,451	-4,759	-5,093	-5,445	-5,832	-6,237	-6,677	-7,143
LPG	-4,073	-4,348	-4,655	-4,992	-5,329	-5,696	-6,094	-6,523	-6,983	-7,473
C4's	-7,263	-7,755	-8,301	-8,902	-9,503	-10,158	-10,868	-11,633	-12,452	-13,326
Aromatic *Gasoline*	-4,335	-4,624	-4,949	-5,310	-5,671	-6,069	-6,502	-6,972	-7,442	-7,984
Fuel	- 591	- 635	- 679	- 723	- 779	- 828	- 889	- 950	-1,017	-1,088
Caustic	-8,484	-9,086	-9,688	-10,350	-11,072	-11,854	-12,697	-13,600	-14,563	-15,586
	-31,606	-33,805	-36,143	-38,680	-41,342	-44,227	-47,339	-50,706	-54,260	-58,063
Total Variable Cost	22,112	23,686	25,329	27,153	29,065	31,106	33,291	35,532	38,029	40,675
(2) Fixed Costs										
Labour & plant overhead	4,977	5,325	5,698	6,097	6,524	6,981	7,469	7,992	8,551	9,150
Maintenance	16,135	17,264	18,473	19,766	21,150	22,630	24,214	24,214	27,723	29,664
Depreciation	73,964	73,964	73,964	73,964	73,964	73,964	73,964	73,964	73,964	73,964
Tax & *Insurance on* fixed Assets	9,113	8,373	7,634	6,894	6,154	5,415	4,675	3,935	3,196	2,456
Foreign Supervisor	13,279	6,816	4,859	5,199	5,563	5,952	6,369	6,815	7,292	7,802
Administration	7,723	8,672	9,211	9,896	10,643	11,445	12,322	13,273	14,227	15,253
Interest on fixed capital	48,957	48,957	48,957	48,957	41,963	34,969	27,975	20,982	13,988	6,994
Interest on working capital	2,984	1,990	995	0	0	0	0	0	0	0
Total Fixed Costs	177,131	171,361	169,790	170,773	165,961	161,355	156,988	152,870	148,940	145,283
(3) Total Production Cost	199,243	195,047	195,119	197,926	195,026	192,461	190,279	188,402	186,969	185,958

Table II-42 Financial Balance of Olefin Complex (Case-3)

(Unit: 10^3 US$)

Fiscal Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
III. Financial Balance										
(1) Profit & Loss										
Sales	257,437	289,065	307,023	329,855	354,772	381,516	410,726	442,436	474,224	508,446
Production cost	99,243	195,047	195,119	197,926	195,026	192,461	190,279	188,402	186,969	185,958
Profit before Tax	58,193	94,018	111,904	131,930	159,745	189,055	220,447	254,035	287,255	322,488
Corporate Income Tax	- Tax exemption period -					85,075	99,201	114,316	129,265	145,119
Net Profit after Tax	58,193	94,018	111,904	131,930	159,745	103,980	121,246	139,719	157,990	177,368
Accumulation	58,193	152,211	264,115	396,045	555,790	659,770	781016	920,736	1,078,725	1,256,093
(2) Capital Payback										
Capital payback *2)	132,157	167,982	185,868	205,894	233,709	177,944	195,210	213,683	231,954	251,332
Capital Unrecovered *1)	957,400	825,243	657,261	471,393	265,499	31,790	-146,154	-341,364	-555,047	-787,001
(3) Repayment of Loan										
Repayment of loans for fixed assets	- Grace period -			93,251	93,251	93,251	93,251	93,251	93,251	93,251
Repayment of loans for working capital	8,290	8,290	8,290	0	0	0	0	0	0	0
	8,290	8,290	8,290	93,251	93,251	93,251	93,251	93,251	93,251	93,251
Outstanding Balance of loans for Fixed assets	652,760	652,760	652,760	652,760	559,509	466,257	373,006	279,755	186,503	93,251
Outstanding Balance of loans for Working Capital	24,870	16,580	8,290	0	0	0	0	0	0	0
	677,530	669,340	661,050	652,760	559,509	466,257	373,006	279,755	186,503	93,251

Notes : *1) Initial Investment (957,400) = Fixed Capital (652,760) + Working Capital (24,870), minus sign indicates accumulation of capital

*2) Net profit after Tax + Depreciation

Table II-43 Financial Analysis Based on DCF Method

(Unit: 10^3 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	INTEREST	DEPRECIATION	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
		*1										
0	1979	932537.	24870.	0.	0.	0.	0.	0.	0.	1.0000	0.	957400.
1	1980	0.	0.	58193.	0.	58193.	51941.	73964.	184098.	0.8274	152319.	0.
2	1981	0.	0.	94018.	0.	94018.	50947.	73964.	218928.	0.6846	149869.	0.
3	1982	0.	0.	111904.	0.	111904.	49952.	73964.	235819.	0.5664	133566.	0.
4	1983	0.	0.	131930.	0.	131930.	48957.	73964.	254851.	0.4686	119428.	0.
5	1984	0.	0.	159745.	0.	159745.	41963.	73964.	275672.	0.3877	106886.	0.
6	1985	0.	0.	189055.	85075.	103980.	34969.	73964.	212913.	0.3208	68302.	0.
7	1986	0.	0.	220447.	99201.	121246.	27975.	73964.	223185.	0.2654	59238.	0.
8	1987	0.	0.	254035.	114316.	139719.	20982.	73964.	234664.	0.2196	51534.	0.
9	1988	0.	0.	287255.	129265.	157990.	13988.	73964.	245942.	0.1817	44687.	0.
10	1989	-192894.	-24870.	322488.	145119.	177368.	6994.	73964.	258326.	0.1503	38835.	-32737.
		*2	*3				*4			*5		
	TOT	739637.	0.	1829067.	572975.	1256093.	348668.	739636.	2344395.	0.3944	924664.	924663.

REMARKS,

*1) INVESTMENT

PLANT	366810
OTHER ASSETS	139750
BUILDING	109290
HOUSING	78300
UTILITIES	92580
LAND	21250
INTRST. DRG CONSTR.	94300
PRE-OPERATING EXPENSE	30250
CAPITAL TOTAL	932530

*2) SALVAGE VALUE + LAND 192893

*3) WORKING CAPITAL CASE 1

WHERE, CASE 1 (WORKING CAPITAL AS INVESTMENT)

CASE 2 (WORKING CAPITAL BEING IGNORED)

*4) IN CASE-2, EXCLUDE W.CAPITAL INTEREST

*5) CALCULATED DCF RATE 0.2086

YEARS OF PAYOUT (NOMINAL) 5.23

YEARS OF PAYOUT (DISCOUNT) 6.17 (INTEREST RATE GIVEN =0.0750)

Internal rate of return: 20.86 %

Table II-44 Foreign Currency Balance of Olefin Complex

(Unit: 10^3 US$)

Fiscal Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
I. Inflow of Foreign Currency										
(1) Acquisition of Foreign Currency by Export	76,397	56,243	33,420	31,126	27,737	23,062	16,358	7,884	4,894	1,242
(2) Saving of Foreign Currency by Substitution of Import	181,040	232,822	273,603	298,729	327,035	358,454	394,368	434,552	469,330	507,204
(3) Indirect Effect of Foreign Currency Saving	31,606	33,805	36,143	38,680	41,342	44,227	47,339	50,706	54,260	58,063
	289,043	322,870	343,166	368,535	396,114	425,743	458,065	493,142	528,484	566,509
II. Outflow of Foreign Currency										
(1) Opportunity loss of Raw & Auxi. Material Export	40,964	43,843	46,869	50,207	53,686	57,443	61,489	65,756	70,373	75,288
(2) Import Material										
Catalyst and Chemicals	6,888	7,370	7,886	8,438	9,029	9,661	10,337	11,061	11,835	12,664
Materials for Maintenance	16,135	17,264	18,473	19,766	21,150	22,630	24,214	25,909	27,723	29,664
(3) Payment of Foreign Currency										
Technical Assistance Fee	13,279	6,816	4,859	5,199	5,563	5,952	6,369	6,815	7,292	7,802
Repayment of Foreign Currency Loans	5,760 *1)	- grace	period -	93,251	93,251	93,251	93,251	93,251	93,251	93,251
Interest on Foreign Currency Loans	48,957	48,957	48,957	48,957	41,963	34,969	27,975	20,982	13,988	6,994
	131,983	124,250	127,044	225,818	224,642	223,906	223,635	223,774	224,462	225,663
III. Blance of Foreign Currency (I - II)	157,060	198,620	216,122	142,717	171,472	201,837	234,430	269,368	304,022	340,846
Accumulation	157,060	355,680	571,802	714,519	885,991	1,087,828	1,322,258	1,591,626	1,895,648	1,236,494

Note: *1) Payment of Foreign Currency Shortage by Own Capital

Table II-45 Olefin Complex, National Benefit on Shadow Price

Table II-45

(Unit: 10^3 US$)

Fiscal year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
I. Sales										
(1) Export	95,496	70,304	41,775	38,908	34,671	28,828	20,448	9,855	6,118	1,553
(2) Domestic	226,300	291,028	342,004	373,411	408,794	448,068	492,960	543,190	586,663	634,005
Total Sales	321,796	361,332	383,779	412,319	443,465	476,896	513,408	553,045	592,721	635,558
II. Production Cost										
(1) Variable costs										
Raw material & fuel	51,205	58,804	58,586	62,759	67,108	71,804	76,861	82,195	87,966	94,110
Packing expense	5,867	6,278	6,717	7,188	7,691	8,229	8,805	9,421	10,081	10,787
Catalyst & chemicals	8,610	9,213	9,858	10,548	11,286	12,076	12,921	13,826	14,794	15,830
By-products	-39,508	-42,256	-45,179	-48,350	-51,678	-55,284	-59,174	-63,383	-67,825	-72,579
(2) Fixed Cost										
Labour & plant overhead	2,240	2,396	2,564	2,744	2,936	3,141	3,361	3,596	3,848	4,118
Maintenance	20,169	21,580	23,091	24,708	26,438	28,288	30,268	32,386	34,654	37,080
Foreign supervisor	16,599	8,520	6,074	6,499	6,954	7,440	7,961	8,519	9,115	9,753
Administration	7,723	8,672	9,211	9,896	10,643	11,445	12,322	13,273	14,227	15,253
Total Production Cost	72,905	69,207	70,942	75,992	81,442	87,139	93,325	99,833	106,860	114,352
III. Benefit	248,891	292,125	312,837	336,327	362,023	389,757	420,083	453,212	485,921	521,206
Accumulation	248,891	541,016	853,853	1,190,180	1,552,203	1,941,960	2,362,043	2,815,255	3,301,176	3,822,382

Table II-46 Calculation of I.R.R. of Olefin Complex (Case-3)

(National Benefit on Shadow Price)

	Investment	+ W. Capital	Net Cash Flow	Discount Rate	Present Value (Cash)	Present Value (Inv)
	1,075,910	24,870		1.0000		1,100,780
1980	0		248,891	0.78186	194,947	0
1981	0		292,125	0.61131	178,928	0
1982	0		312,837	0.47796	149,871	0
1983	0		336,327	0.37370	126,032	0
1984	0		362,023	0.29218	106,123	0
1985	0		389,757	0.22844	89,209	0
1986	0		420,083	0.17861	75,204	0
1987	0		453,212	0.13965	63,464	0
1988	0		485,921	0.10919	53,231	0
1989	-198,898	-24,870	521,206	0.08537	44,668	-19,103
					1,081,677	1,081,677

Internal rate of return 27.9 %

Chapter 5. Data and Information on Olefin Complex

5-1 Organization for Each Case of the Olefin Complex and Labour Requirement

5-1-1 Basic policy on plant organization

The organization to be described in this chapter has been formulated on the basic policy as under-mentioned which has been confirmed at the discussion meetings held in January 1974 with the Directorate General of Chemical Industry, The Departemen Perindustrian and Pertamina.

(1) The olefin plant and the utilities plant are operated under 100% control by Pertamina and the various intermediate raw materials (ethylene, propylene) from the olefin plant and utilities will be supplied to each one of the downstream plants.

(2) Regarding the downstream plants, the operation will be undertaken by means of the joint-venture companies with Pertamina having the majority share.

Regarding the technology to be adopted, it has been decided that the latest and proven techniques shall be introduced and therefore, no installation shall be undertaken within the complex for the "Research & Development Department" necessary for the development and the improvement of technology. Further, the products to be turned out from this complex are assumed to be basically sold entirely to Pertamina and the parent companies of the joint-venture companies so that no "sales division" will be installed in this complex.

On the basis of the above-mentioned basic policy, the charts of organization and the required personnel have been complied for each case as undermentioned.

(a) Case-1.

Indonesian Personnel -	2,127
Expatriate Personnel -	32
Total	2,159

(b) Case-2.

Indonesian Personnel -	2,582
Expatriate Personnel -	32
Total	2,614

(c) Case-3.

Indonesian Personnel -	2,257
Expatriate Personnel -	32
Total	2,289

It must be noted that the above personnel charts have been compiled on the basis of the period approximately two years after the commencement of the commercial operation of the plant when the plant operation attains a stability. As will be mentioned later part of this volume, corporation of further number of expatriate technicians will be necessary during the test operation and for approximately 1.5 years after the commencement of commercial operation. Plant organization of each case is shown in Tables II-47(1) through (3).

5-1-2 The functions and assignments of each department

(1) Divisions to be administered totally by Pertamina.

(a) Production Department

1) Production Division #1 and #2

These divisions will be assigned to undertake the operation of the olefin plant and the utility plants under the instructions given by the Production Cordinate Division. These two production divisions will secure the operators to be manned on a three-shifts four-groups (3 x 4) on the basic requirements of approximately 8,000 operation hours per year. The operator allocation schedule has been compiled on the basis of the above-mentioned prerequisite. Further, it has been assumed that these production divisions will also undertake the production process analyses which are necessary for operation control of the plant and the inspection analysis for the confirmation of the acceptance and rejection of the quality of the products. In other words, the personnel in charge of such analysis activities are also included within the scope of the production division personnel.

Table II-47 (1) Petrochemical Industry Plant Organization and Personnerl-Case-1

		Works Manager	Director	Manager	Superin-tendent	Staff	Foreman	Operator	Labourer	Helper	Total
Pertamina Departments in Charge											
Production Dept.	Production Div. No. 1 (Ethylene)	2	1	1	2	4	14	50	8	10	92
	Production Div. No. 1 (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Production Div. No. 2 (Utilities)			1	3	6	6	36	4	5	61
	Production Coordinate Div.			1	4	8	8	8	8	6	43
	Technical Admi. Div.			1	2	4	4	4	4	4	23
	Sub-Total	2	1	4	11	22	32	98	24	25	219
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
Safety Dept.	Safety Div.		1	1	2	4	6	40	4	6	64
	Environment Div.			1	2	4	6	20	4	4	41
	Sub-Total		1	2	4	8	12	60	8	10	105
Maintenance Dept.	Machinery Div.		1	1	9	18	36	144	16	13	238
	Elect. /Instr. Div.			1	9	18	36	144	16	11	235
	Civil Div.			1	5	8	16	32	16	7	85
	Sub-Total		1	3	23	44	88	320	48	31	558
Administ. Dept.	Gen. Affairs Div.		1	1	2	4	8	24	36	6	82
	Personnel & Employee Relation Div.			1	2	9	18	18	9	4	61
	Finance Div.			1	2	9	18	36	9	4	79
	Purchasing Div.			1	2	9	18	36	9	4	79
	Products Div.			1	2	9	14	20	9	4	59
	Traffic Div.			1	2	4	8	12	48	4	79
	Sub-Total		1	6	12	44	84	146	120	26	439
Pertamina Department Total		2	4	15	50	118	216	624	200	92	1,321
(Expatriates)			(1)	(1)	(1)	(1)					(4)
J. V. - Plant											
Electrolysis Plant (43,000 t/y as Cl_2)	Production Div.	1	1	1	3	6	6	26	12	7	63
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	10	34	18	10	89
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
VCM Plant (70,000 t/y)	Production Div.	1	1	1	3	6	9	34	4	7	66
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	13	42	10	10	92
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PVC Plant (70,000 t/y)	Production Div.	1	1	1	3	6	7	46	22	7	94
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	6	40	8	3	62
	Sub-Total	1	1	2	4	9	13	86	30	10	156
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
LDPE Plant (100,000 t/y)	Production Div.	1	1	1	1	4	13	65	8	7	101
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	9	29	8	3	54
	Sub-Total	1	1	2	2	7	22	94	16	10	155
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
HDPE Plant (30,000 t/y)	Production Div.	1	1	1	1	4	9	48	4	7	76
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	5	9	8	3	30
	Sub-Total	1	1	2	2	7	14	57	12	10	106
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
MEG Plant (50,000 t/y)	Production Div.	1	1	1	1	4	10	26	4	7	55
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	2	7	14	34	10	10	81
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PP Plant (48,000 t/y)	Production Div.	1	1	1	1	4	9	61	4	7	89
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	18	8	3	38
	Sub Total	1	1	2	2	7	13	79	12	10	127
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
J. V. - Plant Total		7	7	14	20	55	99	426	108	70	806
(Expatriates)			(7)	(7)	(7)	(7)					(28)
GRAND TOTAL											
Indonesian		9	11	29	70	173	315	1,050	308	162	2,127
Expatriates			(8)	(8)	(8)	(8)					(32)

Table II-47 (2) Petrochimical Industry Plant Organization and Personnerl-Case-2

		Works Manager	Director	Manager	Superin-tendent	Staff	Foreman	Operator	Labourer	Helper	Total
Pertamina Departments in Charge											
Production Dept.	Production Div. No. 1 (Ethylene)	2	1	1	2	4	14	67	8	10	109
	Production Div. No. 1 (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Production Div. No. 2 (Utilities)			1	3	6	6	48	4	5	73
	Production Coordinate Div.			1	4	8	8	8	8	6	43
	Technical Admi. Div.			1	2	4	4	4	4	4	23
	Sub-Total	2	1	4	11	22	32	127	24	25	248
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
Safety Dept.	Safety Div.		1	1	2	4	6	40	4	6	64
	Environment Div.			1	2	4	6	20	4	4	41
	Sub-Total		1	2	4	8	12	60	8	10	105
Maintenance Dept.	Machinery Div.		1	1	9	18	36	200	16	13	294
	Elect. /Inst. Div.			1	9	18	36	200	16	11	291
	Civil Div.			1	5	8	16	45	16	7	98
	Sub-Total		1	3	23	44	88	445	48	31	683
Administ. Dept.	Gen. Affairs Div.		1	1	2	4	8	24	36	6	82
	Personnel & Employee Relation Div.			1	2	9	18	18	9	4	61
	Finance Div.			1	2	9	18	36	9	4	79
	Purchasing Div.			1	2	9	18	36	9	4	79
	Products Div.			1	2	9	14	20	9	4	59
	Traffic Div.			1	2	4	18	27	108	4	164
	Sub-Total		1	6	12	44	94	161	180	26	524
Pertamina Departments Total		2	4	15	50	118	226	793	260	92	1,560
(Expatriates)			(1)	(1)	(1)	(1)					(4)
J. V. - Plant											
Electrolysis Plant (105,000 t/y as Cl_2)	Production Div.	1	1	1	3	6	8	31	12	7	70
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	12	39	18	10	96
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
VCM Plant (170,000 t/y)	Production Div.	1	1	1	3	6	9	34	8	7	70
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	13	42	14	10	96
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PVC Plant (170,000 t/y)	Production Div.	1	1	1	3	6	8	88	34	7	149
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	14	66	16	3	104
	Sub-Total	1	1	2	4	9	22	154	50	10	253
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
LDPE Plant (200,000 t/y)	Production Div.	1	1	1	1	4	13	84	8	7	120
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	16	64	16	3	104
	Sub-Total	1	1	2	2	7	29	148	24	10	224
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
HDPE Plant (80,000 t/y)	Production Div.	1	1	1	1	4	9	48	6	7	78
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	8	27	8	3	51
	Sub-Total	1	1	2	2	7	17	75	14	10	129
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
MEG Plant (100,000 t/y)	Production Div.	1	1	1	1	4	10	26	4	7	55
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	2	7	14	34	10	10	81
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PP Plant (100,000 t/y)	Production Div.	1	1	1	1	4	9	61	4	7	89
	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Clerical Div.			1	1	3	9	29	8	3	54
	Sub Total	1	1	2	2	7	18	90	12	10	143
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
J. V. - Plant Total		7	7	14	20	55	125	582	142	70	1,022
(Expatriates)			(7)	(7)	(7)	(7)					(28)
GRAND TOTAL											
Indonesian		9	11	29	70	173	351	1,375	402	162	2,582
Expatriates			(8)	(8)	(8)	(8)					(32)

Table II-47 (3) Petrochimical Industry Plant Organization and Personnerl-Case-3

		Works Manager	Director	Manager	Superin-tendent	Staff	Foreman	Operator	Labourer	Helper	Total
Petramina Departments in Charge											
Production Dept.	Production Div. No. 1 (Ethylene)	2	1	1	2	4	14	58	8	10	100
	Production Div. No. 1 (Expatriates)		(1)	(1)	(1)	(1)					(4)
	Production Div. No. 2 (Utilities)			1	3	6	6	42	4	5	67
	Production Coordinate Div.			1	4	8	8	8	8	6	43
	Technical Admi. Div.			1	2	4	4	4	4	4	23
	Sub-Total	2	1	4	11	22	32	112	24	25	233
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
Safety Dept.	Safety Div.		1	1	2	4	6	40	4	6	64
	Environment Div.			1	2	4	6	20	4	4	41
	Sub-Total		1	2	4	8	12	60	8	10	105
Maintenance Dept.	Machinery Div.		1	1	9	18	36	172	16	13	266
	Elect. /Instr. Div.			1	9	18	36	172	16	11	263
	Civil Div.			1	5	8	16	38	16	7	91
	Sub-Total		1	3	23	44	88	382	48	31	620
Administ. Dept.	Gen. Affairs Div.		1	1	2	4	8	24	36	6	82
	Personnel & Employee Relation Div.			1	2	9	18	18	9	4	61
	Finance Div.			1	2	9	18	36	9	4	79
	Purchasing Div.			1	2	9	18	36	9	4	79
	Products Div.			1	2	9	14	20	9	4	59
	Traffic Div.			1	2	4	12	18	72	4	113
	Sub-Total		1	6	12	44	88	152	144	26	473
Pertamina Departments Total		2	4	15	50	118	220	706	224	92	1,431
(Expatriates)			(1)	(1)	(1)	(1)					(4)
J. V. - Plant											
Electorolysis Plant	Production Div.	1	1	1	3	6	6	26	12	7	63
(60,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y as Cl_2)	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	10	34	18	10	89
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
VCM Plant	Production Div.	1	1	1	3	6	9	34	4	7	66
(100,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	4	9	13	42	10	10	92
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PVC Plant	Production Div.	1	1	1	3	6	7	46	22	7	94
(100,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	6	40	8	3	62
	Sub-Total	1	1	2	4	9	13	86	30	10	156
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
LDPE Plant	Production Div.	1	1	1	1	4	13	65	8	7	101
(120,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	10	37	8	3	63
	Sub-Total	1	1	2	2	7	23	102	16	10	164
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
HDPE Plant	Production Div.	1	1	1	1	4	9	48	4	7	76
(50,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	5	18	8	3	39
	Sub-Total	1	1	2	2	7	14	66	12	10	115
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
MEG Plant	Production Div.	1	1	1	1	4	10	26	4	7	55
(100,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	4	8	6	3	26
	Sub-Total	1	1	2	2	7	14	34	10	10	81
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
PP Plant	Production Div.	1	1	1	1	4	9	61	4	7	89
(70,000	Production Div. (Expatriates)		(1)	(1)	(1)	(1)					(4)
t/y)	Clerical Div.			1	1	3	6	18	8	3	40
	Sub-Total	1	1	2	2	7	15	79	12	10	129
	(Expatriates)		(1)	(1)	(1)	(1)					(4)
J. V. - Plant Total		7	7	14	20	55	102	443	108	70	826
(Expatriates)			(7)	(7)	(7)	(7)					(28)
Grand Total											
Indonesian		9	11	29	70	173	322	1,149	332	162	2,257
Expatriates			(8)	(8)	(8)	(8)					(32)

2) Production Coordinate Division

The production coordinate division shall confirm the operation schedule of each one of the downstream plants and further adjusts and coordinates the operation policies of the whole plant. Thus, this division shall be assigned to formulate the operation schedule on monthly basis for the ethylene plant and the utility plants as well as to analyze the actual records of achievements as against the original schedule.

3) Technical Administration Division

The Technical Administration Division shall constantly maintain communications with the Maintenance Dept., Production Coordinate Division, etc. in order to formulate; the shut down schedule, maintenance schedule, longterm operation schedule, etc. for the whole complex including the joint-venture plants. Also, this section shall undertake the establishment of various technical standards (lay-out standards, the design standards for the machinery and equipment, etc.) as well as the technical assistance to be extended to each division engaged in the production.

(b) Safety Dept.

1) Safety Division

The assignments for this division are to establish the safety regulations for the whole complex and the safety standards to be applied to the plant operation. After the commencement of the operation of the complex, the inspection and guidance concerning the established safety standards shall be undertaken by this division in addition to the training, education and drills concerning to the operational safety. Also, a fire extinguishing squadron shall be established within this division in order to engage in the fire fighting activities at the time of accidents and also to undertake the basic drills to the general personnel of the plants concerning the fire fighting activities. As to the fire fighting squadron, the on-duty schedule should be three-shifts four-groups (3 x 4) in the same manner as the Production Division.

2) Environment Division

During the period of complex construction, this division shall undertake the technical planning concerning the prevention of pollution which may be caused by the waste water, dust, waste materials, noise, etc., which will either be emitted or discharged from the whole plants. Further, this division shall carry out the necessary negotiations with outside authorities, etc., concerning the establishment of pollution control standards, the selection of pollution prevention technology, etc.

Also, after the commencement of the operation of the complex, this division shall undertake the watching and monitoring of the emission or the discharge of waste water, dust, waste materials, noise, etc., and at the same time, shall carry out the substantiation of the pollution preventive environment inside and surrounding areas of the complex.

(c) Maintenance Dept.

1) Machinery Division

This division will be assigned to mainly undertake the maintenance servicing and repair to the various devices, machinery, equipment, general pipings, etc. of the whole complex. At the same time, the design work will also be undertaken by this devision concerning various machines and general pipings, for the purpose of minor modifications and rationalizations.

2) Electricity and Instrumentation Division

This division shall undertake the administration of the electrical power distribution, power generation, and telephone communications system of the whole complex as well as the maintenance and improvement of electrical equipment. Further, this division shall undertake the maintenance and improvement of all the instrumentation machinery and equipment in the complex.

3) Civil Division

This division shall undertake the civil engineering works of the whole complex as well as the formulation of civil engineering schedule, relative design and surveys.

(d) Administration Department

1) General Affairs Division

The major assignments to this division is the preparation for all the contract procedures for Pertamina as well as for the related companies and the processing of legal matters and problems centering around the contract conclusion and the proceedings with the governmental authorities. Further, this division shall undertake the procurement and administration of real estates, general affairs inside the organization, and the administration and control of the guest house facilities.

2) Personnel & Employee Relations Division

This division shall undertake the recruitment and employment of employees, personnel affairs, salary and wage administration, education, welfare administration and all the other proceedings pertaining thereto covering the whole complex. In other words, the assignment of this division starts with the employment of the employees, the administration of the dormitories, company housing facilities and welfare facilities for the benefit of the employees, the handling of the salary and wage, social security insurance proceedings, the management of problems pertaining to company cooperatives, etc.

3) Finance Division

This division shall undertake the control of the accounts, finance and the bookkeeping of payments and receipts covering the whole complex. In other words, this division shall be assigned to carry out the proceedings and accountings concerning the properties and assets, the profit/loss calculations pertaining to each plant (cost calculation), the administration of the funds for commencing new ventures as well as the working capitals and other monies pertaining to the operation of the organization.

4) Purchasing Division

The assignment to this division is to undertake the procurement and administration of raw materials and other necessary materials for the whole complex as well as the conclusion of contracts pertaining to the works to be undertaken within the complex. Some specific examples of the assignments are the administration and operation of the raw material and other material warehouses, the raw material tank yard, etc.

5) Products Division

This division will undertake the administration of the products turned out by the production divisions. For example, this division shall undertake the administration of the tanks for liquid products and the warehouses for the solid products. Further, regarding the solid products, the bagging equipment shall be installed in each plant so that the works pertaining up to the filling and/or bagging of the products shall be within the jurisdiction of all the plants.

6) Traffic Division

The major assignment to this division is to undertake the transportation works inside the plant. Further, the substantiation and cleaning works for the transportation conditions inside the plant premises shall also be assigned to this division. The actual examples of the assignments are as follows:

i) The in-plant shifting of products, raw materials and other plant materials inside the complex.

ii) The transit of documents between the plants and offices;

iii) Transportation and disposal of discharged materials or wastes from each plant.

iv) The cleaning works of roads inside the complex.

(2) Plants established by joint-venture arrangements

(a) Production Division

These divisions shall undertake the operation and administration of the plants on the basis of the production schedule instructed by Pertamina as well as by the two parent companies of the joint-venture, while undertaking the production adjustments with the Production Coordinate Division of the Production Department which is totally controlled by Pertamina.

In the same manner as the ethylene plant and utility plants, the number of personnel for these production divisions shall include those who will be engaging in the production process analyses. Also, regarding the liquid products, the Production Divisions shall control the delivery up to the product tank yard As to the solid products, the production divisions shall be responsible for the operations up to the completion of the bagging and/or filling works in the same manner as mentioned earlier. It is necessary to form the administrative members of the production divisions (managers, superintendents and staffs) by including at least one mechanical engineer, one electrical and instrumentation engineer and two chemical engineers (including analyst).

(b) Administration Divisions

The administration divisions to be established within each one of the joint-venture plants shall undertake collaboration with the Administration Dept. of the above-mentioned Organization totally controlled by Pertamina. The Administration Divisions of the joint venture plants shall therefore undertake all the necessary proceedings inside the plants. The actual examples of the assignments are as follows:

1) Coordination of monthly operation expenses of each plant;

2) Control of personnel affairs and monthly on-duty/off-duty schedule;

3) Purchasing of raw materials and plant materials;

4) Confirmation of the produced quantity of the products, inventory and delivery.

5) Other general affairs proceedings necessary for each plant.

5-2 Utility, Service and Other Supporting Facilities

5-2-1. Utility facilities

(1) Power and steam supply

Electric power and steam required for the whole complex operation are to be generated by the own generation unit. In the case of the olefin complex project, it is recommended that electric power be generated by the combination of a boiler-turbine-generator system and with steam pressure of more than 110 kg/cm^2g for easier operation of the olefin plant in which the said pressure of steam is recovered and is used for the gas compression. The steam used in the other processes is at 20 kg/cm^2 or lower so that the steam turbine will be the combined type of steam extracting and condensing. Specification for power generator is shown in Table II-48.

Table II-48 Specifications for Power Generator

Specification	Case 1	Case 2	Case 3
A) Boiler			
Number required	2	2	2
Capacity, t/h	240	520	330
Steam Pressure, kg/cm^2G	120	120	120
Steam temperature, °C	540	540	540
Forced Draft Fan (Motor Driven), kw	240	525	330
Induced Draft Fan (Motor Driven), kw	240	525	330
Boiler Feed Water Pump (Steam Driven), kw	1,450	3,100	2,000
B) Turbine - Generator			
Number required	2 + 0	2 + 0	2 + 0
Extract Steam, 20 kg/cm^2G, t/h	72	158	101
Extract Steam, 10 kg/cm^2G, t/h	82	201	133
Condensing Steam Pressure, ata	0.08	0.08	0.08
Condensing Steam, t/h	165	338	209
Turbine Type	Single	Cylinder	Single flow
C) Generator Output, kw	40,000	87,500	5,500
Generator type	Three phase A.C. synchronous voltage 11,000 V, 50 Hz		

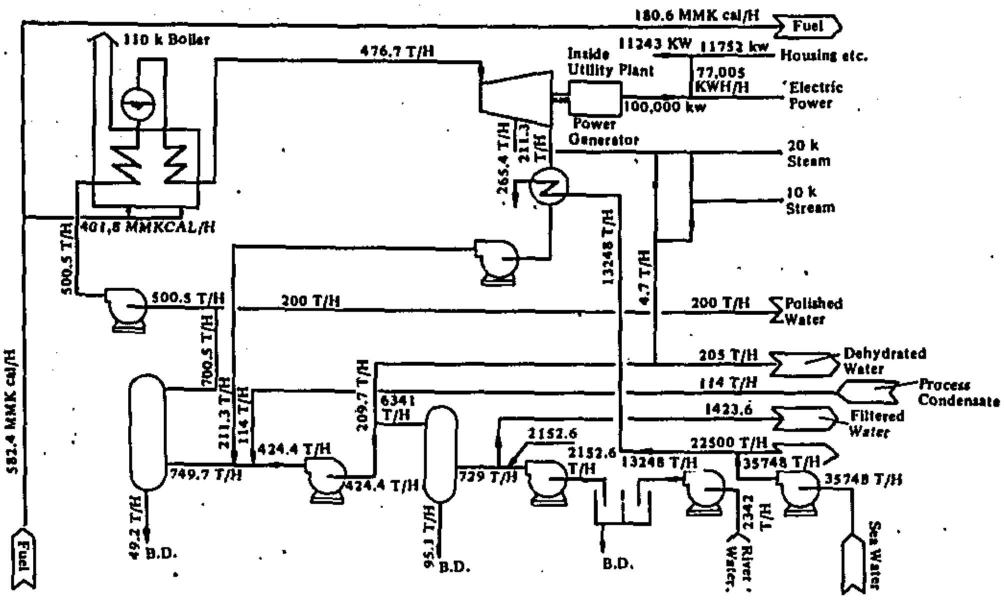


Figure II-14 Utility Flow & Balance Diagram - Olefin Complex

(2) Sea water intake and supply

As the water consumption of the petrochemical complex is considerably high, it is recommended that seawater be used as much as possible in order to reduce fresh water consumption. To obtain clean seawater, it is assumed that a water pipeline will be required for approximately 0.7 km into the sea and approximately 1 km on land. The required amount of seawater for each case is as follows:

Case 1	0 (not available in Palembang)
Case 2	63,000 m^3/h
Case 3	41,000 m^3/h

Specification

	Case 2	Case 3
A) Pipeline		
Length, Km	1.7	1.7
Material	Cast iron	Cast iron
Pipe diameter, m	2.36	1.9
Number of pipeline	2	2
Pump		
Type	Centrifugal	Centrifugal
Capacity, m^2/h	10,000	10,000
Motor, kW	2,200	2,200
Number required	6 + 1	4 + 1

(3) Water treatment system

It is assumed that raw water will be pumped from the river approximately 20 Km away from the plant site, except for Case-1, and will be clarified by precipitation and filtration at the place of the pumping station. The filtered water will be sent to the plant site by a pipeline and will be treated gradually to produce drinking water, de-mineralized water and polished water.

Filtered water is sterilized by chlorine injection in order to produce drinking water. Filtered water is partly led to deionizing equipment to produce de-mineralized water. The deionizing equipment mainly consists of a cation exchanger, a degasifier and an anion exchanger. After passing through the cation exchanger, all the cations are transformed into H^+ ions by the resins, and there will be nothing in the water but the acids of the salts which was originally contained in water. This acid water is led to the top of the de-gasifier to eliminate dissolved carbon-dioxide. Then, the de-gasified water is passed through the anion exchanger and all the anions are transformed into OH ion. The quality of the de-mineralized water is as follows:

Specific Condustivity:	Less than 10 mho/cm
Residual Silica :	Less than 0.5 ppm as SiO_2

A part of the de-mineralized water and the recovered steam condensate will be led to the polisher. The polisher consists of a cation exchanger and an anion exchanger in the same manner as the de-ionizing equipment. The polisher is designed to produce high pressure (more than 60 kg/cm^2) boiler feed water of less than 1 micro mho/cm electric conductivity. The required capacity of the water treatment system for each case is as follows:

		Case-1	Case-2	Case-3
River Water intake	m^3/h	3,400	4,600	3,100
Filtered water	"	3,100	4,250	2,900
Demineralized Water	"	450	1,050	700
Polished Water	"	530	1,170	750

(4) Instrument air and plant air supply

Air is compressed by an oil-free air compressor for both purposes of instrument air supply and plant air supply. For the production of instrument air, the compressed air up to a pressure of 7 kg/cm^2 is purified in an air dehumidifier which is of a dual type with an automatic change-over mechanism so that one cylinder is desiccating, while the other is under regeneration.

	Case 1	Case 2	Case 3
Air volume:			
for instrument air	3,922	7,544	5,232
for plant air	2,300	4,000	3,000
Total	6,222	11,544	8,232
Number of Compressor	1 + 1	1 + 1	1 + 1

Specifications of instrument air:	
Pressure	7 kg/cm^2g
Dew point	-10°C at 7 kg/cm^2
Quality	Oil free, dustless and desiccated air

(5) Oxygen and inert gas supply

For the purpose of fulfilling the oxygen requirement for the VCM and ethylene dioxide plant and also for fulfilling the requirements for the inert gas for the process plants, oxygen and nitrogen are generated by air separation processes.

	Case 1	Case 2	Case 3
Oxygen requirement, Nm^3/h	7,000	14,500	13,500
Nitrogen requirement, "	3,100	6,900	4,400
Required number of unit	1	1	1
Air pressure required, Kg/cm^2g	5.2	5.2	5.2
Product quality			
Oxygen	98 vol %	500 mmAg	
Nitrogen	99,99 "	500 "	

(6) Fuel gas supply

In a petrochemical complex, a large amount of by-products will be generated with the production of olefins. In such a case, it is generally practised that the portion of such by-products which cannot be utilized as products is normally consumed as fuel. On the other hand, the fuel consumption in the case of a petrochemical complex varies in its extent depending upon whether the electrical power is purchased externally or accommodated by an own-generation station. Table II-49 shows the fuel balance in each case.

The shortage portion of the fuel stated in the above table will be replenished by means of the supply of natural gas. However, due to the fact that the by-products turned out at the time of olefin production contain substances which are usable as raw materials for aromatics complex, the actual shortage will be increased by 30%.

Table II-49 Fuel Balance

(10^9 Kcal/y)

Plant production	Composition	Case 1	Case 2	Case 3
Olefin	H_2	734.4	1,598.7	1,065.8
	CH_4	854.7	1,856.5	1,238.9
	C_3=	108.4	207.4	95.1
	LPG	232.7	505.2	337.1
	C_4	521.4	1,133.5	756.3
	Pylosis Gasoline	342.5	744.7	496.8
	Fuel Oil	47.3	102.9	68.3
Electrolysis	H_2	41.0	98.7	58.1
Production Total		2,882.4	6,247.6	4,116.4
Consumption				
Olefin	Gas & Oil	1,539.2	3,344.0	2,231.2
VCM	Gas	87.2	212.8	124.8
Steam & Power Generation	Gas	2,294.4	5,198.4	3,487.4
Consumption Total		3,920.8	8,755.2	5,843.4
Shortage		1,038.4	2,507.6	1,727.0

(7) Utility consumption for whole complex.

Tables II-50 and II-51 show utility consumption of process plant and utility balances for Case 3.

Table II-50 Utilities Consumption of Process Plant

Stream Factor = 100%

	Olefin	VCM	PVC	LDPE	HDPE	EG	PP	Elect	Total
Production t/y	297,500	104,000	100,000	120,000	50,000	100,000	70,000	61,600	
Production t/h	37.19	13.0	12.5	15.0	6.25	12.5	8.75	7.7	
Power KW	2,000	2,834	4,700	22,500	4,844	6,250	8,313	25,564	77,005
Steam HP t/h	40	11.3	--	15.0	--	--	45.1	--	111.4
Steam LP t/h		10.4	35.0	--	43.75	33.75	--	33.11	156.0
(Total t/h)		(21.71)	(35.0)	(15.0)	(43.75)	(33.75)	45.1	(33.11)	(267.5)
C.W. Makeup t/h	--	161	40	150	169	313	236	139	1,208
Sea Water t/h	22,500	--	--	--	--	--	--	--	22,500
Process Water t/h	10.0	14.3	120.0	15.0	12.5	--	43.8	--	215.6
Demineralized Water t/h	2.0	19.5	140.0	--	--	16.3	8.8	1.5	186.0
Polished Water t/h	200	--	--	--	--	--	--	--	200
Instrument Air Nm^3/h	300	377	600	1,350	281	875	394	212	4,389
Inert Gas Nm^3/h	--	572	300	1,200	625	200	1,313	154	4,364
Fuel Gas MMKal/h	165	15.6	--	--	--	--	--	--	180.6
Plant Air Nm^3/h	--	845	600	--	--	--	--	--	1,445
Oxygen Nm^3/h	--	1,360	--	--	--	12,000	--	--	13,360
St.Condensate t/h	9	10.9	17.5	7.5	21.9	16.9	22.6	16.6	113.9

Table II-51 Utilities Balance for Case 3

Stream Factor = 100 %

	Unit	Capacity	476.7t	101,463 KW	35,750t	2,485t	2,284t	634.1t	700.5t	5,049 Nm³	2,745 Nm³	4,364Nm³	13,360Nm³	--	--	
		Process Plant	Steam Boiler	Electric Power Generation	Sea Water	River Water Intake	Filtered Water	Demineralized Water	Polish Water	Instrument Air	Plant Air	Inert Gas	Oxygene	Maintenance Shop	Office Lighting	
Electric Power	KW	77,005	1,300		7,758	1,337	528	848	935	1,017	571	796	6,418	2,000	950	101,465
Steam 110 K	t/h	--	476.7	476.3												476.7
Steam 20 K	t/h	111.4		111.4												111.4
Steam 10 K	t/h	156.0		158.7				0.2	0.5				2.0			158.7
Sea Water	t/h	22,500		13,250												35,750
River Water	t/h	--					2,485									2,485
Filtered Water	t/h	1,423		13				729		47		27	45			2,284
Demineralized Water	t/h	186		4.7					424.4				19			634
Polished Water	t/h	200	500.5													700.5
Instrument Air	Nm^3/h	4,389	500				10	50	50				50			5,049
Plant Air	Nm^3/h	1,445	300											1,000		2,745
Inert Gas	Nm^3/h	4,364														4,364
Oxygene	Nm^3/h	13,360														13,360
Fuel	MM Kal/h	180.6	401.8													582.4
Steam Condensate	t/h	113.9		211.3					325.2							325.2

5-2-2 Service facilities

The following service facilities must be constructed in addition to the utilities facilities which are directly necessary for the operation of the petrochemical complex.

(1) Office and building

- Administration Office
- General warehouse
- Garages
- Canteen
- Change house
- Shower room
- Medical clinic
- Spare parts warehouse
- Chemicals warehouse

(2) Fire protection

- Fire alarm system
- Fire engine
- Fire water system including fire water pumps, hydrants, fire water distribution piping
- Fire boat
- Hand fire extinguishers
- Inert gas distribution system

(3) Maintenance shops

- Machine shop
- Welding shop
- Electrical shop
- Repair shop
- Instrument shop
- Carpenter shop
- Foundry shop
- Forging shop
- Mobile equipment

(4) Communication system

- Telephone system
- Telex system
- Paging system

(5) Waste disposal

- Waste incinerator
- Waste sewer

- Separator
- Ponds
- Blow down and flare

(6) Lighting
- Road lighting
- Tankage area lighting
- Warehouse lighting
- Offices lighting
- Utilities area lighting
- Shipping area lighting

(7) Others
- Smoking station
- Technical service laboratory
- Research laboratory
- Recreation facilities
- Vehicles
- Mosque
- Yard piping
- Sanitary
- Safety

(8) Land

(a) Land preparation
- Land survey fees
- De-watering and drainage
- Site clearing
- Excavation
- Falling
- Finished grading

(b) Others
- Road
- Walkways
- Paving
- Fencing
- Gate house
- Parking lot
- Land scaping

5-2-3 Supporting facilities

(1) Harbor

Vessel

	Tanker	Cargo
Capacity	5,000 DWT	5,000 DWT
length, m	102	111
width, m	13.3	14.8
Draft (full), m	6.3	6.6

Wharf

Length	200m
Depth	-7.0m from L.L.W.L.
Materials	Reinforced concrete
Pile	Steel Pipe

Construction

	Case 1	Case 2	Case 3
Bridge length, m	50	50	-
Bridge width, m	5	5	-
Wharf width, m	15	15	15
Dredging, m	-	200x2,000	500x500 200x500

(2) Company housing

It is commonly practiced in Indonesia that the supply of company housing for key personnel of the plant is undertaken in the case of large-scaled plants. Particularly in the case of ventures such as the present project in which the plant site is located in a remote area, it is absolutely necessary to supply company housing in order to secure the key personnel for the plant operation. A number of key personnel for the plant operation is as shown in the Plant Organization Chart described in Tables II-47(1) through (3), however, the following pre-requisite conditions were assumed for calculating the required number of houses to be incorporated in the company housing construction project.

(a) No company housing will be supplied to the labourer and helpers on an assumption that these personnel are locally available.

(b) In Case 1, the plant site will be selected in the vicinity of Palembang so that the company housing for the operators will be supplied to one-third of the total operators.

(c) The camp for the contractors' personnel at the time of plant construction will be supplied by the contractors.

(d) In all the cases, the number of the expatriate experts on the side of the plant owner at time of the plant test operation shall be 150 in total and shall be lodged in 55 houses.

The houses to be supplied under the company housing project shall be categorized in two classes, one for the personne higher than the staff members inclusive and another for general workers. The size of the house for the higher class personnel will be 150 m^2/unit and that for the lower class will be 60 m .

	Case 1	2	3
Number of houses for high-class personnel:	347	347	347
For lower class personnel:	455	1,726	1,471
Land area for company housing:	138.2 ha	183.2 ha	168.3 ha

5-3 Construction Cost

Table II-52 shows construction cost for each case. Detailed breakdown of cost of each process plant and Utilities & Service Facilities for each case is shown in Table II-53(1) through (3) and Table II-54 respectively.

Table II-52 Construction Cost Summary

(Unit: 10^3 US$)

ITEMS	CASE 1			CASE 2			CASE 3		
	FOREIGN	LOCAL	TOTAL	FOREIGN	LOCAL	TOTAL	FOREIGN	LOCAL	TOTAL
a. Equipment & Materials	137.2	3.5	140.7	243.1	6.2	249.3	174.0	4.5	178.5
b. Erection Work	-	19.3	19.3	-	71.1	71.1	-	30.8	30.8
c. Civil Work	15.9	13.4	29.3	26.5	45.1	71.6	14.8	15.3	30.1
d. Supervision	20.0	5.0	25.0	33.0	8.3	41.3	25.0	6.3	31.3
e. Engineering & Constructor's Fee	43.4	33.1	76.5	77.6	59.2	136.8	54.6	41.6	96.2
Inside Battery Limit Facility	216.2	74.3	290.5	380.2	189.9	570.1	268.4	98.4	366.9
Licence & Know-how	24.0	-	24.0	43.8	-	43.8	30.8	-	30.8
Catalyst & Chemicals	3.6	0.1	3.7	7.1	0.2	7.3	6.5	0.2	6.7
Spare Parts	13.7	0.4	14.1	24.3	0.6	24.9	17.4	0.4	17.8
Contingency	21.6	7.8	29.4	38.0	20.3	58.3	26.8	10.4	37.2
Process Plant	279.1	82.6	361.7	493.4	211.0	704.4	349.9	109.4	459.4
Utility Facilities	65.9	22.6	88.5	151.6	61.4	213.0	103.9	35.9	139.8
Process Control Laboratory	3.8	0.7	4.5	3.7	1.2	4.9	3.8	0.8	4.6
Storage & Handling	19.4	8.2	27.6	37.9	27.0	64.9	24.8	11.8	36.6
Service Facilities	35.6	17.6	53.2	57.9	48.0	105.9	44.9	23.2	68.1
Jetty, Housing, Road etc.	31.7	29.1	60.8	57.2	102.0	159.2	38.1	40.2	78.3
Off-site	90.5	55.6	146.1	156.7	178.2	334.9	111.6	76.0	187.6
Total Construction Cost	435.4	160.7	596.3	801.8	450.6	1252.4	565.4	221.3	786.8

Table II-53(1) Construction Cost for Case 1

(Unit: 10^6 US$)

	Olefin			V C M			P V C			L D P E			H D P E			EG			P P			Electrolysis			Foreign Portion Total	Rupiah Portion Total	Grand Total
	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total			
1. Inside Battery Limit Facility																											
a. Equipment & Materials	31.2	0.8	32.0	9.4	0.2	9.6	7.7	0.2	7.9	41.4	1.1	42.5	7.9	0.2	8.1	13.6	0.3	13.9	14.1	0.4	14.5	12.0	0.3	12.3	137.2	3.5	140.7
b. Erection Work	-	6.5	6.5	-	1.2	1.2	-	0.8	0.8	-	4.0	4.0	-	1.1	1.1	-	1.9	1.9	-	2.1	2.1	-	1.7	1.7	-	19.3	19.3
c. Civil Work	1.4	1.2	2.6	1.7	1.5	3.2	1.3	1.1	2.4	5.4	4.7	10.1	0.9	0.8	1.7	0.9	0.8	1.7	1.8	1.5	3.3	2.1	1.8	3.9	15.6	13.4	29.0
d. Supervision	3.7	0.9	4.6	2.3	0.6	2.9	2.4	0.6	3.0	4.3	1.1	5.4	1.2	0.3	1.5	1.7	0.4	2.1	1.8	0.5	2.3	2.6	0.7	3.3	20.0	5.0	25.0
e. Engineering & Contractor's Fee	9.9	7.5	17.4	3.0	2.3	5.3	2.4	1.9	4.3	13.1	10.0	23.1	2.5	1.9	4.4	4.3	3.3	7.6	4.5	3.4	7.9	3.8	2.9	6.7	43.4	33.1	76.5
Sub Total	46.2	16.9	63.1	16.4	5.8	22.2	13.8	4.6	18.4	64.2	20.9	85.1	12.5	4.3	16.8	20.5	6.7	27.2	22.2	7.9	30.1	20.5	7.4	27.9	216.2	74.3	290.5
2. Licenced Know-how Fee	1.7	-	1.7	1.7	-	1.7	2.6	-	2.6	7.1	-	7.1	3.2	-	3.2	2.2	-	2.2	4.2	-	4.2	1.3	-	1.3	24.0	-	24.0
3. Catalyst & Chemicals	0.4	0	0.4	0.4	0	0.4	0	0	0	-	-	-	-	-	-	2.6	0.1	2.7	-	-	-	0	0	0	3.6	0.1	3.7
4. Spare parts	3.1	0	3.1	0.9	0	0.9	0.8	0	0.8	4.1	0.1	4.2	0.8	0	0.8	1.4	0	1.4	1.4	0	1.4	1.2	0	1.2	13.7	0.4	14.1
5. Storage & Warehouse	7.4	2.3	9.7	1.0	0.3	1.3	2.2	1.5	3.7	4.1	2.1	6.2	1.3	0.7	2.0	0.2	0.1	0.3	2.3	1.0	3.3	1.0	0.2	1.2	19.4	8.2	27.6
6. Process Central Laboratory	2.1	0.1	2.3	-	-	-	0.5	0.1	0.6	0.3	0.1	0.4	0.3	0.1	0.4	0.3	0	0.3	0.3	0.1	0.4	-	-	-	3.8	0.7	4.5
7. Contingency	4.6	1.8	6.4	1.6	0.6	2.2	1.4	0.5	1.9	6.4	2.2	8.6	1.2	0.4	1.6	2.0	0.7	2.7	2.2	0.8	3.0	2.1	0.8	2.9	21.6	7.8	29.4
Grand Total	65.6	21.1	86.7	22.0	6.7	28.7	21.3	6.7	28.0	86.2	25.4	111.6	19.3	5.5	24.8	29.2	7.6	36.8	32.6	9.8	42.4	26.1	8.4	34.5	302.3	91.5	393.8

Table II-53(2) Construction Cost for Case 2

(Unit: 10^6 US$)

	Olefin			V C M			P V C			L D P E			H D P E			EG			P P			Electrolysis			Foreign Portion Total	Rupiah Portion Total	Grand Total
	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total			
1. Inside Battery Limit Facility																											
a. Equipment & Materials	53.6	1.4	55.0	16.7	0.4	17.1	13.5	0.3	13.8	82.0	2.1	84.1	14.7	0.4	15.1	21.2	0.5	21.7	23.4	0.6	24.0	18.1	0.5	18.6	243.1	6.2	249.3
b. Erection Work	-	23.5	23.5	-	4.6	4.6	-	3.1	3.1	-	16.8	16.8	-	4.3	4.3	-	6.3	6.3	-	7.2	7.2	-	5.4	5.4	-	71.1	71.1
c. Civil Work	2.3	4.0	6.3	2.9	5.0	7.9	2.1	3.6	5.7	10.3	17.5	27.8	1.6	2.8	4.4	1.3	2.3	3.6	2.8	4.8	7.6	3.0	5.1	8.1	26.5	45.1	71.6
d. Supervision	6.3	1.6	7.9	4.1	1.0	5.1	4.2	1.1	5.3	6.5	1.6	8.1	2.3	0.6	2.9	2.6	0.7	3.3	3.0	0.8	3.8	4.0	1.0	5.0	33.0	8.3	41.3
e. Engineering & Contractor's Fee	17.1	13.0	30.1	5.3	4.1	9.4	4.3	3.3	7.6	26.2	20.0	46.2	4.7	3.6	8.3	6.8	5.2	12.0	7.5	5.7	13.2	5.8	4.4	10.2	77.6	59.2	136.8
Sub Total	79.3	43.5	122.8	29.0	15.1	44.1	24.1	11.4	35.5	125.0	58.0	183.0	23.3	11.7	35.0	31.9	15.0	46.9	36.7	19.1	55.8	30.9	16.4	47.3	380.2	189.9	570.1
2. Licenced Know-how Fee	3.0	-	3.0	3.0	-	3.0	4.7	-	4.7	14.2	-	14.2	6.0	-	6.0	3.5	-	3.5	7.0	-	7.0	2.4	-	2.4	43.8	-	43.8
3. Catalyst & Chemicals	1.0	0	1.0	0.8	0	0.8	0.1	0	0.1	-	-	-	-	-	-	5.2	0.1	5.3	-	-	-	0.1	0	0.1	7.1	0.2	7.3
4. Spare parts	5.4	0.1	5.5	1.7	0	1.7	1.4	0	1.4	8.2	0.2	8.4	1.5	0	1.5	2.1	0	2.1	2.3	0.1	2.4	1.8	0	1.8	24.3	0.6	24.9
5. Storage & Warehouse	12.8	4.0	16.8	1.9	0.6	2.5	5.1	6.6	11.7	8.1	7.9	16.0	3.6	3.2	6.8	0.4	0.1	0.5	4.2	4.1	8.3	1.8	0.4	2.2	37.9	27.0	64.9
6. Process Central Laboratory	2.1	0.2	2.3	-	-	-	0.4	0.2	0.6	0.3	0.2	0.5	0.3	0.2	0.5	0.2	0.1	0.3	0.3	0.2	0.5	-	-	-	3.7	1.2	4.9
7. Contingency	7.9	4.8	12.7	2.9	1.6	4.5	2.4	1.2	3.6	12.5	6.1	18.6	2.3	1.2	3.5	3.2	1.6	4.8	3.7	2.0	5.7	3.1	1.7	4.8	38.0	20.3	58.3
Grand Total	111.5	52.6	164.1	39.3	17.3	56.6	38.2	19.4	57.6	168.3	72.4	240.7	37.0	16.3	53.3	46.5	16.9	63.4	54.2	25.5	79.7	40.1	18.5	58.6	535.0	239.2	774.2

Table II-53(3) Construction Cost for Case 3

(Unit: 10^6 US$)

	Olefin			V C M			P V C			L D P E		
	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total
1. Inside Battery Limit Facility												
a. Equipment & Materials	41.0	1.1	42.1	12.0	0.3	12.3	9.8	0.3	10.1	47.0	1.2	48.2
b. Erection Work	-	10.6	10.6	-	2.0	2.0	-	1.3	1.3	-	5.7	5.7
c. Civil Work	1.8	1.8	3.6	2.1	2.1	4.2	0.8	0.9	1.7	3.7	3.8	7.5
d. Supervision	4.8	1.2	6.0	2.9	0.7	3.6	3.0	0.8	3.8	4.9	1.2	6.1
e. Engineering & Contractor's Fee	12.9	9.8	22.7	3.8	2.9	6.7	3.1	2.3	5.4	14.7	11.2	25.9
Sub-Total	60.5	24.5	85.0	20.8	8.0	28.8	16.7	5.6	22.3	70.3	23.1	93.4
2. Licenced Know-how Fee	2.2	-	2.2	2.1	-	2.1	3.3	-	3.3	8.0	-	8.0
3. Catalyst & Chemicals	0.7	0	0.7	0.5	0	0.5	0	0	0	-	-	-
4. Spare parts	4.1	0.1	4.2	1.2	0	1.2	1.0	0	1.0	4.7	0.1	4.8
5. Storage & Warehouse	9.2	2.9	12.1	1.3	0.4	1.7	2.8	2.4	5.2	5.0	2.9	7.9
6. Process Central Laboratory	2.1	0.2	2.3	-	-	-	0.4	0.1	0.5	0.3	0.1	0.4
7. Contingency	6.0	2.7	8.7	2.1	0.8	2.9	1.7	0.6	2.3	7.0	2.4	9.4
Grand Total	84.8	30.4	115.2	28.0	9.2	37.2	25.9	8.7	34.6	95.3	28.6	123.9

	H D P E			EG			P P			Electrolysis			Foreign Portion Total	Rupiah Portion Total	Grand Total
	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total	Foreign Currency Portion	Rupiah Portion	Total			
1. Inside Battery Limit Facility															
a. Equipment & Materials	11.0	0.3	11.3	21.6	0.6	22.2	18.9	0.5	19.4	12.8	0.3	13.1	174.0	4.5	178.5
b. Erection Work	-	1.9	1.9	-	3.8	3.8	-	3.4	3.4	-	2.2	2.2	-	30.8	30.8
c. Civil Work	1.2	1.3	2.5	2.4	2.5	4.9	0.8	0.8	1.6	2.1	2.1	4.2	14.8	15.3	30.1
d. Supervision	1.7	0.4	2.1	2.6	0.7	3.3	2.4	0.6	3.0	2.8	0.7	3.5	25.0	6.2	31.3
e. Engineering & Contractor's Fee	3.5	2.6	6.1	6.8	5.2	12.0	5.9	4.5	10.4	4.0	3.1	7.1	54.6	41.6	96.2
Sub-Total	17.4	6.5	23.9	33.4	12.8	46.2	28.0	9.8	37.8	21.7	8.4	30.1	268.4	98.5	366.9
2. Licenced Know-how Fee	4.4	-	4.4	3.5	-	3.5	5.5	-	5.5	1.6	-	1.6	30.8	-	30.8
3. Catalyst & Chemicals	-	-	-	5.2	0.1	5.3	-	-	-	0	0	0	6.5	0.2	6.7
4. Spare parts	1.1	0	1.1	2.2	0.1	2.2	1.9	0	1.9	1.3	0	1.3	17.4	0.4	17.8
5. Storage & Warehouse	2.3	1.2	3.5	0.3	0.1	0.3	2.7	1.7	4.4	1.2	0.3	1.5	24.8	11.8	36.6
6. Process Central Laboratory	0.3	0.1	0.4	0.3	0.1	0.3	0.3	0.1	0.4	-	-	-	3.8	0.8	4.6
7. Contingency	1.7	0.7	2.4	3.3	1.3	4.6	2.8	1.0	3.8	2.2	0.9	3.1	26.8	10.4	37.2
Grand Total	27.2	8.5	35.7	48.2	14.5	62.4	41.2	12.6	53.8	28.0	9.6	37.6	378.5	122.1	500.6

Table II-54 Construction Cost of Utility and Service Facility

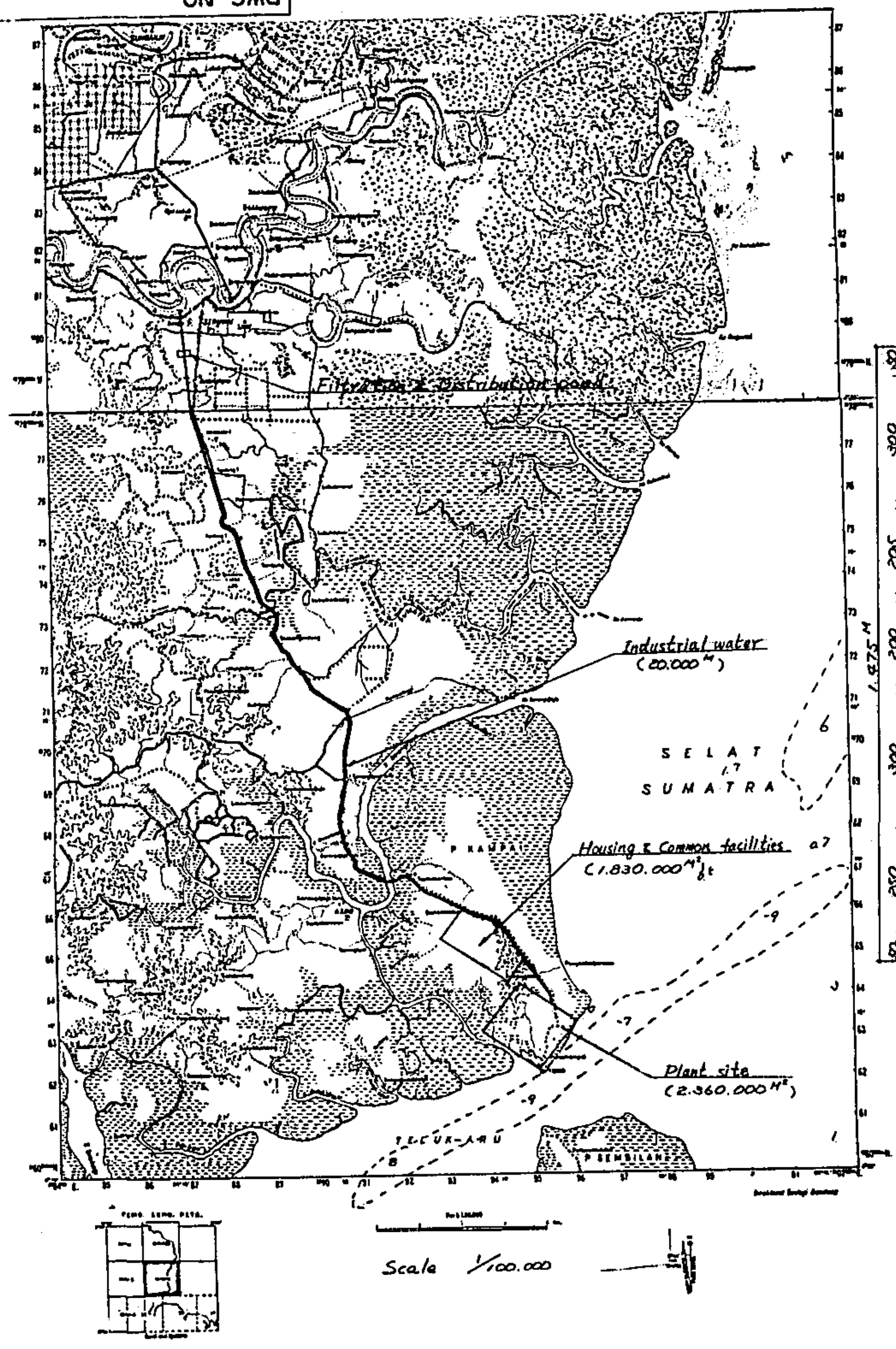
Utilities Facilities	Case 1 Foreign Currency Portion	Case 1 Rupiah Portion	Case 2 Foreign Currency Portion	Case 2 Rupiah Portion	Case 3 Foreign Currency Portion	Case 3 Rupiah Portion
1. Steam & Power Supply	45.1	15.5	84.1	28.1	58.1	20.0
2. Sea Water Intake	-	-	30.3	15.0	19.5	6.7
3. River Water Intake	3.2	1.1	11.2	5.5	5.1	1.7
4. Filtered Water Supply	4.9	1.7	5.8	2.9	4.7	1.6
5. Demineralized Water Supply	1.8	0.6	3.0	1.5	2.3	0.8
6. Polished Water Supply	2.2	0.7	3.5	1.7	1.8	0.6
7. Instrument Air Supply	1.1	0.4	1.7	0.8	1.2	0.4
8. O_2 & N_2 Supply	5.4	1.9	8.4	4.2	8.4	2.9
9. Plant Air Supply	0.8	0.3	1.1	0.5	0.9	0.3
10. Fuel Gas Supply	1.4	0.5	2.4	1.2	1.8	0.6
Total	65.9	22.6	151.6	61.4	103.9	35.9
Grand Total	88.5		213.0		139.7	
Service Facilities						
1. Office & Buildings	25.2	21.6	28.1	47.7	24.6	25.4
2. Fire Protection	2.6	0.9	3.8	1.9	3.2	1.1
3. Maintenance Shops	20.4	7.0	34.6	17.1	27.6	9.5
4. Communication System	0.8	0.3	1.1	0.6	1.0	0.3
5. Waste Disposal	5.5	4.7	9.1	15.5	5.7	5.9
6. Lighting	1.3	0.4	2.2	1.1	1.8	0.6
7. Others	2.5	2.1	4.1	7.0	3.1	3.2
Total	35.6	17.6	57.9	48.0	44.9	23.2
Grand Total	53.2		105.8		68.1	
Land Preparation						
1. Land Preparation	7.2	6.2	18.4	31.3	10.5	10.8
2. Fencing, Road, etc.	3.6	3.1	9.2	15.6	5.2	5.4
Total	10.8	9.2	27.6	46.9	15.7	16.2
Grand Total	20.0		74.6		31.9	

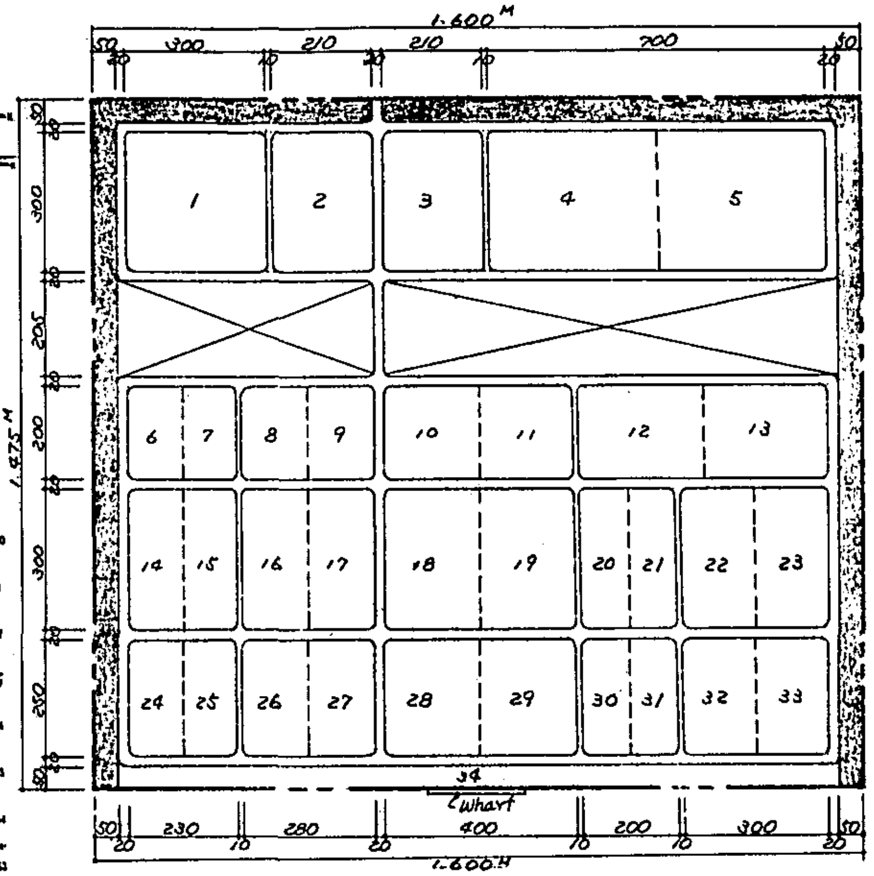
Table II-55 Allocation of Construction Cost of OSBL & Off-site to Process Plant

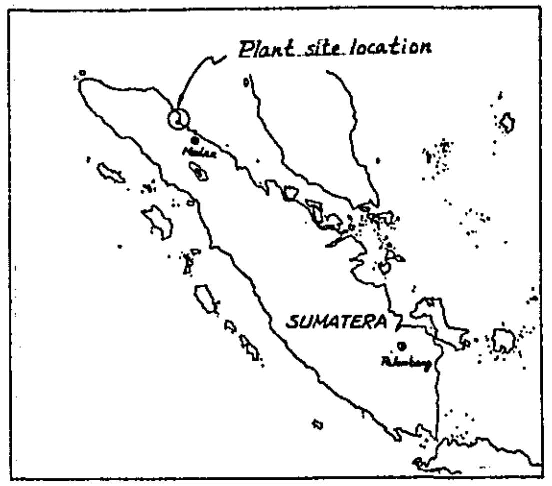
(Unit: 10^6 US$)

	LDPE	HDPE	EOG	Electrysis	VCM	PVC	E G	PP	U	Sub Total
Area ($10^3 m^2$)	56	40	24	28	27	30	40	50	59	354
Man Power	105	76	55	63	66	94	100	89	67	711
I.S.B.L. (10^6 US$)		23.9	46.0	30.1	28.7	22.2	84.9	38.7	172.7	585.3
Service Facilities										
Office & Buildings	0.7	0.5	0.4	0.4	0.5	0.7	0.5	0.6	0.5	5.0
Fire Protection	0.5	0.1	0.2	0.2	0.1	0.1	0.4	0.2	2.1	4.3
Maintenance Shops	4.4	1.1	2.0	1.3	1.2	1.0	3.9	1.8	18.3	37.2
Communication System	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.7	1.3
Waste Disposal	1.4	0.3	0.6	0.4	0.4	0.3	1.2	0.6	5.7	11.7
Lighting	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.4	2.4
Pollution Control	-	-	-	-	-	-	-	-	-	-
Others	0.7	0.2	0.3	0.2	0.2	0.2	0.7	0.3	3.1	6.3
Sub Total	8.3	2.6	3.8	2.8	2.7	2.5	7.0		30.9	68.1
P. C. Labo equip	0.2	0.2	0.2	-	-	0.3	1.3	0.2	-	3.2
P. C. Labo Bldg (m^2)	0.3	0.3	0.1	-	-	0.3	0.1	0.3	-	1.4
Sub Total	0.5	0.5	0.3	-	-	0.6	1.5	0.5	0.5	4.6
Bagging Equip.	1.6	0.8	-	-	-	0.4	-	0.8	-	3.5
Ware house	5.6	2.3	-	-	-	4.6	-	3.2	-	15.8
Storage	-	-	0.4	1.2	1.7	-	7.9	-	-	15.3
Loading & Unloading	0.8	0.4	-	0.3	-	0.2	-	0.4	-	2.0
Sub Total	7.9	3.5	0.4	1.5	1.7	5.2	7.9	4.4	-	36.6
Jetty	0.4	0.2	0.2	0.5	0.1	0.3	0.2	0.2	-	2.1
Housing Colony	9.8	7.4	5.3	6.1	6.4	9.1	6.3	8.6	6.5	69.0
Sub Total	10.2	7.5	5.5	6.6	6.5	9.4	6.5	8.9	6.5	71.1
Fence, Road etc.	1.7	1.2	0.7	0.8	0.8	0.9	0.8	1.5	1.8	10.6
Total (Off-Site)	28.6	15.2	10.7	11.7	11.7	18.6	23.6	19.2	39.0	191.0

Figure II-15 Plot Plan for Petrochemical Plant







NO	Description	Area (M²)
1	Maintenance area	90.000
2	Administration area	63.000
3	Welfare facilities area	63.000
4	Tank yard	105.000
5	〃 (Extension)	105.000
6	EO/EG	23.000
7	〃 (Extension)	23.000
8	V.C.M	28.000
9	〃 (Extension)	28.000
10	Ethylen	40.000
11	〃 (Extension)	40.000
12	Utilities area	51.000
13	〃 (Extension)	51.000
14	Electrolysis	34.500
15	〃 (Extension)	34.500
16	P.V.C	42.000
17	〃 (Extension)	42.000
18	L.D.P.E	60.000
19	〃 (Extension)	60.000
20	H.D.P.E	30.000
21	〃 (Extension)	30.000
22	P.P	45.000
23	〃 (Extension)	45.000
24	Storage area. Bulk salt	28.250
25	〃 〃 (Extension)	28.250
26	Storage area. P.V.C	35.000
27	〃 〃 (Extension)	35.000
28	Storage area. L.D.P.E	50.000
29	〃 〃 (Extension)	50.000
30	Storage area. H.D.P.E	25.000
31	〃 〃 (Extension)	25.000
32	Storage area. P.P	37.500
33	〃 〃 (Extension)	37.500
34	Landing area	25.000
	Others (Road, Green belt, Unoccupied ground)	299.500
	TOTAL	2.360.000

NOTE

---- Green belt (221.500 M²)

---- Unoccupied ground (303.400 M²)

Road (274.600 M²)

A ISSUE 3/13/74

TOYO ENGINEERING CORPORATION
TOKYO JAPAN

TOYO ENG. CO'S JOB NO. 7904 | ACCOUNT | CUSTOMER'S ORDER NO.

PLOT PLAN
FOR PETRO-CHEMICAL PLANT

SCALE. | DWG. NO.

DRAWING STARTED | APPROV. | DATE

JOB	REV.	ISSUE	REV.	DESCRIPTION	DWN.	CHKD.	SC.CH	J.ENG	PROC.	P.ENG	APPR.	DFT MGR.	DATE	CUST APPR.	MICRO
7904	1		1										3/13		

DWG. NO.

Allocation of Utilities and Service Facilities to each process plant in case 3 is shown in Table II-55

5-4 Land Requirement

Considering the factors that the construction of each process plant will be simultaneously undertaken and that the land cost is not high as well as taking into consideration the factors of facility operation and maintenance servicing, the rate of the "inside battery limit" within the plant premises is determined as 25%. The required land areas in each case for the instances of turning out no future expansion and with future expansion will be as shown below:

	Case-1	Case-2	Case-3
Area for L.S.B.L.	23.1 ha	41.4 ha	29.5 ha
Incl. expansion	(46.2)	(82.8)	(59.0)
Total plant area	92.4	165.6	118.0
Incl. expansion	(157.6)	(281.5)	(200.6)

5-5 Project Schedule

5-5-1 Construction

Construction period is assumed as being approximately thirty months after the conclusion of the contract in terms of mechanical completion and the construction schedule of olefin complex will be as follows.

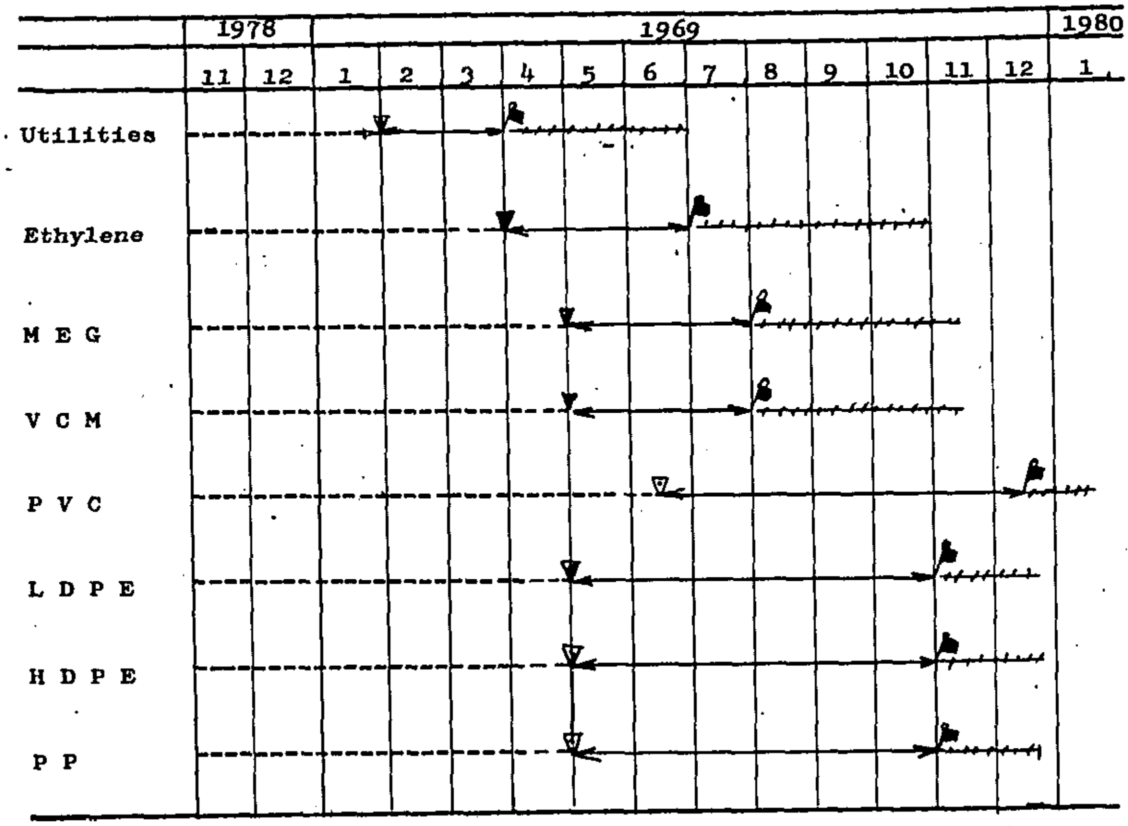
Construction completion	Placement of order for machinery & equipt.	Contract conclusion for plant constr.
March, 1979	From Jan. to March, 1977	Oct., 1976

5-5-2 Test operation period, employment of the necessary personnel and technical training.

(1) Test operation of plants

In the present survey, it is tentatively scheduled that the mechanical completion of the plant will be achieved in March 1979. However, considering the test operation period in practical terms, it is not necessary to achieve simultaneous completion for the whole plant. Instead, it would be necessary to follow the undermentioned procedure (Refer to Table II-56. The Test Operation Period for Petrochemical Industrial Plants).

Table II-56 Petrochemical Complex Pre-operation Schedule



NOTE: ----- Construction Period

▽ Mechanical Completion

——— Testing Operation

Starting Operation

Normal Operation

(a) Firstly, it is necessary to complete the test operations (for approximately two months) of the utilities plants prior to the commencement of the test operation of the ethylene plant.

(b) The test operations for EG, VCM, LDPE, HDPE and PP plants shall be commenced in one month after the commencement of the test operation of the ethylene plant.

(c) Regarding the PVC plant, the test operation shall be started in 1.5 months after the commencement of the VCM plant test operation.

(d) Regarding the monomer plants for ethylene, EG and VCM, approximately three months each should be allocated as the test operation period.

(e) Concerning the respective polymer plants for PVC, LDPE, HDPE and PP, it would be necessary to allocate approximately six months each for test operations.

(2) Employment of the necessary personnel, the employment timing and the technical training to be given.

Strictly speaking, it is impossible to estimate uniform figures for all the plants concerning this point due to the fact that the extent of difficulty in learning the operational technique of each plant varies depending upon the adopted process.

Nevertheless, generally speaking, the under-mentioned training will be required in any case.

(a) Actual on-the-field training

On the assumption that the construction works for all the plants will be completed in March 1979, the employment of all the necessary employees should be completed one year prior to the scheduled completion of the works. For the period of one year until the plant construction completion, the employees should engage in the plant construction works in order to be trained on the basis of on-the-field training periods. Compared with oil refinery plants, etc., the petrochemical industrial plants have complicated and vital relationships amongst the sections of the process. It is therefore absolutely necessary to give sufficient practical training even during the construction period regarding the relationship among the sections of the process in order to smoothly commence the test operation.

(b) Dispatchment of key operational personnel to overseas plants.

Prior to the excecution of the above-mentioned on-the-field training, at least the under-mentioned number of personnel should be dispatched (excluding the utility plants for which such dispatchment is considered to be unnecessary) to overseas plants in order to receive technical training for approximately six months.

1) Operation personnel

Superintendent (or Manager): 1 person
Staffs (candidates for future superintendent): 2 persons

Responsible personnel: 4 persons

2) Analysis Personnel, etc.

Personnel responsible for analysis (or superintendent): 2 persons
Superintendent in Administration Dip. (or Manager): 1 person

As mentioned above, at least 11 persons each times eight plants, totalling 88 persons selected from the key personnel should be dispatched to overseas plants for receiving actual training.

(3) Technical assistance by expatriate experts for each plant.

On the assumption that periodical shut-down for approximately one month every year should be undertaken for each plant of the petrochemical industry, it seems necessary to receive a considerable extent of technological assistance by expatriate expert engineers until the local personnel experience at least twice each of "operation starting" and "shut-down". In this connection also, there are a considerable degree of difference in the difficulty depending upon the complexity of the technology involved in each one of the process. However, generally speaking, the under-mentioned extent of operation and assistance will be necessary.

(a) During the on-the-field training, test operation period and commercial operation period

For the period of six months after the commencement:

Director, Manager and Superintendent: 1 each

Staffs: 2 persons

Foreman: 4 persons (of which one person on shift)

Operators: 8 persons (of which two persons on shift)

Total: 17 persons

Grand Total: 17 persons x 8 plants = 136 persons

(b) For one year from the 7th to the 18th month after the commencement of the commercial operation:

Director, Manager and Superintendent and Staffs: 1 person each
Foreman: 4 persons (of which one person on shift)

Total: 8 persons

Grand Total: 8 persons x 8 plants = 64 persons

During this period, one expatriate engineer stationed for each shift of three shifts on-duty schedule will be sufficient. Concerning the staffs, one expatriate expert will be sufficient.

(c) Period from the 18th month from the commencement of commercial operation

During this period, the on-shift stationing of one expatriate expert will be necessary. Therefore, four such experts in each plant should take up the administrator and staffs positions as follows:

Director, Manaqer, Superintendent and staffs: each

Total: 4 x 8 plants = 32 persons

Chapter 6. Effects of Changes in the Raw Material Hydrocarbon Conditions

At a meeting held with the government of Indonesia, information was given by the authorities that, concerning the olefin plant project, 450,000 tons of ethylene will be produced on the ethane feed basis in the Arun district of North Sumatra, and concerning the price of LNG, the FOB price on the Minas naphtha basis will be applied. Because of the fact that the above-mentioned conditions are different from those which were given to us at the time of January meeting in the gas composition and the gas price, studies were made by us on the extent of the effects of such differences. This chapter will describe the studies and the results thereof.

6-1 Effects Exerted by Change in Gas Price

The prices of the raw materials, intermediate products (naphtha, ethylene, etc.) and the final products (plastics) mentioned in this report have been calculated on the basis of the Middle East crude oil price ($9.36/bbl) prevailing as of January 1974. Also, the construction costs stipulated of the checking points, although 7% per year inflation factor has duly been taken into consideration. It must be regretfully admitted at this stage that construction cost and other relative costs have since been increasing at a rate higher than 7% per year.

In view of the above-mentioned factors, it has been decided that the January 1974 price of Minas crude ($10.8/bbl FOB) shall be taken as the basis for the FOB North Sumatra price for LNG. (The Minas crude price as of August 1974 was $11.7/bbl).

6-1-1 Prices of raw material gas, raw material condensate, by-products, fuel gas, and utilities

(1) Raw material natural gas price

The January 1974 price of Minas crude was $10.8/bbl FOB. On the other hand, the mid-1973 FOB price of Minas crude was $6/bbl and the FOB price of LNG was ¢99/MMBTU. Therefore, if an assumption is made here concerning 90% of the LNG price is calculated on the basis of the Minas crude price proportion, and the remaining 10% on the basis of 3% per year escalation rate, the FOB price of LNG as of January 1974 can be calculated as follows:

$$\text{LNG (FOB) price} = 0.99 \times 90\% \times 10.8/6 + 0.99 \times 10\% \times 1.03 = \$1.70/\text{MMBTU}$$

Therefore, if it is assumed that the liquefying cost for LNG is ¢70/MMBTU, the raw material liquid gas at the entrance of the plant will be:

$$\text{Raw material gas price} = 1.70 - 0.70 = \$1.0/\text{MMBTU} = \$3.97/\text{MMKcal}$$

@ January, 1974

When the escalation factor is taken into account, the 1980 price will be calculated as under:

$$\text{Raw material gas price} = \$1.00/\text{MMBTU} \times (1.07)^6$$
$$= \$1.5/\text{MMBTU}$$
$$= \$5.95/\text{MMKcal} \quad @1980$$

(2) Raw material condensate price

In the same manner as described in Paragraph 2 of Chapter 1, an estimate on the C_2^+ condensate price will be made by taking the liquefying cost allocation into consideration.

The calculations will be as follows:

$$C_2^+ \text{ condensate price} = \$1.00/\text{MMBTU} + \$0.015/\text{MMBTU}$$
$$= \$1.02/\text{MMBTU} \quad @\ 1974$$

If the escalation factor is taken into account:

$$= 1.02 \times (1.07)^6 = \$1.52/\text{MMBTU}$$
$$= \$6.04/\text{MMKcal} \quad @1980$$

Therefore, per ton price will be:

$$= \$6.04/\text{MMKcal} \times 11{,}327\ \text{Kcal/kg}$$
$$= \$68.3/\text{t} \quad @1980$$

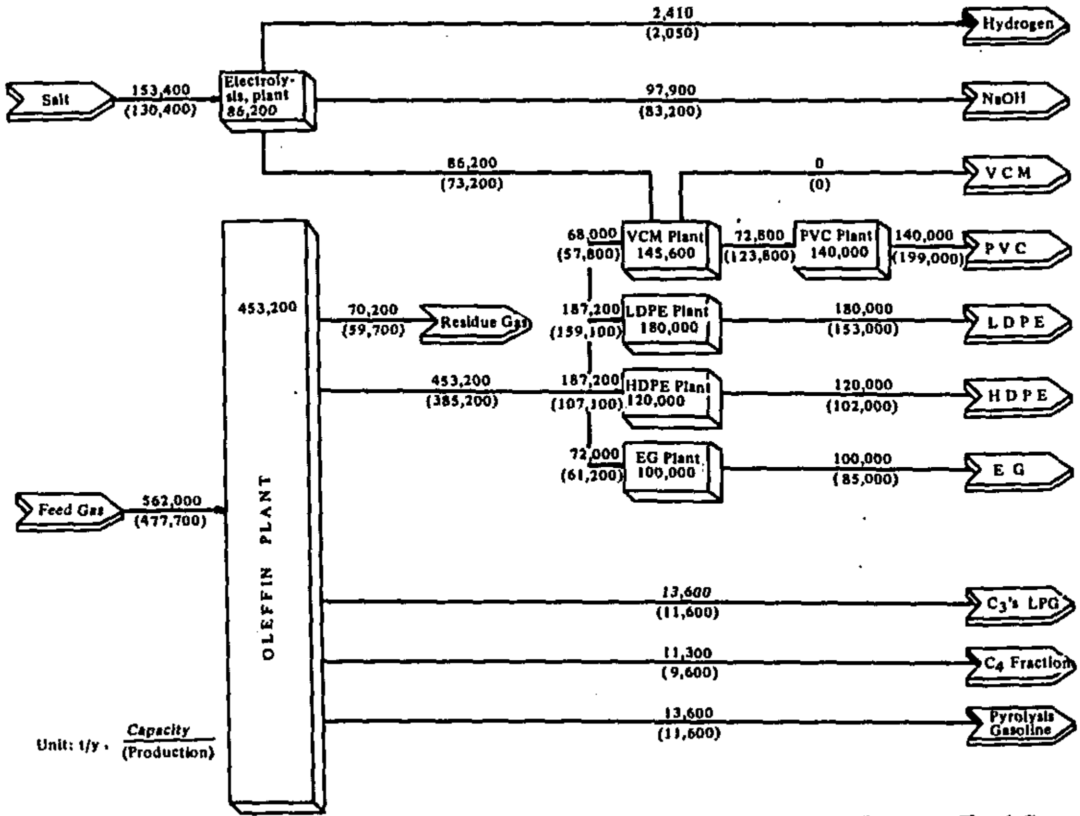


Figure II-16 Process Flow and Balance for Ethylene Feed Complex

6-1-2 By-product prices

The prices of hydrogen and the remaining gas will be affected by the changes made to the price of the fuel gas (i.e., natural gas price), so that the following calculation will ensue:

Hydrogen price = 28.67/MMKcal/t x $5.95/MMKcal = $170.6/t

Remaining gas price = 11.95MMKcal/t x $5.95/MMKcal = $71.1/t

6-1-3 Utilities prices

The utilities prices will also change due to the increment in the fuel gas price. In the same manner as in paragraph 5 of Chapter 1, Case 3 (North Sumatra, 300,000-ton capacity) will be taken as the base case for calculation. (Shown Table II-57)

Electric Power	¢5.8/KWH
Fuel	$5.95/MMKcal

Table II-57 Utility Price - Price of NG Based on Minas Crude Oil

Item		
Stream Factor		85%
Electric Power	$/KWH	0.058
10^k - 20^k Steam	$/t	3.4
Sea Water	$/t	0.034
River Water	$/t	0.12
Filtered Water	$/t	0.25
Deminerized Water	$/t	0.54
Polished Water	$/t	0.84
Instrument Air	$/Nm³	0.027
Oxygen	$/Nm³	0.048
Plant	$/Nm³	0.048
Inert Gas	$/Nm³	0.027
Steam Condensate	$/t	0.53
Fuel Gas	$/MMKcal	5.95

6-1-4 Economical viability of the petrochemical complex assessed on the basis of Minas crude oil

Economical viability calculations were made concerning three cases of the complex, i.e., ethylene production capacities of 200,000 t/y, 300,000 t/y, and 450,000 t/y, on an assumption that North Sumatra will be the site. The obtained calculation results are shown in summary in Tables II-58 through II-60.

The comparison of the profitability of the whole complex with the said price of hydrocarbon and with the price of ¢63/MMBTU for the year of 1974, the following results shown in Table II-17(2) is obtained.

Also, the results shown in Table II-17(1) is obtained regarding each process plant in 300,000 MTA ethylene production capacity complex.

6-2 Olefine Complex on Ethane Feed

6-2-1 Establishment of complex scheme

A complex scheme for 450,000 t/y ethylene production capacity was established on the basis of the domestic demand forecast. (Case 4) In other words, in consideration of the scope of the domestic demand and the growth rate thereof, the scheme was so established that the domestic demand level will meet the capacities of derivative plants in 4 to 5 years after the commencement of the plant operation. (refer to Table II-60) When ethane is thermally cracked the propylene yield is so low that the capacity of a PP plant will not be able to attain the economical minimum scale (refer to Table II-3). Therefore, an assumption was made here that the demand for PP will be covered by the production of HDPE. Further, the production of benzene will attain a level of 400,000 t/y available form the aromatics complex project. Therefore, there is a strong possibility of producing stylene monomer on the basis of the produced benzene. However, this point has not been included within the scope of this study for the reason that such alternative production will vastly exceed the domestic demand level.

Process flow and material balance of Case 4 is shown in Figure II-16. The summary of economic viability is shown in Table II-61.

Also, in order to compare the effector of production scale, the economic calculation on the complex 300,000 MTA ethylene production capacity, whose each process plant capacity is slided down with the Case 4 was carried out. The results is shown in Table II-62.

The economic calculations were made on the basis of the Minas crude oil as of January 1974. The economic viability comparison between the ethane case and the gas condensate case, whose gas analysis has been assumed on the Interim Report, is as Table II-18.

Table II-58 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material Based on Minas Crude Oil, Capacity 200,000 MTA

Purpose of Study: Correction of Raw Materials and Fuel Price, North Sumatra

Cal Number : No. A-3

Case Number : No. 3

Ethylene Production Capacity: 200,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA	200,000	200,000	41,000	69,000	80,005
Investment	10^6 $	610.3	132.3	47.9	49.3	142.1
I.R.R.	%	12.30	15.0	15.0	15.0	11.9
Break Down of Unit Production Cost @ 1980	Variable Cost		58.64	-3.10	352.99	363.53
	Fixed Cost		145.24	282.36	169.46	384.11
	Distri. & Admini.		7.39	10.53	17.32	40.51
	Total Production Cost		211.27	289.78	539.78	788.15
Average Sales Price $/t			246.24	350.95	577.50	833.0

		H D P E	P V C	E G	P P
Plant Capacity	MTA	33,000	67,000	67,000	46,000
Investment	10^6 $	48.2	51.5	70.3	68.7
I.R.R.	%	10.8	0	17.9	16.1
Break Down of Unit Production Cost @ 1980	Variable Cost	364.39	623.2	220.63	333.62
	Fixed Cost	366.42	199.9	230.81	358.75
	Distri. & Admini.	38.45	39.34	18.09	40.33
	Total Production Cost	769.27	862.41	469.52	732.69
Average Sales Price $/t		764.41	794.0	553.0	827.0

Table II-59 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material Based on Minas Crude Oil, Capacity 300,000 MTA

Purpose of Study: Correction of Raw Materials and Fuel Price, North Sumatra
Cal Number : No.A-1
Case Number : No. 3
Ethylene Production Capacity: 30,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA	300,000	300,000	62,000	104,000	120,000
Investment	10^6 $	802	176	62.6	64.5	185.9
I.R.R.	%	17.0	15.0	15.0	15.0	17.8
Break Down of Unit Production Cost @ 1980	Variable Cost		63	26.7	328	342.4
	Fixed Cost		125	234.9	140.8	325.7
	Distri. & Admini.		6.8	9.7	15.5	39.9
	Total Production Cost		194.8	271.4	484.3	708.0
Average Sales Price $/t			225.9	324	517.2	814.1

		H D P E	P V C	E G	P P.
Plant Capacity	MTA	50,000	100,000	100,000	69,000
Investment	10^6 $	63.1	67.7	91.8	90.0
I.R.R.	%	15.2	12.3	21.6	22.7
Break Down of Unit Production Cost @ 1980	Variable Cost	343.1	560.5	206.0	315.1
	Fixed Cost	303.1	164.5	194.9	299.0
	Distri. & Admini.	37.4	38.1	16.7	39.3
	Total Production Cost	683.5	763.1	417.6	653.4
Average Sales Price $/t		727.9	752.4	505.3	794.3

Table II-60 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material Based on Minas Crude Oil, Capacity 450,000 MTA

Purpose of Study: Correction of Raw Materials and Fuel Price, North Sumatra
Cal Number : No. A-2
Case Number : No. 3
Ethylene Production Capacity: 450,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		450,000	92,000	156,000	180,000
Investment	10^6 $	1,054.7	235.6	81.9	84.4	243
I.R.R.	%	20.2	15.0	15.0	15.0	22.3
Break Down of Unit Production Cost @ 1980	Variable Cost		66.56	50.92	307.38	324.64
	Fixed Cost		108.26	196.77	117.82	277.08
	Distri. & Admini.		6.27	9.10	14.04	38.52
	Total Production Cost		181.08	256.79	439.24	640.24
Average Sales Price $/t			208.85	303.40	468.01	766.71

		H D P E	P V C	E G	P P
Plant Capacity	MTA	75,000	150,000	150,000	104,000
Investment	10^6 $	82.7	89.0	120.0	117.9
I.R.R.	%	19.5	21.7	23.6	28.6
Break Down of Unit Production Cost @ 1980	Variable Cost	325.14	509.34	193.71	299.52
	Fixed Cost	252.57	136.42	165.45	250.86
	Distri. & Admini.	36.63	36.74	15.61	38.66
	Total Production Cost	614.34	682.50	374.76	589.04
Average Sales Price $/t		703.63	707.24	470.20	766.71

As is shown in the table the ethane case as compared with the gas condensate case displays a deterioration in economic viability. This is due to the rise of production cost of ethylene caused by the decrease of by-products credit in olefin plant.

Table II-61 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material - Ethane - Based on Minas Crude Oil, Capacity 450,000 MTA

Purpose of Study: Correction of Raw Materials and Fuel Price, North Sumatra
Cal Number : No. B-2
Case Number : No. 4
Ethylene Production Capacity: 302,000 MTA

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		302,000	57,500	97,000	120,000
Investment	10^6 $	700	169.2	59.8	61.9	186.5
I.R.R.	%	14.8	15.0	15.0	15.0	14.0
Break Down of Unit Production Cost @ 1980	Variable Cost		120.64	22.09	354.44	395.99
	Fixed Cost		119.17	242.22	145.67	326.13
	Distri. & Admini.		8.32	9.86	16.52	39.94
	Total Production Cost		248.13	274.17	516.63	762.06
Average Sales Price $/t			277.45	328.78	550.53	813.98

		H D P E	P V C	E G	P P
Plant Capacity	MTA	80,000	93,000	67,000	0
Investment	10^6 $	87.3	64.8	70.4	0
I.R.R.	%	21.3	6	15.5	0
Break Down of Unit Production Cost @ 1980	Variable Cost	397.17	595.16	243.10	362.08
	Fixed Cost	247.10	170.15	230.99	0
	Distri. & Admini.	39.27	38.38	18.09	0
	Total Production Cost	683.54	803.69	492.17	362.08
Average Sales Price $/t		791.68	761.94	553.00	0

Table II-62 Summary of Investment Unit, Production Cost & Profitability of Each Process Plant & Total Complex. Price of Raw Material - Ethane - Based on Minas Crude Oil, Capacity 300,000 MTA

Purpose of Study: Correction of Raw Materials and Fuel Price, North Sumatra
Cal Number : No.B-1
Case Number : No.4
Ethylene Production Capacity: 453,000 MTA
Price of NG: : 100 ¢/MMBTU @1974

		Complex Total	Ethylene	Chlorine	V C M	L D P E
Plant Capacity	MTA		453,000	86,000	145,600	180,000
Investment	10^6 $	920.1	225.4	78.3	81.0	243.8
I.R.R.	%	18.07	15.0	15.0	15.0	18.5
Break Down of Unit Production Cost @ 1980	Variable Cost		120.64	47.13	332.03	375.15
	Fixed Cost		102.96	202.70	121.84	277.59
	Distri. & Admini.		7.72	9.20	14.95	38.52
	Total Production Cost		231.33	259.04	468.82	691.26
Average Sales Price $/t			257.41	306.73	498.47	766.71

		H D P E	P V C	E G	P P
Plant Capacity	MTA	120,000	140,000	100,000	0
Investment	10^6 $	114.4	85.2	92.0	0
I.R.R.	%	26.9	16.5	19.1	0
Break Down of Unit Production Cost @ 1980	Variable Cost	376.13	541.01	228.67	
	Fixed Cost	207.55	140.98	195.16	0
	Distri. & Admini.	37.91	36.93	16.66	0
	Total Production Cost	621.58	718.92	440.49	
Average Sales Price $/t		746.18	713.68	505.30	0

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ANNEX I

RAW MATERIALS AND PRODUCTS PRICES

CONTENTS

Chapter 1. Crude Oil

Tables AI-1-1 through 3 respectively exhibits past trend of rising in Middle East countries' posted price, market price, governmental taxes and royalty: all of which are put into the graphic form as given in Figures AI-1-1 and AI-1-2; and, historical backgrounds are shown in Table AI-1-4.

Crude oil prices gradually started increasing in 1971 and have shown a very rapid increase since October, 1973. At the moment, prices are being discussed by OAPEC and related concerns, and it has been said that some price reduction proposals were submitted, but chances are remote that they will pass, and that present price levels will be maintained.

It is natural that inflation per se will influence crude oil prices which held the greatest share of the world energy market, and is, therefore, a very difficult problem to handle to the satisfaction of all concerned.

As we see it, crude price increases have resulted in a 20% increase in construction costs, and we anticipate that inflation will grow at a rate of 7% annually. If we accept this general inflationary trend, it appears that crude oil prices will follow this inflationary trend.

Crude oil prices, at the moment, are being decided politically rather than by production cost or by the balance between supply and demand. Should any change occur in this situation, if would be brought about by an alternative energy source becoming quantitatively competitive with crude oil.

It is rather difficult to predict when this will happen, but crude oil strength will remain as it is now until the mid 1980s. Crude oils importance as an organic raw material will be emphasized because of the short supply of crude oil.

Since it is not known when such influences will appear on the crude oil price, we would apply, for the present, the aforementioned conditions for the purpose of this estimation.

Chapter 2. Product Pricing

In performing economic claculations on the Indonesian petrochemical complex, the method of determining product prices would play a very important role. The below mentioned three concepts are being considered as the fundamental ones;

(1) Import price as the criteria:

In the project, all products shall be made available by importation until domestic production is started. This concept signifies that import prices determine the pricings of domestic products. Importation from Japan is assumed as the subject import prices. However, importation from the Middle East was also considered, and trial calculations of production costs with importation from the Middle East were also carried out (Refer to Annex IX International Competitiveness of Petrochemical Industry.)

Table AI-1-1 Trends in Posted Prices of Middle East Crude Oils

(Unit: US$/bbl)

	API	1971 2/15 (up to)	2/15	6/1	1972 1/20	1973 1/1	4/1	6/1	7/1	8/1	10/1	10/16	11/1	12/1	1974 1/1
Saudi Arabia															
Arabian Light	34	1.800	2.180	2.285	2.479	2.591	2.742	2.898	2.955	3.066	3.011	5.119	5.176	5.036	11.651
Arabian Medium	31	1.680	2.085	2.187	2.373	2.482	2.626	2.776	2.830	2.936	2.884	4.903	4.957	4.822	11.561
Arabian Heavy	27	1.560	1.960	2.064	2.239	2.345	2.481	2.623	2.674	2.755	2.725	4.633	4.684	4.557	11.441
Iran															
Iranian Light	34	1.790	2.170	2.274	2.467	2.579	2.729	2.884	2.940	3.050	2.995	5.341	5.401	5.254	11.875
Iranian Heavy	31	1.720	2.125	2.228	2.417	2.527	2.674	2.826	2.881	2.989	2.936	4.991	5.046	5.006	11.635
Kuwait															
Kuwait	31	1.680	2.085	2.187	2.373	2.482	2.626	2.776	2.830	2.936	2.884	4.903	4.957	4.822	11.545
Abu Dhabi															
Murban	39	1.880	2.235	2.341	2.540	2.654	2.808	2.968	3.026	3.140	3.084	6.045	6.113	5.944	12.636
Umm Shaif		1.860	2.225	2.331	2.529	2.642	2.796	2.955	3.013	3.126	3.070	5.537	5.599	5.446	12.086
Zakum		-	-	-	-	-	-	-	-	-	-	5.964	6.031	5.865	12.566
Iraq															
Basra		1.720	2.155	2.259	2.451	2.562	2.711	2.865	2.921	3.031	2.977	5.061	5.117	4.978	11.672
Qatar															
Dukhan		1.930	2.280	2.387	2.590	2.705	2.862	3.025	3.084	3.200	3.143	5.834	5.899	5.737	12.414
Qatar Marine		1.830	2.200	2.305	2.501	2.614	2.766	2.923	2.980	3.092	3.037	5.503	5.563	5.412	12.013
Neutral Zone															
Khafuji	28	1.550	1.970	2.069	2.245	2.351	2.487	2.630	2.681	2.782	2.732	4.644	4.695	4.573	11.461
Hout	35	1.810	2.185	2.290	2.484	2.596	2.747	2.903	2.960	3.071	3.016	5.127	5.184	5.050	11.701

Table AI-1-2 Market Price of Crude Oils in Persian Gulf

(Unit: US$/bbl)

		1970		1971		1972	1973									1974
	API	1/1	11/14	2/15	6/1	1/20	1/1	4/1	6/1	7/1	8/1	10/1	10/16	11/1	12/1	1/1
Arabian Light	34	1.350	1.440	1.700	1.800	1.900	2.100	2.200	2.300	2.500	2.550	2.750	3.650	3.697	3.601	8.322
Arabian Medium	31	1.250	1.350	1.650	1.700	1.800	1.950	2.050	2.150	2.350	2.400	2.500	3.500	3.541	3.449	8.258
Arabian Heavy	27	1.200	1.300	1.550	1.600	1.700	1.850	1.950	2.050	2.200	2.300	2.400	3.310	3.346	3.259	8.172
Iran Light	34	1.350	1.400	1.700	1.800	1.900	2.100	2.200	2.300	2.500	2.600	2.750	3.640	3.858	3.757	8.482
Iran Heavy	31	1.250	1.350	1.650	1.750	1.850	2.050	2.150	2.250	2.400	2.500	2.650	3.560	3.604	3.511	8.311
Kuwait	31	1.250	1.350	1.650	1.700	1.800	1.950	2.050	2.150	2.350	2.400	2.500	3.500	3.541	3.449	8.246
Murban	39	1.500	1.550	1.850	2.000	2.100	2.350	2.450	2.550	2.850	2.900	3.050	4.520	4.366	4.251	9.026
Khafuji	28	1.280	1.394	1.662	1.644	-	1.819	1.976	2.065	2.097	2.160	2.279	3.320	3.358	3.279	8.186
Hout	35	1.380	1.456	1.695	1.742	-	1.931	2.121	2.218	2.253	2.322	2.488	3.660	3.705	3.618	8.358

Table AI-1-3 Trends in Governmental Tax & Royalty on Crude Oil

(Unit: US$/bbl)

	1971			1972	1973									1974
	2/15 (up to)	2/15	6/1	1/20	1/1	4/1	6/1	7/1	8/1	10/1	10/16	11/1	12/1	1/1
Saudi Arabia														
Arabian Light	0.989	1.261	1.325	1.448	1.516	1.607	1.702	1.736	1.804	1.770	3.048	3.083	2.998	7.008
Arabian Medium	0.930	1.203	1.265	1.384	1.450	1.537	1.628	1.661	1.725	1.694	2.917	2.950	2.868	6.954
Arabian Heavy	0.043	1.106	1.169	1.302	1.367	1.449	1.535	1.566	1.627	1.597	2.754	2.785	2.708	6.881
Iran														
Iranian Light	0.983	1.250	1.313	1.430	1.497	1.588	1.683	1.717	1.783	1.750	3.172	3.208	3.119	7.133
Iranian Heavy	0.944	1.222	1.285	1.400	1.466	1.555	1.647	1.681	1.746	1.744	2.960	2.993	2.969	6.988
Kuwait														
Kuwait	0.958	1.231	1.293	1.406	1.472	1.559	1.650	1.683	1.747	1.716	2.939	2.972	2.890	6.966
Abu Dhabi														
Murban	1.005	1.272	1.337	1.458	1.527	1.620	1.717	1.752	1.821	1.787	3.582	3.623	3.521	7.578
Umm Shaif	0.966	1.239	1.288	1.391	1.460	1.553	1.650	1.685	1.753	1.720	3.192	3.229	3.137	7.162
Zakum	-	-	-	-	-	-	-	-	-	-	3.451	3.492	3.391	7.453
Iraq														
Basra	0.933	1.240	1.303	1.419	1.487	1.578	1.671	1.705	1.772	1.739	3.002	3.036	2.952	7.010
Qatar														
Dukhan	1.052	1.316	1.381	1.493	1.546	1.641	1.740	1.776	1.847	1.812	3.443	3.482	3.384	7.432
Qatar Marine	0.924	1.196	1.260	1.351	1.464	1.556	1.651	1.686	1.754	1.720	3.215	3.252	3.160	7.162

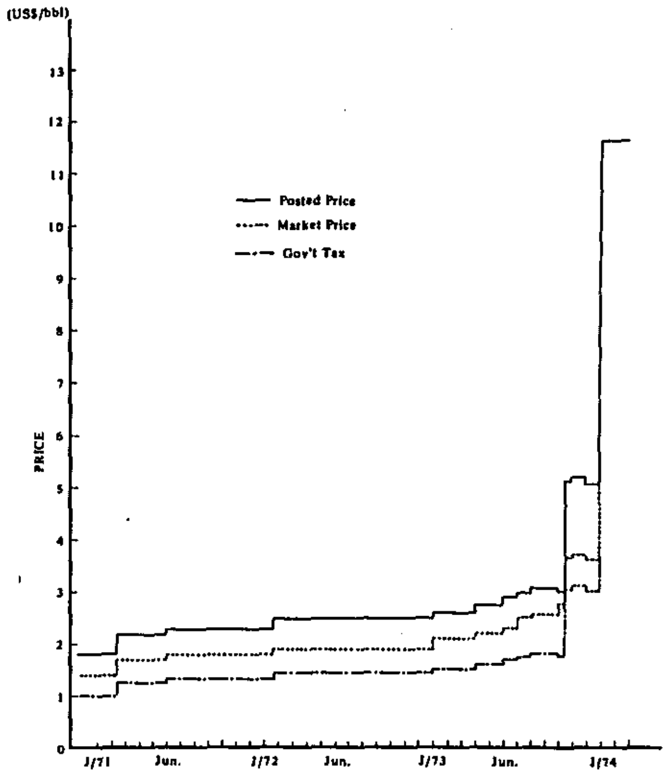


Figure AI-1-1 Trend in Crude Oil Prices (Arabian Light)

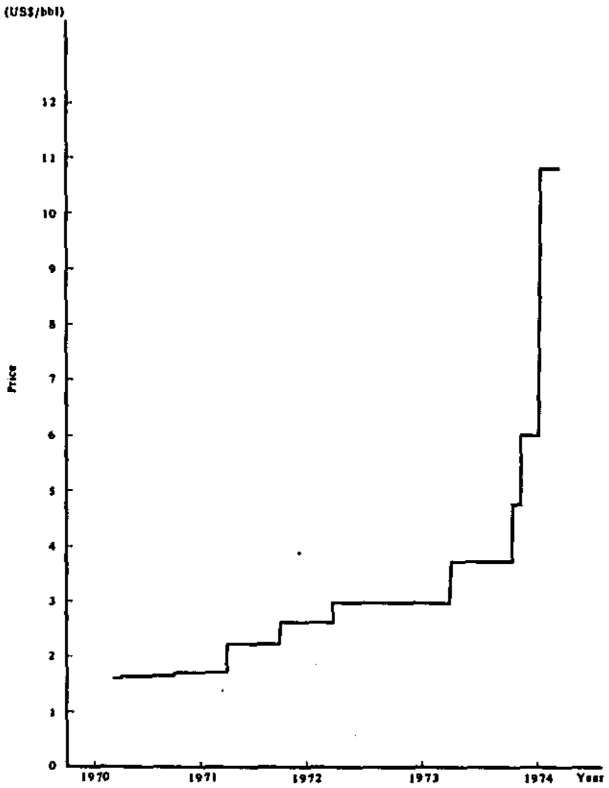


Figure AI-1-2 Trend in Crude Oil Prices (Market Price, FOB) (Indonesian Minas Crude)

Table AI-1-4 Trends of Crude Oil Price and Remarks

Date Effective	Remarks		Posted Price of Arabian Light (US$/bbl)
Prior to Nov. 14, 1970			1.800
Nov. 15, 1970	OPEC,	Tax Rate Increae from 50% to 55%	1.800
Feb. 15, 1971	OPEC,	Posted Price Increase	2.190
June 1, 1971	OPEC,	Posted Price Increase	2.285
Jan. 1, 1972	OPEC,	Inflation Adjustment	2.479
Jan. 1, 1973	OPEC,	Inflation Adjustment	2.591
Jan. 1973	Major Oil,	Market Adjustment Price Increase due to *Stringency between Demand & Supply*	
	OPEC,	Price Increase by Enterprises Participation Agreement	
April 1, 1973	OPEC,	Provisional Increase by Geneva Conventions	2.742
	Indonesia	Indonesian Crude Oil Price Increase	
June 1, 1973	OPEC,	Price Increase by New Geneva Conventions	2.896
From April to June,1973	Major Oil,	Price Increase due to Market Adjustment	
July 1, 1973	OPEC,	Price Increase by New Geneva Conventions	2.955
Aug. 1, 1973	OPEC,	Price Increase by New Geneva Conventions	3.066
From July to Sep.,1973	Major Oil,	Market Adjustment Price Increase	
Oct. 1, 1973	OPEC,	Price Decrease by New Geneva Conventions	3.011
	Indonesia,	Indonesian Crude Oil Price Increase	
	Major Oil,	Market Adjustment Price Increase	
Oct. 16, 1973	OAPEC,	Price Unilaterial Increase by 6 Arabian Gulf Countries	5.119
Nov. 1973	Indonesia,	Indonesian Crude Oil Price Increase	
Jan. 1, 1974	OAPEC,	Price Unilaterial Increase by 6 Arabian Gulf Countries	11.651

(2) Production cost as the criteria:

On such an occasion where either an exclusivity or oligopoly is being maintained for the petrochemical industry, and the production cost thereof is internationally optimized, then the market price will be determined by adding optimum profit and distribution cost to production cost.

(3) Relationship of demand and prices as the criteria:

While this concept correlates to the above mentioned (1) and (2), prices will go down as the demand increases, and demand will increase as prices go down. The elasticity in prices is different depending on the country and on the product that is being considered; and also whether the product is in development, maturity, or in the declining state.

In this chapter a description of price estimation will be given, based on the above mentioned concepts.

2-1 Exfactory prices of petrochemical products in the U.S.A. and Japan

2-1-1 Exfactory prices of petrochemical products in the U.S.A.

The figures in the aforementioned chapter become sort of standard market prices. However, the market prices contain distribution costs and, the prices differ depending on the delivery quantity, thus it is necessary to investigate exfactory prices.

Table AI-2-1 exhibits the trends of average exfactory unit price of petrochemical products in the United States calculated from the statistical data published by the Customs Association. Figure AI-2-1 illustrates these trends from which it is seen that low-density polyethylene, polystyrene, and PVC are maintaining a stabilized price level since 1968, but prices on high-density polyethylene and polypropylene were still demonstrating lowering trends as of 1971. On the contrary, prices of VCM, styrene monomer, ethylene, propylene and all other monomers are holding at a stabilized level. However, propylene prices are gradually going up and the gap between ethylene and propylene prices is closing.

Table AI-2-1 Trend of Exfactory Price of Petrochemical Products (Olefin Derivatives) in the U.S.A.

(Unit: US¢/lb)

	Polyethylene		Poly-styrene	PVC	Poly-Propylene	Styrene Monomer	Vinyl Chloride Monomer	Ethylene	Propylene
	Low Density	High Density							
1966	17.3	17.6	17.2	16.6	22.6	8.03	5.92	4.13	2.15
1967	14.7	16.9	18.4	15.1	21.4	7.71	5.27	3.95	2.05
1968	12.1	15.5	17.4	14.0	20.9	6.69	4.57	3.43	2.30
1969	12.1	15.2	17.2	13.7	21.7	-	4.37	3.30	2.48
1970	12.6	14.1	17.1	13.8	19.8	6.47	3.93	3.04	2.67
1971	12.6	12.0	16.3	13.4	17.5	6.03	4.17	3.03	2.65

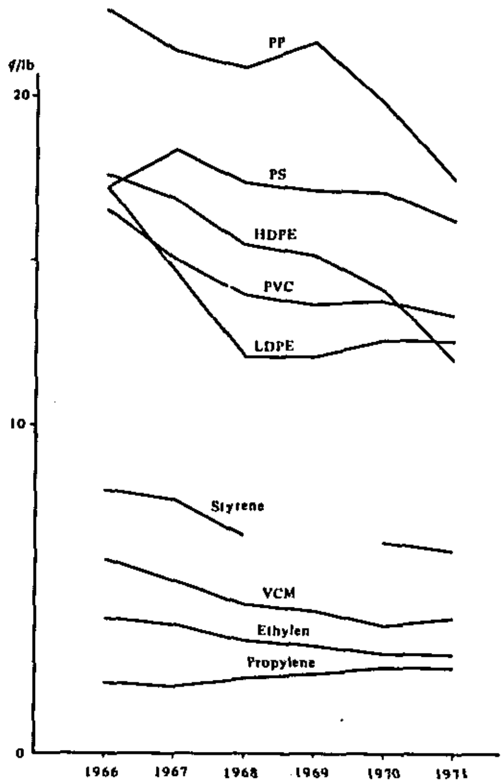


Figure AI-2-1 Trend of Exfactory Prices in the U.S.A.

2-1-2 Exfactory prices of petrochemical products in Japan

Similarly with the case of America, average petrochemical exfactory prices in Japan are calculated from Monthly Chemical Industry Statistics shown in Table AI-2-2 and Figure AI-2-2 from which it will be seen that also in case of Japan, exfactory prices on low-density polyethylene, polystyrene and PVC have been almost stabilized between 1968 and 1972, but the prices on high-density polyethylene and polypropylene have rapidly declined. Nevertheless, prices on these petrochemical products have again started increasing since 1973 and are given in said figure.

2-1-3 Trends on additive value

As the market expanded, prices on petrochemical products showed a lowering trend in general until 1972. Major reasons are as follows:

Scale up of production facilities, rationalization on facilities cost, construction cost and production process; improvements in operational rate and yield rate; increased utilization of by-products,

Table AI-2-2 Trend of Exfactory Price of Petrochemical Products (Olefin Derivatives) in Japan

(Unit : ¥/Kg)

	Polyethylene		Poly-	PVC	Polystyrene	Styrene	Vinyl Chloride
	Low density	High density	propylene			Monomer	Monomer
1966	133	178	197	98.5	171	95.3	64.9
1967	111	176	165	96.5	160	90.7	66.8
1968	98	163	155	94.1	150	84.2	63.8
1969	101	150	145	90.7	144	71.3	59.8
1970	102	138	135	88.4	138	65.3	54.6
1971	100	128	121	83.9	138	61.3	46.3
1972	92	119	107	81.1	141	56.1	44.5

Source: Statistical Year Book of Chemical Industries in Japan

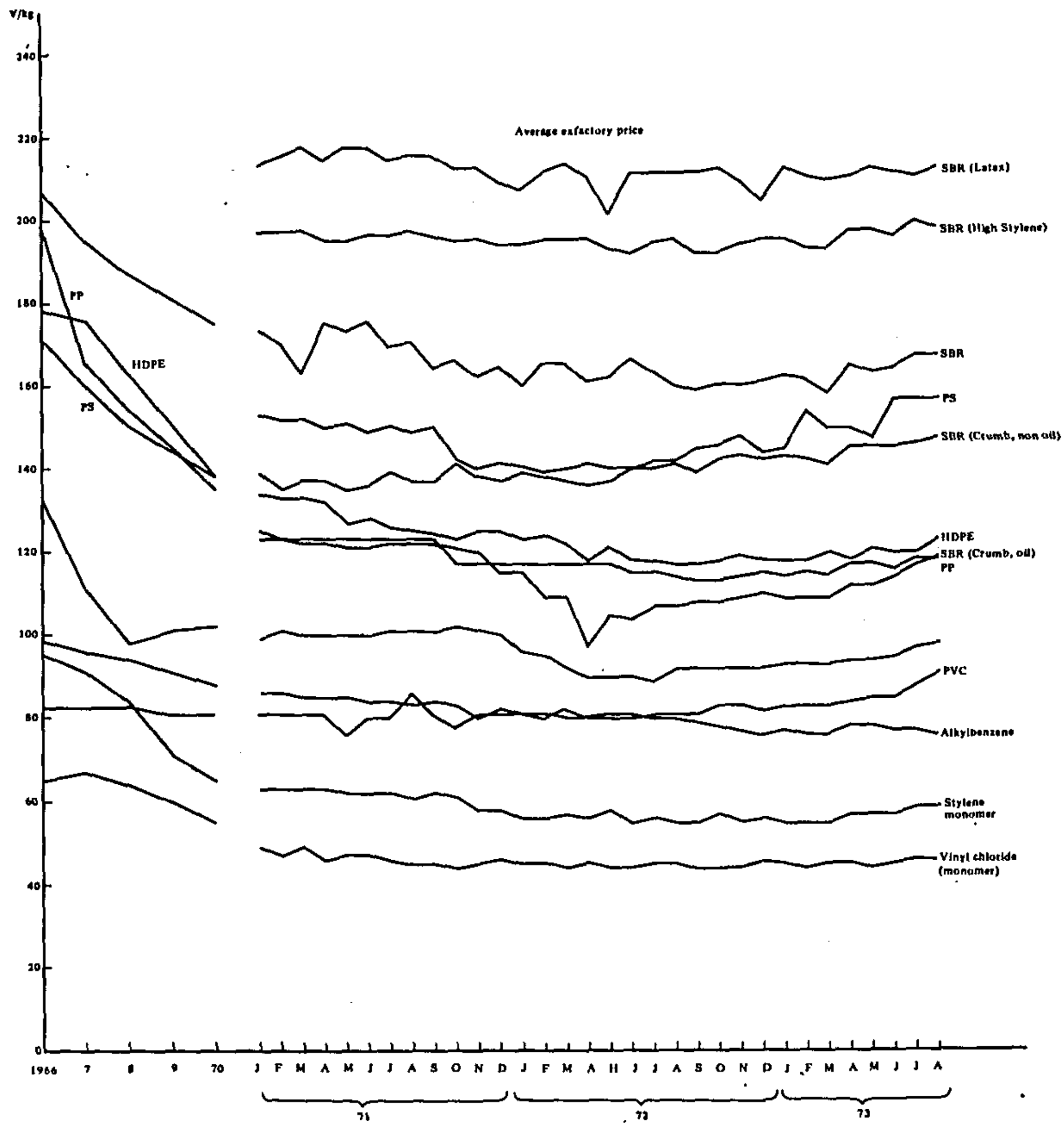


Figure AI-2-2 Exfactory Prices of Petrochemical Products in Japan

etc. However, since 1971, the lowering trend of production costs has levelled off, this is especially true of the Japanese petrochemical industry which has severely suffered from the continuous price decline and fell into structural stagnation as described in the Annex VIII. The increases in petrochemical products after 1972 were due to the world-wide supply shortage started by the Japanese production cartel, increases in crude oil prices and the resultant inflationary influence, thus all these factors reached a level which could no longer be incomposed in production cost. Moreover, the situation was much more aggravated by the additional costs incurred from the installation of pollution control devices. The fluctuation in crude oil prices will directly affect basic material prices such as ethylene, propylene or benzene.

The increases in general commodity prices affects not only construction costs, but also personnel costs, utilities cost, etc. Accordingly, to fully scrutinize these influences, it would be convenient to first separate the raw material cost from additive values.

Table AI-2-3 gives the trends on additive values both in the U.S.A. and in Japan on the representative polymers. The calculation of additive values was made by the following equation:

Table AI-2-3 Trend of Additive Values of Major Polymers

		Polyethylene				
		Low density	High density	Polypro-pylene	Poly-styrene	Polyvinyl Chloride
USA (¢/lb)	1966	13.0	13.3	20.2	9.17	10.4
	1967	10.6	12.8	19.1	10.7	9.57
	1968	8.53	11.9	18.3	10.7	9.21
	1969	8.67	11.8	18.9	-	9.11
	1970	9.44	10.9	16.8	10.6	9.67
	1971	9.45	8.85	14.5	10.3	9.02
Japan (¥/kg)	1966	96.1	142	174	75.8	30.4
	1967	74.7	141	142	69.2	29.7
	1968	63.8	129	132	65.8	27.1
	1969	67.4	117	124	73.1	27.9
	1970	70.1	106	114	72.3	31.1
	1971	69.1	96.4	101	76.3	35.3
	1972	60.8	88.2	87.0	85.2	34.4

Additive Value = Exfactory Price - $\sum$ ((prices on major raw materials) x (Unit of the major raw materials))

Figure AI-2-3 illustrates the changes in the additive values. American changes in additive values through the years show almost the same trend as with delivery prices, but, in the case of Japan additive value was on an upward trend since about 1968 except for high-density polyethylene and polypropylene. Also it will be seen that additive values of both high-density polyethylene and poly-propylne are almost the same.

Table AI-2-4 gives the comparisons on additive values in 1971 for petrochemical products in Japan and America. It shows almost the same additive values on low-density polyethylene, polypropylene, and polystyrene, but as far as high-density polyethylene is concerned Japan shows a higher trend and PVC is higher in America. This was due to the fact, that in Japan, the former was kept in the so-called oligopoly until about 1971, but for the latter the value was constantly at a lower level.

Table AI-2-4 Price Comparison of Petrochemical Products between Japan and the U.S.A. (1971)

(Unit: ¢/lb)

	Japan		U.S.A.	
	Price	Additive Value	Price	Additive Value
Ethylene	4.32		3.03	
Propylene	2.59		2.65	
Stylene Monomer	8.83		6.03	
VCM	6.67		4.17	
LDPE	14.45	9.96	12.6	9.45
HDPE	18.39	13.89	12.0	8.85
PP	17.45	14.53	17.5	14.5
PS	19.83	10.99	16.3	10.3
PVC	12.09	5.09	13.4	9.02

Note : 1 US$ = ¥ 314.8

From the above observations, we have taken the Japanese delivery prices as the criteria rather than the American ones, for the following calculations.

2-2 Forecasts on future product prices in major countries

Drawing a demarcation line of 1972, the world's petrochemical product prices started an all round increase, and this is a vital problem for the petrochemical industry influencing its future to a large extent.

Various forecasts were made on product prices by some organizations, SRI for example, but all of these forecasts are either based on past analysis of price lowering or on the fluctuation of prices on crude oil or natural gas.

2-2-1 Prices on petroleum products

The below mentioned concept may be applied on the changes in petrochemical products resulting from price increases on crude oil.

Analyzing the cost rises of petrochemical prices, we may point out the price rise in crude oil (9.36 - 1.3) US$/BBL (15.12¥/l), and the cost of pollution control devices (1¥/l). Removing the 3% captive combustion expense and apportioning these to the product exfactory prices results in the following. The basic year for the delivery price will be 1971, and the price in said year shall be added with the above mentioned cost rises.

Now, therefore, overall cost rises C is a function of average gain ratio η_{av}, production rate W_i of product 'i' per 1 litre of crude oil and product price P_i;

$$\Delta C = \eta_{av} \sum k \,(w_i p_i)$$

accordingly,

$$k = \frac{\Delta C}{\eta_{av} \sum w_i p_i}$$

where, 'k' represents the apportioning rate. From this, the price rise (Δp_i) may be expressed by the following equation:

$$\Delta p_i = \frac{k w_i p_i}{w_i} = k p_i$$

Finally, the new price is:

$$(p_i)_N = p_i + \Delta p_i = (1 + k)\, p_i$$

Item	Gain ratio	Price (¥/l) 1971	Price (¥/l) New price
Gasoline	11.0	11	40.6
Naphtha	13.26	6	22.1
Jet fuel kerosene	10.68	8	29.5
Light oil	7.29	6	22.1
Heavy oil	57.69	5	18.45

With the average product price for 1971 being 6.18 ¥/l, and the price rise being (15.12 + 1) ¥/l, the value on 'k' obtainable from the above equation is 2.69.

2-2-2 Prices on petrochemical products

(1) Price estimation of basic raw materials

Estimation on prices for basic raw materials such as ethylene to be utilized destinated for petrochemical products, based on the above naphtha price reveals the following:

Item	Gain ratio	Price (¥/kg) 1971	New price
Ethylene	1.0	30	75.6
Propylene	0.5	22.5	56.7
B-B fraction	0.271	10	25.2
Aromatic gasoline	0.661	8	20.2
Fuel oil	0.16	6	20.0
Fuel gas	0.598	6	20.0

Where, cost rise due to the naphtha price rise is 22.14 ¥/kg, and the price rise for utilities fuel is 19.2 ¥/kg (= 0.96 t/t x 20,000 ¥/t), and the cost rise per ethylene 1 kg, taken the gain rate of 3.2, will be:

$$22.14 \times 3.2 + 19.2 = 90.0 \ (¥/kg)$$

accordingly the below mentioned equation is obtainable with the deductions from the above of fuel gas and fuel oil, 20 ¥/kg giving the same equation symbol as with the previous equation:

$$\Delta C - \Delta f = k \sum p_i w_i$$

from which

$$k = \frac{\Delta C - \Delta f}{\sum p_i w_i}$$

$$\Delta p_i = \frac{k p_i w_i}{w_i} \ k\text{-}p_i$$

$$(p_i)_N = p_i + \Delta p_i = (1 + k) \ p_i$$

The value calculated therefrom is 1.52 which is the value for an existing plant, and for a newly established plant the rise in construction cost shall have to be taken into consideration, thus the followings are obtainable:

Item	¥/kg
Ethylene	81.3
Propylene	61.0
B-B fraction	27.1
Aromatic gasoline	21.7

At this time the ratio between the new and the old prices is 2.71.

(2) Price estimation method for petrochemical products

As mentioned earlier, the product price is being separated from the raw material portion and additive value portion, and each of these was made to fluctuate separately. The additive value may be further classified to the following two portions:

Fixed portion - Depreciation, monetary interest, fixed asset tax, insurance, etc.

Variable portion- Personnel cost, utilities cost, etc.

Using existing facilities, the fixed portion does not fluctuate, only the fluctuating portion contributes to the cost fluctuation.

In case of a newly established plant, fixed portion will have a direct influence on the cost due to the fluctuation in construction cost.

(3) Making of price model

Prices are obtainable from the following calculation model, viz.:

Price on the basic year	P_o
Price on n-th year (1971 = 1)	Pn, $\widetilde{Pn}$
Raw material price on the basic year	Ro, $\widetilde{Ro}$
Raw material unit consumption	η
Additive value on the basic year	A_o
Variable portion ratio in the additive value	κ
Increased rate of overall commodity prices	ρ

and, the basic year is made to 1974 for raw material price, and the basic year for additive value is made to 1971. The reason for the former is based on the assumption that the price amendment of basic raw materials as a result of the crude oil price rise would be made in 1974 (for ethylene, propylene, etc.). The reason for the latter is that the adoption of the nearly rock bottom price of 1971 would be most appropriate, as the prices after 1972 onward are unstable.

The following two price models are conceivable:

$$\widetilde{Pn} = \widetilde{Ro}\ (1+\rho)^{n-4} \times \eta + A_o\ (1+W)(1+\rho)^{n} \qquad (1)$$

$$\left.\begin{aligned} Pn &= Rn\,\eta + A_o\ (1+\kappa p)^{n-1} \\ Rn &= R_{o,v}\ (1+\rho)^{n-4} + R_{o,f} \end{aligned}\right\} \qquad (2)$$

where, Pn and R_o signify the product and material prices; $R_{o,v}$. $R_{o,f}$ signify both the variable portion and the fixed portion of the raw material. Equation (1) is for the newly established plant, the (1 + w) after A_o is the temporary cost rise during 1971 - 1974 resulting from the rise in construction cost, which thereafter shall be sliding with the rise in overall commodity price index. Equation (2) is for the existing plant, and is the approximation equation in case inflation is deemed to affect only on the variable portion. Equation (1) gives the maximum value and (2) the minimum value.

Besides the two cases mentioned above, we calculated a medium case, i.e., there is no temporary increase in construction cost, (w = 0), but the fixed cost portion, in additive value, changes by 7 % according to the inflationary trend.

(4) Hypothesis

In making an estimation on future prices using the above mentioned price model, the following hypotheses were made:

(a) Basic prices and the subjected year

As mentioned earlier, prices on basic raw materials of 1974 after the price amendment on crude oil and 1971 Japanese additive value were taken.

(b) Increase rate on commodity prices (ρ)

This was made to 7%.

(c) Temporary increase rate on construction cost (w)

This was made to 20%.

(d) Unit consumption (η), rate of fluctuation cost (μ).

Product	Raw Material	η	μ	Increase rate of additive value ($\mu\rho$) (%)
LDPE	Ethylene	1.04	0.67	4.7
HDPE	Ethylene	1.04	0.57	4.0
Polypropylene	Propylene	1.13	0.67	4.7
Styrene monomer	Ethylene	0.313	0.61	4.3
	Benzene	0.841		
VCM	Ethylene	0.48	0.69	4.8
	Chlorine	0.67		
Polystyrene	Styrene monomer	1.00	0.65	4.6
PVC	VCM	1.05	0.78	5.5
Ethylene oxide	Ethylene	0.95	0.49	3.4
Ethylene glycol	Ethylene oxide	0.83	0.59	4.1

(e) Variable cost and fixed cost for basic raw materials

(Unit: ¥/kg 1974 price)

Basic raw materials	Fluctuation cost ($R_{o,v}$)	Fixed cost ($R_{o,f}$)
Ethylene	66.8	8.8
Propylene	50.1	6.6
Butadiene	33.0	-
Benzene	59.2	1.8
Xylene	53.9	1.6
Chlorine	37.3	-

(5) Result of price estimation

Table AI-2-5 shows the calculation result, in which maximum price stands for the price at the newly established plant using the equation (1), and minimum price stands for the price for the existing plant using equation (2).

2-3 Estimation on exfactory price on petrochemical products made in Middle East countries.

In Annex IX International Competitiveness of Petrochemical Industry, we have given details on the exfactory prices on 1980 exports of Middle East countries, the basic condition for said trial calculation is given as follows:

(1) Internal rate of return of each process plant is made to 15%.

(2) Ethylene production of the petrochemical complex is made to 300,000 t/y.

(3) In regard to the main raw material price, the light condensation at the inlet of the ethylene plant is assumed to be 40/MMBTU in 1974. Constituents and the product pattern of said light condensate are deemed to be the same as the Indonesian ones.

Tables AIX-5-1 through 8 show the calculation results.

2-4 Estimation of exfactory price in Indonesia based on import prices

When the manufactured petrochemical product is marketed the prices that are applied thereto will be the same as a like item which has been imported. Also the import price in Indonesia depending on the respective costs incurred there; that is the transportation cost, import duties and other miscellaneous expenses are deducted from the landed cost, and thus said price after these deductions may be made to be the delivery price.

This section, therefore, describes the calculation method of determining exfactory prices in Indonesia.

Table AI-2-5 Estimated Exfactory Price in Japan

(Unit: US¢/Kg)

		Maximum				Medium				Minimum			
		1977	1978	1979	1980	1977	1978	1979	1980	1977	1978	1979	1980
Polyethylene	Low density	76	81	87	93	67	71	76	82	62	65	96	72
	High density	92	99	106	113	80	86	92	98	60	64	67	70
Polypropylene		89	95	102	109	77	82	88	94	67	70	74	78
Polystyrene		99	106	113	121	86	92	98	105	76	80	83	87
Polyvinyl chloride		57	61	65	70	51	55	59	63	48	51	54	58
Styrene monomer		53	57	61	65	47	51	54	58	44	46	49	52
Vinyl chloride monomer		34	37	39	42	32	34	36	39	31	33	35	37

	Maximum				Minimum			
	1977	1978	1979	1980	1977	1978	1979	1980
SBR	-	-	-	-	81	85	90	95
Alkylbenzene	-	-	-	-	72	74	76	78
Cyclohexane	28	30	32	34	26	27	29	31
Paraxylene	41	44	47	50	38	40	43	45
Benzene	26	28	30	32	25	26	28	30
Toluene	24	26	28	30	23	24	26	28
Mixed Xylene	22	24	6	27	22	23	25	27

(1) Exfactory price for domestic market

The market price in Indonesia for imported products is expressed by the following equation:

(Market price) = (CIF Price) + (Landing cost) + (Import Duties) + (Miscellaneous Import Expenses) + (Domestic Distribution Cost)

On the other hand, the market price in case of domestic production is expressed by the following equation:

(Market Price) =(Exfactory Price) + (Miscellaneous Sales Cost) + (Domestic Distirubiton Cost)

Accordingly, there is the below mentioned relation between the exfactory price and the import price in Indonesia:

(Exfactory price) + (Miscellaneous Sales Expenses)
= (CIF Price) + (Landing Cost) + (Customs Duties)
+ (Miscellaneous Import Expenses)

Of the Indonesian petrochemical plants, olefin plants have already decided to use natural gas as raw material, thus these olefin plants shall have to be constructed taking into consideration the material availability as the first priority, and thus the plants shall have to be constructed in distant locations from the actual consumption places. It should be noted that transportation costs from the plant to the market areas, Jakarta and Surabaya, must be considered because of the distance involved.

Hereinafter, various equations required for calculation are enumerated.

(a) FOB price in Japan & Middle East countries

(FOB Price) = Pej + M + Ce + I ------------------- (1)

where, Pej: Exfactory price in Japan & Middle East Countries

I: Inland freight

Ce: Loading cost M: Exporter's margin

Now, therefore, taken:

I = O, M = (2% of the FOB Price), Ce = 0 (zero) as the exclusive monomer ship is being used, and polymers (plastics) are usually being loaded with other cargoes mixed and is made to 1.1¢ per kg.

(FOB Price) =(Pej + Ce)/0.98 ------------------------- (1)'

(b) Japanese CIF Price

(CIF Price) = (FOB Price) + Im + I + M + Fo ---------- (2)

where,

Im: Marine insurance, I: Monetary interest,
M: Importer's margin, F_o: Ocean freight.

We take

Im = 0.015 x (CIF Price)

I = 0.045 x (CIF Price)

M = 0.02 x (CIF Price)

then, (CIF Price) = (FOB Price) + F_o)/0.92 ------------------- (2)'

(c) Price after unloading (Landed cost)

Import duty and other miscellaneous expenses in Indonesia are as follows:

	x(CIF Price)
Bank charge & cable charge	0.01
Import commission	0.03
MPO	0.03
Import duty	0.15
Sales tax	0.05
Clearance charge	0.02
Damage	0.019
Total:	0.309

Calculating the landed cost from the above:

P_1 = 1.309 x (CIF Price) + Cu ------------------- (3)

where, P_1 Landed cost

Cu Unloading cost

for polymer 0.7 ¢/kg
for monomer 0

(d) Exfactory price in Indonesia

Miscellaenous sales expenses when production and sales are carried out in Indonesia are enumerated as follows:

	x (Exfactory price)
Margin	0.03
MPO	0.03
Sales tax	0.02
Damage	0.016
Total	0.096

Accordingly, the exfactory price, Pei can be expressed by the following equation:

$$Pei = (P_1 - Ii)/1.096 \quad \text{------------------------------------} \quad (4)$$

where, P_1: Landed price, Ii: Inland freight

By totalling all the above through (1)', (2)', (3) and (4) the following is obtainable:

$$Pei = 1.325\ (Pej + Ce) + 1.298\ F_o + 0.912\ (Cu - Ii) \quad \text{----------} \quad (5)$$

where, Pei : Indonesian exfactory price

Pej : Japanese exfactory price

Ce : Loading costs (for Plastics 1.1 ¢/kg)
(for Monomer 0)

F_o : Ocean freight

Cu : Unloading cost (for Plastics 0.7 ¢/kg)
(for Monomer 0)

Ii : Inland freight

Calculations based on exfactory prices of Japan (minimum) and the Middle East are shown in Tables AI-2-6 through AI-2-13. Other cases are calculated likewise, and shown in Tables AI-2-14 through AI-2-16.

(2) Exfactory price for exports

Japanese export exfactory prices have lowered considerably since 1971 and 1972 reaching almost to a marginal price. However, from the latter half of 1972(shown in Table AI-2-5), and reflected by the supply shortage to the Japanese domestic demands, export prices started rising. As a result, export prices went up more than the domestic market prices. This trend for petrochemical products will continue. The Japanese situation was described in

Annex AVIII, judged from this point, it is not conceivable for Japanese production capacity of petrochemical products to keep pace with increase as hitherto achieved if we take the difficulty of availability of plant sites in Japan, problems of naphtha acquisition for the petrochemical raw material, etc. into consideration. However, if the currently projected expansion of 4 ethylene plants with 300,000 to 400,000 tons capacity is completed by 1980, Japanese export capacity will be maintained at approximately the same level.

With the above concepts included in our premises, an export estimation was made for Indonesian export prices assuming that they would become identical with Japanese export prices, at the importing countries, with the condition, however, that the Japanese export price is the same as the exfactory price for domestic demands. This is based on our forecasts that the aforementioned supply/demand balance in Japan will stabilize and no exports will be made at the marginal price.

Table AI-2-6 Estimated Exfactory Price for Domestic Market Based on Import from Japan (Min. Price, Import Duty 15%)

(1) Estimated Landed Price of Imported Petrochemical Products from Japan at Jakarta

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Japan	72.0	70.0	78.0	58.0	37.0	50.0
F O B Cost	2.6	2.6	2.7	2.3	0.8	1.0
F O B Price	74.6	72.6	80.7	60.3	37.8	51.0
Ocean Freight	4.1	4.1	4.1	4.4	5.2	3.2
Insurance, etc.	6.8	6.7	7.4	5.6	3.7	4.7
C I F Price	85.6	83.3	92.2	70.3	46.7	58.9
Import Duty 15%	12.8	12.5	13.8	10.5	7.0	8.8
M P O Sales Tax, etc.	14.3	14.0	15.4	12.0	7.4	9.4
Landed Price at Jakarta	112.7	109.8	121.4	92.8	61.1	77.1

(2) Estimated Exfactory Price for Domestic Market in Indonesia based on Landed Price from Japan

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Indonesia	100.2	97.6	108.2	81.9	53.7	69.1
Inland Transportation	2.9	2.9	2.9	3.0	2.2	1.4
M P O Sales Tax, etc.	9.6	9.4	10.4	7.9	5.2	6.6
Landed Price at Jakarta	112.7	109.8	121.4	92.8	61.1	77.1

Table AI-2-7 Estimated Exfactory Price for Domestic Market Based on Import from Middle East (Import Duty 15%)

(1) Estimated Landed Price of Imported Petrochemical Products from Middle East at Jakarta

(unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Middle East	74.9	72.9	70.1	82.6	50.9	44.1
F O B Cost	2.7	2.6	2.6	2.8	1.0	0.9
F O B Price	77.6	75.5	72.7	85.4	51.9	45.0
Ocean Freight	5.5	5.5	5.5	5.9	5.5	4.3
Insurance, etc.	7.2	7.0	6.8	7.9	5.0	4.3
C I F Price	90.3	88.1	85.0	99.2	62.4	53.6
Import Duty 15%	13.5	13.2	12.7	14.9	9.4	8.0
M P O Sales Tax, etc.	15.1	14.7	14.2	16.5	9.9	8.5
Landed Price at Jakarta	118.9	116.0	111.9	130.6	81.7	70.1

(2) Estimated Exfactory Price for Domestic Market in Indonesia based on Landed Price from Middle East

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Indonesia	105.8	103.2	99.5	116.4	72.5	62.7
Inland Transportation	2.9	2.9	2.9	3.0	2.2	1.4
M P O Sales Tax, etc.	10.2	9.9	9.6	11.2	7.0	6.0
Landed Price at Jakarta	118.9	116.0	111.9	130.6	81.7	70.1

Table AI-2-8 Estimated Exfactory Price for Domestic Market Based on Import from Japan (Japanese Max. Price and Max. Price and Min. Price)

Upper column : Japanese Max. Price
Lower column : Japanese Min. Price

(Unit: In US¢/Kg)

	Product	Benzene	Toluene	Xylene	Para-xylene	Cyclo Hexan
	Main Domestic Market	Jakarta	Palembang	Palembang	Palembang	Surabaya
	Items					
Estimation of Landed Price	Exfactory Price in Japan					
	Max.	27.6	25.5	24.3	44.0	29.6
	Min.	26.0	24.0	23.0	40.0	
	FOB Cost					
	Max.	0.56	0.52	0.50	0.90	0.60
	Min.	0.53	0.49	0.47	0.82	0.55
	Ocean Freight					
	Max.	2.78	2.62	2.62	2.77	2.78
	Min.	2.78	2.62	2.62	2.62	2.78
	Insurance etc.					
	Max.	2.69	2.49	2.49	4.15	2.89
	Min.	2.55	2.36	2.67	2.78	2.64
	CIF Indonesian Port					
	Max.	33.64	31.13	29.80	51.81	35.85
	Min.	31.86	29.46	28.36	47.21	32.97
	Import Duty					
	Max.	5.04	4.67	4.47	7.77	5.38
	Min.	4.78	4.42	4.25	7.08	4.95
	Sales Tax. etc.					
	Max.	4.78	4.95	4.74	8.24	5.70
	Min.	5.07	4.68	4.51	7.51	5.24
	Landed Price					
	Max.	44.03	40.75	39.01	67.82	46.93
	Min.	41.71	38.57	37.12	61.80	43.16
Estimation of Exfactory Price	Inland Transportation					
	Max.	3.14	-	-	-	1.09
	Min.	0.83	-	-	-	1.05
	MOP Sales Tax.etc.					
	Max.	0.83	3.57	3.42	5.94	4.02
	Min.	3.58	3.38	3.25	5.41	3.67
	Exfactory Price at New Plant					
	Max.	40.07	37.18	35.59	61.88	41.83
	Min.	37.30	35.12	33.87	56.39	38.43

Table AI-2-9 Estimated Exfactory Price for Domestic Market Based on Import from Japan (Min. Price, Import Duty 0%)

(1) Estimated Landed Price of Imported Petrochemical Products from Japan at Jakarta

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Japan	72.0	70.0	78.0	58.0	37.0	50.0
F O B Cost	2.6	2.6	2.7	2.3	0.8	1.0
F O B Price	74.6	72.6	80.7	60.3	37.8	51.0
Ocean Freight	4.1	4.1	4.1	4.4	5.2	3.2
Insurance, etc.	6.8	6.7	7.4	5.6	3.7	4.7
C I F Price	85.6	83.3	92.2	70.3	46.7	58.9
Import Duty 0%	0	0	0	0	0	0
M P O Sales Tax, etc.	14.1	13.8	15.2	11.7	7.3	9.3
Landed Price at Jakarta	99.7	97.1	107.4	82.1	54.0	68.2

(2) Estimated Exfactory Price for Domestic Market in Indonesia based on Landed Price from Japan

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Indonesia	88.3	86.0	95.4	72.1	47.2	61.0
Inland Transportation	2.9	2.9	2.9	3.0	2.2	1.4
M P O Sales Tax, etc.	8.5	8.3	9.2	6.9	4.5	5.9
Landed Price at Jakarta	99.7	97.1	107.4	82.1	54.0	68.2

Table AI-2-10 Estimated Exfactory Price for Domestic Market Based on Import from Middle East (Import Duty 0%)

(1) Estimated Landed Price of Imported Petrochemical Products from Middle East at Jakarta

(unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price at Middle East	74.9	72.9	70.1	82.6	50.9	44.1
F O B Cost	2.7	2.6	2.6	2.8	1.0	0.9
F O B Price	77.6	75.5	72.7	85.4	51.9	45.0
Ocean Freight	5.5	5.5	5.5	5.9	5.5	4.3
Insurance, etc.	7.2	7.0	6.8	7.9	5.0	4.3
C I F Price	90.3	88.1	85.0	99.2	62.4	53.6
Import Duty 0%	0	0	0	0	0	0
M P O Sales Tax, etc.	14.9	14.5	14.0	16.3	9.8	8.4
Landed Price at Jakarta	105.2	102.6	99.0	115.5	72.2	62.0

(2) Estimated Exfactory Price for Domestic Market in Indonesia based on Landed Price from Middle East

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Indonesia	93.3	91.0	87.7	102.6	63.9	55.3
Inland Transportation	2.9	2.9	2.9	3.0	2.2	1.4
M P O Sales Tax, etc.	9.0	8.7	8.4	9.9	6.1	5.3
Landed Price at Jakarta	105.2	102.6	99.0	115.5	72.2	62.0

Table AI-2-11 Estimated Exfactory Price for Overseas Market Based on Import from Japan (Japanese Max. Price and Min. Price)

Upper column : Japanese Max. Price
Lower column : Japanese Min. Price

(Unit: US¢/Kg)

	Product	Benzene	Toluene	Xylene	Para-xylene	Cyclo Hexan
	Market	Manila	Manila	Manila	Manila	Manila
Estimation of Landed Price	Items					
	Exfactory Price in Japan					
	Max.	27.6	25.5	24.3	44.0	29.6
	Min.	26.0	24.0	23.0	40.0	27.0
	FOB Cost					
	Max.	0.56	0.52	0.50	0.90	0.60
	Min.	0.53	0.49	0.47	0.82	0.55
	Ocean Freight					
	Max.	1.74	1.74	1.74	1.74	1.74
	Min.	1.74	1.74	1.74	1.74	1.74
	Insurance etc.					
	Max.	2.60	2.41	2.31	4.06	2.28
	Min.	2.46	2.28	2.20	3.70	2.55
	CIF Price					
	Max.	32.50	30.17	28.84	50.69	34.72
	Min.	30.72	28.51	27.40	46.25	31.83
Estimation of Exfactory Price	Ocean Freight					
	Max.	1.56	1.56	1.56	1.56	1.56
	Min.	1.56	1.56	1.56	1.56	1.56
	Insurance etc.					
	Max.	2.60	2.41	2.31	4.06	2.78
	Min.	2.46	2.28	2.19	3.70	2.55
	FOB Cost					
	Max.	0.57	0.52	0.50	0.90	0.61
	Min.	0.53	0.49	0.47	0.82	0.55
	Exfactory Price					
	Max.	27.77	25.67	24.47	44.17	29.77
	Min.	26.17	24.17	23.17	40.17	27.17

Table AI-2-12 Exfactory Price in Japan & Middle East 1980 CIF at Jakarta. (Japan & Middle East Base)

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price						
Japan Base						
Medium	82.0	98.0	94.0	63.0	39.0	58.1
Maximum	93.0	113.0	109.0	70.0	42.0	66.0
Minimum	72.0	70.0	78.0	58.0	37.0	50.0
Calculated (IRR=15%)	114.0	107.0	97.4	109.0	73.1	73.6
Middle East Base						
Calculated (IRR=15%)	74.9	72.9	70.1	82.6	30.9	44.1
CIF at Jakarta						
Japan Base						
Medium	95.0	113.0	108.0	74.1	48.9	67.9
Maximum	107.0	129.0	125.0	81.9	-	76.7
Minimum	85.6	83.3	92.2	70.3	46.7	58.9
Calculated (IRR=15%)						
Middle East Base						
Calculated (IRR=15%)	90.3	88.1	85.0	99.2	62.4	53.6

Table AI-2-13 Landed Price at Jakarta

(Unit: ¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Import Duty=15% x CIF						
Japan Base						
Medium	125.0	148.0	143.0	97.8	64.0	88.9
Maximum	141.0	170.0	164.0	108.0	-	100.0
Minimum	113.0	110.0	121.0	92.8	61.1	77.1
Middle East Base						
Calculated (IRR=15%)	119.0	116.0	112.0	131.0	81.7	70.1
Import Duty = 0						
Japan Base						
Medium	111.0	131.0	126.0	86.5	56.6	78.6
Maximum	125.0	150.0	145.0	95.5	-	88.7
Minimum	99.7	97.1	107.0	82.1	54.0	68.2
Middle East Base						
Calculated (IRR=15%)	105.0	103.0	99.0	115.0	72.2	62.0

Table AI-2-14 Estimated Exfactory Price for Domestic Market in 1980

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Import Duty = 15% x CIF						
Japan Base						
Medium	112.0	133.0	127.0	86.5	56.3	79.9
Maximum	126.0	153.0	147.0	95.8	-	90.3
Minimum	100.0	97.6	108.0	81.9	53.7	69.1
Middle East Base						
Calculated (IRR=15%)	106.0	103.0	99.5	116.0	72.5	62.7
Import Duty = 0						
Japan Base						
Medium	98.4	117.0	112.0	76.2	49.6	70.4
Maximum	111.0	135.0	130.0	84.4	-	79.7
Minimum	88.3	86.0	95.4	72.1	47.2	61.0
Middle East Base						
Calculated (IRR=15%)	93.3	91.0	87.7	103.0	63.9	55.3

Table AI-2-15 Estimated Exfactory Price for Export Based on CIF Price Exported from Japan (Min. Price)

(1) Estimated CIF Price at Manila of Exported Petrochemical Products from Japan

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Japan	72.0	70.0	78.0	58.0	37.0	50.0
F O B Cost	2.6	2.6	2.7	2.3	0.8	1.0
F O B Price	74.6	72.6	80.7	60.3	37.8	51.0
Ocean Freight	2.7	2.7	2.7	2.8	3.3	2.0
Insurance, etc.	6.7	6.5	7.3	5.5	3.6	4.6
C I F Price	84.0	81.8	90.6	68.4	44.6	57.6

(2) Estimated Exfactory Price for Export in Indonesia based on CIF Price at Manila

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price for Export	71.9	69.9	77.9	57.9	37.1	50.0
F O B Cost	2.6	2.5	2.7	2.3	0.8	1.0
F O B Price	74.5	72.4	80.6	60.2	37.8	51.0
Ocean Freight	2.8	2.8	2.8	3.0	3.3	2.0
Insurance, etc.	6.7	6.5	7.3	5.5	3.6	4.6
C I F Price	84.0	81.8	90.6	68.6	44.6	57.6

Table AI-2-16 Estimated Exfactory Price for Export Based on CIF Price Exported from Middle East

(1) Estimated CIF Price at Manila of Exported Petrochemical Products from Middle East

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price in Middle East	74.9	72.9	70.1	82.6	50.9	44.1
F O B Cost	2.7	2.6	2.6	2.8	1.0	0.9
F O B Price	77.6	75.5	72.7	85.4	51.9	45.0
Ocean Freight	6.3	6.3	6.3	6.7	7.7	4.8
Insurance, etc.	7.3	7.1	6.9	8.0	5.2	4.3
C I F Price	91.1	88.9	85.8	100.1	64.9	54.1

(2) Estimated Exfactory Price for Export in Indonesia based on CIF Price at Manila

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
Exfactory Price for Export	78.3	76.3	73.5	86.2	55.3	46.9
F O B Cost	2.7	2.7	2.6	2.9	1.1	1.0
F O B Price	81.0	79.0	76.1	89.1	56.4	47.8
Ocean Freight	2.8	2.8	2.8	3.0	3.3	2.0
Insurance, etc.	7.3	7.1	6.9	8.0	5.2	4.3
C I F Price	91.1	88.9	85.8	100.1	64.9	54.1

A calculation equation for the Indonesian exfactory delivery price is given below. Manila, the Philippines, is taken as an example for the export destination.

(a) FOB and CIF price

From the above (1)' and (2)' equations,

$$(\text{FOB Price}) = (Pe + Ce)/0.98$$

$$(\text{CIF Price}) = ((\text{FOB Price}) + F_o)/0.92$$

where, P_e, C_e, F_o respectively stands for exfactory price, shipping cost and ocean freight in each exporting country, Japan and Indonesia.

(b) Export price of Indonesia on exfactory price basis

Supposing that the CIF prices in both countries are the same, the Indonesian exfactory price, Pei, will be expressed by the following equation:

$$Pei = Pej + (Cej - Cei) + 0.980\ (Foj - Foi)$$

where, suffix 'i' represents Indonesia, and 'j' for Japan

Now, taken Cej = Cei

$$Pei = Pej + 0.980\ (Foj - Foi) \text{ -------------------- } (6)$$

where, (Foj- Foi) represents the difference in ocean freight between Japan and Indonesia.

2-5 Estimation on exfactory price in Indonesia based on the production cost

If an oligopolic status would be maintained and the existence of competition could be ignored, the sales price would be obtained by adding the adequate profit and distribution cost to the production cost.

At present, inclusive of U.S.A., major advanced industrial countries are faced with the difficulty of availing themselves of natural gas or naphtha, which are the raw materials for petrochemical products; the prices on these raw materials are still increasing, thus the possibility of making a petrochemical industry in the oil-producing countries is being considered. The petrochemical production cost in the oil-roducing countries will be most competitive with the advanced countries in view of the advantages in obtaining the raw materials, low cost, etc. On such an occasion, the market prices on petrochemical products should be established irrespective of the past import price trends.

Table AI-2-17 Exfactory Price for Export in 1980

(Unit:¢/kg)

	LDPE	HDPE	PP	PVC	VCM	EG
C I F at Manila						
Japan Base						
Medium	95.0	113.0	108.0	74.1	46.9	66.6
Maximum	107.0	129.0	125.0	81.9	50.2	75.4
Minimum	84.0	81.8	90.6	68.6	44.6	57.6
Middle East Base						
Calculated (IRR=15%)	91.1	88.9	85.8	100.0	64.9	54.1
Exfactory Price for Export in Indonesia						
Japan Base						
Medium	81.9	97.9	93.9	62.9	39.1	58.1
Maximum	92.9	112.9	108.9	69.9	42.1	66.0
Minimum	71.9	69.9	77.9	57.9	37.1	50.0
Middle East Base						
Calculated (IRR=15%)	79.0	77.0	74.2	87.0	56.0	47.3

The conditions as given below are taken for the calculation of exfactory price in Indonesia based on the production cost:

Internal rate of return,	(1)	Products	15%
	(2)	Intermediate products	15%
		Polymer (plastic)	20%
Overall commodity price increasing rates:	(1)		7%
	(2)		0%

By combining these conditions, 4 cases were calculated.

The reason of estimating the rise in the market price (accordignly the exfactory price) sliding with the overall commodity price index, for example with the GNP deflater is based on the concept that the actual price is always constant, and similarly the reason for assuming the 0 % of commodity price rise is that the price is constant irrespective of general commodity prices and the real price will decrease.

2-6 Estimation on exfactory price viewed from the relations between the demand and sales price

In case the production, and sales are done in the freely competing market, the product market price will mostly depend on the supply/demand balance. As given earlier, the past price trend on the petrochemical products indicated always a lowering trend which was due to the repetition of series of actions such as expansion of production scale, lowering of production cost, lowering of sales price and the expansion in demands. On the contrary, however, an oversight could not be made about the effect of vicious cycle of excessive production, competitions between the companies, lowering of sales prices, expansion in demands and expansion in production scale. In any case, there is a correlation between the sales price and demand through consideration to these factors the price estimation may be made possible.

Figures AI-2-5 & 6 show the relation between the price and demands in Japan, and Figures AI-2-7 & 8 the same for U.S.A., where, however, average exfactory price for the price and delivery quantity inclusive of the exports for Japan are taken note. A real price was taken for the price by dividing with GNP deflator, which is because of the fact that even if the current price is the same, a relative product price will lower down together with the general price rise resulting in the increase of the demands.

Note: For the case of U.S.A., the production quantity, for convenience, is deemed to be the delivery quantity inclusive of the exports.

As we go on looking into the Japanese graphs given in the Figures AI-2-4 & 5 almost all the upper part of supply/demand curves is bending to the inside, which shows the shortage of an increased demand corresponding to the price decrease. This occurred in the period from 1970 to 1972. At present, however, the curves are moved to the highly priced direction due to the production cartel, and, therefore, the curves are showing a temporary demand increase, which is often times being experienced in the past in U.S.A. This example is seen in the polypropylene of Figure AI-2-5, and in the low density polyethylene of Figure AI-2-6.

Between the demands and prices, there exists the following relation:

$$\log D = a - b \log P \qquad (b > o)$$

where, D = quantity of delivery inclusive of exports

P = similarly the average exfactory price inclusive of the exports

b = so-called price elasticity signifying the 'b' % change in demand as the price changes by 1%.

Price elasticity on major petrochemical products in Japan and U.S.A. is given in Table AI-2-18, from which it will be seen that in Japan the LDPE demands increase by 1.6% as the price lowers by 1%, and the price should be lowered by about 6% to have the demands increase by 10%.

Table AI-2-18 Price Elasticity of Major Petrochemical Products

Item	Japan	U.S.A.
Low density polyethylene	1.60	1.38
High density polyethylene	3.38	2.76
Polypropylene	2.51	1.88
Polystyrene	2.83	1.71
Polyvinyl chloride	1.61	1.36
Styrene butadiene rubber (SBR)	1.27	0.45
Styrene monomer	1.87	-
Vinyl chloride monomer	0.71	-
Ethylene oxide	2.21	-
Alkylbenzene	2.32	-
Benzene	2.61	-
Toluene	2.82	1.98
Mixed xylene	4.17	

Both in Japan and U.S.A., the price elasticity on low density polyethylene and PVC is respectively almost the same remaining on the minimum level, high density polyethylene has the highest price elasticity; polypropylene and polystyrene are in the middle.

Viewed from the different standpoint, the price elasticity signifies that the larger the value the smaller the price fluctuations. Good examples in Japan are high density polyethylene and mixed xylene.

Simple average in the price elasticity for major plastics as polyethylene and polypropylene is about 2.4 for Japan and 1.8 for U.S.A., from which the demand - price regression equation is roughly expressed by:

$$\log D = a - 2.2 \log P$$

where, 'a' stands for the constant different by country. With the major resin demands in 1980 estimated to be 275,000 tons by the UNIDO Report, the average real price (exfactory price) for 5 kinds of plastics thereafter will be expressed by:

$$\frac{P}{Po} = \frac{297}{D^{0.4545}}$$

where, P = average real price for 5 kinds of plastics,

Po = average real price in 1980

D = demand

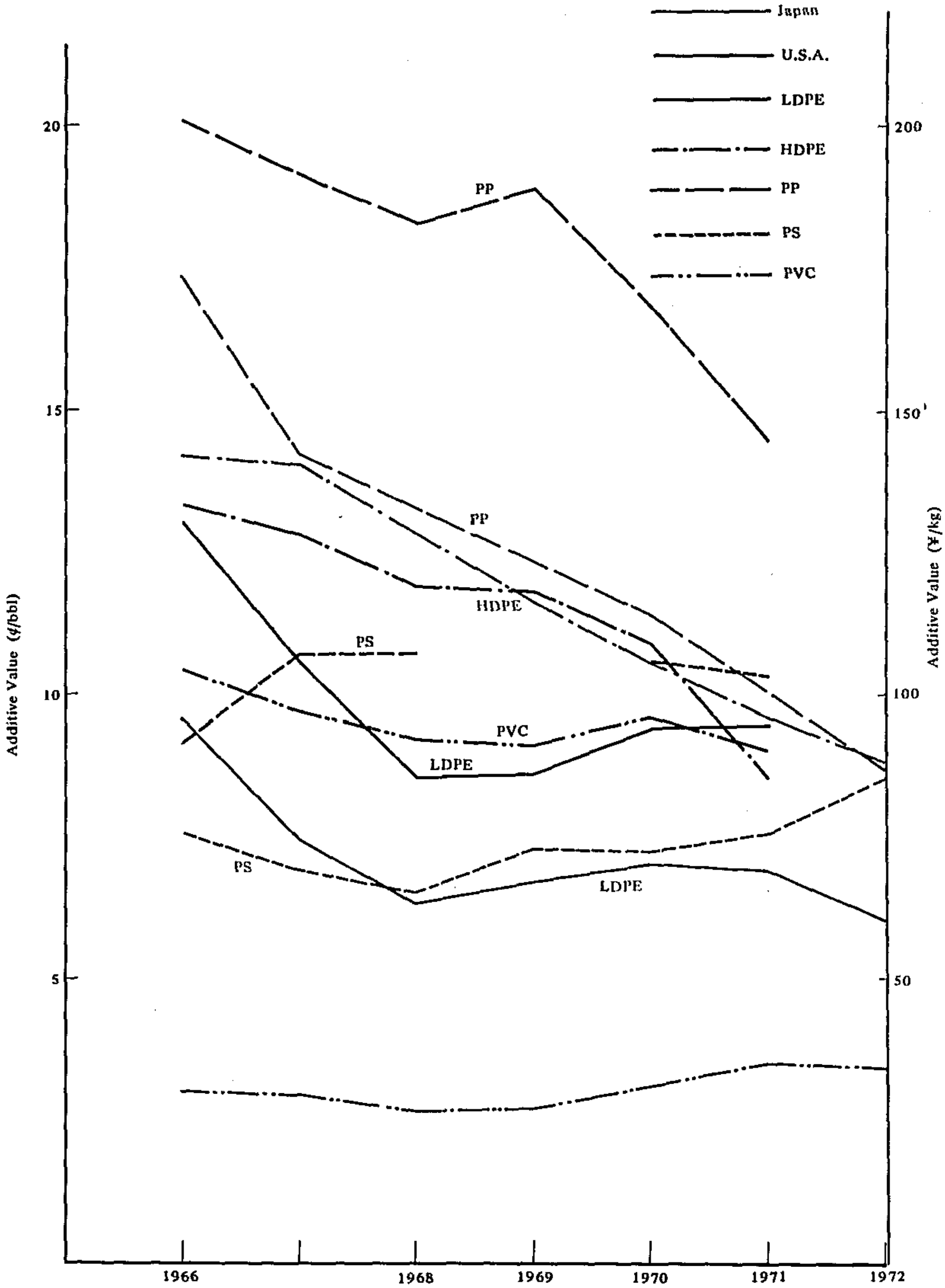


Figure AI-2-3 Trend of Additive Value of Major Polymers

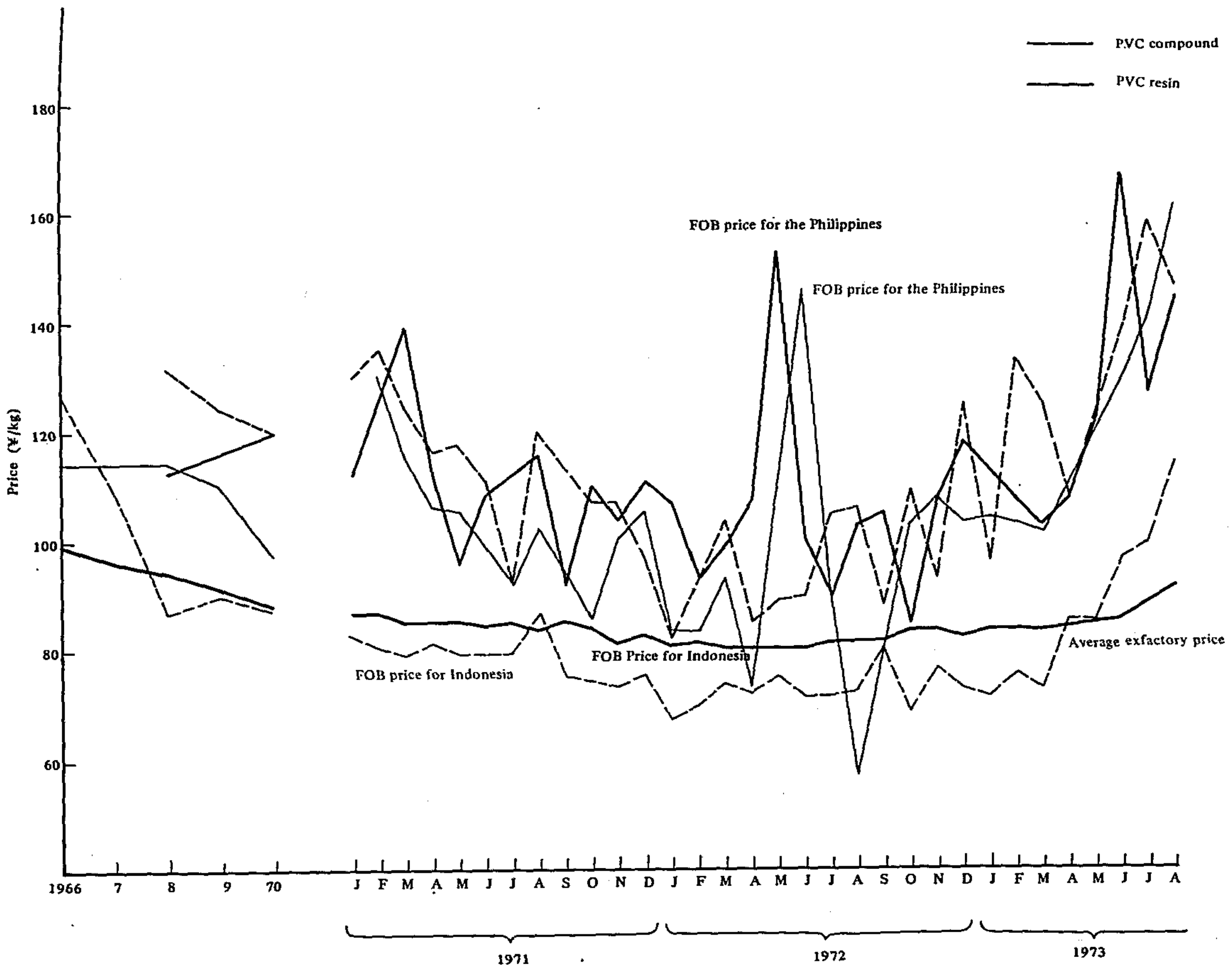
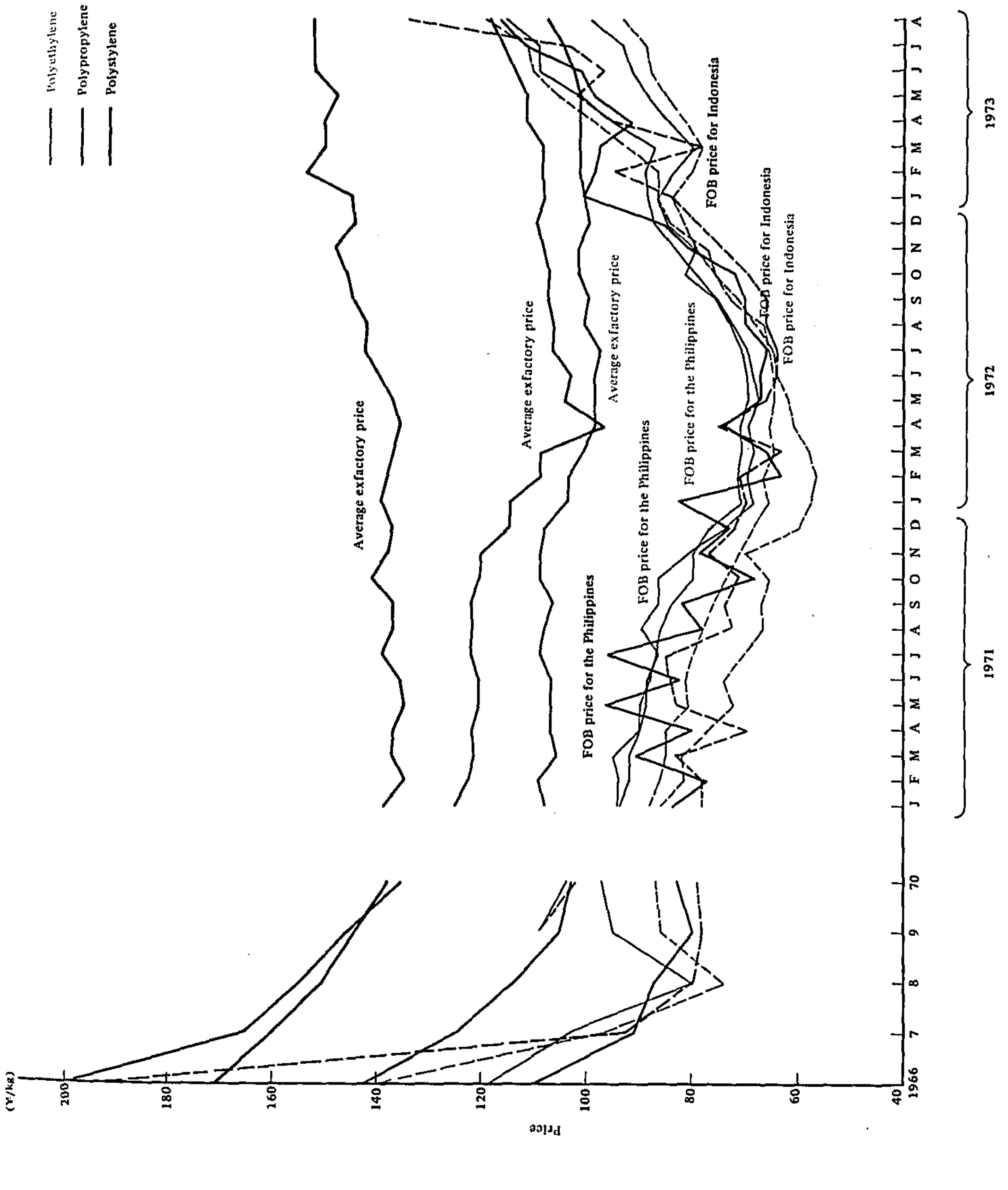


Figure AI-2-4 Comparison of FOB Price and Exfactory Price


Polyethylene
Polypropylene
Polystyrene
(¥/kg)
Price
200
180
160
140
120
100
80
60
40
1966
7
8
9
70
J F M A M J J A S O N D
1971
1972
1973
Average exfactory price
Average exfactory price
Average exfactory price
FOB price for the Philippines
FOB price for the Philippines
FOB price for the Philippines
FOB price for Indonesia
FOB price for Indonesia
FOB price for Indonesia

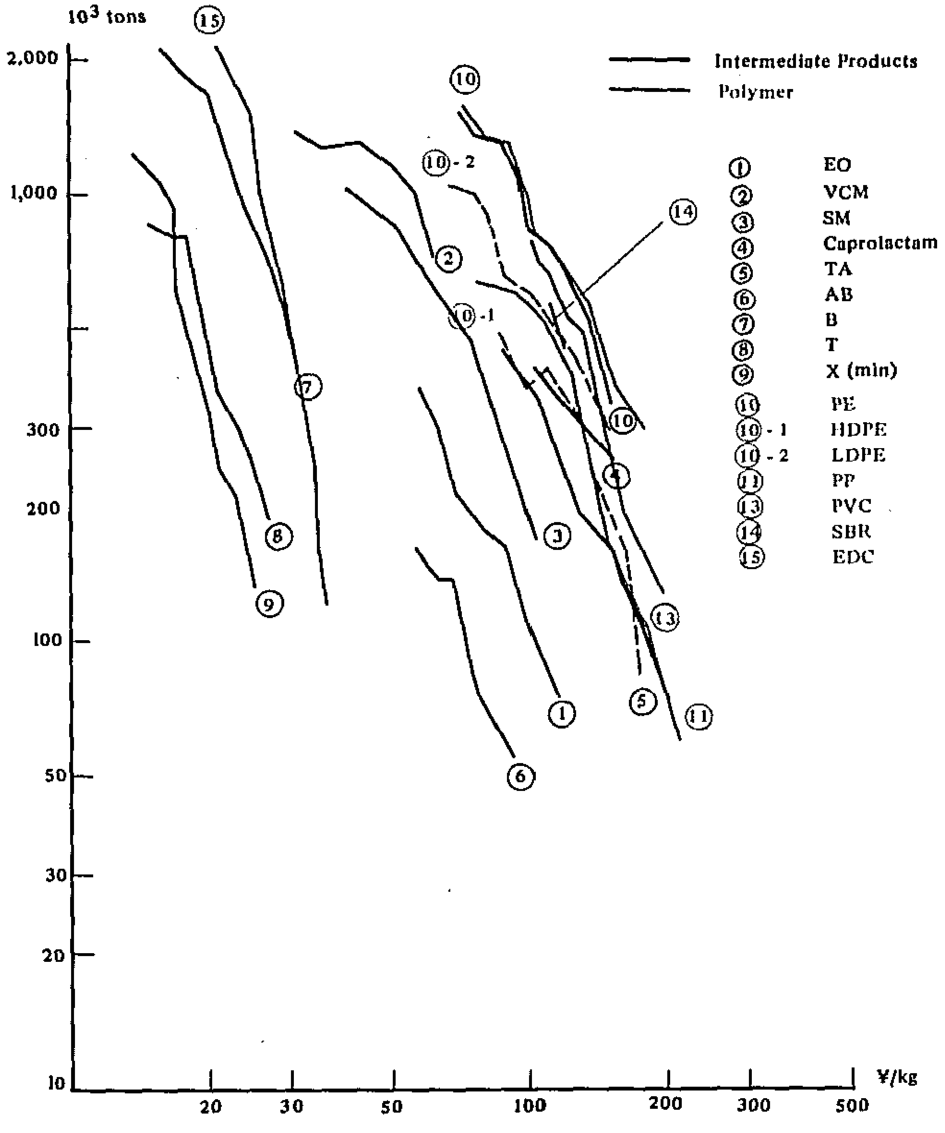


Figure AI-2-5 Relation between Price and Demand in Japan (Polymer and Intermediate Products)

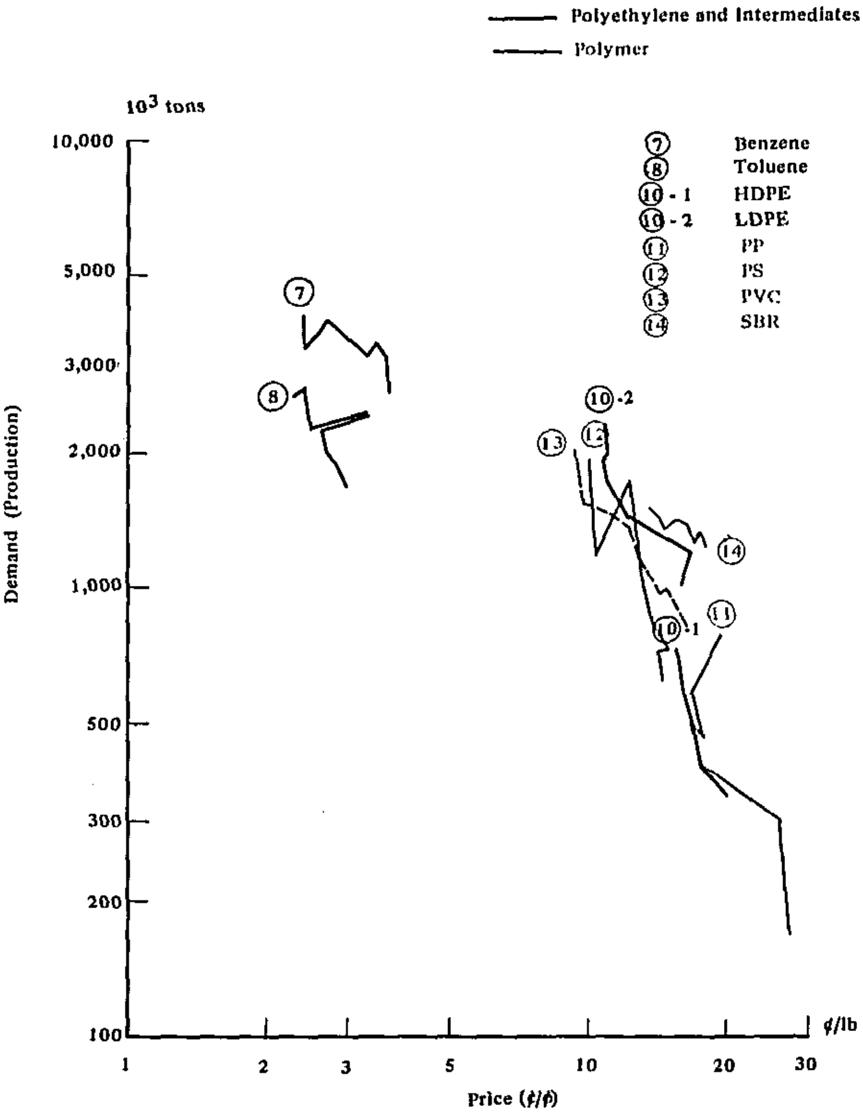


Figure AI-2-6 Relation between Price and Demand in the U.S.A. (Polymer, Polyethylene and Intermediates)

ANNEX II

OCEAN FREIGHT FOR RAW MATERIALS AND PRODUCTS OF PETROCHEMICAL INDUSTRY

CONTENTS

Chapter 1. Estimates on the Ship's Cost

The required vessels for this projects as shown in the Table AII-1-1 are of smaller sized type comparing with the tanker of more than 200,000 DWT capacity and bulk carrier of more than 100,000 DWT which are now under planning in Japan. The ship's cost for this project will be estimated taking the size difference between the small sized vessels and large sized vessels and the escalator of price into consideration.

The price of large scale vessels in 1974 are estimated considering the general price increase in recent year and 7% of annual increment is taken thereafter.

For pressure gas tankers such as carriers for VCM, LPG, Propylene etc., the extent of merits of proportionate unit ship's cost decrease by means of size increase is low, because the number of cylinders will have to be increased along with the increase in the size of ship. 835 US$/$m^3$ is taken as the basis of estimation for pressure gas vessels.

In the case of bulk transportation, vessels under atmospheric pressure and low temperature will be advantageous.

As for ethylene carrier, transportation under -104°C and atomospheric pressure and that under -30°C and 20 kg/cm^2 g can be considered. However carriers under -30°C and 20 kg/cm^2 g are very few in Japan and maximum capacity of that kinds of carrier is only 600 K/T.

Therefore in this project, 10,000 m^3 (5,377 K/t) ethylene carrier under -104°C and atomospheric conditions will be used and the cost of which will be estimated as follows, based on the newly constructed vessels in 1969.

Unit cost in 1969	Merit by size increase	Price increase-rate		
US$1,100/$m^3$	x 8.3/11	x 1.5	x 10,000 m^3	= US$12,500,000

Table AII-1-1 List of Ships Required

Type of Ship	(1) 5,000DWT Cargo Boat	(2) 7,000M3 Pressured Tanker	(3) 9,000DWT Chemical Tanker	(4) 10,000M3 Ethylene Tanker	(5) 22,000DWT Clean Tanker	(6) 65,000DWT Clean Tanker
Particulars						
Length P.P. (m)	90	115	120	120	170	230
Width (m)	15.6	18	18	18.3	22.2	35
Depth (m)	8.0	9.0	9.6	9.5	12.5	16.7
Summer Draft (m)	6.5	7.3	7.5	7.0	9.6	12.0
Deadweight (K/t)	5,000	8,000	9,000	8,000	22,000	65,000
Gross Tons	2,950	5,000	6,000	5,500	13,500	37,000
Net Tons	1,750	3,400	4,000	3,600	9,000	23,500
Measurement (m^3)	6,500	7,000	11,500	10,000	28,500	81,600
Main Engine (PS)	3,500	5,000	5,400	5,400	10,000	20,800
Speed Loaded (Knots)	12.0	12.5	13.5	13.5	14.5	15.0
Speed in Ballast (Knots)	12.5	13.0	14.0	14.0	15.0	15.5
Complement (men)	26	26	28	28	30	33
Estimated Price						
Year of 1974	700	1,750	1,620	3,750	1,980	4,160
1975	749	1,873	1,733	4,013	2,119	4,451
1976	801	2,004	1,855	4,293	2,267	4,763
1977	858	2,144	1,985	4,594	2,426	5,096
1978	918	2,294	2,123	4,916	2,595	5,453
1979	982	2,455	2,272	5,260	2,777	5,835
1980	1,051	2,626	2,431	5,628	2,971	6,243

Remarks : (1) Equipped with cargo handling gears.

(2) 9 cylinder tanks made of high-tension steel, 18 kgs/cm^2.

(3) Partly stainless steel tank, other tanks with coating.

(4) All tanks insulated by membrance method at -104°C.

(5) Center tanks coated by Epoxy, Side tanks zinc coated.

Chapter 2. Initial Ship's Cost

Ship building cost generally involves interest during down payment at the time of the Contract, at the time of keel laying, launching and completion of the building. Further, the cost for spare parts and consumables, living quarters of the crew, launching reception etc. will be required.

These costs, which amounts to 5 to 7 % of the contracted ship cost, are aggregately called the initial excess cost.

The ship's cost including this initial excess cost is called the ship's cost and is subject cost figure for depreciation.

Chapter 3. Hire Base

Hire Base involves the vessel's expenses to keep the vessel in a condition to be ready for operation with required crew.

This hire base is required regardless of whether the ship is anchored or on a voyage.

Items of the expenses are:

Fixed Cost: Depreciation cost or repayment cost
Interest on the outstanding balance of borrowing
Insurance premium.

Crew Cost: Salaries, allowances, bonuses, meal and food cost, crew insurance premium, travel expenses.

Ship's Cost: Cost for ship's miscellaneous items, ship's fittings and replenishment cost for expendables.

Lubrication costs, lub oil cost for miscellaneous machinery and equipment.

Ship's repair cost, including running repair and also the cost for annual inspection in stock.

Miscellaneous charges

Office Cost: Cost incurred for the maintenance of onland crew.

Ship owner's profit:

Approximately 10%

The total of the above-mentioned items will be taken as the annual expenses and the day basis amount is calculated based on the actual operating days. The actual operating days is get by subtracting in-stock days from the total days in a year.

Chapter 4. Hire Base by Type of Ship

Type of Ship / Item of Expenses	5000DWT Cargo Boat	7000m³ Pressured Tanker 18Kg/cm²	9000DWT Chemical Tanker	10000m³ Ethylene Tanker -104°C	22000DWT Clean Tanker	65000DWT Clean Tanker
Contract Price of Ship in Million Yen	982	2,455	*1,985	5,260	2,777	5,835
-ditto- in $1,000 (Exch. @¥300)	3,273	8,183	6,617	17,533	9,257	19,450
Interest 4.25% (During Construction)	139	348	281	745	393	827
Spare Parts & Initial Supplies 2.0%	65	164	132	351	185	389
Initial Cost of Ship (A)	3,477	8,695	7,030	18,629	9,835	20,666
Repayment (A)÷10 Yrs.	348	870	703	1,863	984	2,066
Interest (A)x0.1x0.525	183	456	369	978	516	1,085
Insurance (A)x(Rate)x 0.838	(3.0) 87	(3.5) 255	(3.0) 177	(4.0) 624	(2.5) 206	(2.0) 346
Total Fixed Cost (B)	618	1,581	1,249	3,465	1,706	3,497
Crew's Wage (C) (Complement)	(26)	(26)	(28)	(28)	(30)	(33)
$970x(P)x12 mon.x1.755			*572			
$1200x(P)x12 mon.x1.755	657	657		708	758	834
Maintenance (D)						
Running Supplies 0.25						
Lubricating Oils 0.38						
Repairing Charges 1.55						
Petties 0.22						
Overhead 0.60						
3.00						
(A) x 3% x 1.382	144	360	291	773	408	857
Ship's Expense per year	1,419	2,598	2,112	4,946	2,872	5,188
Owner's Profit (B+C+D) x 10%	142	260	211	495	287	519
Total in $1,000	1,561	2,858	2,323	5,441	3,159	5,707
Hire Base Per Day						
Total ÷ 330 Working Days	$4,730	$8,661	$7,039	$16,488	$9,573	
Total ÷ 345 Working Days	$4,525		$6,733		$9,157	$16,542
Equivalent to Time Charter Rate Per DWT Per Month	$27.15		$22.44		$12.487	$7.635
		Changed			Unchanged	

Remarks: * Based on ship's price in 1977, based on charges in 1978.
Others based on ship's price in 1979, based on charges in 1980.

In this report, 35 days for inspection are assumed including trip to inspection stock. Therefore, the actual operating days are, 365 minus 35, equals 330 days.

Chapter 5. Ocean Freight Chart

The freight figures are compiled in Tables AII-5-1(1) and (2).

Chapter 6. Distance Chart

The distance between relative ports has been made and illustrated in Figure AII-6-1 entitles, "Distance Chart".

(Remarks)

The coefficients, 0.838, 1.755 and 1,382 quoted in the "Hire Base" by type of ship, are the average figures over the past ten years pertaining to the increment rate over the previous years.

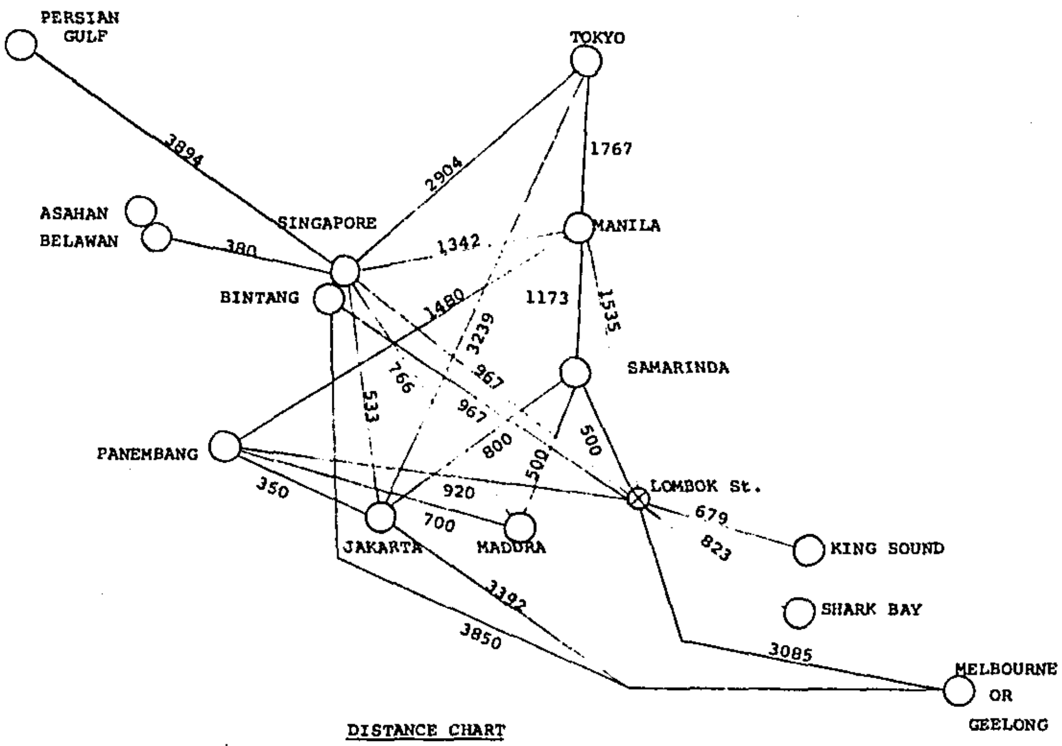


Figure AII-6-1 Distance Chart

Table AII-5-1 (1) List of Carrying Capacity and Freight Rates

Unit: Car
Carrying Capacity: 1,000 Kilo tons p.a. in ( )
Freight Rate: Per Kilo ton in US$

(To Commence Operation in 1978)

Type of Vessel	Cargo	To	From Samarinda		From Palembang		From Belawan		From Melbourne		From Tokyo		From Persian Gulf	
9,000 DWT Chemical Product Tanker (Partly Stainless Tank)	PX, CH SM EG EDC etc.	Palembang									(115)	$26.18		
		Surabaya			(290)	$10.47								
		Jakarta	(273)	$11.11	(370)	8.26	(254)	$11.96	(103)	$29.34	(108)	27.84		
		Manila	(222)	13.60	(193)	15.64	(176)	17.15			(172)	17.35	(71)	$ 41.99
		Tokyo											(56)	53.41

(To Commence Operation in 1980)

Type of Vessel	Cargo	From	To Samarinda		To Palembang		To Belawan	
5,000 DWT Cargo Boat	Salt	Madura	(144)	$14.04	(127)	$15.98	(102)	$19.91
		W. Aust.	(105)	19.90	(87)	23.89	(74)	27.93

W. Aust. = King Sound or Shark Bay

Type of Vessel	Cargo	To	From Samarinda		From Palembang		From Belawan		From Melbourne		From Tokyo		From Persian Gulf	
5,000 DWT Cargo Boat	P.E. P.P.	Jakarta	(108)	$18.71	(143)	$14.23	(103)	$19.69	(45)	$44.76	(49)	$41.29	(37)	$ 55.04
		Manila	(97)	20.83	(79)	25.32	(72)	27.84			(75)	26.72	(32)	62.63
		Tokyo											(26)	77.58
- " -	PVC	Jakarta	(102)	$19.94	(134)	$15.16	(97)	$20.98	(43)	$47.68	(46)	$43.99	(35)	$ 58.64
		Manila	(91)	22.19	(74)	26.97	(68)	29.66			(71)	28.46	(30)	66.73
		Tokyo											(24)	82.66
7,000 m^3 Pressured Gas Tanker (18 Kgs./cm^2)	VCM	Jakarta	(172)	$20.88	(235)	$15.23	(161)	$22.38	(66)	$54.28	(69)	$51.83		
		Manila	(141)	25.48	(121)	29.42	(109)	32.60			(107)	33.16	(46)	$ 77.24
		Tokyo											(37)	95.06
- " -	LPG	Jakarta	(96)	$37.28	(132)	$27.19	(90)	$39.97	(37)	$96.90	(39)	$92.52		
		Manila	(79)	45.49	(68)	52.52	(61)	58.21			(60)	59.21	(26)	$137.90
		Tokyo											(21)	169.71
- " -	Pro-Pylene	Jakarta	(99)	$36.42	(145)	$26.56	(92)	$39.04	(38)	$94.66	(39)	$90.39		
		Manila	(81)	44.43	(69)	51.30	(63)	56.86			(61)	57.84	(26)	$134.72
		Tokyo											(21)	165.80
10,000 m^3 Ethylene Carrier	Ethylene -104°C	Manila	(138)	$47.01			(108)	$59.68					(46)	$139.81
		Tokyo											(37)	174.46

Table AII-5-1 (2) List of Carrying Capacity and Freight Rates

Unit: Car
Carrying Capacity: 1,000 Kilo tons p.a. in ( )
Freight Rate: per Kilo ton in US$

Type of Vessel	Cargo	To	From Samarinda		From Palembang		From Belawan		From Melbourne		From Tokyo		From Persian Gulf	
22,000 DWT	Caustic	Jakarta	(693)	$6.32	(958)	$4.62	(655)	$6.69	(279)	$15.72	(286)	$15.08		
Clean Tanker	Soda	Manila	(570)	7.62	(500)	8.66	(453)	9.59			(442)	9.67	(192)	$22.57
	(SG 1.4)	Tokyo											(151)	28.38
		Bintang					(882)	4.98	(249)	$17.60				
- " -		Jakarta	(647)	$6.77	(892)	$4.96	(611)	$7.16	(264)	$16.58	(270)	$15.92		
	Naphtha	Manila	(533)	8.14	(469)	9.25	(425)	10.21			(415)	10.30	(184)	$23.54
	(SG 0.74)	Tokyo			(284)	15.08							(146)	29.31
		Bintang							(236)	$18.52				
65,000 DWT	Caustic	Manila							(651)	$12.10			(593)	$13.32
Clean Tanker	Soda	Tokyo											(476)	16.58
	(SG 1.4)	Bintang							(754)	10.53			(748)	10.76
- " -		Manila							(591)	$13.33			(531)	$14.65
	Naphtha	Tokyo											(436)	18.12
	(SG 0.74)	Bintang							(683)	11.63			(677)	11.88
		Singapore											(677)	11.88

ANNEX III

METHOD FOR ESTIMATING PLANT CONSTRUCTION COST FOR PETROCHEMICAL INDUSTRIES

CONTENTS

Chapter 1. Forecast on Manufacturing Cost of Chemical Machinery and Equipment

The U.S.A., European countries and Japan are the only countries which have the capability of manufacturing and delivering various machinery and equipment used for petrochemical industrial plants. However, the relative manufacturing potentiality of the countries has been changing along with the progress of inflation and the fluctuation or alternation of foreign exchange rates adding to the existing difference of the machinery and equipment manufacturing cost amongst those countries. Further, the price increase of crude oil carried out by oil producing countries, evidently accelerates and also intensifies such general changes. Moreover, it seems inevitable to forecast at this stage that the progress of inflation in each country continues in the future. The following paragraphs outline the background leading to such present stages.

Figure AIII-1-1 shows the trend of the wholesale price levels of machinery and equipment from 1970 to 1974 in the U.S.A., European countries and Japan. Japan showed the most stable trend up to 1971. Thereafter Japan displayed a downtrend towards the end of 1972 and then achieved a quick increase. On the other hand, the U.S.A. has been showing the most stable trend from 1971 ownward. In addition to these changes displayed by the various countries, the foreign exchange rates have been vastly changed twice since 1971. US$1.00 was equivalent to ¥360 during the early part of 1971, however, the rate was changed to ¥260 thereafter, and the present position shows a level of approximately ¥300. By taking US$1.00 as equivalent to ¥300, the change represents an up-valuation of Japanese yen by 1.2 times.

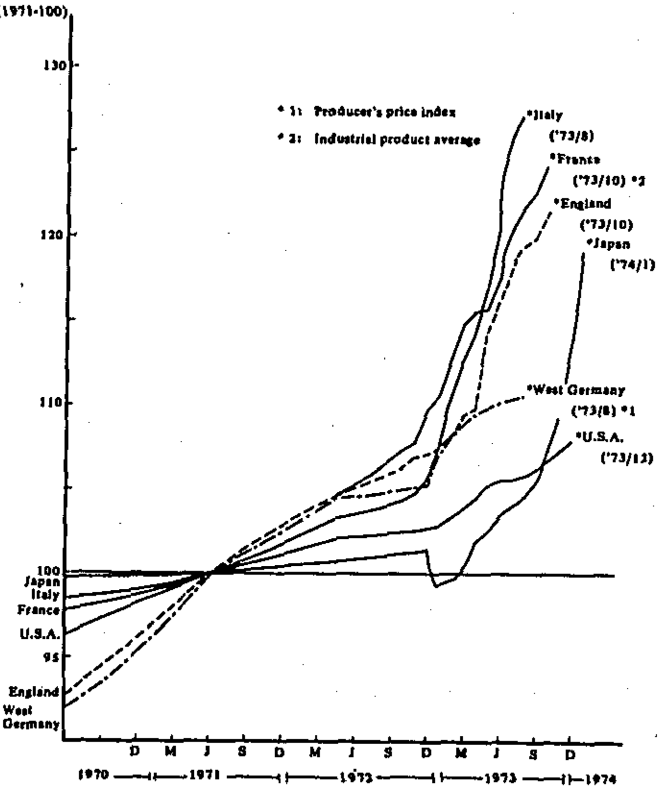


Figure AIII-1-1 Trend of Machinery and Equipment Wholesale Price

The figure shows that Japanese cost index taking the year 1971 as basis is 1.19 times in 1974. In addition to this cost factor, considering the said foreign exchange rate index of 1.2, the wholesale price of machinery and equipment of Japan is approximately 1.43 times.

On the other hand, the index achieved by the U.S.A. is 1.08 times during this period. In 1971, the machinery and equipment cost level in the U.S.A. was 1.19 times that of Japan (refer to the "Oil and Gas Journal"). Therefore, if the Japanese cost level in 1971 is taken as the basis, the present position for Japan is 1.43 times, whereas the U.S.A. is standing on 1.19 x 1.08 = 1.29 times. Therefore, it could be seen that the cost in the U.S.A. is lower by 0.14 in 1.43 than that in Japan, the difference of which is about 10%. By the same token, the West German cost is higher than that of the U.S.A.

The above-mentioned pertains to the cost of general machinery and equipment. For chemical industrial use machinery and equipment the Nelson Index from which it could be understood that about 7%/year increment in the U.S.A. is available. In this report, the Japanese cost level during the year 1971 is taken as the basis for its stability. The changes taken place from 1971 onward, the figure of 7%, the American increment rate, employed as the basis for the forecast.

As has been discussed in the above paragraphas, the Japanese machinery cost is on a higher level than the American counterpart, however, as and when the crude oil price, etc., attain a stability, the Japanese level will no longer stay on a high level than that of the U.S.A. This assumption derives from the facts that in Japan the vast extent of facility investments into steel mills etc., have already been carried out and that the labor cost is definitely lower than the U.S.A. and further the dependency upon exportation is much higher than the U.S.A. This being the circumstance, the macinery and equipment cost obtained on the basis of this assumption may be taken as the future Japanese cost level.

The above-mentioned pertains to the cost of general machinery and equipment. For chemical industrial use machinery and equipment, the Nelson Index is prevailing. The index shows 7% of annual increment in cost in the U.S.A., taking the index as the trend in the U.S.A. In this respect, the Japanese cost level during the year 1971, when Japanese cost level shows the most stable condition, is taken as the basis. Thereafter, a 7% of annual increment rate, that of the U.S.A. where the most constant increment ratio has been observed in recent years, will be taken into account for estimation of machinery and equipment. For the purpose, Japanese price level in 1971 is converted into the American price level. In addition to the above consideration.

The price increase of the crude oil is now being undertaken and, along with that the increment in the progressing. Although how much these condition will affect the cost level of machinery and equipment is not clear at this stage, 20% of price increment is assumed for the study. The above-mentioned calculation method is illustrated in Figure AIII-1-2.

The present Japanese machinery cost reflects the process of general living cost increase and economic instability, thereby making it impossible for the manufacturers to compile any realistic estimates and the actual price at present is on much higher level than the above-mentioned assumed figure. It is assumed that the stabilization of general cost and prices will be forthcoming soon or later. Therefore, should the order be placed immediately, i.e., in the case of aromatics complex plant project, it would be absolutely impossible to construct the plant at the prices on the above-assumed level.

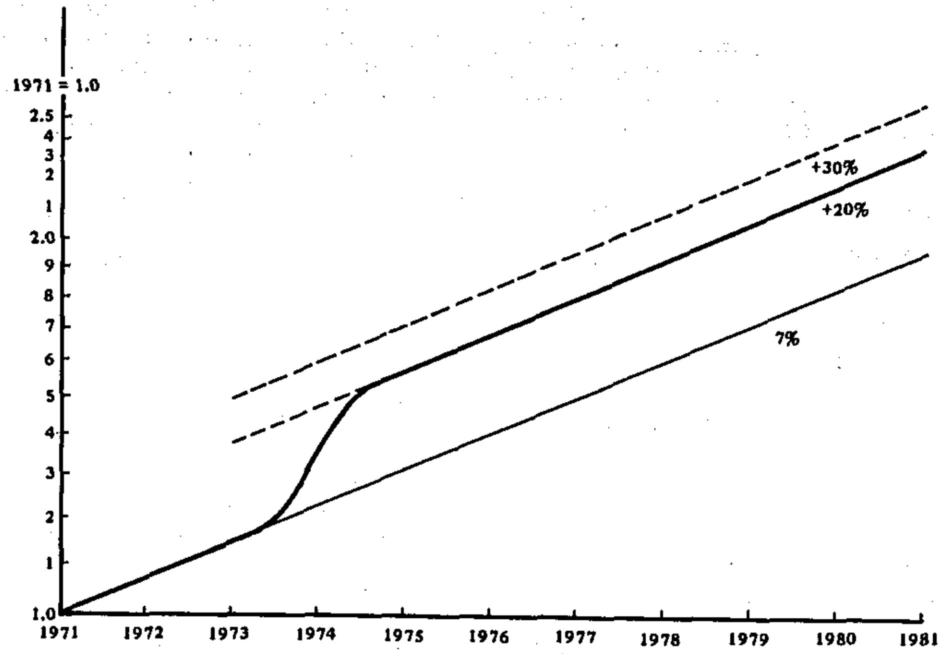


Figure AIII-1-2 Trend of Machinery and Equipment Cost

Chapter 2. Estimation of Construction Cost in Various Candidate Sites in Indonesia

The world construction cost is in extremely unstable conditions at present. The machinery prices in Japan are especially showing abnormal trends. Therefore the cost for machinery and equipment is estimated adding inflation factor of 7%/year and cost increment of 20% caused by the oil crisis to the estimated cost of machinery in the U.S.A. which shows the comparatively stable trends.

However, in several years to come, the Japanese economy will regain stability and it is also expected that the Japanese price level will approach to that of the U.S.A. through the adjustment and stability in international exchange rate, etc. Therefore, the price level thus obtained is adopted as the Japanese price.

Following table shows the location factors regarding the petrochemical industrial cost in North Sumatra, East Kalimantan and Palembang.

	Japan	Case 1 Palembang Factor	Case 1 Palembang Cost	Case 2 East Kalimantan Factor	Case 2 East Kalimantan Cost	Case 3 North Sumatra Factor	Case 3 North Sumatra Cost
Equipt. & mat'ls	49.8	1.15	57.3	1.14	56.8	1.16	57.8
Erection work	4.6	0.8	3.7	1.67	7.7	1.0	4.6
Civil work	11.6	1.01	11.7	1.47	17.0	1.1	12.8
Supervision/ Expatriate	3.0	6.0	18.0	6.0	18.0	6.0	18.0
Engineering & Constractor's fee	31.0	1.2	37.2	1.2	37.2	1.2	37.2
Relative cost	100.0		127.9		136.7		130.4

The variables in the location factors are taken for the cost of the equipment and materials, erection work, civil work, supervision and expatriate, engineering and contractor's fee, etc. and the assessment is made on the basis of the construction cost distribution adopted for the Japanese petrochemical industrial plants, while taking into consideration the following prerequisite conditions. It must be noted here that as far as the prices are concerned, the future price increase which will take place in the United States is used as the basis as mentioned earlier.

1. The scope of equipment and materials covers the machinery, equipment and materials necessary for the construction of the plant, excepting material for civil work.

The cost includes such necessary cost to deliver the equipment and materials up to the plant site as export packing cost, handling cost, freight and insurances, duties, forwarding charges etc.

2. The cost for erection work consists of the wage rates and workers benefit. Basic wage in each plant site, which is the basis for location factor selection, is estimated as follows:

North Sumatra	1,500 Rp/d
East Kalimantan	2,500 Rp/d
South Sumatra	1,200 Rp/d

The wage rates in Indonesia are on a lower level than the rates in Japan, in however productivity is low in Indonesia.

Therefore, total cost for erection work in North Sumatra, is taken as being on the same basis as that of Japan.

3. The Civil work consists of the materials and labor. Sand, gravel and wooden materials are counted as locally available items and the rest of the materials shall be imported from Japan. Of the civil work cost, the labor cost will take up 40% and the 20% of the cost of these civil materials is assumed to be locally available. The location factors for the locally available material are based on the following typical value of cost obtained through an analysis of the unit prices of reinforced concrete work.

North Sumatra: 8,276 Rp/m^3

East Kalimantan: 10,627 Rp/m^3

South Sumatra: 6,576 Rp/m^3

4. The cost for Supervision and Expatriate includes the salaries to be paid for the foreign persons from Japan and other overseas countries for the execution of the erection and civil work as well as the related expenses incurred. This item has been taken as identical for all the candidate sites.

5. The Engineering and Contractor's fee consists of the fees required for design and engineering and the fees for general contractors. The general contractors fee includes the procurement and the inspection services, construction equipment and tools, field expenses temporary facilities and all the necessary overheads. Because of the longer job duration, the required cost of this item is 1.2 times the Japanese level.

6. Others

A. Civil work

No accurate data regarding the soil conditions of the candidate sites have been available, thereby calling for further surveys. Nevertheless, as has been mentioned in the Design Basis, the hard layer depth is approximately 30 meters in the Palembang area in which oil refineries are already existing. This being the case, piling will be necessary for the installation of heavy equipment. The cost required for the piling work will be 35% of the civil work cost in the case of employing 30 meter concrete pile and this cost shall be added to the civil work cost.

B. Spare parts

In Indonesia where no manufacturing of equipment and machinery is undertaken, the provision of spare parts will be necessary in order to maintain the production activities. Therefore, spare parts for covering two years of operation, 10% of the equipment and material costs has been included within the scope.

ANNEX IV

DESIGN BASIS

CONTENTS

The proposed candidate areas, i.e., North Sumatra, East Kalimantan and South Sumatra are all located in the so-called tropical heavy rainfall area, thereby showing mutually analogous climate conditions. Due to this fact as well as to the insufficiency of the data collected so far, the design data in this respect have been set forth as under-mentioned in terms of "typical design data" which have been obtained from the Pertamina, Unit II.

Chapter 1. Meteorological Conditions

Mean daily maximum temperature	32.5°C
Mean daily minimum temperature	21.0°C
Mean daily maximum atmospheric pressure	760.5mmHg
Mean daily minimum atomospheric pressure	759.5mmHg
Mean daily maximum relative humidity	94 %
Mean daily minimum relative humidity	52 %
Wind, maximum gust speed for 3 seconds	90Km/h
Rainfall	7-17 inch/month
Earthquakes	nil
Thunder	frequent

Chapter 2. Geological Conditions

Soil bearing capacity at - 2m level	0.22-0.25 kg/cm^2
Hard layer sounding data	30m depth
Site elevation from the sea level	0.39m

Chapter 3. River Water

Temperature	30 - 32°C
PH	6.0 - 6.5
CO_2	5.0 - 15.0 ppm
CO_3	nil
HCO_3	20 - 80 ppm
Cl	10 - 40 ppm
Alkalinity	nil
Free CO_2	5 - 7 ppm
Total hardness (as $CaCO_3$)	10 - 30 ppm
Ca	1 - 7 ppm
Mg	1 - 5 ppm
Al	less than 1 ppm
Fe	less than 1 ppm
Na	1 - 4 ppm
PO_4	Traces ppm
SO_4	10 - 30 ppm
Si	10 - 30 ppm
Residue on evaporation	50-175 ppm
Oil Content	± 6 ppm

Chapter 4. Sea Water

Temperature:	Max. 26°C
Average salt content:	3.7 %

Chapter 5. Electricity

Number of circuits:	1 - feeder circuit,
Type:	Alternating current, 3-phase, 3-wire system
Voltage:	11 KV, 5.5 KV and 380/220 V

Chapter 6. Codes and Standards

No Indonesian industrial codes or standards are available except for "The Construction Standard of the Government Office Building and Government Financed Housing" which includes general descriptions. Most of the facilities and equipment are designed to conform to the Japanese Industrial Standards (JIS, JPI, AIJ, JEM and JEC) with an exception of foreign procurement for which the applicable codes of the countries of origin are employed.

ANNEX V

PLANT SITE FOR PETROCHEMICAL COMPLEX

CONTENTS

Chapter 1. Conditions for Plant Sites

The following are the main factors to be considered in selecting the candidate sites:

1-1 Whether the Site is Suitable for Port Construction

Geographically speaking, the islands of Indonesia are so located that the areas facing the Indian Ocean of rough waves do not provide suitable areas for constructing ports, unless the georgraphical set-up of the areas is extremely favorable for construction. On the other hand, the areas facing strait of Malacca and Java Sea will afford areas for port construction due to the comparatively calm status of the waves of the sea.

1-2 Geographical and Geological Conditions

Generally speaking, the geological and geographical factors of Indonesia seem to present favorable conditions regarding the areas facing the Indian Ocean. In these areas, the coasts are exposed to rough waves, thereby showing exposed rocks and having comparatively coarse-grain sand.

On the other hand, the areas facing Strait of Malacca and the Java Sea are exposed to calm waves and forming a vast swampy areas by the sedimentation of finegrain sand which has been carried around from the Indian Ocean. This being the circumstance, the conditions of this areas are generally so poor that geological surveys will be necessary when selecting sites for constructing plants.

1-3 Availability of Industrial Water

Sea water and fresh water are both considered as the industrial water. No particular problems will be presented as far as the sea water is concerned because the plant will be constructed in the vicinity of seashore in any event. Regarding fresh water, natural flowing river water will be considered as the industrial water source in order to secure the supply on an economical basis.

From the above conditions, the order of priority shall be given in the following order when selecting plant sites.

1. Selection of suitable rivers

2. Ports

3. Geological and geographic conditions

As the candidate sites for filling the above conditions, there areas, i.e., Sumatra Island, Java Island and Kalimantan Island are selected.

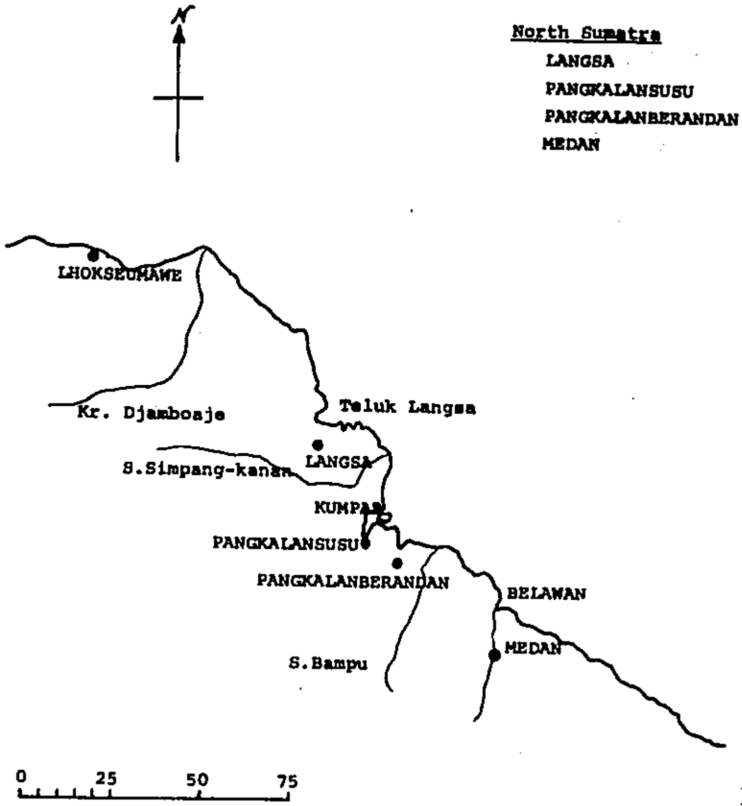


Figure AV-1-1 North Sumatra

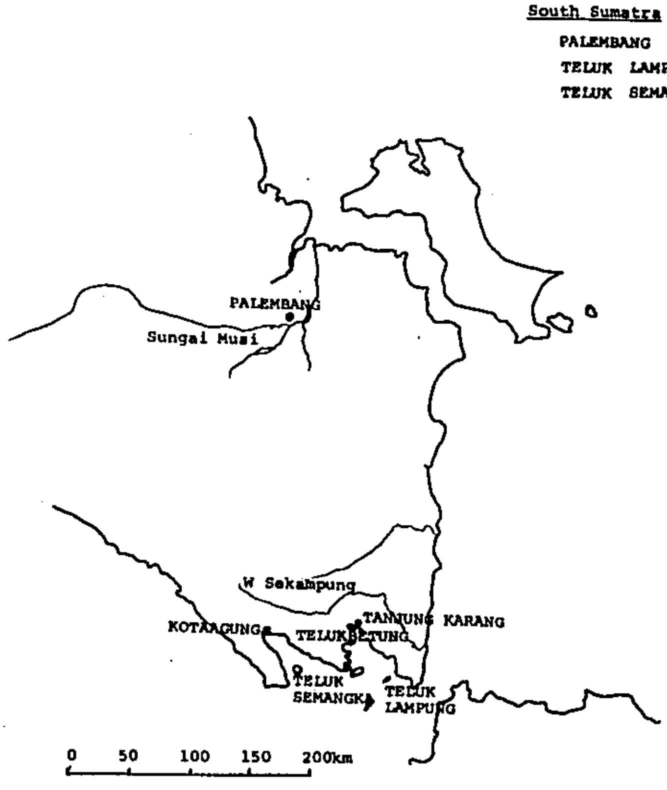


Figure AV-1-2 South Sumatra

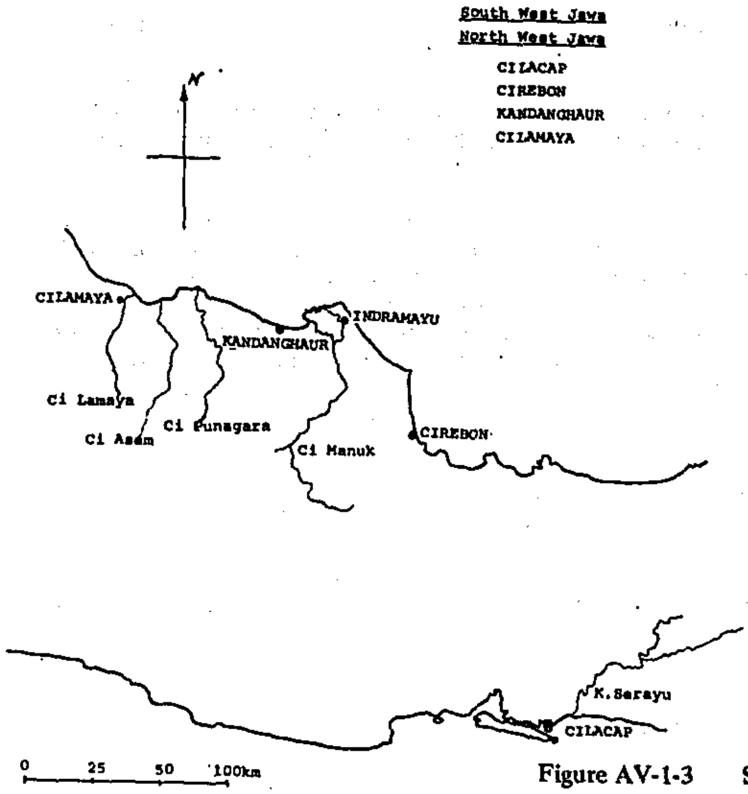


Figure AV-1-3 South West Java, North West Java

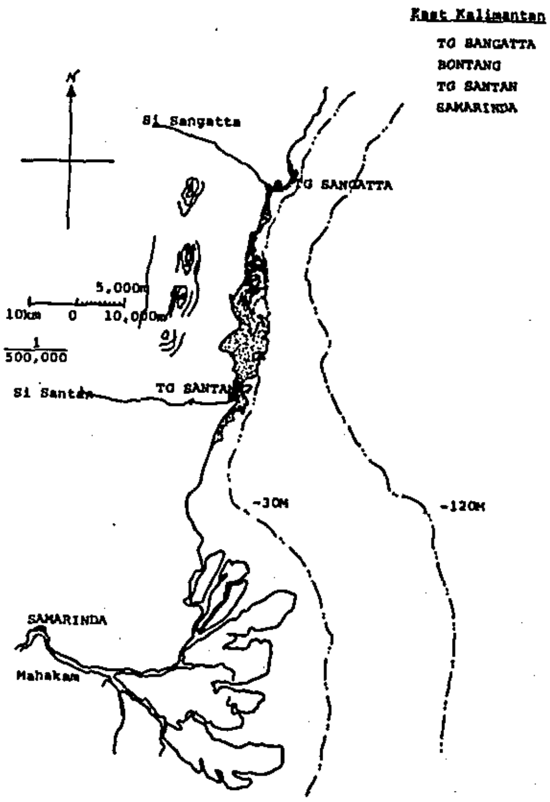


Figure AV-1-4 East Kalimantan

Chapter 2. Industrial Water

The intake of sea water will present no serious problem as this project is on condition that the site is selected from the areas in the vicinity of sea.

Therefore, availability of industrial fresh water will be studied. When intaking industrial water from rivers, the run-off of such rivers must be studied based on actual survey data covering a long period. However the actual survey data are available only for six rivers described hereafter and run-off quantities of other rivers will be estimated by minimum run-off coefficient calculated from the available data of six rivers. The run-off coefficient of six rivers are calculated by actual dividing drainage area by actual minimum run-off quantity.

2-1 Actual Survey Data and Its Analysis

The actual data of rivers Asahan Sekampung, Kali Seraju, Bengawan Solo GiUjung and CiTanduj are available now and calculation result of the run-off coefficient based on the available data are as follows.

	Sumatra	Drainage Area	Run off Coefficient	Run off Amount (Min.)
i)	Asahan Siruar	3,782 Km^2	0.014	52.5m^3/sec.
	Asahan Simorea	3,843 "	0.011	43.0 "
ii)	Sekampung Tegineneng	2,153 "	0.0036	7.8 "
	Sekampung Agrogoeroch	2,155 "	0.0022	4.8 "
	Java			
iii)	Kali Seraju	3,096 Km^2	0.012	37.3m^3/sec.
vi)	Bengawan Solo	15,440 "	0.004	60.16 "
v)	CiUjung	18,579 "	0.0032	6.0 "
vi)	CiTanduj	2,624 "	0.0130	35.0 "

(Observations made on the actually surveyed data.)

The run off coefficient figures have irregularity, covering the range from 0.0022 up to 0.014.

Comments on the actually surveyed data:

Concerning Asahan, Kali Seraju and CiTanduj rivers, the coefficient figures are on the second place of the decimal point.

It is assumed here that these rivers have a dam or a lake on the upsteam so that the flow amount is being controlled either artificially or naturally. When other rivers are concerned, it seems that no such control is being undertaken. Regarding the run off coefficient to be adopted in this report, the run off for the Sekampung river which shows the smallest value, i.e., 0.0020 is selected as sufficient safety side.

2-2 Candidate Rivers

As shown in Table AV-2-1, the following rivers can be enumerated as the candidates for the selection.

2-3 Evaluations

Selections made on the basis of the run off of rivers:

The required amounts of fresh water for this petrochemical industrial plant project are as follows:

Case 1 = 3,400 m^3/h = 0.95 m^3/sec.

Case 2 = 4,600 m^3/h = 1.28 m^3/sec.

Case 3 = 3,100 m^3/h = 0.86 m^3/sec.

From the above requirements, evaluations will be made concerning each one of the rivers shown in the candidate river list. However, prior to proceeding with the evaluations, the following points must be taken into consideration.

(1) The confirmation of the water consumption amount of the fresh river water in the future must be made. In particular, the confirmation of required amount of water for irrigation is important.

(2) Confirmation of the existence of dam construction projects or reservoir projects in relation to the run off.

(3) Confirmation on the effects of flood must be undertaken. However, from the presently available data for the above points cannot be clarified. Therefore, these points should be clarified along with the progress of the future survey, and the evalustions will be made in this report on the basis of the run off.

2-3-1 North Sumatra Area:

The area facing Strait of Malacca, approximately 200 kilometers north-west of Medan, involving the rivers #1 through #6.

Run off each river in this area is enough to cover the fresh water required. Therefore, a tentative evaluation of being satisfactory can be given. Particularly Kr. Jamboaye, S. Simpany Kanan and S. Bampu are recommendable for their abundant water. These areas are highly prospective because no utilization of fresh water for irrigation is undertaken at present.

2-3-2 South Sumatra Area:

Teluk Semangka on the southern tip of the Sumatra Island and the areas facing the base of Teluk and Lampung are included within the scope, covering the rivers #7 and #8.

Table AV-2-1 Candidate Rivers

River	Rainfall (m/m)	Railfall Coeff.	Drainage Area (Km2)	Run off Coeff.	Run Amt(M^3/sec)
(Sumatra)					
1. Kr. Peusangan	75 (Jul)	1.00	1,600	0.0020	3.2
2. Kr. Jamboaye	125 (Jul)	1.67	4,000	0.0033	13.2
3. Kr. Peureulak	110 (Feb)	1.47	900	0.0029	2.6
4. S. Simpang Kanan	100 (Feb)	1.33	3,900	0.0027	10.5
5. S. Bampu	130 (Jul)	1.73	4,100	0.0035	14.4
6. S. Belawan	125 (Jul)	1.67	400	0.0033	1.4
7. W. Semangka	75 (Jun & Jul)	1.00	300	0.0020	0.6
*8. W. Sekampung	75 (Jul, Aug & Sep)	1.00	3,000	0.0020	6.0
*9. Asahan	-	-	3,844	0.0110	43.0
10. Sungai Musi	-	-	33,600	0.0020	67.2
(Jawa)					
11. Ci Manuk	50 (Aug)	0.67	3,000	0.0013	3.7
12. K. Logawa	100 (Aug)	1.33	400	0.0027	1.1
*13. Kali Seraju	-	-	3,096	0.0120	37.3
*14. Bengawan Solo	-	-	15,440	0.004	60.2
*15. Ci Ujung	-	-	1,858	0.0032	6.0
*16. Ci Tanduj	-	-	2,624	0.0130	35.0
(Kalimantan)					
17. S. Sengta	100 (Aug & Sep)	1.33	1,800	0.0027	4.9
18. S. Santen	90 (Aug)	1.20	1,200	0.0024	2.9
19. S. Telakai	75 (Aug)	1.00	2,500	0.0020	5.0
20. S. Mahakan	175 (Aug)	2.33	65,000	0.0047	305.5

* Actually observed data are available for the rivers marked with an asterisk.

Notes:

The rainfall in this table has been obtained by estimation based on The Meteorological Note No. 9 of the Department of Communications, Meteorological and Geophysical Institute.

Rainfall coefficient: The rainfall intensity of W. Sekampung of Sumatra Island was taken as being 1 and the ratio between the estimated rainfall described in the foregoing column have been stipulated by it.

Drainage area: The estimated areas were calculated on the basis of 1/1,000,000 scale map and by actually measuring the areas on the map.

Run off coefficient: The figures are the minimum run off coefficients and, as far as those actually surveyed data are concerned, the figures were obtained by run off divided by the drainage area.

Run off = (Drainage area) x (Run off coefficient)

Run off amount of the W. Sekampung River satisfies the required extent. The W. Samang Ka River can afford industrial water if a dam or reservoir is constructed, however, the cost in such a case will become necessarily higher and therefore is not recommendable.

2-3-3 Mid Sumatra Area:

The Asahan River flowing out from the Toba Lake and the Sangai Musi River flowing in the vicinity of Palemtang will be included withint this area, covering the rivers #9 and #10.

Both rivers possess ample extent of run off and therefore are prospective.

2-3-4 Java:

Including the rivers #11 through #16.

Rivers in Java Island are mostly used for extracting irrigation water and availability of industrial water cannot be made clear to the present stage. The rivers such as Ci Manuk and Kali Seraju might sadisty the requirement, that depend on a further detailed survey.

2-3-5 Kalimantan (East Kalimantan, Balikpapan, Samarinda and Bontang and the surrounding areas thereof, including rivers #17 through #20.)

Little water is being utilized for irrigation in these areas and therefore all the rivers are potential candidates. However, Balikpapan river has several problems in securing water for industrial use.

From the above evaluation, the prospective areas concerning the availability of industrial water are as follows in the order of preference:

(1) North Sumatra Area

(2) South Sumatra Area

(3) Mid-Sumatra Area

(4) East Kalimantan Area

Depending upon the results of future surveys, the Ci Manuk and Kali Seraju Rivers in Java Island will also be counted as the potential candidates.

Chapter 3. Ports

Following are to be considered in checking the suitability of areas for port construction.

a) Routes for ocean going vessels should exist or the securing of such routes can be made by undertaking comparatively simple dredging works.

b) The wave should be calm throughout the year.

c) The areas for constructing port facilities must be available.

d) Securing of traffic which will not impede upon the utilization of the voyage routes for the ocean going vessels must be made.

Detailed observations will be made in the following paragraphs concerning above-mentioned conditions.

3-1 Voyage Routes

3-1-1 North Sumatra Area

As this area faces Strait of Malacca, it is extremely favourable for securing the voyage routes and the actual vessels.

3-1-2 South Sumatra Area

The port of Pandjang exists in the Bay of Teluk Lampung so that both voyage routes and ocean going vessel traveling conditions are favourable. Although no specific problem is present in the Bay of Teluk Semangka, further surveys seem imperative.

3-1-3 Mid Sumatra Area

The areas in the vicinity of Tandjungbalai along the flow of S. Asahan River have been taken into consideration and the voyage routes in this area can be secured favourably. However, a further survey is necessary. The vicinity of Palembang along the flow of Sungai Musi River is also considered as a candidate site. In this area, 20,000 DWT vessels' entry is already possible and more than 20 jetties have already been constructed. Therefore, this area is considerably favourable in view both of the voyage routing and the actual travel of the ocean going vessels.

3-1-4 East Kalimantan Area

The area near Bontang between Tg. Santan and Tg. Sangatta is not suitable for port construction because coral reef projects into the sea shore about 5 - 10 km.

Mahakan River, there is a project to make it possible to receive 7,000 DWT vessels by the autumn of 1974. For more than 500 meters is available for ocean going vessel travel into the river, this area seems to be favourable in view both of the voyage routing and for the actual travel of the vessels. The areas in the vicinity of Balikpapan is now undergoing dredging works on the coastal areas so that both the voyage routings and the actual travel of vessels will be favourably undertaken.

3-1-5 Java Island

Cilacap is a port facing the Indian Ocean and entry of ocean going vessel is favourably undertaken and the voyage routings are easily secured. (Downstream of K. Seraju River) Areas on the downstream of Ci Manuk River requires dreding for opening vessel traffic routes for approximately 5 km so that this area is not suitable as a site.

3-2 Wave Factors

Reference was made to the meteorological data issued by the Indonesian Governmental Meteorological Observatory as well as to the data concerning the tide observation made by the same authorities.

3-2-1 North Sumatra Area

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Direction of Wind	-	NW	NW	-	-	NE	SE	SE	SE	NW	E	NW
The Max. Wave (M)	-	2.2	1.3	-	-	1.0	Q	Q	Q	2.2	1.7	1.7
Mean Wave (M)	-	Q	Q	-	-	Q	Q	Q	Q	0.4	0.4	0.4
Tidal Range (M)	3.7	3.5	3.8	3.6	3.5	3.4	3.7	3.8	3.8	3.3	3.4	3.4

Q = Quiet (0.3^m or less)

The high waves mostly caused by wind in the NW direction so that, from the geographical set-up, Teluk Langsa and Teluk Aru both seem to be recommendable. Particularly Teluk Aru, in the vicinity of Pangkalansusu has the Sembilan Island at the mouth of the bay which seems to be effectively useable as the asylum at the time of storm. However, the tidal range is wide when compared with the other areas, and therefore it is likely that a considerable extent of effects will be exerted by the tidal current. Future surveys concerning tidal current are imperative.

3-2-2 South Sumatra Area

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Direction of Wind	W	W	W	W	SW	W/S	W	SE	SE	SE	SE	W
The Max. Wave (M)	2.8	5.5	5.5	3.8	3.9	1.3	7.5	3.8	3.9	1.7	1.7	1.7
Mean Wave (M)	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
Tidal Range (M)	1.4	1.3	1.1	1.2	1.3	1.2	1.2	1.2	1.1	1.2	1.2	1.2

Q = Quiet (0.3^m or less)

The above data have been taken from the Bangkulu, on the site of Indian Ocean. The candidate sites i.e., Teluk Semangka and Teluk Lampung Bay seem to be exposed to waves much calmer than the figures stipulated in these data. According to this data, the high waves are mostly in the direction of W, SW and SE directions and the area seems to have a high potential in view of the geographic set-up. The tidal range in this area is not wide and will therefore present no serious problem.

3-2-3 East Kalimantan

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Direction of Wind	N	NW	N	S	NW	W	W	W	W	NW	NW	E
The Max. Wave (M)	Q	Q	Q	1.0	Q	Q	Q	Q	Q	Q	Q	2.0
Mean Wave (M)	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
Tidal Range (M)	2.4	2.5	2.5	2.6	2.5	2.5	2.4	2.5	2.4	2.5	2.3	2.4

Q = Quiet (0.3^m or less)

As far as the East Kalimantan area is concerned, the waves are extremely calm when compared with the above data. The tidal range is also normal and therefore, this area is highly recommendable.

3-2-4 Java Island

(1) Cilacap

(This area is in the Mid Java Island facing the Indian Ocean)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Direction of Wind	-	-	-	-	SE	SE	-	SE	SE	SE	SE	SE
The Max. Wave (M)	-	-	-	-	Q	1	-	1.3	1	1	0.6	Q
Mean Wave (M)	-	-	-	-	Q	Q	-	Q	Q	Q	Q	Q
Tidal Range (M)	2.0	1.9	1.9	1.9	1.9	1.7	1.9	1.7	1.8	2.0	1.9	1.9

Q = Quiet (0.3^{m} or less)

Although Cilacap faces the Indian Ocean, a large-size cape is functioning as a wave-breaker, so that the wave condition is as calm as shown in the Table. This area is recommendable for the tidal range is also normal.

(2) North-West Java (Areas downstream of Ci Manuk River)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Prevailing Direction of Wind	W	W	W	E	E	E	SE	E	E	E	E	W
Tax Max. Wave (M)	1.2	1.2	1.6	1.2	1.2	1.2	Q	1.2	1.2	1.2	1.2	1.2
Mean Wave (M)	Q	Q	Q	Q	0.6	0.6	Q	0.6	0.6	0.6	Q	Q
Tidal Range (M)	0.9	0.8	0.8	0.8	1.1	1.0	0.9	0.8	0.8	0.8	1.1	1.1

Q = Quiet (0.3^{m} or less)

The waves in this area are comparatively high and therefore not quite recommendable as a site.

3-3 Availability of Areas in Which Port Facilities Can Be Constructed

Concerning this point, a further survey is necessary, however, as of present, it seems no particular impediment exists in the candidate sites selected.

3-4 Confirmation of the Traffic Extent of Ocean-going Vessels

Further surveys will be necessary regarding specific conditions of Mid-Sumatra, Palembang, East Kalimantan and Samarinda areas. Considering the rest of the sites, it seems that no particular problems exist.

3-5 Conclusion

From the above discussions, the following areas can be nominated as suitable areas for port construction.

(1) North Sumatra area in general, and in particular, the downstream areas of S. Simpang Kanan River and Teluk Aru are recommendable.

(2) South Sumatra area, Teluk Semangka and Teluk Lampung Bay seem recommendable as the candidates.

(3) The areas in the vicinity of Samarinda in East Kalimantan, Balikpapan and Tg. Santan all seem recommendable.

(4) Cilacap in Java seems recommendable.

Chapter 4. Soil Conditions, Plants and Plant Premises

Outline observation of the soil conditions for the sites are undertaken in the following paragraphs by referring to the data obtained from the Bandung Geological Institute.

4-1 North Sumatra

The hard layer in the vicinity of Medan exists approximately 15 to 20 meters from the surface and that in the coastal area exists 17 to 20 meters approximately. Also, there are a number of swampy areas along the coastal areas and therefore, special attention must be paid to this respect. In any case, because no sufficient confirmation can be made based on the presently available data, the selection of the site must be made on the basis of the contour map and boring surveys.

Of the areas in North Sumatra, an available land exists on the North side of Teluk Aru, where soil condition is not considered to be swampy judging from presently available data. So, this area might be a good site.

4-2 South Sumatra

No decisive comments can be made concerning this area due to the lack of data on soil conditions, however, port construction has already been undertaken in the Teluk Lampung Bay, it seems that the soil conditions in the areas are favorable. Also, no particular development has so far been undertaken in this area, it will be possible to secure available areas for the construction of the plants and the housing colony.

4-3 Mid Sumatra

In Palambang areas, a number of plants have already been constructed and relative surveys have been well conducted. Generally speaking, approximately 2 meters from the surface of the soil consists of a soft layer, thereby requiring earth filling of approximately 2 meters in thickness. The hard layer exists approximately 25 to 35 meters underground. The necessary areas for the construction of plants and housing can be amply secured.

4-4 East Kalimantan

At present, a project for constructing an industrial complex is under planning for the area of one kilometer width and 11 kilometers inland from Samarinda and it seems that relative boring tests are being conducted. However, no specific results have been revealed in this respect. Both the availability of the area and the soil conditions will have to be confirmed from the future surveys. However, the areas adjacent to Samarinda generally have favorable soil conditions thereby necessitating a small amount of earth filling works. Therefore, this area seems to have favorable qualifications as the candidate site. As for Balikpapan area, data for soil conditions are not available at present and also it is difficult to secure the plant construction site. In addition to the above, there are a number of swampy areas and problems exist in securing industrial water. Therefore this area will be unsuitable as the candidate site.

4-5 Java Island

4-5-1 Southeast Java

The soil conditions of Cilacap present an alternate layer formation of sand and clay. Soft layers exist approximately 3 meters from the surface of the soil, then followed by a sand layer at 5 to 6 meters from the surface and the layer thereunder is a clay layer. The hard layer exists 20 to 24 meters from the surface, which signifies a much more favourable conditions when compared with the other areas. Also, a flat and vast area is available and therefore, ample lands for the construction of plants and housing facilities will be available.

4-5-2 North Java

This area is the major crop yielding area of Indonesia and flooding in several area during rainy season shall be noted. The hard layer exists approximately 20 to 25 meters from the surface. Although it seems necessary that a survey be conducted concerning the soil conditions and the flooded area conditions, Required area will be secured for the construction of the plants and the housing facilities.

Chapter 5. Conclusion

From the above discussion, the selection of suitable sites for constructing petrochemical plants in Sumatra, Java and Kalimantan inlands are made, however, in number of area, assumptions alone have been used due to the lack of relative data.

This being the circumstance, further on-site surveys will be necessary when implementing the actual projects.

Overall judgements have been made on the basis of the presently available data and the order of preference may thereby be given as follows.

(1) Palembang (Mid Sumatra area)

This area satisfies such conditions as the port availability, securing of industrial water, soil conditions and the area availability for the petrochemical plants construction. Also the development of the surrounding areas for the construction of plants has already been conducted, this area is recommendable as a candidate site.

(2) North Sumatra (Pangkalansusu)

Both the port availability and industrial water availability are satisfied in this area, however a further confirmation survey must be conducted regarding soil conditions and area availability. Geographically speaking, this area seems to be the most suitable for port construction and therefore appears to be recommendable in this respect. However, a thorough survey is nevertheless required for there is a possibility of intrusion of sea-water into fresh water in intaking industrial water.

(3) East Kalimantan (Samarinda)

The port availability and the industrial water availability can both be satisfied in this area, however, a further survey is required concerning soil conditions and area availability.

(4) East Kalimantan (Near Ci Sandan, Ci Sangatta areas where no coral reef impediment exists)

The port availability and industrial water availability can both be satisfied in this area, however, further survey must be conducted to confirm soil conditions and area availability.

(5) South Java (Cilatiap)

(6) South Sumatra (Hinterland of Teluk Lampung)

(7) North Java

(8) South Sumatra (Hinterland of Teluk Semangka)

(9) East Kalimantan (Balikpapan)

Concerning the above (8) and (9), there is a uncertainty regarding industrial water availability.

ANNEX VI

PROCESS DESCRIPTION

CONTENTS

Chapter 1. Olefin Manufacturing Plant by Steam Cracking

1-1 Licensor List

Ethylene	Braun Fluor Foster Wheeler MW Kellogg Linde Lummus Stone & Webster UOP

1-2 Process Description

Ethylene is so essential and important a raw material that the production capacity thereof could represent the size of the petrochemical industry.

Ethylene can be produced by recovery from by-product gas from various cracking processes or coke oven gas or also by dehydration of ethanol available by hydrogenation of acetaldehyde and fermentation. Today, however, most of ethylene in large-scale production is manufactured by thermal cracking of ethane, propane, or butane separated from natural gas refinery off gas, or light fractions of petroleum like naphtha.

1-2-1 Raw material

In the United States, while natural gas is abundant and by-product gas is available at low cost from domestic refineries, demand for naphtha fraction is great for use as automobile gasoline. Accordingly, the overwhelming majority of ethylene plants in this country uses natural gas or refinery off gas as feed.

On the other hand, in Europe and Japan demands for petroleum product are centered upon middle and heavy fractions and, further, gasoline demand is relatively small and natural gas is not abundant. Therefore, most of ethylene plants in Europe and Japan use naphtha as feedstock. Presently, increasing attention is being given to cracking of heavy fractions such as gas oil, vacuum gas oil and crude oil in accordance with the growing shortage of naphtha and natural gas.

When feed is natural gas, as stated later almost nothing but ethylene and propylene is produced from a cracking plant. However, when naphtha is used as feed, butadiene, aromatics, etc., are available as by-products though olefin yield decreases. Therefore, utilization of such by-products could reduce production costs of a naphtha cracking plant, as long as significantly large-scale production is permitted.

1-2-2 Production Process

Ethylene manufacturing process using gas as raw material can be roughly divided into the following three sections:

1. Cracking Section
2. Quenching Section
3. Purification Section

Cracking Section

The cracking section, consists of some pairs of crackers, cracks feed gas and forms olefin-rich gas. The cracker is of several types (shown below). For the cracking of gas, naphtha, or gas oil, the external-heat tubular furnace is mostly used and for crude cracking, other types are generally used to avoid coking inside the tubes.

- External-heat tubular furnace
- Heat medium circulation cracker
- Superheated steam (as heat medium) cracker
- Partial combustion furnace
- Flame cracker
- Catalytic cracker

The external-heat tubular furnace is designed to apply heat from outside the tubes in which feedstock flows. The composition of cracked gas depends on cracking temperature, residence time and partial pressures of hydrocarbon (to be reduced with steam). Generally, cracking temperature is as high as 700-900°C and residence time is from approximately a fraction of a second to 2 seconds. While cracking proceeds inside the tubes, polymerization reactions of cracked products occur forming tar, etc.

Quenching Section

Cracked gas needs to be quenched to minimize the second order reaction, like polymerization, which forms tar and thereby reduces the yield of olefin including ethylene. Therefore, the quenching section is installed immediately after a cracker.

The quencher is of the following types:

- Up flow type
- Down flow type
- Horizontal type
- Melting metal direct flow type

Today, the melting metal direct flow type is rarely used because there is fear that metal fine particles enter cracked gas. In the other three types, quenching is performed on the basis that effluent gas runs in the tubes and cooling water runs in the shell, when high-pressure steam is recovered.

Recovery and Purification Section

Quenched cracked gas is sent to a recovery and purification section where C4 lighter gas is separated from the heavy fuel oil fraction with a gasoline fractionator and from cracked gasoline with a quenching tower.

For the recovery and purification of the separated C4 lighter gas, the following three means are conceivable:

- Low-temperature fractionation
- Selective absorption
- Selective adsorption

Selective absorption and selective adsorption are no longer adopted in newly constructed plants.

Low temperature fractionation is of two types: one under high operating pressures of 30 - 40 kg/cm^2 and the other, under low pressures of 2 - 10 kg/cm^2. Today, large plants generally employ the high-pressure process. The C4 and lighter fractions separated in the quenching tower are further pressurized, washed, dried, cooled, and then separated into hydrogen, methane, ethylene, propylene, and the C4 fraction with fractionators. During the processing, acetylene in the ethylene and ethane fractions and propadiene in the propylene and propane fractions are hydrogenated. Recovered ethane is recycled to the cracking furnace.

1-2-3 Yields by raw material

Cracked yields from an example of type of raw materials is shown in Figure AVI-1-1.

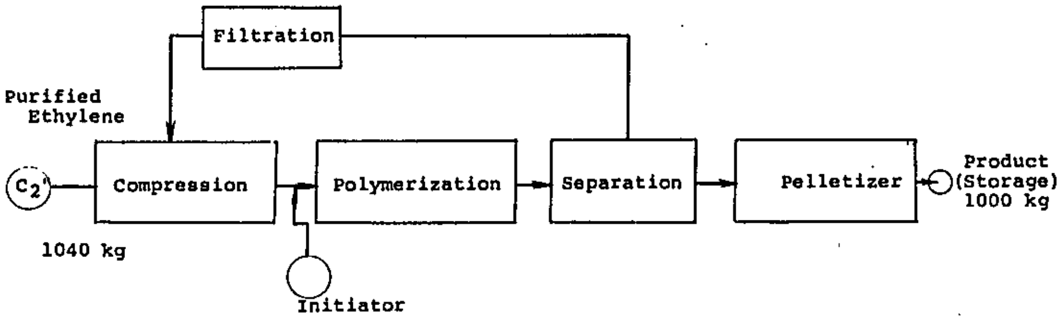


Figure AVI-1-1 Process Flow & Yield Pattern for Ethylene Plant

Chapter 2. Electrolysis of Salt

2-1 Licensor List

Diaphragm Cell Process

- Diamond shamrock Corp.
- Hooker Chemical
- PPG Industries
- Dow Chemical
- USSR

Mercury Cell Process

- Diamond Shamrock Corp.
- Hooker Chemical
- Asahi Glass
- De Nora
- Kureha
- Krebs-BASF
- Krebs-Zuerich
- Mitsui Toatsu
- Olin Corp.
- PPG Industries
- Solvay
- Toyo Soda
- Uhde-Hoechst

2-2 Process Description

Salt (sodium chloride) in an aqueous solution dissociates to give sodium and chloride ions. When cathode and anode are placed in the aqueous solution and then direct current is supplied between the electrodes, the chlorine ion moves toward the anode and the sodium ion toward the cathode. At the cathode, the sodium ion discharges and at the same time reacts with water to give sodium hydroxide (caustic soda) and hydrogen gas. The chloride ion is converted into chlorine gas by discharge at the anode.

$$Na^+ + H_2O + e^- \longrightarrow NaOH + 1/2H_2$$

$$2\ Cl^- \longrightarrow Cl_2 + e^-$$

When mixing takes place between the cathode and anode, different reactions occur and also the efficiency of the current decreases. In order to avoid this undesirable process, two methods are adopted in industry. They are 'Mercury process' and 'Diaphragm process'.

In the diaphragm process, the mixing of the polar components is inhibited by inserting a diaphragm made of asbestos between the cathode and anode. The concentration of sodium hydroxide in the electrolyte is low (12 %), and also the solution contains about 17 % of sodium chloride. Caustic soda concentration and salt separation process by vacuum evapolation is necessary.

In the mercury process, mercury cathode is used. At the cathode, discharged sodium reacts with mercury to form sodium amalgam, which is transferred into another vessel. Decomposition of the amalgam with water gives sodium hydroxide and hydrogen.

$$Hg\text{-}Na + H_2O \longrightarrow Hg + NaOH + 1/2H_2$$

High concentration 50% of sodium hydroxide is obtained by the mercury process. Since sodium amalgam is separated from salt solution and decomposed with water, low chloride content caustic soda is produced. On the other hand, caustic soda and waste materials are contaminated with mercury.

Generally speaking, the mercury process is superior economically to the diaphragm process and industrial production of sodium hydroxide is carried out mostly by the mercury process. However, pollution by mercury is now a serious ecological problem, and at present the diaphragm process is replacing the mercury process.

Chapter 3. Products from Ethylene

3-1 Vinyl Chloride Monomer

3-1-1 Licensor list

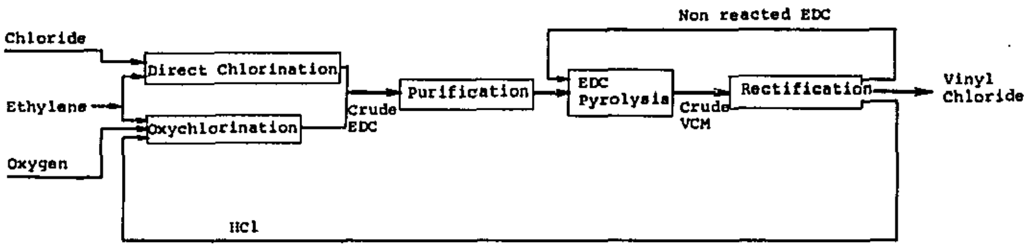
Chemishe Werke Huels

Farbwerke Hoechst

Kureha-Chiyoda
Mitsui-Toatsu Chemical
Monsanto
Solvay ICI
Toyo Soda
Tokuyama Soda
Union Carbide
Goodrich
Montedison
Scientific Design
Stauffer

3-1-3 Process flow for vinyl chloride monomer

Figure AVI-3-1 shows process flow and unit consumption of raw material for Vinyl chloride monomer.



	Unit consumption /ton-VCM	For the production of VCM 110,000 t/y
Ethylene	467 kg	51,400 t/y
Chlorine	592 kg	65,100 t/y
Oxygen	142 kg	15,600 t/y
Vinyl chloride	1,000 kg	110,000 t/y
By-product Hydrochloric Acid (15%)	120 kg	13,200 t/y

Figure AVI-3-1 Process Flow for Vinyl Chloride Monomer

3-1-2 Process description

This is the raw material for polyvinyl-chloride, and used to be produced by the reaction of hydrogen chloride and acethylene which was produced from calcium carbide and water.

$$CH = CH + HCl \longleftrightarrow CH_2 = CH - Cl \qquad (VCM)$$

Recently, ethylene dichloride (EDC) which is produced by ethylene chlorination can be decomposed to vinylchloride and hydrogen chloride.

$$\begin{array}{l} CH_2 = CH_2 + Cl_2 \longleftrightarrow \begin{array}{cc} CH_2 & - \; CH_2 \\ | & | \\ Cl & Cl \end{array} \end{array}$$

$$\begin{array}{cc} CH_2 & - \; CH_2 \\ | & | \\ Cl & Cl \end{array} \xleftrightarrow[\text{Pyrolysis}]{} CH_2 = CH\text{-}Cl + HCl$$

In this Process, the problem is the disposal of hydrogen chloride. Conventional acetylene hydrochlorination process plant is built combined with EDC pyrolysis-process plant to consume hydrogen chloride, but acethylene is more expensive than ethylene.

Fortunately ethylene oxychlorination can also produce ethylene dichloride, using hydrogen chloride from the decomposition process.

$$CH_2 = CH_2 + 2HCl + 1/2O_2 \longrightarrow \begin{array}{cc} CH_2 & - \; CH_2 \\ | & | \\ Cl & Cl \end{array} + H_2O$$

Thus the problem of surplus hydrogen chloride by chlorination and pylorysis can be solved by the combination of oxychlorination process.

3-2 Polyvinyl Chloride

3-2-1 Licensor list

B.K. Goodrich
Chemishe Werke Huels
Kureha Chemical
Pechiney-St. Gobain
Scientific Design
Sumitomo Chemical
Union Carbide
Uniroyal
Woodall-Duckham
Mitsui-Toatsu
Monsanto

3-2-2 Process description

There are three ways to polymerize vinyl chloride monomer:

1) Suspension polymerization
2) Emulsion polymerization
3) Bulk polymerization

In suspension polymerization the vinyl chloride monomer is dispersed in water with a suspending agent, which is surface active compound to stabilize monomer dispersion and to prevent agglomeration of polymer particles. The reaction is initiated with initiator such as organic peroxide. All the commercial plants are batch process, although there are some patents of continuous reactors. The polymerization is terminated by controlling the temperature or pressure then the batch is transferred into a blowdown tank. The unreacted monomer is recycled after separation and purification. The polymer is separated from the water, dried and packed.

In emulsion polymerization, emulsifiers have a surface active effect to disperse monomer droplets in a diluent, water. As the initiators of emulsion polymerizations, such as inorganic peroxides, are mostly water soluble, the reaction proceeds in the aqueous phase around the monomer droplets to grow monomer-polymer latex particles.

In both polymerizations, the heat of polymerization can be removed by water diluent.

Bulk polymerization are conducted in the absence of diluents, emulsifiers or suspending agents and the heat removal in commercial bulk polymerization is therefore a difficult problem. On the other hand the absence of diluents completely eliminates a process to dry the polymer.

$$n\ CH_2 = CH\text{-}Cl \longrightarrow n\ (\text{-}CH_2\text{-}\underset{\displaystyle Cl}{\underset{|}{CH}}\text{-})$$

3-3 Low Density Polyethylene

3-3-1 Licensor list

a) ICI
b) UCC
c) Du pont
d) Dow
e) BASF
f) DART (REXALL)
g) USI
h) Gulf
i) Ethylene Plastics.

3-3-2 Process description

In the high pressure polyethylene process, ethylene gas is kept under the conditions of high temperature and pressure and is polymerized in the presence of initiator. Although the polymerization proceeds in accordance with the ordinary radical mechanism, it is characterized with polymerization under very high pressure. Generally selected pressure and temperature range from 1,000 to 3,000 kg/cm^2 and from 100 to 300°C respectively.

The polymerization mechanism of ethylene can usually be represented by an elementary process equiation in the ordinary radical polymerization.

1) Decomposition of initiator

$$R_2 \longrightarrow 2R.$$

2) Initial reaction

$$R + CH_2 = CH_2 \longrightarrow R - CH_2 \cdot CH_2$$

3) Polymerization

$$R - (CH_2 \cdot CH_2)_n\ CH_2 \cdot CH_2 + CH_2 = CH_2 \longrightarrow$$

$$R - (CH_2 \cdot CH_2) -_{n1} CH_2 - CH_2$$

4) Termination of reaction

$$R - (CH_2 \cdot CH_2)_n\ CH_2 - CH_2 \cdot + R - (CH_2 \cdot CH_2)_m CH_2 - CH_2 \cdot \longrightarrow$$

$$R - (CH_2 \cdot CH_2)_n +1- (CH_2 \cdot CH_2)_m + 1R$$

5) Transfer reaction

$$R - (CH_2 \cdot CH_2)_n\ CH_2 - CH_2 \cdot + HA \longrightarrow$$

$$R - (CH_2 \cdot CH_2)_n\ CH_2 - CH_3 + A \cdot$$

Besides the above reactions, various complicated reactions take place.

Since the polymerization of ethylene is such an exothermic reaction as stated below, its yield depends, in fact, on the capability to remove the polymerization heat.

$$CH_2 = CH_2 \longrightarrow \frac{1}{n} (C_2E_4)_n - \Delta H = 22.17 \frac{Kcal}{mol}\ 500°K$$

The polymerization process comprises the following:

1) Purification of ethylene gas
2) Compression and pressurization of ethylene gas
3) Polymerization
4) Separation of polymer from unreacted ethylene monomer
5) Pelletization of polymer
6) Recycling of ethylene gas

a) Ethylene gas

Ethylene gas to be used as monomer usually requires to have purity of 99.9% or more, and content of acetylene especially should be less than 10 ppm. If mixed in the ethylene gas even in a trace amount, CO and aldehyde entail poorer electrical property of the product monomer.

b) Polymerization

Ethylene gas is pressurized by a high pressure compressor to a given polymerization pressure, which, in most cases, ranges from 1,000 to 3,000 kg/cm^2g

There are two types of reactors: one is of a vessel type and the other is of a tubular type. In the case of the former, the pressurized ethylene gas is fed to the reactor after being cooled, while in the latter case, the said gas goes through the preheating system and then is polymerized after being heated up to a given temperature. The polymerization temperature ordinarily ranges from 100 to 300°C. The types and quantity of the initiator to be fed to the reactor vary with polymerization temperature. Peroxide and other compounds which generate free radical are usually used as initiator.

c) Separation and recycling

Mixture of polyethylene and unreacted ethylene gas which has gone through the reactor is fed to the separator where it is de-pressurized. The reduction in pressure lowers the solubility of ethylene monomer in molten polyethylene with the result of their easy separation. The ethylene so separated from polyethylene is recycled to the compressor through a filter.

d) Pelletization

Polyethylene which has left the separator is fed to the extruder where the said polyethylene is extruded to be pelletized. There are two cutting methods in pelletization: one is "under-water cutting method" which cuts the polymer under water, and the other is "hot cutting method" which cut it in the atmosphere.

The physical properties and quality of the polyethylene so produced are indicated in terms of molecular weight distribution, density, etc. The density of this polymer, however, is from 0.915 to 0.930, thus is lower in density in comparison with the poly-ethylene manufactured by the medium pressure process described in 4-4, and is called "low density polyethylene".

3-3-3 Process flow diagram with material balance

Figure AVI-3-2 shows process flow diagram with material balance.

3-4 High Density Polyethylene

3-4-1 Licensor list

a) Mitsui Petrochemical Ind.
b) Union Carbide
c) Solvay
d) Hoechst
e) Montedison
f) Phillips
g) ICI
h) SOI
i) Dupont
j) Hercules

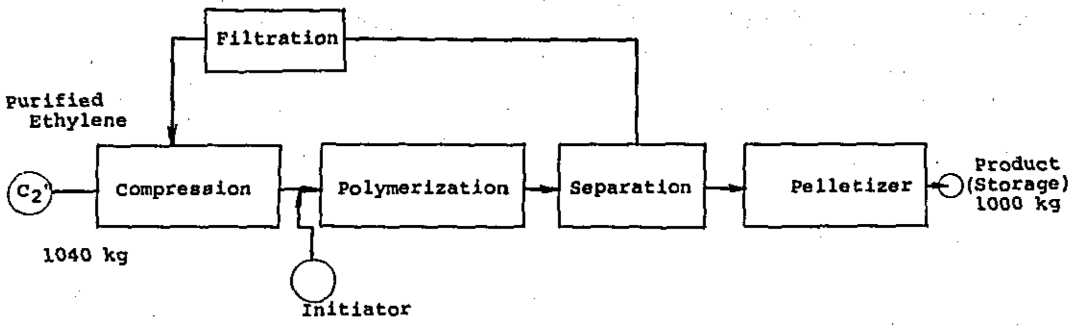


Figure AVI-3-2 Process Flow with Material Balance for LDPE Plant.

3-4-2 Process description

There are two high density polyethylene manufacturing processes: the Low Pressure Process (Ziegler Process) using the so-called Ziegler catalyst (named after the discoverer, Dr. K. Ziegler) composed of alkyl aluminum and titanium chloride and the Medium Pressure Process using the cromina-silica-aluminum catalyst developed by Phillips of U.S.A. Manufactured on these Processes is polyethylene with a density of 0.940 to 0.970, which is called high density polyethylene because of the higher level of density than that of polyethylene manufactured on the High Pressure Process mentioned in 4.3.

The feature of the Low and Medium Pressure Processes is that reactions progress under relatively mild conditions of low polymerization pressure with reaction temperatures close to ordinary temperautres and it is possible to manufacture polyethylene having a very wide range of molecular weight by appropriately selecting reaction conditions and the concentration composition of the catalyst.

The Processes consist of such processes as polymerization, post-treatment (catalyst deactivation, washing, filtration), solvent recovery and purification, recovery and purification of catalyst deactivator, and pelletizing.

a) Polymerization

The reactor is usually a vertical drum equipped with an agitator, and is made of glass lining or stainless steel. Usually, purified ethylene gas, catalyst of controlled concentration composition, and hydrocarbon solvent are continuously fed to the reactor, and the produced polyethylene is drawn out in a state of slurry. During the process of this reaction, that is an exothermic reaction of 910 to 930 Kcal per 1 kg, the heat of reaction is removed with jacket and the like.

b) Post-treatment and Recovery

The catalyst in the produced polyethylene drawn out from the reactor is still active, which is deactivated with a catalyst deactivator such as alcohol. The deactivated catalyst residue is extracted on dissolution in the catalyst deactivator. After being separated from the solvent on filtration, the polymer is dried and sent to the powder hopper. The solvent and catalyst deactivator so separated, on the other hand, are respectively recovered, purified, and recycled.

c) Pelletizing

After the addition of a stabilizer and the like to the dried polymer powder and the subsequent mixing, the polymer so mixed is extruded on an extruder into pellets.

3-4-3 Process flow diagram with material balance

Figure AVI-3-3 shows process flow diagram with material balance for HDPE plant.

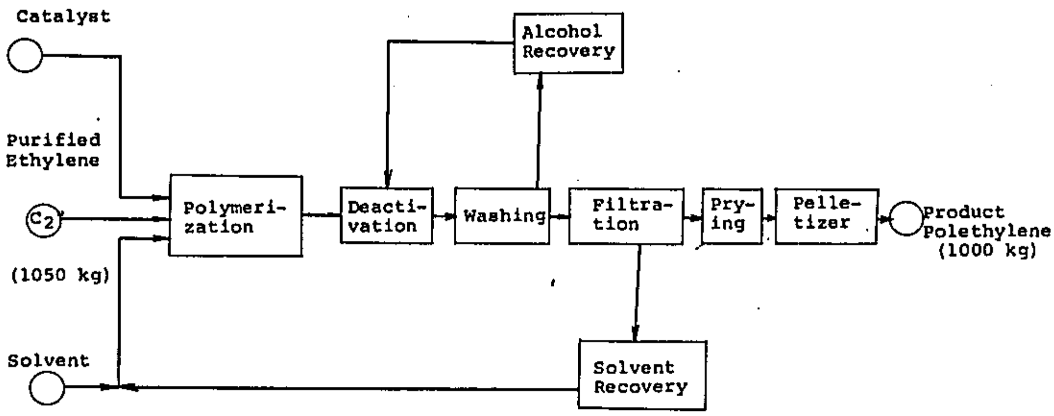


Figure AVI-3-3 Process Flow with Material Balance for HDPE Plant

3-5 Ethylene Oxide and Glycol

3-5-1 Licensor list

a) Scientific Design
b) Shell
c) Japan Catalytic Chemical
d) Montedison
e) Hüls

3-5-2 Process description

Ethylene oxide is a precursor of ethylene-glycol, and ethylene oxide itself is a starting material for the manufacturing of ethanolamines, polyethylene-glycols cellosolves and phenolic nonionic detergents. Monoethylene glycol is a raw material of polyester and an antifreezer for engine coolants.

Ethylene-glycol was manufactured from ethylene-chlorohydrin until the process of direct oxidation of ethylene was developed.

Now, almost all the commercial process to synthesize Ethylene oxide and Glycol is:-

$$\underset{\text{(Ethylene)}}{CH_2 - CH_2} + \underset{\text{(Oxygene of Air)}}{1/2\ O_2} \longrightarrow \underset{\text{Ethylene-oxide}}{CH_2 - CH_2 \ (-O-)} \quad \cdots\cdots \quad (1)$$

$$CH_2 - CH_2 \ (-O-) + H_2O \longrightarrow \underset{\text{Ethylene Glycol}}{HOCH_2 - CH_2 - OH} \quad .. \quad (2)$$

The commercial process to realize the above process, there are two ways; one uses air (e.g. conventional-Halcon process or Japan catalytic Chemical Co. process) another uses pure oxygen (e.g. Shell process or new Halcon).

A chart on the next page - Air-oxidation process of Halcon is shown, beside the different parts of air and oxygen process are simply indicated on the Note 1.

In both cases, compressed oxygen or air is mixed with ethylene put into the reactor and at around 250°C ethylene and oxygen partly change into ethylene oxide (EG) on the surface of silver catalyst. EG,in the effluent gas from the reactor, is absorbed by the water scrubbing. (for CO_2 removal)

The tail water of scrubber, containing EO is liberated from water in the stripper. Stripped EO is rectified and produces the final product EO. For increasing the yield and also guaranteeing the safety, severl parts of gas are recycled, and also purge reactor systems are attached to the main reactor.

EO then goes to the hydration system, there, EO is hydrated and produces Ethylene-glycol (EG). The main product of this step is Mono-Ethylene Glycol, but some quantities of di-ethylene glycol (D. EG) etc. are produced.

The important points of this process are;

1) Safety, from the hazard of the formation of explosive gas mixtures.

2) Ideal balance of selectivity and activity of the catalyst and reaction conditions should be kept, for the profitability of the plant.

3) Slight amount of carbonyl compounds are produced in the EO system.

They are the cause of deterioration in the EO and EG quality.

Oxygen process is an improved process of air process. Thus it is more efficient than air, but it depends upon a availability of oxygen.

3-5-3 Process flow diagram with material balance

Figure AVI-3-4 shows process flow diagram with material balance.

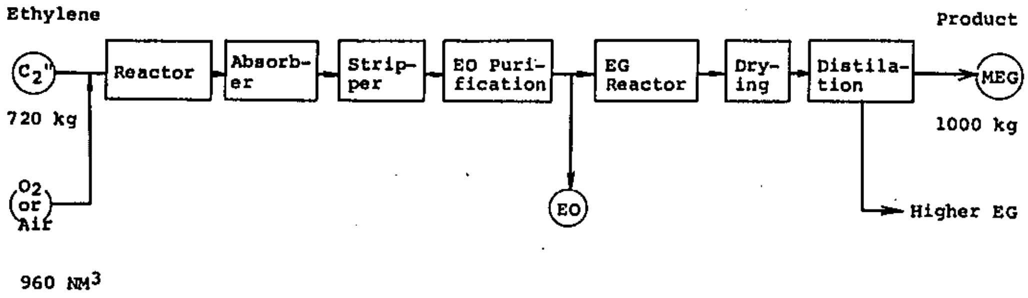


Figure AVI-3-4 Process Flow with Material Balance for EO/EG Plant

3-6 Styrene Monomer

3-6-1 Licensor list

Catalyst and Chemical
Dow Chemical
Monsanto
Scientific Design Company
Universal Oil Products
Union Carbide-Cosden (Badger)

3-6-2 Process description

To Manufacture styrene monomer, there were several ways:

1) $C_6H_5 - CH_2CHCl \xleftrightarrow{-HCl} C_6H_5CH = CH_2$

2) $C_6H_5CH_2CHNH_3 \xleftrightarrow{-NH_3} C_6H_5CH = CH_2$

3) $C_6H_5CH_2CH_3 \xleftrightarrow{-H_2} C_6H_5CH = CH_2$

Nowadays, dehydrogenation of ethylbenzene 3) is commercially used. Although thermal dehydrogenation has been studied, present commercial process by dehydrogenation is catalytic. Catalysts used now practically are ferric oxide catalysts promoted with potassium and chrome. As this dehydrogenation is a endothermic reaction, heat energy for this reaction is necessary to raise the temperature to 570°C by the addition of superheated steam. The amount of heat is recovered partially by heat exchange with the incoming reactant, then the product is condensed and disdistilled to separate the unreacted ethylbenzene.

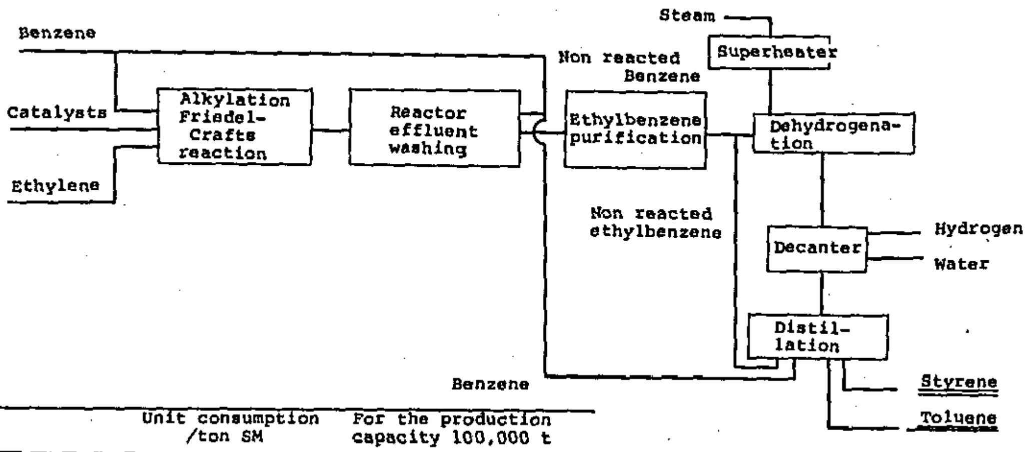
Ethylbenzene is made by the Friedel-Crafts reaction from benzene and ethylene.

$$C_6H_6 + C_2H_4 \longrightarrow C_6H_5C_2H_5$$

Using aluminum chloride, the alkylation can be done at the temperature of 100°C. The gas effluent is refluxed and scrubbed to recover benzene and ethylene.

3-6-3 Process flow for styrene monomer

Figure AVI-3-5 shows process flow for styrene monomer plant.



	Unit consumption /ton SM	For the production capacity 100,000 t
Benzene	835 kg	83,500 t
Ethylene	314 kg	31,400 t
Electric power	184 KWH	18,400 KWH
Steam	4.4 t	440,000 t
Cooling water	18 t	1,800,000 t
SM	1,000 kg	100,000 t
Toluene	70 kg	7,000 t

Figure AVI-3-5 Process Flow for Styrene Monomer Plant

3-7 Polystyrene

3-7-1 Licensor list

Bakol
BP Chemicals
Cosden
Dow Chemical
Idemitsu Petrochemical
Koppers
Mitsui-Toatsu Chemical
Monsanto
Montedison
Petrocarbon Development

Polysar International

Showa Denko

SNPA

Southern Petrochemicals

Union Carbide

3-7-2 Process description

Polystyrene is a polymerized styrene. There are four ways to polymerize styrene monomer:

1) Mass (Bulk) polymerization
2) Suspension polymerization
3) Emulsion polymerization
4) Solution polymerization

The most common method to produce polystyrene commercially is mass polymerization and the next is suspension polymerization, which is widely used for the production of expandable beads.

Polystyrene is classified into four typical types, general purpose (GP), middle impact (MI), high impact (HI), and expandable.

In mass polymerization, styrene monomer is usually polymerized without catalyst. As the polymerization is exothermic, heat transfer to remove the heat of the polymerization is the key parameter in commercial production.

Styrene monomer is fed to prepolymerizer first to get a 30 - 60% conversion under controled rate of polymerization. Then the polymer-monomer mixture is fed to the polymerizer to complete the reaction. The polymer coming out of the polymerizer is transfered to a vacuum chamber where the remaining monomer is devolatilized. The relatively pure polystyrene is pelletized through an extruder.

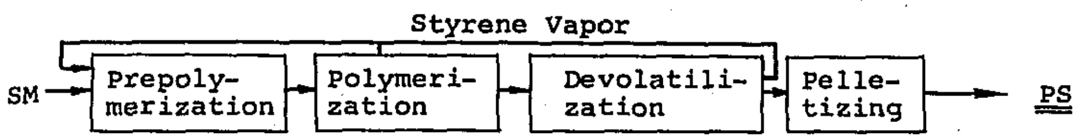
In suspension polymerization, as the monomer is suspended in water with a suspending agent and catalyst such as organic peroxide soluble in styrene, heat of polymerization can be easily removed through aqueous phase of the suspension. The polystyrene is separated from the water and suspending agent and then dried.

In emulsion polymerization, styrene monomer is dispersed with an emulsifier and catalyst in water under agitation to form a stable latex. The rate of polymerization and molecular weight of the polymer can be controlled independently by the temperature and by the catalyst and emulsifier concentration.

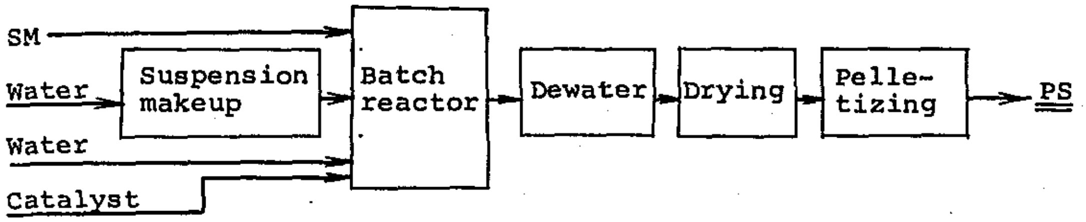
3-7-3 Process fow for polystyrene

Figure AVI-3-6 shows process flow for polystyrene.

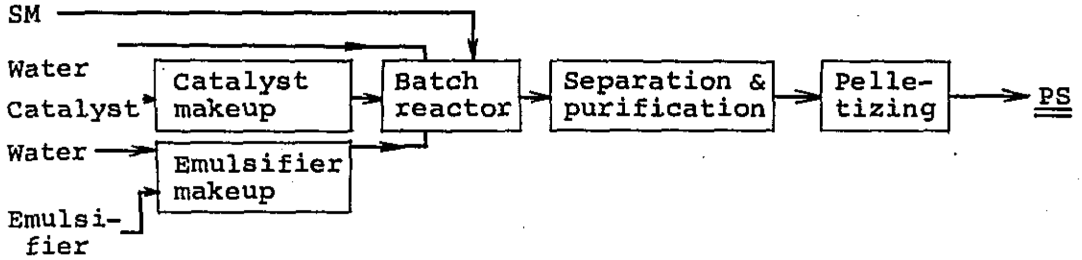
Mass polymerization



Suspension polymerization



Emulsion polymerization



Consumption by mass polymerization

	Unit consumption /ton PS	For production capacity 50,000 ton/year
SM	996 kg	49,830 ton
Electric power	340 kwh	17,000 kwh x 10^3 kwh
Steam	400 kg	20,000 ton
Cooling water	3.2 ton	160,000 ton
PS	1,000 kg	50,000 ton

Figure AVI-3-6 Process Flow for Polystyrene Plant

3-8 Acetaldehyde

3-8-1 Licensor list

a) Wacker Chemie

b) BP Chemicals

c) Hoechst

d) Aldehyd GmbH

3-8-2 Process description

Acetaldehyde has been synthesized via acetylene and water by the catalyst of mercuric salt.

$$CH{=}CH + H_2O \xrightarrow[Hg]{} CH_3CHO$$

About fifteen years ago, Wacker Chemie in Germany established the new process for manufacturing Acetaldehyde via Ethylene.

In this process, ethylene is oxidized by oxygen or air in the presence of conjugated paradium chloride and the copper chlorides catalyst system.

In the reaction system, the following reactions occur:

$$CH_2 = CH_2 + PdCl_2 + H_2O \longrightarrow CH_3CHO + Pd + 2HCl \;\ldots\; (1)$$

$$(Pd + 2CUCl_2) \longrightarrow (PdCl_2 + 2CuCl) \;\ldots\ldots\; (2)$$

$$2CuCl + 1/2\ O_2 + 2HCl \longrightarrow 2CuCl_2 + H_2O \;\ldots\ldots\ldots\; (3)$$

(1) is the oxidation of ethylene by $PdCl_2$ — H_2O, (2) is the regeneration of $PdCl_2$ by $CuCl_2$ and (3) is the $CuCl_2$ regeneration by oxygen, such a conjugated catalyst system is called a "Redox system". For the implementation of this process, there are two ways, one is one stage oxidation process another is two stage process; in the former the above three reactions take place simultaneously in a single reactor, in latter case (1) and (2) take place in the main reactor and (3) takes place in the catalyst recovery section.

In the former case oxygen is used; and in the latter, air can be used as an oxidizing agent.

Almost all the plants in Japan and Germany are applying the one stage system, because of less impurities, simpler operability and less utilities, but in this case an investment for oxygen plant is necessary.

In this process, ethylene is fed to the bottom of the reactor, where the catalyst solution is already prepared, and oxygen is fed into the reactor just above the ethylene sparger. Then reactions start and formed acetaldehyde goes into the condenser and scrubber through the mist separator.

In the scrubber aldehyde is absorbed into the process water up to 10 - 12% (at the temperature of 25° - 20°C).

In concentration. This dilute aldehyde solution is stored in the crude acetaldehyde tank.

The crude product is fed into the degasser and finally fractionated in the aldehyde column.

The problems of this process would be:

1) Corrosion of hydrochloric acid is severe, thus the materials of the reactor are brick-rubber-double lining and the cementing matter of the brick is high resistant Asprit or Furan Resin are used; and sparger of oxygen is also attacked from hydrochloric acid and pure oxygen so it contains a special measure against their hazard conditions.

2) In the condensor-scrubber temperature of the scrubbing water is fatal to the concentration of crude acetaldehyde.

Thus it is better to use colder process water, here.

3) This catalysts system is somewhat delicate for the normal "redox" balance, thus the hydrogen ion concentration and Cu/total Cu must be carefully checked.

3-8-3 Process flow diagram with material balance

Figure AVI-3-7 shows process flow with material balance for acetaldehyde plant.

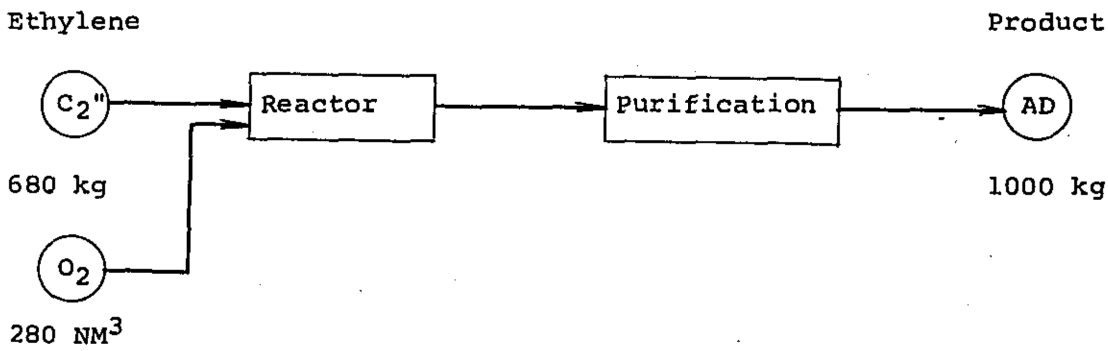


Figure AVI-3-7 Process Flow for Acetaldehyde Plant

3-9 Acetic Acid

3-9-1 Licensor list

a) Wacker Chemie

b) BP Chemicals

c) Daicel

d) Showa Denko

e) Melle Benzons

3-9-2 Process description

Almost all industrial process to manufacture acetic acid is the oxydation of acetaldehyde.

Recently, British Petroleum Co. developed the process by the direct oxidation of light naphtha, but it is realized commercially at Daicel Co. Japan (Ohtake) and BP (Hull-UK).

The process, to manufacture acetic acid from acetaldehyde is rather simple.

$$CH_3CHO + 1/2\ O_2 \longrightarrow CH_3COOH$$

Acetaldehyde　　　　　　　Acetic acid

Oxygen or air is used for oxydizing agent. Oxygen-process is said to be more efficient than air process, because of lower pressure and temperature, compact reactor size and less by-products.

We show the oxygen process in the following chart.

(Note; in the chart, the use of ethyl acetate, is eliminated but actually it is used in the recovery section as the azeotropic solvent.)

3-9-3 Process flow diagram

Figure AVI-3-8 shows process flow for acetic acid plant.

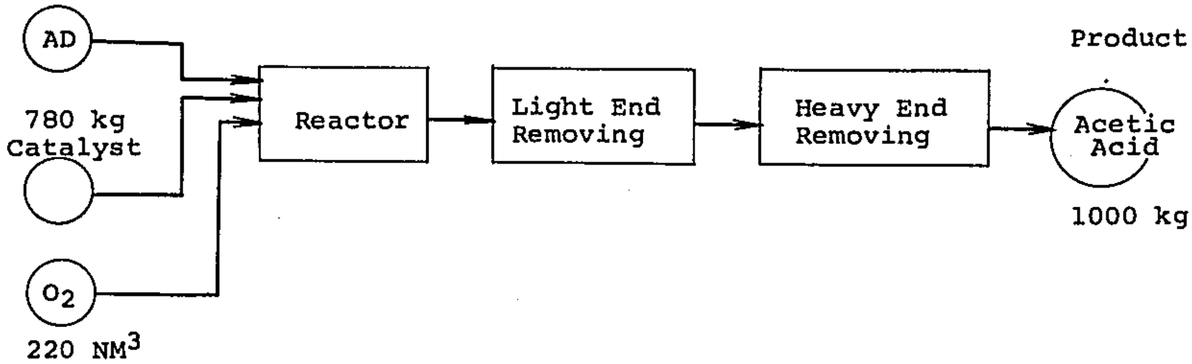


Figure AVI-3-8 Process Flow for Acetic Acid Plant

4. Products from Propylene

4-1 Polypropylene

4-1-1 Licensor list

a) Mitsui Petrochemical Ind.
b) Montedison
c) Phillips
d) Hüls/Veba Chemic
e) BASF
f) SOI
g) ICI
h) Hercules
i) Hoechst

4-1-2 Process description

1) Propylene polymerizes with the Ziegler Natta catalyst system and produces polypropylene. Propylene used for this feed must be free from acetylenic compounds, thus the propylene is rectified and hydrogenated before feeding. (There are two methods here; one uses extremely high purity propylene with solvents (hexane or heptane), another uses propylene from which is removed just the acetylenics but propane exists without solvents. In the latter case, a big propylene rectifier is not necessary but the propylene is wasted with the purged propane.)

2) Polypropylene has a branch of the methyl group, thus it forms some part of the atactic arrangement of molecules, it is not valuable as a plastic, it is separated by the solubility of the solvent. The improvement in the process of diminishing the atactic formation will be successful in near future.

3) There are co-polymers of propylene and ethylene other than propylene-homopolymer in the category of polypropylene.

They are an improvement on polymer characteristics for tenacity with strength at low temperature services.

4) The process: Process, with high purity propylene and solvent, is illustrated on the next following chart.

Catalysts are prepared in the catalyst preparation drum, and propylene is fed into the reactor system with solvent. In case of co-polymer, the ethylene is fed into the series of reactors.

Formed polypropylene slurry is put into the deactivator where the catalysts are deactivated with alcohol and then washed with water.

Alcohol goes into the water stream and it is distilled to recover alcohol. Hexane-polymer slurry is separated from the water-alcohol solution with gravity. The polymer is separated from hexane by the dehydrator. The mother liquor, which contains hexane and atactic polymer, is put into the evaporator where solvent is removed from atactics.

Isotactic polymer, separated by the dehydrator, is dried in the dryer and becomes polypropylene powder. This powder is pelletized with extruders.

4-1-3 Process flow diagram

Figure AVI-4-1 shows process flow for polypropylene plant

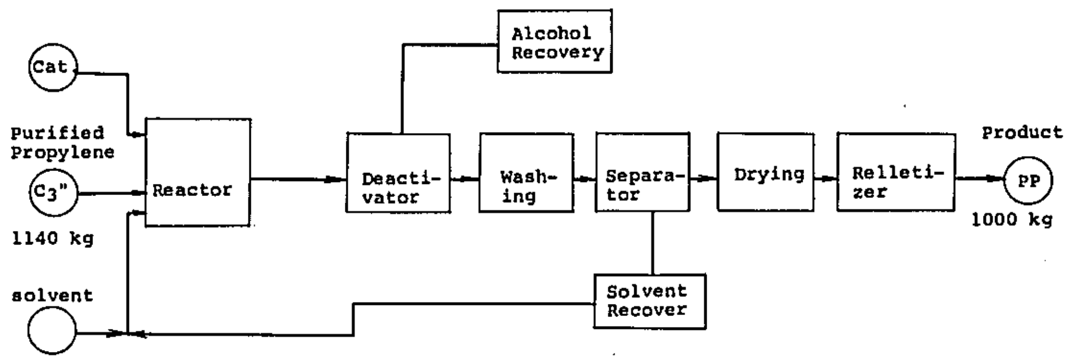


Figure AVI-4-1 Process Flow for Polypropylene Plant

4-2 Phenol (via Cumene)

4-2-1 Licensor list

(Cumen)

a) Scientific Design
b) Mitsui Petrochemical
c) UOP
d) Hüls
e) UCC

(Phenol)

a) Scientific Design
b) Hooker
c) Allied Chem.
d) BP Chemicals
e) Rhone Poubene
f) Badger
g) UOP

4-2-2 Process description (Cumene & phenol)

Phenol is a broadly used for thermo-set resins and raw materials of Bisphenol A (to Epoxy Resin and Poly carbonates), nonionic surfactants, agricultural chemicals and cyclohexanol to caprolactam.

Conventionally, Phenol was synthesized by the sulphonation of Benzene and subsiquent alkali fusion.

$$C_6H_6 + H_2SO_4 \longrightarrow C_6H_5SO_3H$$

$$C_6H_5SO_3Na + NaOH \longrightarrow C_6H_5OH + Na_2SO_3$$

(Phenol) (Sodium sulphite)

For, 1,000 kg of phenol, 1,400 kg Sodium sulphite is produced.

This process is batch wise and the alkalifusion process is very corrosive, but it is suitable for smaller scale production.

Around 1930s, Raschich in Germany invented the Raschich process:

$$C_6H_5 + HCl \longrightarrow C_6H_5Cl$$

$$C_6H_5Cl + H_2O \longrightarrow HCl + C6H5OH$$

Hooker Co. of U.S. improved this and established The "Hooker Process".

Dow Chemical Co. developed the toluene originated process.

Finally, Cumene process came on the scene. This process plays a major role in the recent phenol production. Cumene was the high octane gasoline for aircraft engines in World War II. After the war, reciprocal engines shifted to jet or turbines. Thus the use of Cumene is investigated by many companies who have big production facilities for Cumene.

Chevron (Oronite), Allied chemical, Hercules in U.S. and ICI, Distillers (BP) in UK, Progil and Rhon Poulenc in France or Riitgers in Germany established the Phenol via Cumene process.

The product quality of this process was worse than Sulphonic Acid process, but it is improved now and the economical value is superior to the conventional process, according to the credit of by-produced acetone.

The process chemistry is simply expressed as follows.

Cumene -- $C_6H_6 + C_3H_6 \longrightarrow C_6H_5C_3H_7$ -- (Alkylation)

(Benzene) (Propylene) (Cumene)

Phenol

$C_6H_5C_3H_7 + O_2 \longrightarrow C_6H_5 \cdot C_3H_6OOH$ (Oxydation)

(CHP)

$C_6H_5C_3H_6OCH \longrightarrow C_6H_5OH + CH_3COCH_3$

(Cleavage)

(CHP) (Phenol) (Acetone)

Cumene is synthesized by alkylation of benzene. UOP has the licence for commercial process of vapor phase system with phosphoric acid and catalysed Alkar. Scientific Design Co. developed the liquid phase alkylation process (Aluminium chloride catalysed).

Both processes are used for commercial production but UOP's process is adopted more than the Aluminium process. Mitsui Petrochemical Ind. Ltd. improved the Aluminium process and use it for their production plant.

In the following chart is shown Aluminium chloride-alkylation process for Cumene and BP type oxidation and cleavage etc. for phenol production.

(Note: 1 CHP: Cumen hydroperoxide

2 Cresol is synthesized similarly from Toluene.)

4-2-3 Process flow diagram

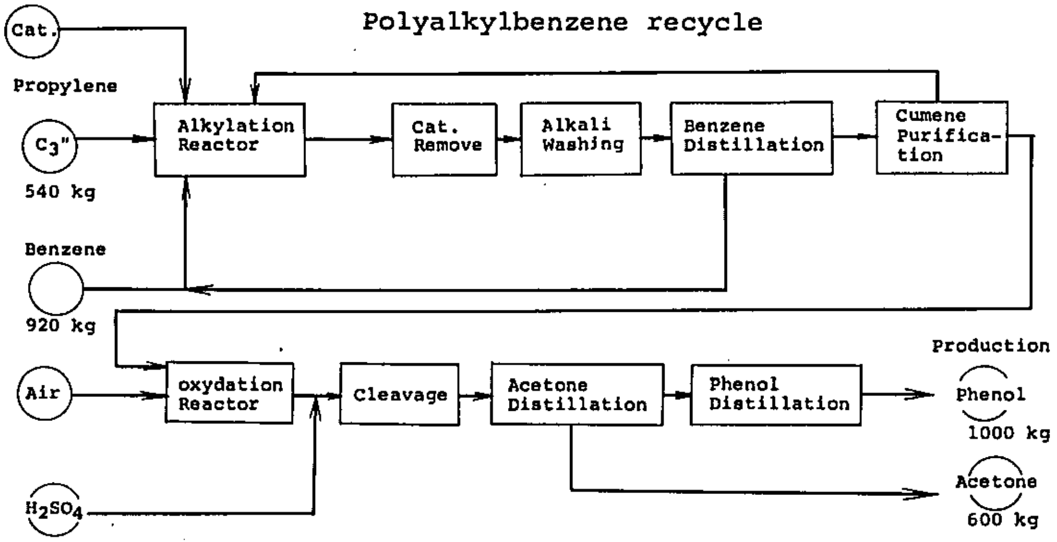


Figure AVI-4-2 Process Flow for Phenol Plant

4-3 Acrylonitrile

4-3-1 Licensor list

BF Goodrich
BP Chemicals-Urgine Kuhlmann
Distillers
Du Pont
Montedison
Snam Progetti
Standard Oil (Ohio)

4-3-2 Process description

Acrylonitrile is an important raw material of acrylic fiber, ABS, and AS resin. It is synthesized by direct ammoxidation of propylene.

$$CH_2 = CH\text{-}CH_3 + NH_3 + 1\ 1/2O_2 \longrightarrow$$

$$CH_2\ CH\text{-}CN + 3\ H_2O$$

For this reaction, various combinations of antimony, bismuth cobalt, molybenum, vanadium and uranium are used as catalysts.

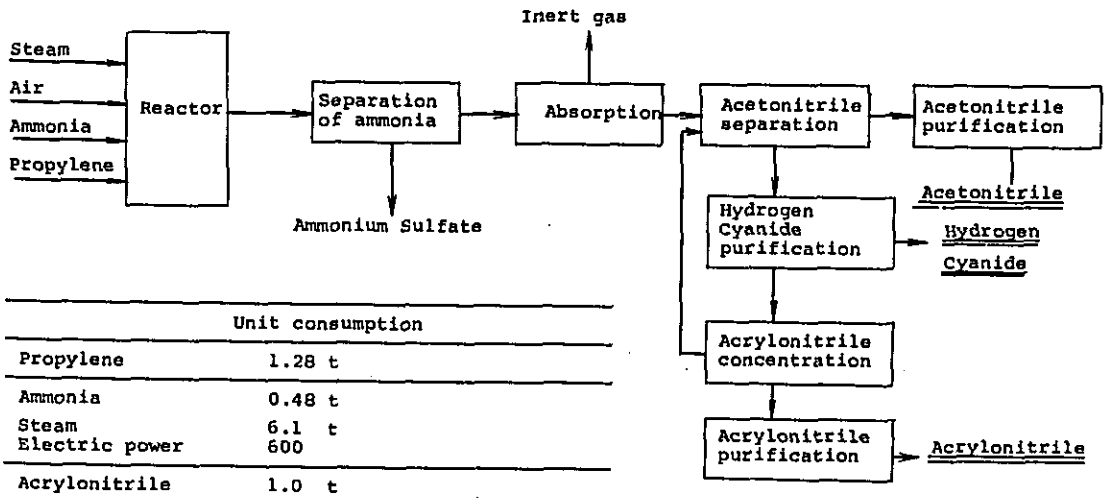
This process developed by Standard Oil of Ohio (SOHIO), but BP in United Kingdom developed the almost similar process. Before this process was established, the process via acetylene and hydrogen cyanide was used, but acetylene is more expensive than propylene, thus almost all the commercial plants adopt the SOHIO process.

Propylene, ammonia, air and steam are fed to ammoxidation reactors to be converted to acrylonitrile.

The reaction is exothermic and the heat transfer is the key factor to design them. Fluidized bed reactors have higher heat transfer and obtain more uniform bed temperature than fixed bed reactors. Non-reacted ammonia and incert gas are separated first, and then hydrogen cyanide and acetonitrile, the by-products of the process, are separated to purify acrylonitrile product.

Care must be taken, that by-produced hydrogen cyanide and acetonitrile are very poisnous.

4-3-3 Process flow for acrylonitrile



Unit consumption	
Propylene	1.28 t
Ammonia	0.48 t
Steam	6.1 t
Electric power	600
Acrylonitrile	1.0 t
Hydrogen cyanide	0.016 t
Acetonitrile	0.022 t
Ammonium Sulfate	0.015 t

Figure AVI-4-3 Process Flow for Acrylonitrile Plant

ANNEX VII

UTILIZATION POSSIBILITY OF NAPHTHA AND GAS IN INDONESIA

CONTENTS

Chapter 1. Naphtha

Pertamina is now contemplating a project for the construction of an Aromatics Complex by utilizing naphtha as the raw material. The SPD and TAP crude available in the South Sumatra, Arjuna crude in West Java, Minas crude in Central Sumatra, will be employed in this project with a total of 14,860 BPSD naphtha fraction representing 2,230, 6,230, 3,200 and 3,200 BPSD, respectively. On the other hand, the raw material naphtha for olefin production is not as yet secured at present. It seems that this is due to the following reasons.

The first reason is the fact that crude oil exportation holds a extremely important position in the Indonesian economy. At present, oil reserve excavations and surveys are conducted covering the whole of Indonesia. As shown in Table AVII-1-1 approximately 63 million kiloliters were produced in 1972, approximately 76% of which were exported to Japan, the USA and various other areas of the world.

Table AVII-1-1 Production and Export Records of Crude Oil in Indonesia

(Unit: 10^3 Kl)

	Production amount	Export amount	Export rate (%)
1966	27,111	15,087	56
1967	29,594	17,817	60
1968	34,956	23,129	66
1969	43,077	30,020	70
1970	49,532	36,292	73
1971	51,768	38,091	74
1972	62,770	47,552	76

While undertaking crude oil exportation as mentioned in the above, the petroleum products refined in seven refineries owned by Pertamina are also partly exported in Indonesia. Such exports covering crude oil and petroleum products are extremely high and the rate comprised by the oil and oil products in the total Indonesian export amounts has been increasing year after year as shown in Table AVII-1-2. Also, approximately 40% of the national budget is financed by the corporate tax etc. from oil-related industries. Such a situation persists to exist for some time to come. The increase of national budget has been supported by the revenues from the oil-related industries and therefore the oil development is actively taken and most portion of the increased oil productions will be allocated for exportation.

Table AVII-1-2 Export Amount in Indonesia

(Unit: 10^6 US$)

	Petroleum	Others	Total
1968	303 (40%)	454	757
1969	366 (37%)	629	995
1970	450 (38%)	737	1,187
1971	541 (42%)	755	1,296

Note: ( ): Ratio of petroleum to total amount

The second reason, as shown in Table AVII-1-3 concerning the production, exportation and demand for petroleum products, is that the rate of demand for automobile gasoline and kerosene is high.

The demand for automobil gasoline is considered to increase in the future along with progress of road construction and rehabilitation, and motorization caused by improvements in the living standard.

Kerosene is consumed in great quantities for household fuel, and approximately 1 million kiloliters of kerosene was imported from overseas in 1972.

Due to the fact that the naphtha for petrochemical industry use entirely coincide with the fraction to be utilized for the fulfillment of the above demand, it would be extremely difficult to secure naphtha supply from the existing oil refineries.

Therefore, if the naphtha for 300,000 tons of ethylene production is to be secured, it will be necessary to construct refineries with the capacity of more than 100 thousand bbl/d in order to merely secure the raw material supply for the petrochemical industries.

Naphtha for petrochemical industry has not yet been secured because of the above-mentioned reasons. The same situation applies to the condensates which contains heavy fractions by-produced from LNG plants.

Table AVII-1-3 Production, Exportation and Domestic Demand of Petroleum Product

(Unit: 10^3Kl)

	Prod.	Export	Dom. demand	Prod.	Export	Dom. demand
Aviation gasoline	32	2	22	20	-	17
Motor gasoline	1,919	47	1,696	2,019	399	1,745
Jet fuel	164	-	156	188	-	189
Kerosene	2,362	-	3,128	2,437	-	3,467
Gas oil	1,147	-	1,169	1,502	-	1,441
Diesel engine oil	477	-	381	536	-	441
Fuel oil	2,881	1,623	663	948	1,540	288
Waxy distillate	5	6	-	-	-	
Heavy distillate	3,483	3,579	-	6,332	5,289	-
Others	-	-	-	-	-	
Total	12,470	5,257	7,215	13,982	7,228	7,588

Source: Far East Oil Trading Co., Ltd.

Chapter 2. Natural Gas

The production of natural gas in Indonesia has been undertaken in Table AVII-2-1.

However, at present fertilizer and LNG projects are being implemented on a large scale by utilizing natural gas in East Kalimantan, West Java and North Sumatra. The reserve of natural gas in addition to the amounts supplied by these projects are also enormous. It was reported that BAPPENAS is now formulating a second five-year plan with the basic policy of securing approximately 150 BSCF gas for petrochemical industry for the period of 1978 to 1979. This amount may vary the ethylene amount to be produced depending upon the composition of the obtained gas. However, the gas amount is sufficient for the production of 400,000 to 500,000 tons per year of ethylene in this study. Therefore, on the basis of the assumption that this amount of natural gas will be secured, the consultants will proceed with the studies.

Table AVII-2-1 Production Amount of Natural Gas

(Unit: 10^6 m^3)

	Production amount
1968	3,074
1969	1,656
1970	2,718
1971	3,417
1972	4,139

ANNEX VIII

CURRENT SITUATIONS & FORECAST ON THE WORLD'S PETROCHEMICAL INDUSTRIES

CONTENTS

Chapter 1. Current Production & Demand of the World Petrochemical Industries

1-1 Plastics

Plastics production from the latter part of the 1960's through the early part of the 1970's are shown in Table AVIII-1-1. For 1971 the total production amounted to 32,650,000 tons, which when compared with that of 1966, is found to have doubled during the ensuing 5 years. Comparing the world's major 7 producing countries, those productions carried out by U.S.A., Japan, West Germany, U.S.S.R., Italy, England and France amounted every year to approximately 80% of the total, further indicating a continuous increase of about 10% over the previous year, which can be seen from the Table AVIII-1-2.

Polyolefin, polystyrene and PVC, as given in the Table AVIII-1-3, except for the West Germany[1], show that approximately 70% of production is shared among them.

(1) U.S.A.

The American polyolefin demands have, as given in the Table AVIII-1-4, rapidly increased from 1971 to 1972, thus the supply demand situation is rather stringent.

During 1972, LDPE indicated an increase of approximately 20% in both production and demand, production was 2,386,000 tons and demands were 2,372,000 tons. As against these figures, the production capacity was 2,495,000 tons. A delicate balance was maintained between the demands and supply capacity.

HDPE indicated since 1965 onward, an annual high increase rate of 17 - 18%, 1972 demands have shown 1,026,000 tons, the production capacity thereto was 1,134,000 and indicated a high operational rate of 1,027,000 tons.

Demand for PP wavered during 1969 - 1970, however, after 1971 a very rapid annual rate increase of 30% was shown, which was mainly due to a low, stabilized price and comparatively ample material and production capacities. There is no longer any prospect for new expansion of the production facilities due to the lower pricing level, thus no further supply increase is expected until the end of 1974 when new capacity will be starting up by Amoco and Hercules, and the stringent supply situation may remain until the early part of 1975.

Demand for PVC indicated an annual rate of 12% during 1967-1971, which, however, in 1972 indicated 26% as against the previous

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Note: 1) Production of polystyrene is not announced in West Germany.

Table AVIII-1-1 World Plastics Production

(Unit: 10^3 tons)

Note: Figures in ( ) show the estimation

Name of Country	Year 1966	1967	1968	1969	1970	1971
Asia						
Japan	1,994.0	2,675.4	3,462.3	4,275.3	5,127.3	5,198.4
Korea	7.8	11.5	20.0	48.5	62.5	(83.0)
India	36.6	36.2	55.1	85.0	80.9	(85.0)
China	150.0	(200.0)				
Formosa	75.2	98.3				
Pakistan	15.0	(18.0)	(378.0)	(440.0)	(500.0)	(500.0)
Israel	30.0	38.0				36.0
Sub Total	2,308.6	3,077.4	3,915.4	4,848.8	5,770.9	5,902.4
Africa						
South Africa	35.0	(40.0)	(40.0)	(45.0)	(45.0)	(50.0)
Western Europe						
England	1,001.0	1,112.0	1,244.0	1,364.0	1,458.0	1,580.0
Holland	294.0	372.3	546.3	682.6	910.0	998.0
Belgium	118.0	131.0	148.5	180.0	230.0	350.0
Spain	147.0	182.0	272.0	292.5	380.0	448.0
Portugal	13.6	17.9	18.6	25.6	(30.0)	27.0
France	759.0	885.0	1,008.0	1,319.3	1,515.0	1,650.0
Italy	1,060.0	1,310.0	1,425.0	1,490.0	1,740.0	1,890.0
Switzerland	46.0	48.0	54.0	60.3	(70.0)	(68.0)
Greece	6.0	6.0	9.0	20.3	20.3	37.0
West Germany	2,292.0	2,635.0	3,250.0	3,963.0	4,326.0	4,760.0
Denmark	12.0	13.0	13.5	18.0	20.0	78.0
Norway	69.0	78.0	81.0	94.5	100.0	130.0
Sweden	145.0	180.0	229.5	276.7	310.0	345.0
Finland	11.0	28.0	30.7	62.0	(68.0)	70.0
Austria	94.0	106.0	127.4	158.6	190.0	208.0
Sub Total	6,067.6	7,104.2	8,455.5	9,989.4	11,367.3	12,639.0
Eastern Europe						
Poland	132.0	167.0	196.0	234.0	(260.0)	267.0
Hungary	32.6	36.0	43.0	(50.0)	(60.0)	82.0
Czechoslovakia	152.0	185.0	197.0	210.0	240.0	265.0
Burgaria	30.6	51.0	70.0	(75.0)	(80.0)	89.0
Rumania	94.7	108.0	135.0	(170.0)	(225.0)	251.0
East Germany	246.6	273.0	311.0	(330.0)	(340.0)	370.0
Yugoslavia	62.0	75.0	95.0	(95.0)	(96.0)	97.0
U.S.S.R.	882.4	971.0	1,312.0	1,386.0	1,553.0	1,860.0
Sub Total	1,641.9	1,866.0	2,359.0	2,550.0	2,854.0	3,281.0
North America						
Canada	270.0	273.6	296.1	350.2	(380.0)	431.0
U.S.A.	6,113.2	6,207.0	7,110.0	8,339.0	8,820.0	9,473.0
Sub Total	6,383.2	6,480.6	7,406.1	8,689.2	9,200.0	9,904.0
Central & South America						
Argentina	76.3	78.2	(85.0)	(105.0)	118.3	135.3
Brazil	120.0	141.0	(155.0)	(170.0)	189.4	228.8
Venezuela	(30.0)	(30.0)	(40.0)	(50.0)	66.5	75.2
Mexico	65.2	85.4	90.7			
Chile	13.3	(15.0)				
Puerto Rico	(30.0)	(30.0)				
Colombia	(30.0)	(30.0)	(83.0)	(175.0)	(175.8)	(180.0)
Peru	10.0	11.0				
Sub Total	374.8	420.6	453.7	500.0	550.0	619.3
Oceania						
Australia	107.0	169.0	192.0	(210.0)	(240.0)	254.3
GRAND TOTAL	16,918.1	19,157.8	22,321.7	26,832.4	30,027.2	32,650.0

Table AVIII-1-2 Plastics Production in Major Countries

(Unit: 10^3 tons)

	1970			1971			1972		
	Production	Growth Rate	Composite Ratio	Production	Growth Rate	Composite Ratio	Production	Growth Rate	Composite Ratio
America	8,820	105.8	29.4	9,473	107.4	29.0	11,000	116.1	30.0
Japan	5,128	119.9	17.1	5,198	101.4	15.9	5,657	108.8	15.5
W. Germany	4,326	109.2	14.4	4,760	110.0	14.6	(5,200)	109.2	14.2
U.S.S.R.	1,553	112.1	5.2	1,860	119.8	5.7	(2,000)	107.5	5.5
Italy	1,740	116.8	5.8	1,800	108.6	5.8	(2,080)	110.1	5.7
England	1,458	108.3	4.8	1,580	108.4	4.8	(1,680)	106.3	4.6
France	1,515	114.9	5.0	1,650	108.9	5.1	(1,800)	109.1	4.9
Others	5,487	115.4	18.3	(6,239)	113.7	19.1	(7,183)	115.6	19.6
Total	30,027	111.7	100.0	(32,650)	108.7	100.0	(36,600)	112.1	100.0
Sub total of Major 7 Countries	24,540	110.1	81.7	26,411	107.6	80.9	(29,417)	111.4	80.4

Figures in (   ) show the estimation made by Plastics Industry Assn. of Japan

Table AVIII-1-3 Commodity Plastics Production in Major Countries

(Unit: 10^3 tons)

	U.S.A.			Japan			W. Germany			Italy			U.K.			France		
	1970	1971	1972	1970	1971	1972	1970	1971	1972	1970	1971	1972	1970	1971	1972	1970	1971	1972
LDPE	1,908	2,004	2,372	861	964	1,072	900	1,009		358	410		315	305		352	415	
HDPE	705	874	1,062	369	423	479				83	95		61	63		58	84	
PP	464	566	767	529	619	633				60	61		62	78		20	25	
PS	1,598	1,688	2,111	633	694	765	-	-		195	199		168	172		132	147	
PVC	1,690	1,834	2,345	1,138	1,063	1,125	870	951		569	600		350	375		412	455	
Commodity plastics total	6,365	6,966	8,657	3,530	3,763	4,074	1,770*	1,960*		1,265	1,365		956	993		974	1,126	
Plastics total	8,627	9,473	11,597	5,128	5,198	5,657	4,326	4,760		1,741	1,890		1,450	1,580		1,519	1,650	
																(in percent)		
LDPE	22	21	20	17	19	19	21	21		21	22		22	19		23	25	
HDPE	8	9	9	7	8	8				5	5		4	4		4	5	
PP	5	6	7	10	12	11				3	3		4	5		1	2	
PS	19	18	18	12	13	14	-			11	11		12	11		9	9	
PVC	20	19	20	22	20	20	20	20		33	32		24	24		27	28	
Commodity plastics total	74	74	75	69	72	72	41*	41*		73	72		66	63		64	68	
Plastics total	100	100	100	100	100	100	100	100		100	100		100	100		100	100	

* Excluded Polystyrene

Table AVIII-1-4 American Polyolefin Demand & Supply Situation

(Unit: 10^3 tons)

	LDPE			HDPE			PP		
	Production	Demand	Capacity	Production	Demand	Capacity	Production	Demand	Capacity
1965	997	1,043		354	336		168	163	240
66	1,134	1,160		417	404	573	231	247	275
67	1,270	1,179		499	468		293	291	326
68	1,406	1,361		567	544		367	413	430
69	1,714	1,622		670	635	795	515	443	527
70	1,950	1,896		771	737	937	458	447	686
71	2,022	1,974	*3 2,190	873	864	*3 987	585	590	
72	2,386	2,372	*4 2,495	1,072	1,026	*4 1,134	796	766	*2 891
73(Estimated)		*1 2,631	*1 2,799		*1 1,224	*1 1,207			*2 1,030
74(Forecasted)		*1 2,948	*1 2,957		*1 1,294	*1 1,407			*2 1,030
75(Forecasted)		*1 3,270	*1 3,280		*1 1,433	*1 1,402			*2 1,280

INFORMATION SOURCES: 1) Production & Demand Actuals: Modern Plastics International (however, the production for the years of 1971 and 1972 are taken from the statistics of SPI).

2) *1 CMR (73.9.24)
*2 CW (73.5.14) and CEN (73.7.9)
*3 Modern Plastics I (71.2) (71.1.1, as of this date)
*4 Plastic World (72.10)

Table AVIII-1-5 PVC Demand & Supply Balance in U.S.A.

(Unit: 10^3 tons)

	1967	1968	1969	1970	1971	1972	1973 (Estimated)
Production	998	1,123	1,247	1,402	1,545	1,962	
Domestic	911	1,052	1,224	1,288	1,496	1,901	2,271
Export	32	41	74	95	75	73	
Capacity						2,014	2,177

Source: Modern Plastics International (1973,1 & others) year showing a rapid demand increase. It is said that this was mainly due to the rapid demand increase on pipes, taking advantage of the FDA approval. Besides pipe demands, and supported by the good recovery in general of other economic situations, all demands such as blow container, furniture, and electric cable have indicated an increase of 20 - 30%. Future demands are forecasted to continue the constant increase of 10 - 12%.

As of 1972, the supply capacity of PVC is said to be 2,014,000 tons, and is at full production rate at the moment.

As of 1973, the production capacity for VCM is said to be 2,615,000 - 2,660,000 tons, with a 95% production rate, and the production quantity is estimated to be 2,500,000 tons. On the other hand, exports to Western Europe in 1972 amounted to 280,000 tons, but it had to be reduced to about 180,000 tons due to increasing domestic demands in 1973.

With reference to the expansion program for VCM, there is only Shell's plant (with the capacity of 317,500 tons, scheduled to start up at the end of 1973), thus the tight supply demand condition will remain for the time being.

(2) Western Europe

According to LDPE supply demand balance given in Table AVIII-1-6, while the production rate is kept as a higher rate there is still about an 80,000 - 130,000 tons shortage predicted in total. This is because, not only have domestic demands increased, but also the supply shortage felt in U.S.A. and Japan has had great influence on many countries. As a result, higher levels of exports are being made to these countries, shorted by the U.S.A. and Japan.

Table AVIII-1-6 LDPE Demand & Supply Balance in Western Europe

(Unit: 10^3 tons)

	1971	1972	1973 (Estimated)
Capacity	2,750	3,350	3,740
Production (A)	2,450	2,930	3,400
Operating Efficiency(%)	89.4	87.5	90.9
Domestic	2,230	2,600	3,030
Export	210	290	450 - 500
Grand Total (B)	2,440	2,900	3,480 - 3,530
(A) - (B)	10	40	△80 - △130

INFORMATION SOURCE: ECN Chemscope (73.10.12)

Demand for HDPE has rapidly increased since the latter part of 1972, and this trend will be continuing in 1973 in Western Europe indicating about a 16% increase. However, imports from the United States are predicted to decrease greatly, and the supply demand condition will become very tight.

PVC production and consumption in various EEC countries are, except for the year 1971, maintaining a growth ratio of 15 - 30% on an annual basis, and it is predicted that in 1973 there will be about a 15% increase. A great shock was given to the British market as a result of the accident that occurred at the Baglan Bay complex of BP Chemicals in the early half of 1973, and its suspension of operation of a new plant, for VCM, having a capacity of 260,000 tons was quite a shock, thus ICI could acquire a provisional exemption from the import duty levied on VCM, but the export capability of the United States is rather small, and, exports to the British market have almost no merit for Western European countries inasmuch as PVC prices are being frozen by the British authorities.

Import requests to EEC countries, from areas previously exported from U.S.A. and Japan, hitherto, are increasing a lot. As a result, those PVC exports of EEC countries which were on the level of 280,000 - 300,000 annually jumped at the end of 1972 to 400,000 tons at an annual rate. Accordingly, while the PVC supply demand situation in Western Europe is not so much aggravated as that of Japan and U.S.A., it is certain that the situation will become more tight unless the supply demand situation of the two countries is improved in some way.

(3) Japan

Plastics production in Japan has steadily continued to increase at an annual approximate rate of 25% since the petrochemical industries started developing, from 1960 to 1970, taking only 10 years to grow from 550,000 tons to 5,130,000 tons. However, a rapid change in the situation has occurred since 1970 and the trend started levelling off in 1971 indicating about 101.4%, and in 1972 it recovered slightly indicating 108.8% as compared with the preceding year. The major factor that supported production increases of the 1970s was the export market. The domestic consumption growth was below 1965 levels, when the Japanese market was in an overall recession. In comparison with 1970, the year 1972 indicated a wavering rate of only 106%. As a result of this situation, a HDPE and PP cartel inclusive of ethylene, and PVC was formed in 1972 to counter the recession, and it was continued for approximately 9 months for ethylene starting from April, for 9 months for PVC from January to September, and for approximately 8 months for HDPE and PP from March.

However, growth of domestic consumption since 1973 was unexpectedly great. Most petrochemical products have shown a two digit increase ratio, except for LDPE on which some shipping restrictions were made in view of the stabilization cartel on polyolefin film. Thus it has recorded, on an ethylene base, a production increase of 8% annual rate on average. Moreover, in the light of the continued export cartel since 1972, a sweeping export cut was made, and the export quantity for almost all products decreased compared with the previous year, i.e., an export cut was made, with the exception of the Southeast Asian markets inclusive of mainland China. However, while it was in the same supply demand tightness, the export ratio from various European countries, where a Domestic

Table AVIII-1-7 PVC Demand & Supply Balance in EEC & England

(Unit: 10^3 tons)

		1967	1968	1969	1970	1971	1972
Production	E E C	1,192	1,457	1,701	1,929	2,014	2,378
	England	228	271	283	315	315	333
*Consumption	E E C	1,033	1,233	1,475	1,629	1,774	2,052
	England	225	277	290	336	313	337 (Estimated)
Capacity	E E C			2,000	2,440	2,685	3,270 (Estimated)
	England			360	500	500	515

INFORMATION SOURCES: Production & Consumption Quantity: EEC --- Plastiques Modernes et Elastomeres (73/3)

England --- IPC Business Press

Capacity --- Modern Plastics International (71.2)

NOTE: *Consumption = Production + Importation - Exportation

Commodity Price Control Ordinance is being enforced, was raised. As a result, the Japanese share in the Southeast Asian countries was unavoidably forced to be reduced a bit. The rise in export price was also conspicuous, and a reversal phenomenon occurred between the domestic price and export price.

The increase in production capacity after the end of the aforementioned cartel was rapidly slowed as a result of the halt in expansion of production facilities. However, the sudden accident that occurred at the Idemitsu petrochemical complex, in July 1973, has given a drastic and decisive blow to the supply shortage of ethylene. Referring to the accident, the supply capacity decrease, aggravated as a result of a series of accidents that occurred within the petrochemical industries during the latter half of 1973, is said to be estimated to 150,000 t/y, at an annual ethylene rate, inclusive of the results or aftermaths of both direct and indirect natures.

The other elements influencing the decrease of supply capacity of petrochemical products are air pollution, due to the photo-sensitive phenomenon, unusually dry season aggravating the water supply, saving of electricity, shortening of operational hours, plant closures due to the mercury disputes, etc.

1-2 Ethylene

As given in Table AVIII-1-8, ethylene production facilities of the world stood at 29,147,000 t/y at the end of 1972. A capacity of 1,015,000 t/y was owned by communist countries and is included as against that of the free world, 28,132,000 t/y. Classified into U.S.A., EEC countries and Japan, as given in Figure AVIII-1-1, the growth of production capacities of EEC countries was remarkable exceeding in 1973 the U.S. capacity. Table AVIII-1-9, shows that 6 major countries, the U.S.A., Japan, West Germany, Italy, France and England had 82% of the world's capacity in 1970. This is predicted to drop to 74% in 1974.

Production quantities are as given in the Table AVIII-1-10 with Holland, who has indicated recent rapid increase in production, as one of the major countries. The production rate of these major countries during 1968 to 1971 indicated an annual average increase of 15%, but after 1971 onward the rate of increase is on a decreasing trend.

(1) U.S.A.

Ethylene demand during the 1960s in the United States showed a comparatively mild increase of approximately 13% on an annual level. During 1971 a temporary wavering was observed. This, however, was recovered during 1972, and it is considered that an average increase of about 10 - 12% may continue to be felt.

Supply capacity up until 1968 was somewhat excessive. However, as we reached the 1970s, it has become compatible with actual demands, and lately ethylene capacity is completely shorted, i.e., as against the 1973 ethylene demand forecast of 10,000,000 - 10,400,000 tons, the production capacity is on the level of 10,400,000 - 10,700,000, which apparently signifies that the production level is at full capacity. In spite of the mentioned circumstances, ethylene

Table AVIII-1-8 Country-wise Ethylene Production Facilities (1972)

Country-wise Ethylene Production Facilities (as of 1972)

	Current (10^3 t/y)	Scheduled (10^3 t/y)	After Completion (10^3 t/y)
North & South America			
U. S. A.	9,026	1,915	10,713
Puerto Rico	806	454	1,260
Sub-total	(9,832)	(2,369)	(11,973)
Canada	624	891	1,488
Mexico	253	182	435
Argentin	43	447	475
Brazil	329	133	462
Bolivia	—	50	50
Chile	60	-	60
Colombia	20	-	20
Peru	5	40	45
Venezuela	-	150	150
Antilles Is.	-	230	230
Sub-total	(1,334)	(2,123)	(3,415)
Europe			
U. K.	1,420	790	2,210
W. Germany	3,208	1,463	4,671
France	1,773	200	1,973
Italy	1,933	258	2 191
Belgium	525	500	1,025
Holland	1,640	450	1,930
Denmark	45	-	45
Austria	70	70	140
Greece	15	250	265
Portugal	-	200	200
Spain	325	345	670
Switzerland	14	-	14
Finland	165	-	165
Norway	-	250	250
Sweden	250	-	250
Sub-total	(11,383)	(4,776)	(16,019)
Africa & Near East			
Algeria		120	120
Egypt	9	80	89
South Africa	158	250	408
Iran	12	323	335
Israel	24	150	150
Syria	-	20	20
Turkey	30	213	243
Sub-total	(233)	(1,156)	(1,365)
Asia & Oceania			
Japan	4,814		4,814
India	105	283	388
Pakistan	-	30	30
Thailand	-	150	150
Singapore	-	300	300
Philippines	-	250	250
Formosa	55	254	309
Korea	100	50	150
Australia	276	60	336
Sub-total	(5,350)	(1,377)	(6,727)
Free World Total(A)	28,132	11,801	39,499
Communist Block			
U. S. S. R.	155	1,050	1,205
Bulgaria	230	250	480
Czechislovakia	120	525	645
E. Germany	200	630	730
Hungary	25	250	275
Poland	100	300	400
Rumania	135	620	755
Yugoslavia	50	500	550
China	-	420	420
North Korea	-	60	60
Communist Block Total (B)	1,015	4,605	5,520
Grand Total (A + B)	29,147	16,406	45,019

NOTE: Current (a)------ Includes spare capacities
(b)------ Includes capacities under construction
(c)------ (a) + (b) Closed capacities

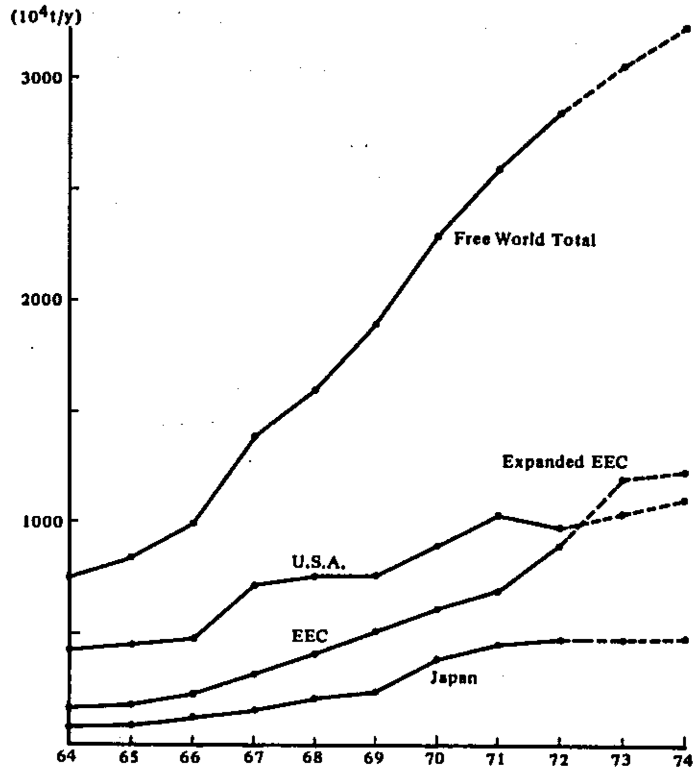

Figure AVIII-1-1 Ethylene Production Capacity in the Free World

prices are very low, and desires for investment in ethylene plants have diminished, moreover, in view of the aggravated material feed problems and the difficulty of making justifiable forecasts thereof, all the related concerns regard that the realization of new expansion of ethylene plants would be rather distressing.

(2) Western Europe

Ethylene demand during 1967 - 1972 in the Western Europe kept higher rate of annual growth 22%, and it reached in 1972 to approximately 7,500,000 tons, which, compared with nominal production capacity, seems that there has been a considerable amount of excessive capacity. Taking factors such as plant startup delays, periodical repairs and maintenance, shutdowns, feedstock shortage, environmental problems, etc. and other operational restrictions into consideration, it is believed that actual production capacity stays at about 85 - 90% of nominal capacity, and the substantial operational level is estimated to be a little less than 90%. However, the tempo of new expansion in the future will remain at a lower level, while operational levels will be increased.

Table AVIII-1-9 Ethylene Capacity Situation in Major Countries & Rate of Increase against Previous Year

	1970	1971	1972	1973	1974
	10^3 tons(%)	10^3 tons(%)	10^3 tons(%)	10^3 tons(%) (Estimated)	10^3ntons(%) (Estimated)
U. S.	8,880 (+16)	10,231 (+15)	9,832 (- 4)	10,421 (+ 6)	11,065 (+ 6)
Japan	3,914 (+62)	4,514 (+15)	4,814 (+ 7)	4,814 (0)	4,814 (0)
W. Germany	2,616 (+31)	2,723 (+ 4)	3,208 (+18)	3,811 (+19)	3,811 (0)
Italy	1,446 (+52)	1,588 (+10)	1,933 (+22)	1,933 (0)	1,933 (0)
France	1,168 (+11)	1,163 (0)	1,773 (+52)	1,773 (0)	1,973 (+11)
U. K.	1,555 (- 6)	1,510 (- 3)	1,420 (- 6)	1,760 (+24)	1,760 (0)
Major Countries Total	19,579	21,729 (11)	22,980 (7)	24,512 (7)	25,356 (3)
Free World Total (A)	22,903 (+21)	25,950 (+13)	28,132 (+ 8)	30,264 (+ 8)	32,226 (+ 6)
Communist Block Total (B)	1,007 (+30)	1,047 (+ 4)	1,015 (- 3)	1,265 (+25)	2,215 (+75)
World's Total (A + B)	23,910 (+21)	27,007 (+13)	29,147 (+ 8)	31,529 (+ 8)	34,441 (+ 9)
Major Countries Share (%)	82	80	79	78	74

Table AVIII-1-10 Major Country-wise Ethylene Production (Actuals & Estimations), & Rate of Increase against Previous Year

	1968 (10^3 tons)	1969 (10^3 tons)(%)	1970 (10^3 tons)(%)	1971 (10^3 tons)(%)	1972 (10^3 tons)(%)
U. S. A.	(5,958	7,431 (25)	8,386 (13)	8,364 (0)	9,350 (12) (Estimated)
Japan	1,793	2,400 (34)	3,097 (29)	3,537 (14)	3,851 (9)
W. Germany	1,534	1,933 (26)	2,019 (4)	2,004 (-1)	2,100 (5) (Estimated)
Italy	644	673 (5)	917 (36)	1,017 (11)	1,100 (8) (Estimated)
France	534	760 (42)	934 (23)	1,016 (9)	1,215 (20)
Holland	245	274 (12)	559 (104)	850 (52) (Estimated)	1,350 (59) (Estimated)
England	702	889 (27)	998 (12)	1,040 (4)	1,122 (8)
Total	11,410	14,360 (26)	16,910 (18)	17,828 (5)	20,088 (13)

INFORMATION SOURCES: Figures on the U.S.A. were taken from the data of Customs Commission and the estimations made by the related concerns. Those of Japan - by Petrochemical Industries Association of Japan, for France - by Union des Industrie Chimiques data; for Italy, Holland, England and Canada were taken from OECD data, estimations made by the Petrochemical Industries Association of Japan, etc.

Table AVIII-1-11 Ethylene Demand & Supply Balance in U.S.A.

(Unit: 10^3 tons)

	Production	Year-end Capacity	b/a (%)
1965	4,341	4,526	98
1966		4,849	
1967	5,379	6,953	80
1968	5,958	7,487	80
1969	7,431	7,672	97
1970	8,386	8,880	94
1971	8,364	10,231	82
1972	9,344	9,832	95
1973*	10,300	10,421	99
1974 (Forecast)		11,065	
1975 (Forecast)		11,519 - 12,427	

Note : * Estimated

Sources :

Year-end capacity ; Rearranged the investigation performanced by the Petrochemical Industry Assen of Japan (1973, May)

Production ; By Tariff Commission & Industrial Estimation

Table AVIII-1-12 Ethylene Demand & Supply Balance in Western Europe

(Unit: 10^3 tons)

	Nominal Capacity	Actual Produc-tion Capacity (b)	Production (a)	b/a	Consumption
1967	3,636	3,281	2,886	88	2,858
1968	4,873	4,310	3,627	84	3,645
1969	5,830	5,385	4,579	85	4,587
1970	6,885	6,271	5,562	89	5,524
1971	7,481	6,901	6,110	89	6,167
1972	10,064	8,406	7,478	89	7,422
1973*	10,812	9,859	8,701	88	8,561
1974**	11,804	10,973	10,153	93	9,749
1975**	11,914	11,399	11,003	97	10,710
1976**	12,949	12,530	11,787	94	11,795
1977**	14,269	13,689	12,736	93	12,871
72/67***	22.5 %	21 %	21 %		22 %
77/72***	7	10	11		11

Note : * Estimated
** Forecast
*** Annual average increase

Source :
"Conseil Europeen des Federatuibs de I'lndustrie Chimique (CEFIC)"

(3) Japan

During the period from 1969 to 1972, 9 large-scale ethylene plants, each with the production capacity of 300,000 t/y, were constructed in Japan. Thus if added to previous ethylene production capacities already existing, the nominal ethylene capacity in Japan, as of April 1972, totalled 4,769,000 t/y. As a result of improved operational techniques, the total figure is estimated to be 5,060,000 t/y.

Since the latter part of the 1970s, the demand increase was slowed as a result of overall economic recession in this country. The operational rate of plants lowered to 102.5% of 1969 (actual operational base, 90.2%) and down in 1971 to 88.3% (82.3%), hence the related Government authorities approved the recession cartel, for the period from April 15, 1972, to the end of said year.

1972 ethylene production was 3,816,000 t/y, the operational rate was 79.3% on average (on the basis of the actuals, it was 75%) inclusive of the ethylene plants completed in said year, but it was only 7.9% increase over the previous year.

1973 Japanese ethylene production actuals, are given in Table 13, production was 4,112,208 t/y indicating an increase of 7.8% over the previous year. This was due to the aggravating influence resulting from the plant accident of Idemitsu Petrochemical Industries, which occurred in July, and due to the oil crisis and the affected naphtha supply reduction after October. Supplies are expected to be restored to a certain extent in 1974.

Table AVIII-1-13 Japanese Ethylene Production Actuals & Application-wise Consumption Actuals

(Unit : 10^3 tons)

	Ethylene	L D P E (incl. EVA)	H D P E	E O	S M	Aldehyde	P V C	P V A	Others	Total
Production in 1973	3,816	1,067	541	361	283	399	611			
1974 January	373,358	93,956	57,294	34,421	28,466	39,914	60,847	11,953	14,253	341,104
February	342,182	84,122	52,489	32,655	27,187	36,508	55,061	11,310	14,072	313,404
March	334,630	81,994	53,023	36,409	23,340	36,700	60,068	12,934	13,415	317,883
Sub-total	1,050,170	260,072	162,806	103,485	78,933	113,122	175,976	36,197	41,740	972,391
April	333,968	94,048	43,834	26,478	26,902	32,890	61,037	12,278	12,890	310,357
May	333,524	95,608	47,448	32,984	27,583	36,507	58,863	9,012	16,248	324,253
June	362,735	100,506	57,778	34,381	26,832	39,334	58,569	11,669	15,099	344,168
Sub-total	1,030,227	290,162	149,060	93,843	81,317	108,731	178,469	32,959	44,237	978,778
July	325,333	96,940	60,217	29,982	23,377	31,081	46,294	10,523	12,201	310,615
August	353,742	97,784	63,189	33,559	26,995	33,572	54,897	11,707	16,077	337,780
September	340,017	92,080	62,938	34,743	27,176	34,194	57,822	7,989	14,109	331,052
Sub-total	1,019,092	286,804	186,344	98,284	77,548	98,848	159,013	30,219	42,387	979,447
October	342,949	92,925	59,689	30,354	20,377	36,787	55,159	10,983	16,136	322,410
November	327,004	84,086	53,863	34,695	21,588	34,169	57,444	12,313	12,850	311,008
December	342,766	102,454	61,600	32,654	27,897	31,846	58,647	11,506	12,553	339,157
Sub-total	1,012,719	279,465	175,152	97,703	69,862	102,802	171,250	34,802	41,539	972,575
Total	4,112,208	1,116,503	673,362	393,315	307,720	423,503	684,708	134,177	169,903	3,903,191
1974/1973	107.8	104.6	124.5	109.0	108.7	106.1	112.1			

Chapter 2. World's Future Supply and Demand Trends

2-1 Plastics

2-1-1 Predictions of world plastics consumption

We performed an estimation of the world's plastics consumption by several methods. Methods of prediction adopted are as follows.

- The time series model method
- The correlation model method
- The multiple regression model method

(1) Analysis and forecast by the time series method

The world production quantity of plastics is estimated by years as shown in Table AVIII-2-1. From this figure we can get the equation,

$$\log P = 0.9558 + 0.06637\ t$$

And, the correlation coefficient will be 0.9990. Where P is the production quantity (million tons) and t is the year with the figure of 1963 as 1 (one).

Using this equation, production quantities for 1975 and 1980 are calculated and figures of 65.9 million tons and 142.7 million tons are obtained respectively.

If we adopt the logistic function as a time series model, we can get the equation mentioned below;

$$\log \left(\frac{q}{30 - q} \times 10^3 \right) = 2.018 + 0.7090t$$

Where, q is per capita plastics consumption and t is the year. The correlation factor is 0.9989.

The per capita consumption of plastics in the world in 1975 and 1980 is calculated by this equation as 13.96 and 19.89 kg, respectively.

Assuming that the current growth rate is maintained, the world population is roughly estimated to be about 4,004 billion and 4,416 billion in 1975 and 1980, respectively. When these figures are multiplied by the per capita consumption, the total demands for plastics are obtained as 55.90 million tons and 87.83 million tons in 1975 and 1980 respectively.

Table AVIII-2-1 World Plastics Production

(Unit: 10^3 tons)

	1963	1964	1965	1966	1967	1968	1969	1970
Plastic Production	10,355	12,464	14,162	16,934	19,123	22,748	26,875	30,027

SOURCE: Plastic Industry Association

(2) Analysis and forecast by the correlation method

Using the gross domestic product index issued by the United Nations, relationship between the per capita consumption and per capita gross domestic product index was obtained as follows;

$$\log \left(\frac{q}{30 - q} \times 10^3 \right) = 0.4390 + 1.6511\ u$$

Where, q: the per capita consumption, and

u: the per capita gross domestic product index (the figure for 1963 as 1.00)

In addition, the correlation factor r is 0.9989.

The per capita gross domestic product index may be represented by the equation below.

$$\log u = -0.01527 + 0.01663\ t \quad (r=0.9975)$$

Estimating the figures of 1975 and 1980 from this, figures 1.59 and 1.92 are obtained, respectively. Putting them in the equation above mentioned, figures for per capita plastic consumption as 16.05 kg for 1975 and 24.13 kg for 1980 are obtained.

By utilizing the estimated world population, the total quantities of plastics consumption are obtained as 64.26 million tons for 1975 and 106.56 million tons for 1980.

(3) Analysis and forecast by the multiple regression model method

Plastics requirement, performed the multiple regression analysis using the variables, GDP and the growth rate, is very closely related with these two variables.

World plastics requirements as given in the Table Table AVIII-2-1 totla GDP and the growth rate of GDP are all correlated by the below mentioned equation:

$$P = -36{,}6613 + 0.4467\ U + 0.07628\ v \quad (r = 0.9949)$$

where, P : production quantity (million tons)

U : index number of total gross domestic production

v : growth rate of U.

Suppose now that the growth rate up until 1980 of total gross domestic production is 5% to 6%, the calculation of world plastics demands, in 1980 becomes 70.7 million tons and 81.3 million tons respectively, which, in comparison with the time series of the preceding section is very low.

(4) Comparisons on predictions performed by various methods, and the conclusion

Plastics consumption in 1980 calculated by various methods as given above are as follows:

By:	Time series method	142.7	10^6 tons
	Same as the above (Logistics)	87.8	
	Correlation method (k=60 kg)	106.6	
	Multiple regression method(v=6%)	81.3	

from which we can note that the resultant values are different even if we use the same data but change the forecasting method.

Integrating these results, world plastics consumption in 1980 is estimated to be approximately 100 million tons.

(5) Various forecasts carried out

World plastics consumption forecast have been made by many people, some of the representative ones are as follows:

(a) Forecast by Roenitz

Roenitz considers the plastics industry in the 1970s as still having a high growth potential. Above all, the share of polyolefins continues to increase every year and further describes that the industry as a whole is led by the polyolefins. Furthermore, he estimated the total demand for plastics based on the quantity of demand for polyolefins and presented the estimated figures as shown in Tables AVIII-2-2 and 3.

Table AVIII-2-2 World Plastics Demand (Unit: 10^3 tons)

Year	1955	1960	1965	1970	1975	1980
World	3,300	6,900	14,500	30,000	53,500	92,000
U.S.	1,760	2,850	5,300	9,500	15,500	23,500
Japan	110	545	1,370	3,800	7,500	13,000
W. Europe	1,000	2,550	5,350	11,000	19,000	29,000
W. Germany	305	860	1,731	3,600	6,500	9,000
Italy	71	250	617	1,450	2,600	3,600
France	144	346	703	1,400	2,500	3,500
U.K.	220	482	804	1,300	2,100	3,400

Table AVIII-2-3 World Per Capita Plastics Demand (Unit: kg/year)

Year	1955	1960	1965	1970	1975	1980
World	1.2	2.3	4.3	8.1	13.1	20.5
U.S.	10.7	15.7	27.2	45.7	69.4	98.7
Japan	1.2	5.8	15.0	36.9	69.6	116.3
W. Europe	3.0	7.3	14.2	27.9	46.2	68.2
W. Germany	5.9	15.5	29.3	59.0	104.7	143.3
Italy	1.8	5.0	12.0	27.2	47.3	64.1
France	3.3	7.6	14.4	27.6	47.4	64.5
U.K.	4.3	9.2	14.7	23.3	36.8	59.1

According to his report, the total demand for plastics in the world would be 92 million tons in 1980, while the per capita quantity would be 20.5 kg.

(b) ICI's Forecast

According to the forecast made by ICI, the demand for plastics in the world would increase by 12 or 13% every year and by 1980, it would exceed 100 million tons.

(c) Forecast by Predicasts, Inc.

Predicasts Inc., reports that world production of plastic materials (exclusive of Communist Asia) increased from 17.3 billion pounds in the 1960/1962 period to 58.4 billion pounds in 1969, and is projected to reach 220 billion pounds by 1980. As compared to a historic growth rate of 16.4% per year in the 1960s annual rate of growth in the 1970s should average 12.8%. Factors which will support this rate of growth include the following:

1) Growing material requirements because of an expected increase of 68% in real world gross national product:

2) Rising raw material and assembly cost of competitive products; and

3) New and broader dissemination of plastic technology.

(d) Prediction by S. Squires

From 1950 to 1970, consumption of plastic materials in the world excluding communist countries increased from 1.5 to 27 million tons, which shows a growth rate of 16%. From the viewpoint of volume, plastic materials became three times that of non-metal materials.

It is predicted that plastic materials will increase to 90 million tons by 1980, and show a increasing rate of 13% per annum. The volume of plastic materials at that time will exceed that of steel.

This forecast is the same as above cited one done by the Predicasts Inc., but it gives the demand growth rate on country-wise, resin-wise basis.

Each of the above forecasted values show that the plastics consumption in 1980 would stand on the level of 90,000,000 - 100,000,000 tons.

In respect to polyolefin, Roenitz indicates 1/3 of the entire plastics consumption, viz., 30,000,000 tons, and Predicasts Inc. gives the rate of 40%, viz., 40,000,000 tons.

2-2 Ethylene

According to the Kunststoff , the ethylene/propylene demands in Western Europe and U.S.A. are forecasted as given in the following Table AVIII-2-5.

Converted the production figures of plastics raw materials made by Predicasts Inc. into ethylene, we can get Table AVIII-2-5.

Table AVIII-2-4 World Ethylene & Propylene Production

(Unit: 10^9 lb)

COUNTRY	1963/1965 Prod.	1963/1965 Cons.	1963/1965 Net Exp.	1969 Prod.	1969 Cons.	1969 Net Exp.	1975 Prod.	1975 Cons.	1975 Net Exp.	1980 Prod.	1980 Cons.	1980 Net Exp.	Annual growth % 1980/1969 Prod.	Annual growth % 1980/1969 Cons.
United States	10.3	9.2	1.1	18.4	16.3	2.1	33.1	30.0	3.1	50.0	46.0	4.0	9.5	9.9
Canada	0.5	0.6	-0.1	0.8	1.1	-0.4	1.5	2.2	-0.7	2.8	3.7	-0.9	12.1	11.7
NORTH AMERICA	10.7	9.8	1.0	19.2	17.5	1.7	34.6	32.2	2.4	52.8	49.7	3.1	9.6	10.0
Benelux	0.6	0.8	-0.2	0.2	1.5	0.6	4.3	2.8	1.4	7.4	4.6	2.8	12.6	10.7
France	1.3	1.3	-	2.8	2.9	-0.1	5.7	5.4	0.2	9.6	9.0	0.6	11.8	10.8
Italy	1.7	1.2	0.4	3.3	2.8	0.5	7.2	6.0	1.2	12.8	11.0	1.8	13.1	13.2
Spain	0.2	0.3	-0.2	0.7	1.1	-0.3	2.1	2.4	-0.3	4.0	4.3	-0.3	17.2	13.2
Sweden	0.2	0.4	-0.1	0.6	0.8	-0.2	1.1	1.4	-0.3	1.7	2.2	-0.4	9.9	9.6
United Kingdom	1.9	1.6	0.3	3.1	2.7	0.4	6.6	5.6	0.4	10.0	9.2	0.8	11.2	11.8
West Germany	3.8	3.0	0.7	8.6	6.6	2.0	15.0	12.0	3.0	22.5	18.5	4.0	9.1	9.8
Other Western Europe	0.4	1.0	-0.6	0.9	2.4	1.4	2.2	4.4	2.1	4.1	7.1	-3.0	14.8	10.4
WESTERN EUROPE	10.2	9.7	0.5	22.1	20.7	-1.6	43.7	40.1	3.6	72.1	65.8	6.3	11.3	11.1
Soviet Union	1.5	1.7	-0.2	3.2	3.6	-0.4	9.0	10.0	-1.0	21.5	23.0	-1.5	18.9	18.4
Other Eastern Europe	1.2	1.4	-0.2	2.7	3.0	-0.3	6.5	6.9	-0.4	13.6	14.1	-0.5	15.8	15.1
EASTERN EUROPE	2.8	3.1	-0.3	5.9	6.6	-0.7	15.5	16.9	-1.4	35.1	37.1	-2.0	17.6	17.0
Japan	3.0	2.7	0.3	9.2	7.5	1.7	22.0	18.0	4.0	41.5	35.0	6.5	14.7	15.0
Rest of World NEC	0.8	2.2	-1.5	2.0	6.2	4.1	6.4	14.9	-8.5	18.6	31.4	-12.8	22.1	15.9
REST OF WORLD	3.8	5.0	-1.2	11.2	13.7	2.4	28.4	32.9	-4.5	60.1	66.4	-6.3	16.5	15.4
TOTAL WORLD	27.5	27.5	-	58.4	58.4	-	122.2	122.1	0.1	220.1	219.0	1.1	12.8	12.8

Source: Predicasts, Inc., 11001 Cedar Ave., Cleveland, Ohio 44106.

Table AVIII-2-5 World Production & Consumption of Plastic Materials

(Unit: 10^6 tons)

		1970	1975	1980
West Europe	Ethylene	5.3	10.9	18.1
	Propylene	3.0	5.4	8.5
U.S.A.	Ethylene	7.0	10.6	14.9
	Propylene	3.8	6.1	8.5

Table AVIII-2-6 World Demand of Ethylene for Major Plastics

(Unit: 10^6 tons)

	Unit consumption	1963/5	1969	1975	1980
For Polyethylene	1.04	2.55	6.70	16.84	33.49
Polyvinyl Chloride	0.50	1.34	2.74	5.65	9.82
Polystylene	0.33	0.42	0.97	1.87	3.17
Total (1)		4.31	10.41	24.36	46.48
Ethylene total ((1) ÷ 0.6)		7.2	17.4	40.6	77.5

Chapter 3. World's Future Supply Program

New expansion plants which were announced by the end of 1971 are given in the Table AVIII-3-1, and all those publicized until recently, in major countries, (until August 1973) are arranged in the Table AVIII-3-2. Compared with the requirements given in the preceding section, a considerable amount of difference is observed. However advanced industrial countries have strong desires to make expansion of their production facilities and to start new facilities. In the light of rapid expansion by Canada, Holland and Scandinavian countries, the supply will become well matched with the demand in 1980 in the U.S.A. and the European continent. This concept is considered in the production forecast performed by Predicasts Inc., which states that those countries feeling the supply shortage will be all others except the U.S.A., Western Europe and Japan.

Table AVIII-3-1 World Production Capacity of Petrochemical Products

(Unit: tons)

	1971	Planned (up to 1975)	Planned (not fixed year)	Total
Ethylene	24,085,938	16,075,500	7,430,000	47,591,438
Propylene	15,414,790	11,005,500	5,641,500	32,061,790
Polyethylene	9,370,700	4,911,000	1,169,500	15,451,200
Polypropylene	2,053,210	1,184,000	730,700	3,967,910
Polystyrene	3,237,270	1,061,800	657,340	4,956,410
PVC	7,058,700	3,147,000	1,831,400	12,037,100
Polyvinyl Acetate	742,425	53,000	26,600	822,025
Styrene Monomer	5,537,000	3,830,000	1,594,000	10,961,000
Vinyl Chloride	7,948,800	3,255,500	2,527,500	13,731,800
SBR	4,408,100	536,200	689,700	5,634,000
Ethylene Oxide	4,375,300	1,195,500	430,000	6,000,800
Ethylene Glycol	3,169,700	1,058,500	233,400	4,461,600

However, the above forecasts were done prior to 1970, the conditions then are on the basis of excessive production in the above territories and a large amount of export capacities. Short material supply and the problem of pollution controls are inhibiting expansion and new plant construction in advanced industrial countries. This conspicuously affects domestic demands. Therefore, export-oriented production would not be expected in the future.

Moreover, those petrochemical projects now being planned in Iran, Saudi Arabia, plans in other petroleum-producing countries, and the oil-refining area such as Singapore are not included. Suppose that these projects have been accomplished as expected, the entire production in such areas may exceed the requirements in their area.

As given in Table AVIII-2-6, polymer alone becomes in 1980 on the level of 46.48 million ton, thus supposing that 60% of the entire ethylene production is directed to the polymer use, an ethylene amount of 77.5 million tons is required in total.

Table AVIII-3-2 Production Capacities of Petrochemical Products in Major Countries

(Unit: 10^3 tons)

	Ethylene			Propylene			Polyethylene		
	Present (End of 1972)	Plan (Up to 1980)	Total (Up to 1980)	Present	Plan	Total	Present	Plan	Total
U. S. A.	9,718	4,190	13,908	3,735	1,070	4,805	4,295	953	5,248
Japan	4,679	1,000	5,679	2,749	620	3,369	2,011	180	2,191
W. Germany	4,144	1,590	5,734	2,295	335	2,630	1,310	1,440	2,750
Italy	2,502	2,300	4,802	1,238	383	1,621	1,017	320	1,337
France	1,835	800	2,635	1,492	350	1,842	721	380	1,101
U. K.	1,500	790	2,290	1,183	300	1,483	733	190	923
Total	24,378	10,670	35,048	12,692	3,058	15,750	10,087	3,463	13,550

	Polypropylene			Polystylene			Polyvinyl Chloride		
	Present (End of 1972)	Plan (Up to 1980)	Total (Up to 1980)	Present	Plan	Total	Present	Plan	Total
U. S. A.	1,382	498	1,880	1,648	744	2,392	1,717	974	2,691
Japan	899	165	1,064	937	97	1,034	1,908	384	2,292
W. Germany	224	669	893	522	236	758	1,130	715	1,845
Italy	212	129	341	249	115	364	973	425	1,398
France	29	80	109	362	205	567	625	440	1,065
U. K.	106	150	256	348	141	489	535	90	125
Total	2,852	1,691	4,543	4,066	1,538	5,604	6,888	3,028	9,916

Source: ECN; Chemical Plant Data

Let us look at the future supply projects in the Pacific Area inclusive of the Middle East, Iran and Japan as the importance of these are very closely correlated with petrochemical industry projects in South East Asian countries.

3-1 Petrochemical industrialization projects in the Middle East

(1) Iran

Iran Petrochemical Development Co., Ltd., which is the Japanese firm with the major participation of Mitsui Group, and Iran Petrochemical Corporation have formed a joint venture company called IJPC on 50/50 basis, as of April 29, 1973; decided to construct, with a target startup date of 1976 a facility. This was to be started with the 1st term project putting majority efforts on the accomplishment of ethylene production; 300,000 tons and electrolysis 240,000 tons. Those products under project are as follows:

(Unit: 10^3 tons)

Ethylene	300
EDC	170
VCM	150
LDPE	100
HDPE	60
PP	50
SBR	40

For the 2nd term projects, SBR and so forth will be added, and a further 300,000 tons of ethylene capacity will be added.

Further a giant ethylene plant complex is scheduled to be constructed utilizing 75,000 bbl. of naphtha obtainable from new Iranian refineries.

(2) Other Middle East Countries

The realization of a petrochemical industry utilizing petroleum resources is the strong desire of top political leaders of various industry-minded countries. It seems that the statement announced by the Iranian Government, "We will supply our DD crude oil to those countries who are quite willing to cooperate with the industrialization of the Iranian down-stream projects" will be the future formula that would fully permeate to other countries. One example is that the Saudi Arabian Petroleum Corporation, "PETROMIN" is now consulting with the Japanese Mitsubishi Group about Saudi Arabian petrochemical projects. Kuwait is also paying high interest to the immediate realization of the petrochemical industries to start its various industrialization programs and is now asking for capital participation from Japan. In light of the lack of technical development of Saudi Arabia, smallness and weakness of Kuwait and Abdabi, it will take many years before the contemplated projects are finally accomplished even with the great possibilities viewed from the point of abundant natural resources.

3-2 Petrochemical Industry Project in Pacific Area

3-2-1 South Korea

In January, 1973, Korea announced a proclamation of heavy chemical industrialization, contemplating the upbringing of the chemical industry. The Korean Government, therefore, is now considering expansion of the Urusan complex now being operated in ethylene capacity from 100,000 tons to 300,000 - 400,000 tons at the finalization; moreover, it is considering a formation of a huge chemical industry complex of approximately 10,000 ha in Yosu and Kohyo districts starting with the introduction of foreign investment to The 7th Fertilizer (ammonium) and to methanol plant.

The 2nd Urusan projects are as follows:

Item	Capacity in 10^3 tons	Target Completion year
Ethylene	350 (of which 50 are expansions)	1976
Low density polyethylene	50 (expansions)	1976
High density polyethylene	35	1974
Polypropylene	30	1976
EDC	110	1976
SM	60	1976
AN	27	1976
SBR	25	1976
EO / EG	90	1976

Yosu Project has not been finalized yet, but according to reliable information the following tonnages are most probable:

	(10^3 tons)
Ethylene	350
Propylene	180
Low density polyethylene	100
High density polyethylene	70
Polypropylene	80
VCM	150
SM	100
2-EM	40
SBR	50
EG	80
PO	40

3-2-2 Republic of China

Ethane naphtha cracking project of China Petroleum Corporation is scheduled to complete at the end of 1975 with the following capacities:

	(10^3 tons)
Ethylene	568
Propylene	257
Butadiene	65

Of which, the 1st term naphtha cracking plant was completed enabling them to avail themselves of ethylene, 54,000 tons and propylene 27,000 tons. The downstream project resulting from this completion has not yet been finalized.

Double expansion project of the existing LDPE plant with 45,000 tons production capacity of USI Fareast will be completed by the end of 1974; the HDPE 25,000 tons plant of USI Fareast was completed in October 1974; CGPC's (China Gulf Plastics Corp.) polypropylene 50,000 tons plant will be completed in February, 1975. Furthermore, in relation to the VCM, VCM Corp. is scheduled to expand to 60,000 tons to be completed in April, 1974, and Ye Fong, Formosa Plastics Corp. and Cathey Plastics are said to be in the planning or preparatory stage now.

3-2-3 Singapore

It is being said that the overall petrochemical project at the Melbau Island would cover an ethylene production scale of 300,000 tons to be completed by the beginning of 1978. However, there is no fixed project as to the derivatives, only predicted to cover the following:

	(10^3 tons)
Low density polyethylene	100
High density polyethylene	50
Polypropylene	80
SM	100
PVC	100
VCM	120
EO / EG	100

The material naphtha is said to be supplied from the refineries of Shell and Exxon.

3-2-4 Thailand

Tonnages mentioned in the next page are being planned at present as the downstream for 150,000 tons of ethylene capacity for Thai Petro-chemical:

	(10^3 tons)
Low density polyethylene	70
High density polyethylene	30
Polypropylene	30
VCM	43
Alkylbenzene	20

Each plant required for these downstreams is targeted to complete by the end of 1977.

3-2-5 Australia

Through the utilization of natural gas, available at the Red Cliff district, located at the coastal area of Spencer Bay of Southern Australia, various projects are being pushed forward covering: annual ethylene capacity of 350,000 tons, 490,000 tons of caustic soda by electrolysis, 440,000 tons of chlorine, 600,000 tons of EDC, and 135,000 tons of LDPE.

Similar projects are being drafted for the overall development plan in Pillbarough of Western Australia.

3-2-6 Japan

The petrochemical industry of Japan has been contemplating its scaleup and formation of a giant complex through the introduction of techniques and technologies, since its birth in the market, from various advanced European countries and the United States. The major factors of growth of the petrochemical industry were the raising of the level of utilization of ethylene, propylene, C_4 fraction and other heavy substances as the chemicals in total.

The petrochemical projects of earlier starters at the beginning of the 1950s were as follows: In the production pattern planned respectively by Mitsui Petrochemical Industries, Ltd., Mitsubishi Petrochemical Industries, Ltd., Nippon Petrochemical Industries, Ltd. and other Kawasaki Group members, each planned the utilization of the fractions making the most use of the capabilities of each group, the major pillars therein were polyethylene resins made from low-pressure, high-pressure and medium-pressure processes, styrene, phenol, acetone, benzene, toluene, xylene, isopropylalcohol and other organic chemicals; ethylene oxide, ethylene glycol, paraxylene, terephthalic acid fiber material and other synthetic rubbers were industrialized. Thereafter, the concepts owned by 3 firms such as Sumitomo Chemical Industries, Co., Ltd., Maruzen Petroleum Co., Ltd., and Mitsubishi Petroleum Co., Ltd. followed up their own, and similarly their major pillars were high-pressure polyethylene for the Sumitomo Chemicals; secondary butanol, methylethyl keton, benzene, toluene, xylene solvent, benzoic acid, phthalic anhydride, isophthalic acid, fiber materials of terephthalic acid, etc. were for the other 2 firms.

In the commercialization and industrialization planning of the petrochemical industry to raise the level of utilization of every fraction available through naphtha cracking, the security measures for the complex of production factors such as synthetic resins, organic chemicals, synthetic fiber materials, synthetic rubbers played the most important role. In Table AVIII-3-3, the actual productions on every 3 years, after 1958, are given; and

Table AVIII-3-3 Production Trend of Major Petrochemical Products

(Unit: 10^3 tons)

Item \ Calendar year	1958	1961	1964	1967	1970	1973	1975(Estimated)	1977(Estimated)
Synthetic resin and (synthetic resin materials)								
High-pressure polyehtylene	10,226 (high- and medium-pressure polyethylene combined)	31,908	207,001	580,979	894,332	1,059,963	1,179,000	1,308,000
Medium-pressure polyethylene		26,190	83,384	166,785	410,438	611,732	640,000	744,000
(Styrene monomer)		46,781	133,324	312,822	816,419	935,474	1,252,000	1,488,000
(Ethylene dichloride = EDC)			44,777	247,634	1,331,484	2,180,994	(1,981,000) Vinylchloride monomer*	(2,193,000) Vinylchloride monomer*
Polypropylene			39,477	170,201	581,091	693,318	798,000	911,000
Organic chemicals								
Acetoaldehyde			91,892	255,123	537,872	610,778	682,000	755,000
Alkylbenzene			44,111	86,367	127,445	168,754		
Raw materials for synthetic fiber								
Ethylene oxide	2,416	22,668	54,277	159,327	304,347	402,553	504,000	602,000
Caprolactam	25,461	55,373	124,258	229,643	349,407	459,341		
Synthetic rubber		51,129	11,,912	251,569	697,527	976,278	1,111,000	1,279,000
Ethylene	14,265	107,167	504,675	1,368,488	3,096,890	4,170,703	4,760,000	5,462,000

NOTE: Those figures on 1975 and 1977 are based on the estimation done by the Petrochemical Coordination Deliberation Council, and for *ethylene chloride based on the fiscal year prepared by the Vinyl Chloride Industry Association.

estimated productions on 1975 and 1977 (corresponding to the consumption) are given in accordance with the estimation done by Petrochemical Coordination Deliberation Council (for ethylene dichloride by the Vinyl Chloride Industry Association). As given in said table, the production and consumption of petrochemical products in Japan were driven forward by the pulling powers of synthetic resins such as high-pressure polyethylene, styrene monomer (mostly directed for polystyrene), ethylene dichloride (mostly directed for the vinyl chloride resins).

In making further predictions of the Japanese petrochemical industry in 1975 and in 1980, inclusive of polypropylene which is the produce of the propylene fraction, the demand forecast on mutually substitutable polyethylene, polystyrene, vinyl chloride resin, and polypropylene, etc. will be the greatest decisive factors. As given in Table AVIII-3-4, the exports of low density and high density polyethylene, polystyrene, vinyl chloride resins and polypropylene inclusive of exports under the monomer form, are estimated to be 16% of 1973, and 14% for the year 1977. In respect to domestic demands, etc. of petrochemical products in the year 1980, an extensive deliberation is being carried out inclusive of the changes in the industrial structures at the Industrial Structure Deliberation Council. The maximum future demands will be over 5 million and several tens thousand tons in 1980. Said premises are:

> "Total demands inclusive of both domestic and exports, based on 1972 actuals to be the criteria, will grow in proportion to GNP".

In respect to production, the ethylene production capacity at the beginning of 1973 will be approximately 5 million tons/year. As mentioned above, the exports of 1977 of synthetic resins or synthetic resin raw materials will be about 14% of the total demands, and the exports of ethylene-series products will be about 20% converted to feedstock ethylene.

In the future, all the basic industries inclusive of the petrochemical industries will have difficulties in getting land lot, water, electricity and other utilities, and it is estimated that the advantages of the Japanese side in the procurement of overseas raw materials will gradually be diminished, and the Japanese role as the export base is also considered to be lessening. Ethylene production facilities available in the future at the existing 10 plant sites and in newly planned plant sites will have a net ethylene capacity increase of about 1 million and several tens thousand tons a year production. Japanese ethylene production capacity at the

beginning of 1973 is about 5,000,000 t/y so assuming that ethylene domestic demands would be over 5,000,000 t/y, the ethylene quantity to be directed to products for export from Japan would be a little less than 1,000,000 tons.

Table AVIII-3-4 Domestic & Export Demand for Major Petrochemical Products

(Unit: 10^3 tons)

Item \ Calendar year		1973	1975	1977
LDPE	Domestic	830	959	1,088
	Export	260	220	220
	Total	1,090	1,179	1,308
HDPE	Domestic	361	452	546
	Export	173	188	198
	Total	534	640	744
Styrene monomer	Domestic	984	1,202	1,448
	Export	48	50	40
	Total	1,032	1,252	1,488
PS	Export	94	102	108
Vinylchloride monomer	Domestic	1,592	1,838	2,097
	Export	130	143	96
	Total	1,722	1,981	2,193
PVC	Export	130	110	100
PP	Domestic	546	648	751
	Export	140	150	160
	Total	686	798	911
Acetoaldehyde	Domestic	607	677	750
	Export	5	5	5
	Total	612	682	755
Alkylbenzene	Domestic	102	7	-
	Export	46	-	-
	Total	148	7	-
Ethylene oxide	Domestic	362	449	540
	Export	36	55	62
	Total	398	504	602
Synthetic rubber		914	1,111	1,279

Chapter 4. Observations on the Demand/Supply Situation in South East Asian Countries

In this section, let us make some observations on the future demand/supply balance in the ECAFE area inclusive of the South East Asian countries we should not ignore these areas because we may, in the future make exports of petrochemical products from Indonesia to these areas. On the other hand, it is clear that the future movement of the petrochemical industries and the demand/supply trends in said areas will greatly influence the Indonesian projects.

The requirements forecast for the ECAFE area are as described in the Phase I report of UNIDO. However, as far as the Philippines are concerned, the forecasted values seem rather excessive and might be exaggerated.

Viz., a comparison on the forecasted values of each country as described in the Phase I report gives us the impression that the growth rate during 1972 to 1975 is rather excessive and inclined to exaggeration. Therefore, the forecast for this country shall have to be redone.

4-1 Predictions of Plastics Consumption in the Philippines

4-1-1 Forecast made by Board of Investment of the Philippines

Those values given in the UNIDO Phase I report are the modifications of the forecasts prepared by the BOI of the Philippines. Said BOI looks at the growth rate of the plastics requirement in the future for principal plastics as follows:

Polyethylene	Until 1975 30%(log); afterwards 30%(linear)
Polypropylene	Gradual increase from 1973 15% down to 1977 11%
Polystyrene	Until 1973 39%(log), afterwards 39%(linear)
PVC	30%(log)

and, moreover, looks at the demand as follows:

Polyethylene	LDPE	28,440	tons
	HDPE	7,560	
Polypropylene		10,020	(In 1972 21,960 tons)
Polystyrene		5,570	
PVC		15,590	

thus, the forecasts were made by calculating from these years to 1980.

4-1-2 Trend of Plastics Demand in the Philippines

(1) Imports of plastics material and product

AVIII-4-1 through 5 exhibits the commodity-wise and country-wise plastics importations during the 7 years from 1965 to 1971 taken from the Philippines trade statistics.

Table AVIII-4-1 Commodity-wise Plastic Material Imports in the Philippines

(Unit: tons)

	1965	1966	1967	1968	1969	1970	1971
Aminoplastic	2,649	4,450	1,813	856	2,315	302	294
Polyester	13	11	7	4	40	18	12
Alkyd	4	9	5	17	9	12	-
Phenolics	326	404	376	299	257	430	317
Silicones	22	18	16	13	21	34	30
Polyamid	2	9	19	32	35	97	99
PU	1		15	1	5	13	23
Epoxies	8	5	10	21	43	17	103
PE	4,002	6,411	8,835	14,635	16,548	15,968	23,919
PS	547	1,333	1,939	2,849	2,809	3,396	4,771
PVC	2,199	2,314	1,562	1,484	2,039	3,371	6,342
Acrilics	76	45	35	88	113	103	42
Cellulose	3,986	5,506	5,722	7,130	6,897	7,505	6,718
Cumarone indene	60	40	56	45	69	86	42
Synthetic Plastics	5,705	5,842	5,529	9,496	20,305	29,954	45,744
Others	15	1,477	699	346	273	397	10
Total	19,615	27,874	26,638	37,316	51,778	61,703	88,466

Source : Trade Statistics of the Philippines

Table AVIII-4-2 Country-wise Plastic Material Imports in the Philippines

(Unit: tons)

		1965	1966	1967	1968	1969	1970	1971
	Japan	7,957	11,638	12,785	20,979	31,772	44,678	68,166
	Taiwan	389	1,111	544	807	2,517	1,351	957
	Korea	-	-	-	9	-	1,290	1,857
Asia	Hong Kong	173	39	36	26	153	148	112
	Singapore	-	-	-	-	-	-	500
	Malaysia	2	1	-	-	-	-	-
	Asia n.e.s.	20	-	-	25	255	-	-
	Total	8,541	12,789	13,365	21,846	34,697	47,467	71,592
North America		6,703	7,373	7,467	9,153	9,872	8,315	8,195
Europe		4,347	7,654	5,633	5,899	6,450	5,495	7,980
Oceania		63	60	175	419	852	425	699
Others		-	-	-	-	-	-	-
	Total	19,654	27,876	26,640	37,317	51,871	61,702	88,466

Source: Trade Statistics of the Philippines

Table AVIII-4-3 Country-wise Plastic Intermediate Products Imports in the Philippines

(Unit: tons)

		1965	1966	1967	1968	1969	1970	1971
	Japan	2,485	2,720	3,327	2,597	1,220	853	1,341
	Taiwan	7	269	264	335	221	87	37
	Korea	-	-	-	-	-	-	-
Asia	Hong Kong	3	26	59	91	67	17	10
	Singapore	-	-	-	-	-	-	-
	Malaysia	-	-	-	-	-	-	-
	Asia n.e.s.	-	-	-	-	-	-	-
	Total	2,495	3,015	3,650	3,023	1,508	957	1,388
North America		238	276	297	302	286	152	129
Europe		131	117	1,172	230	373	114	77
Oceania		23	19	22	28	15	17	2
Others		-	-	-	-	-	-	-
	Total	2,887	3,427	5,141	3,583	2,182	1,240	1,596

1) Plastic veneer films or sheets

Table AVIII-4-4 Commodity-wise Plastic Articles Imports in the Philippines

(Unit: 10^3 US$)

	1965	1966	1967	1968	1969	1970	1971
Garden hose	-	-	-	-	-	-	-
Belts	-	-	-	1	-	2	1
Pressure sensitive plastic tape	32	45	40	70	72	72	27
Bags of synthetic material	59	37	42	23	46	30	50
Laminated & molded structural matl.	40	127	137	106	254	160	184
Beads & spangles	9	14	21	55	82	71	31
Sheets cut to shape	13	12	7	8	15	-	6
Hygienic, medical & surgical articles	23	37	50	74	97	37	23
Garments	1	-	-	-	1	-	-
Tiles	70	82	76	58	2	-	-
Cellulose bands	76	81	68	9	4	7	21
Pipes, tubes & fittings	73	55	97	58	23	39	56
Wire screen	-	58	10	34	9	7	7
Reflecting sheet	2	20	86	33	38	77	7
Bottles caps	87	147	47	132	133	112	39
Tableware	15	57	549	384	91	-	-
Articles of plastics, n.e.s.	205	159	164	342	301	399	234
Total	706	933	1,393	1,387	1,168	1,014	686

Table AVIII-4-5 Country-wise Plastic Articles Imports in the Philippines

(Unit: 10^3 US$)

		1965	1966	1967	1968	1969	1970	1971
	Japan	64	206	534	611	545	432	306
	Taiwan	37	10	20	46	32	15	25
	Korea	-	-	-	-	-	-	-
Asia	Hong Kong	20	31	55	60	93	83	35
	Singapore	-	-	-	-	-	4	1
	Malaysia	-	2	-	-	2	-	-
	Asia n.e.s.	-	-	-	-	18	7	-
	Total	121	249	609	717	690	541	367
North America		368	493	427	414	313	292	190
Europe		212	171	263	169	137	101	99
Oceania		6	20	94	86	30	79	29
Others		-	-	-	-	-	-	1
	Total	707	933	1,393	1,386	1,170	1,013	686

(2) Exports of plastics material and product

These figures are exhibited commodity-wise in Table AVIII-4-6. A great majority of plastics material exports are cumaroneindene resins followed by a small lot of PVC resins. In 1971, the intermediate products, as plastics material and film sheet, amounted to approximately 2,000 t/y exceeding US$100,000.

(3) Production of plastics material

In 1971, production of plastics material was only PVC manufactured by Mabuhay Vinyl. Its annual rate capacity was 10,000 metric tons of PVC and utilization was on the 88% level. Trend of production amount of PVC by Mabuhay Vinyl is as follows:

	(Unit: tons)
1965	213
1966	3,743
1967	4,764
1968	6,566
1969	7,578
1970	7,660
1971	8,861

(4) Apparent domestic consumption of plastics in the Philippines

Looking at plastics material and intermediate products expressed in metric tons, calculations were made to get the apparent domestic consumption through the import, export, and the production, the results are given in the Table AVIII-4-7. Converted into the per capita rate, it is observed that 0.7 kg consumption of 1965 has jumped rapidly to 2.6 kg in 1971. The relations of this between the per capita GDP (at 1965 constant market price) are given in equation (1):

$$\log q = -19.527 + 8.556 \log u \quad (r = 0.9899) \quad . . . . (1)$$

where, q : per capita plastics consumption (kg)

u : per capita GDP (US$)

According to the aforementioned equation, as the per capita GDP increases by 1%, plastics increase by 8.6%.

Further, preparation of a multiple regression model on total domestic consumption, and the total GDP and the growth rate results in the following equation:

$$P = -188.80 + 7.7476\ U + 2.2550\ v \quad (r = 0.9706) \quad . . . (2)$$

where, P : total plastics consumption (in thousand tons)

v : growth rate of GDP (in %)

U : total GDP (1965 constant price) (in billion pesos)

Table AVIII-4-6 Commodity-wise Plastic Materials and Products Exports in the Philippines

Commodity		Unit	1965	1966	1967	1968	1969	1970	1971
Plastic Materials	Cellulosics	t	-	-	-	1	-	-	-
	Vinyl plastics	"	-	177	1	-	33	3	19
	Cumarene indene	"	-	58	3	179	363	412	1,853
	Others	"	-	46	-	-	12	-	46
	Total	t	12	282	3	180	-	415	1,918
Intermediate Products	Veneer films or sheets	t	1	1	-	-	-	-	7
Final Products	Bags	10^3US$	-	-	-	n.a.	-	-	7
	Laminated & molded materials	"	-	-	-	n.a.	-	-	-
	Sheets	"	-	-	-	n.a.	1	2	2
	Pipes, tubes and fittings	"	-	-	-	n.a.	-	1	13
	Reflective sheeting	"	-	1	6	n.a.	23	14	2
	Bottles, caps	"	-	-	-	n.a.	-	-	-
	Pressure sensitive plastic tape	"	-	1	-	n.a.	-	-	-
	Articles of plastics, n.e.s.	"	4	12	7	n.a.	35	63	82
	Total	10^3US$	4	14	13	n.a.	59	81	106

1) Including re-exports

Table AVIII-4-7 Plastic Consumption in the Philippines

			1965	1966	1967	1968	1969	1970	1971
Importation	Material	(t)	19,614	27,876	26,641	37,315	51,872	61,701	88,466
	Intermediate products	(t)	2,886	3,427	5,140	3,591	2,183	1,240	1,595
Production		(t)	213	3,743	4,764	6,566	7,578	7,660	8,861
Exportation		(t)	12	282	3	180	-	415	1,918
Domestic apparent consumption		(t)	22,701	34,764	36,542	47,472	61,633	70,186	97,004
Population 1)		(10^6)	31.67	32.63	33.63	34.66	35.74	36.85	37.92
Per capita consumption		(kg)	0.717	1.065	1.087	1.370	1.724	1.905	2.558

1) UN, Monthly Bulletin of Statistics XXVIII, (1), 3 (Jan. 1974)

Equation (1) has an extremely high correlation coefficient. Therefore, using it as the model for the prediction results in an extremely large forecast, for example, taking future per capita GDP growth rate to be 3.3%*) for the calculation of 1980 value, the per capita consumption results in 31.8 kg. This is the usual problem whenever a correlation model other than a linear one is used.

It should be pointed out that there is no guarantee that GDP elasticity will be maintained at the same rate.

The model expressed by equation (2) indicates the relations between consumption and GDP on a linear basis, thus it can be used for the long-term forecast.

Suppose that the GDP growth rate is taken to be 6.4%, the 1980 consumption forecastable by equation (2) becomes 338,000 tons and the per capita consumption 6.8 kg, which may be considered as a 'pessimistic' value.

4-1-3 Predictions of principal plastics demands in the Philippines

Bearing in mind the forecasts in connection with total plastics as given in the preceding section, forecasts were obtained inferring the annual growth rate for every resin by the time series method just the same as the BOI. Consideration was given to past actuals for the annual growth rate. The past and future annual growth rates are as given hereunder. In this calculation, the consumption for the years 1971 - 1974 was quoted from the "Studies on Philippines Industries, No. 8."

Basic 1971 consumption was expressed by the exponential regression equation of past actuals. Thus obtained 1971 values and the forecasts after 1972 are given in Table AVIII-4-8.

According to the above, the total consumption in 1980 for principal plastics is forecasted to be 350,000 tons and the per capita consumption 7.0 kg. where the population was assumed to be 49.9 million. Now, suppose that the shares of principal plastics in the total plastics consumption are 70%, per capita consumption of total plastics becomes 10.0 kg. which is exactly the median values of a rather pessimistic forecast by the above multiple correlation and BOI's forecasts.

The amount of ethylene required for production of these principal plastics in 1980 are as follows:

	(Unit: 10^3 tons)
For Polyethylene use	146
For Polystyrene use	11
For PVC use	61
Total	218

Note: * After 1972, the GDP growth rate is taken to be 6.4% and population increase rate to be 3.1%. These are the target values for the 5-year plan.

Table AVIII-4-8 Predictions of Principal Plastics Demands in the Philippines

(Unit: tons)

	Polyethylene	Polypropylene	Polystylene	Polyvinyl chloride	Total
1971 (calculation)	23,100	21,500	4,500	16,300	65,400
1972	28,900	24,300	5,900	20,400	79,500
1973	36,100	27,500	7,600	25,500	96,700
1974	45,100	31,000	9,900	31,800	117,800
1975	56,400	35,000	12,900	39,800	144,100
1976	67,700	38,600	15,400	49,700	171,400
1977	81,200	42,400	18,500	62,200	204,300
1978	97,500	46,700	22,200	77,700	244,100
1979	116,900	51,300	26,700	97,200	292,100
1980	140,300	56,500	32,000	121,400	350,200

4-2 Ethylene Consumption of ECAFE Countries

The latest estimations prepared by The Association of Petrochemical Industries in Japan and Japan Polyvinyl Chloride Association were used to determine plastics consumption in Japan. The above mentioned forecasts, of ours, are used for plastics consumption in the Philippines. Using the above forecasted values of ours and with the additional quotations from the figures given in UNIDO Phase I Report, Table AVIII-4-8 will result. Also Tables AVIII-4-9 and 10 exhibit the domestic demands for synthetic fiber of those countries having membership in ECAFE as given in the UNIDO report. From these figures, estimations are made on required ethylene amount. These are given in Table AVIII-4-11, where, the following figures were used for consumption of ethylene for respective product:

Polyethylene	1.04
Polystyrene	0.33
PVC	0.50
Polyester fiber material	0.25

Furthermore, as given in the Table AVIII-4-12, the ethylene quantity consumed for the above 4 products in Japan is about 70% of the entire ethylene usage. These 4 products are being exported, but exports of products corresponding to the remaining ethylene (30%) are almost impossible. In the preparation of Table 30, these relations were taken into account. It was assumed that the same ethylene consumption pattern of Japan will be followed by Korea, Hong Kong and Singapore; and, for the other countries, it was inferred that the ethylene consumption will almost be limited only to the aforementioned 4 products.

For the aforementioned demand forecasts, however, the prices and demand correlations between ethylene and plastics are not taken into consideration. Prices and demands have, as taken for granted, the closest correlations. Suppose that the high price on crude oil will greatly affect the prices for petroleum and petrochemical products, then the demand and the structure in the future might become a considerably modified ones.

Moreover, the change in the production environment, as a result of the public nuisance problem, will inhibit the production of petrochemical products and the resultant prices rise and supply shortage will simultaneously have an influences on demands.

In the observations of the above demand forecasts, these two points should always be borne in mind.

Table AVIII-4-9 Domestic Demand of Principal Plastics Material in ECAFE Countries

(Unit: 10^3 tons)

Region	Country	LDPE 1970	LDPE 1975	LDPE 1980	HDPE 1970	HDPE 1975	HDPE 1980	PS 1970	PS 1975	PS 1980	PP 1970	PP 1975	PP 1980	PVC 1970	PVC 1975	PVC 1980
Far East	Japan[5]	631	959	1,300	245	452	688	465	638	1,062	399	648	920	1,004	1,528	2,165
	Korea	30	80	175	13	43	93	7	24	58	9	34	78	37	89	163
	Hongkong	75	110	161	10	19	28	56	80	112	5	11	16	31[1)3)]	49[3]	64[3]
	Sub total	736	1,149	1,636	268	514	809	528	742	1,232	413	693	1,014	1,072	1,666	2,392
Asian	Indonesia	22[2]	36	90	6[2]	12	20	4[2]	9	25	4[2]	-	40	18	23	65
	Philippines[6]	16[4]	56[4]	140[4]	-[4]	-[4]	-[4]	3	13	32	16	35	51	11	40	121
	Malaysia	13	26	41	3	7	11	2	4	6	2	7	14	3	10	20
	Singapore	18[2]	31	52	4[2]	8	13	4[2]	7	13	4[2]	4	9	14[2]	25	49
	Thailand	30[2]	58	112	15[2]	28	59	7[2]	11	23	8[2]	14	30	14[2]	24	48
	Sub total	99	207	435	28	55	103	20	44	99	34	60	144	60	122	303
South West Asia	India	25[1]	72	115	5[1]	22	35	-	45	79	2[1]	8	13	20	63	95
	Sri Lanka	4[2]	12	24	0[2]	2	4	1[2]	2	4	-	-	-	2[2]	6	13
	Iran	14	30	63	2	11	26	6	11	20	2	5	8	30[1]	50	80
	Sub total	43	114	202	7	35	65	7	58	104	4	13	21	52	119	188
Oceania	Australia	50[1]	119	238	22[1]	51	102	15[1]	27	43	28[2]	35	49	49	78	126
	New Zealand	15[2]	22	31	6[2]	10	16	n.a.	8	11	1[2]	2	3	n.a.	10	12
	Sub total	65	141	269	28	61	118	15	35	54	29	37	51	49	88	138
	Total	943	1,611	2,542	331	665	1,095	570	879	1,488	480	803	1,237	1,233	1,995	3,021

Source: Survey on the Petrochemical Industry in Indonesia UNIDO (1973)

Notes:)
1) 1969
2) 1971
3) Including resins for PVC sheet, pipe, rod, film
4) Including HDPE
5) The Association of Petrochemical Industries in Japan (May, 1973) and Japan PVC Association (May, 1973)
6) UNICO's estimates

Table AVIII-4-10 Domestic Demand of Synthetic Fibers in ECAFE Countries

(Unit: 10^3 tons)

	Synthetic Fibers			Nylon			Polyester Fibers		
	1970	1975	1980	1970	1975	1980	1970	1975	1980
Australia	58	123	210	17	41	65	29	69	119
Hongkong	11	23	38	3	6	10	6	12	18
India	-	-	-	n.a.	42	92	n.a.	37	108
Indonesia	12	49	113	4	10	20	7	34	80
Iran	-	-	-	10	15	23	3	15	30
Japan	-	-	-	319	363	421	418	563	718
Korea	-	-	-	35	71	85	19	71	85
Malaysia	9	17	27	2	4	6	6	11	17
New Zealand	1	27	41	-	8	12	-	12	18
Philippines	31	132	224	7	31	52	-	49	83
Singapore	35	88	140	10	25	41	21	54	87
Sri Lanka	3	6	12	1	2	4	1	2	5
Thailand	31	74	138	8	18	33	12	32	57
Total	-	-	-	416	636	864	522	961	1,425

Source: Survey on the Petrochemical Industry in Indonesia, UNIDO (1973)

Table AVIII-4-11 Future Ethylene Consumption and Production (Estimate) in EDAFE Countries

(Unit: 10^3 tons)

Areas and countries		Ethylene Consumption for the domestic use in 1980	Ethylene production capacity			
			Present	Planned	Future	Balance
Far East	Japan	5,259	4,814	1,200	6,014	755
	Korea	573	100	450	550	- 23
	Hongkong	386	-	-	-	- 386
	Sub-total	6,218	4,914	1,650	6,564	346
Asian	Indonesia	176	-	450	450	274
	Philippines	239	-	250	250	11
	Malaysia	70	-	-	-	- 70
	Singapore	170	-	300	300	130
	Thailand	223	-	-	-	223
	Sub-total	878	-	1,000	1,000	122
South West Asia	India	257	105	283	388	131
	Sri-Lanka	38	-	-	-	- 38
	Iran	148	12	588	600	452
	Sub-total	443	117	871	988	545
Oceania	Australia	431	276	360	636	205
	New Zealand	64	-	-	-	- 64
	Sub-total	495	276	360	636	141
	Grand Total	8,034	5,307	3,881	9,188	1,154

Table AVIII-4-12 Derivative-wise Ethylene Consumption in Japan

(Unit: 10^3 t/y)

	Ethylene Production	LDPE	HDPE	EO	AD	EDC	Stylene Monomer	EPR	Others	Total
1969	2,400	858	342	230	334	277	183	-	32	2,254
1970	3,097	983	446	287	367	432	256	-	67	2,838
1971	3,537	1,046	441	331	352	595	260	6	60	3,091
1972	3,851	1,064	543	353	394	642	294	9	60	3,360
1973	4,171	1,117	671	393	423	704	318	12	135	3,773

(Unit: %)

	Ethylene Production	LDPE	HDPE	EO	AD	EDC	SM	EPR	Others	Polymer 2) +PET 1)	Total
1969	100.0	35.7	14.3	9.5	13.9	11.5	7.6	-	1.3	72.3	93.9
1970	100.0	31.7	14.4	9.3	11.9	13.9	8.3	-	2.2	71.4	91.6
1971	100.0	29.6	12.5	9.4	10.0	16.8	7.4	0.2	1.7	69.4	87.4
1972	100.0	27.6	14.1	9.2	10.2	16.7	7.6	0.2	1.6	69.1	87.2
1973	100.0	26.8	16.1	9.4	10.1	16.9	7.6	0.3	3.2	70.5	90.5
									(Assumption	70 %)	

1) Assumption: 30 % of EO is used for PET

2) Polymer includes LDPE, HDPE,SM, EPR and EDC

ANNEX IX

INTERNATIONAL COMPETITIVENESS OF PETROCHEMICAL INDUSTRY

CONTENTS

Chapter 1. Necessity for Observing the International Competitiveness

As described in Annex VIII,"Current Situations & Forecast of the World's Petrochemical Industries", it is highly difficult to formulate any forecast on the future trend of products supply. Further the price factors are increasing due to the increment in the prices of crude oil and in the construction cost, so that it is dangerous to formulate a forecast on the future international prices simply on the basis of the presently prevailing price trend. Therefore, when considering exportation, it is not possible to make any decision or determination for the estimation of price level or assessment of the export amount without considering the competition factors. In the case of Indoensia, from the point of the export competitiveness following countries should be the subjects of the consideration.

(1) Japan, the U.S.A. and the West European Countries

Of the above three groups, Japan will have the most serious effects on the Indonesian export markets when the price factors are stable, because of the geographic proximity between Japan and Indonesia. All of the countries in these groups have already possessed large-scaled petrochemical industry and therefore have advantages in the following points.

a) These developed countires are in a position to carry out their production operations by the facilities which were constructed prior to the days of construction cost hike and also the depreciation of the facilities has already progressed to a considerable extent.

b) The effective utilization of the by-products can be undertaken.

c) A large domestic market is available and therefore the export prices can be lowered by shifting the cost factor onto the domestic price structure.

d) The related industries are well developed and the substantiation of the infrastructures are also sufficient so that the construction cost is comparatively low even in the case of new plant construction.

e) They already have a high level of technology and therefore it is not necessary to pay a large amount of fees and royalties to overseas experts.

f) Due to the fully substantiated port facilities, the transportation cost for a large quantity of raw materials and products are low.

g) The distribution network has already been established overseas and also the actual results of exportation has already been substantiated.

This being the circumstance, there is a possibility that Japan will become one of the leaders in deciding the product prices in the world.

(2) Korea and Taiwan

Although these countries still rely on importation concerning most of the production facilities, they already have petrochemical industry within the country and the substance of the related industries and the infrastructures are also progressing. Also, the quality of labour force is high, thereby reducing the burden of dependency on foreign support. In this report, Korea will be studied.

(3) Middle East Countries

For their rich and low cost oil and gas, these countries are projecting constructions of petrochemical industrial facilities on export-oriented policies. At present, production projects of more than 3 million tons per year of ethylene is being undertaken.

(4) Singapore

Singapore has oil refining facilities of more than 1 million bbl per day including the plants being constructed now, so that the abailability of naphtha is high and the investment conditions including the facilitation in procurement has also been progressed. It has been announced that Singapore is now projecting a construction of an ethylene plant with a capacity of 300,000 t/y.

(5) Australia

A petrochemical project on the basis of natural gas is being contemplated (EDC 800 thousand tons, etc.) In this case, caustic soda will be supplied to the aluminium industry and the advantage is evident in the possibility of utilizing low cost chlorine.

(6) The Philippines

A considerable extent of market is existing within the country and also possesses comparatively highly educated labour force. However, as the Philippines is facing the problem of naphtha procurement, this country is excluded from the scope of the present scrutinization.

(7) Thailand

It has already been decided in Thailand to construct an ethylene plant of 120,000 t/y capacity and the project is progressing, however, this ethylene plant is for covering only the domestic market of Thailand, this country will also be excluded from the scope of study.

(8) The socialist countries including China are undergoing a vast extent of production facility expansion at present, however, they will be excluded from the scope of this study for the fact that their respective domestic markets are considerably large.

Chapter 2. Factor of Competitiveness

There are several factors which affect the competitiveness as follows.

(1) Raw material prices

Comparing naphtha with natural gas, the utilization of natural gas within a gas producing country will be more advantageous for its cheap price. However, such an assumption is made on the actual utilization aspect alone and is not based on the consideration of gas production cost.

If Middle East countries should start exporting petrochemical industrial products even on the basis of the naphtha or gas, prices much lower than the cost level which would be available by directly exporting such raw materials, by means of taking into consideration the low level of the production costs of natural gas and crude oil, it would become necessary to carefully study the lowest limitation of such a price level which the oil producing countries could attain.

(2) Construction cost

As petrochemical industry is one of the capital-intensive industries, the weight taken up by the fixed cost portion will be large so that the level of construction cost have a serious effect on the competitiveness of the products. Although the investment amount required for the infrastructures including port facilities, etc. also largely affect the competitiveness, such projects depend highly on the governmental policy and also it is assumed that they are undertaken by the government. Therefore these infrastructure factors were excluded from the scope of this study.

(3) Transportation cost

The transportation cost is incurred from the transit of the products from the site of production up to the market. The cost in this respect is affected not only by distance but also by amount to be transported.

(4) Scale of domestic market

Countries possessing a large scale of domestic market will have the advantage in the transportation distance and also in the possession of a market protected by import duties, etc. Therefore, such a country will have the potential of obtaining higher export competitiveness in setting export prices by controlling the operational rates of the production facilities.

(5) Possibility of by-product utilization

The ability to utilize the by-products other than ethylene and propylene on a high price level directly enables cost reduction in ethylene and propylene production.

(6) Effects of operational rate (stream factor)

Because of the fact that petrochemical industry is one of the capital-intensive industries, the decrease in the operational rate will cause a drastic deterioration of the economic viability of the production. Therefore, the operational rate is one of the most important factors controlling and affecting the competitiveness of the products.

The factors which will lower the operation rate are the erroneous market forecast, the level of technology including that of the related industries, the problems in the transportation facilities including warehouses, etc.

However, in this study, an assumption is made that all the countries concerned will equally undertake the best possible methods for the improvement of the operational rate and therefore, it is tentatively assumed as mentioned in the Table AIX-5-1.

Chapter 3. Raw Material Prices and By-Product Prices

Since Japan is the largest importing country of the products in this area, the calculation of the price levels in various countries is made on the basis of the CIF Japan prices or on the Japanese domestic prices.

Chapter 4. Construction Cost

The international comparison of petrochemical plant cost is shown in Table AIX-4-1. The method of carrying out the relative comparison was adapted from the article entitled Productivity Costmating (No. 68, Wage Ratio and Productivity, July 30, 1973; No. 69, Location Affects Materials Prices, Aug. 6, 1973; No. 70, Effect of Location on Refinery Costs, Aug. 20, 1973) by Mr. W.L. Nelson published in the "Oil and Gas Journal".

We take the ratio of plant cost amongst Japan, Iran, Korea, Singapore and Indonesia from this table though the relations of plant cost amongst U.S.A., Europe and Japan are remarkably changed.

Chapter 5. Calculations for Economy Comparison on International Competitiveness

In order to evaluate the inherent international competitiveness of future Indonesian petrochemical industry, studies & comparison were made regarding the production costs and ex-factory prices of each product with adequate profit which produced by olefinic petrochemical complex in Middle East countries, Singapore, and Japan which will be potential competitors in the future with the indonesian petrochemical complex. Economic calculations were made regarding standard and newly constructed petrochemical complex. These calculations have been made on the basis of the following prerequisite conditions.

Table AIX-4-1 Effect of Location on Petrochemical Plant Cost

	Japan		U.S.A.		Germany		Iran		Korea		Singapore		Indonesia	
	Factor	%	Factor	%	Factor	%	Factor	%	Factor	%	Factor	%	Factor	%
1. Equip. & Matls.	1.0	49.8	1.19	59.4	1.04	51.8	1.22	60.7	1.09	54.3	1.14	56.8	1.16	57.8
2. Erection Work	1.0	4.6	3.15	14.5	1.26	5.8	1.03	47	0.81	4.0	0.97	4.5	1.03	4.7
3. Civil Work	1.0	11.6	1.91	22.2	1.07	12.4	1.15	13.4	1.0	11.6	1.08	12.5	1.11	12.9
4. Supervisor & Expatriate	1.0	3.0		2.4	0.90	2.7	6.0	18.0	5.0	15.0	5.0	15.0	6.0	18.0
5. Eng'g & Contractors Fee	1.0	31.0	0.46	29.7	1.0	31.0	1.2	37.2	1.2	37.2	1.2	37.2	1.2	37.2
1) - 5) Total		100.0		128.2		103.7		134.0		122.1		126.0		130.6
6. License & Know-how	1.0	31.3	1.0	31.3	1.0	31.3	1.0	31.3	1.0	31.3	1.0	31.3	1.0	31.3
7. Catalyst & Chemicals	1.0	1.8		2.0		1.9		2.2		2.0		2.5	1.17	2.1
8. Spare parts (10%)	1.0	2.0		2.4		2.1		6.1		5.4		5.7	2.9	5.8
9. Contingency (10%)	1.0	-		-		-		13.4		12.2		12.6		13.1
Total Relative Cost		135.1		163.9		139.0		187.0		173.0		177.7		182.9
		(1.00)		(1.21)		(1.03)		(1.38)		(1.28)		(1.31)		(1.35)

5-1 Prerequisite Conditions

5-1-1 Scale of complex and the product pattern

(1) Ethylene production scale: 300,000 t/y

It is assumed that the scale of petrochemical complex centers are identical as 300,000 t/y.

(2) Production scale for ethylene derivatives:

The scale of ethylene derivatives production, will be taken as being identical to the case for Indonesia which is being employed as the basis for comparison. In other words, the following capacity scale will apply.

		Capacity
a)	LDPE	120,000 MTA
b)	HDPE	50,000 MTA
c)	Electrolysis, Chlorine	62,000 MTA
d)	VCM	104,000 MTA
e)	PVC	100,000 MTA
f)	EG	100,000 MTA

(3) Other derivatives

a) Polypropylene: The scale for polypropylene plant is deemed as being equivalent to the amount of the high purity propylene produced by the olefin plant. In other words, the following figures shall be assumed here.

	Capacity
In the case of gas-basis raw materials:	70,000 MTA
In the case of naphtha-basis raw materials:	100,000 MTA

b) Other derivatives

When naphtha is to be employed as the raw material, a large quantity of by-products of heavier than C4 fraction will be produced in the olefin plant. Although it is highly important from the economical viability of the complex, to fully utilize such by-products by installing within the complex a derivative plant.

However, such a consideration has been disregarded in this writing.

5-1-2 Raw materials and fuel

(1) Hydrocarbon raw materials and fuel

The light condensate gas consisting mainly of ethane and propane is taken as hydrocarbon raw materials and fuel in the Indonesia and Middle East cases.

In the Middle East case, the composition of the condensates has been assumed to be identical to that set forth for the case of Indonesian petrochemical industry and the prices of such light condensates, was taken as US¢40/MMBTU figure on the basis of 1974 by assessing the gases as fuel. However, in the Middle East case, it is possible to evaluate the price of the gases on a much lower level when considering the fact that the associated gas is being directly flared without utilization and also the fact that the ethane and propane contents in the associated gas are rich and recovery of the light condensates is easily facilitated.

In the Indonesian case, we take two different levels of price of natural gas ((a) is based on US¢100/MMBTU, (b) is based on US¢63/MMBTU in 1974).

In the cases of Japan, Korea and Singapore, the main raw material is the praffine-rich Middle East light naphtha and the price has been deemed as being US$105/t (¥22,000/Kl) in Japan in the year 1974.

By incorporating 7% per year of escalation factor, the price for the year 1980 has been deemed as being US$150.8/t. The same figures were assumed for the case of Korea. For Singapore, the price level was set at US$140/t by subtracting the ocean freight cost up to Japan. In the naphtha-basis case, fuel oil is assumed as the fuel to be employed in these three countries and the 1974-basis price thereof in Japan has been set at US$66.7/t (¥20,000/t), i.e., US$100/t on 1980 basis. Therefore, the unit price per calorie can be calculated as follows on an assumption that the calorific value of fuel oil is at 10,500 Kcal/kg.

$$\text{(Unit Price per Calorie)} = \frac{100}{10{,}500 \times 1{,}000} \text{ US\$/Kcal} = \text{US\$9.52/MMKcal}$$

@1980

The Korean case was deemed as being identical to that of Japan and for Singapore, a figure US$9.24/MMKcal was assumed by subtracting the ocean freight cost up to Japan.

(2) Salt

The price of salt was US$3.5/t average FOB during 1973 when the price fluctuation was comparatively stabilized.

The ocean freight cost to Japan was US$7 to US$9/t, so that salt was available in Japan at a total price of US$11 to US$13/t. However, the global trend of inflation represented by such a phenomenon as the skyrocketing of oil price, etc., an acute salt price increase is now taking place in major salt producing countries all over the world.

Recent salt FOB prices (As of March 1974)

Producting Countries	Prices
China	US$6.7/t
Mexico	US$3.5/t
Australia	US$6.1/t

Mexico which displayed a comparatively low level of salt price as of March 1974 seems to be presently undertaking negotiations for effecting a price increase. This being the circumstance, the 1974-basis FOB price of salt has been set at US$6.1/t.

Although the ocean freight factor varies on the origin of salt production and the location of the importing country, a tentative and uniform freight factor figure of US$7/t x 130%=US$9.1/t has been assumed for this study. Therefore, the 1980-basis procurement price of salt will be as follows.

CIF price $(6.1 + 9.1) \times (1.07)^6$ =	US$22.8/t
Unloading cost	US$ 0.5/t
	US$23.1/t

As has been mentioned earlier, this figure shall be applied equally to all the subject countries.

(3) By-product prices

Price of fuel have been applied to prices of such items as C_3LPG, C_4 fraction, fuel oil, fuel gas and hydrogen. In the case of such countries as Middle East countries, Indonesia, Singapore, etc. from where it is possible to export fuel, the possible exportation price to Japan, a large amount of fuel importing country, is obtained by subtracting the ocean freight cost from the prices prevailing in Japan for LPG and fuel oil. Concerning the fuel gas price, the natural gas price was directly applied in such countries as Middle East countries and Indonesia where domestic production of natural gas is possible. For other countries, the figure obtained by increasing the fuel oil price by 10% on calorific value basis shall be applied for the sake of simplicity in handling. Hydrogen has been deemed on the same level as fuel gas on the calorific value basis consideration.

(4) Utilities prices

Calculations were made based on the fuel costs and the construction costs on the same criteria employed for the calculation of the utility unit prices for olefin complex.

(5) Construction cost and investment

As has been described in Chapter 4 "Construction Cost", the cost of construction has been calibrated by employing the construction cost rates calculated by means of the method shown in an article in the "Oil and Gas Journal". (reference should be made to Table AIX-4-1) The calculations pertaining to the amount of investment have been made through the identical methods to those employed in Chapter 6, Part II. (VolumeII) Therefore, an assumption is made that the construction will be made in an entirely new construction site on the Grass-root basis in the cases of all the subject countries.

(6) Prerequisite condition for the calculations of production cost and market prices

As has been shown in Table AIX-5-1, "Major Prerequisite Conditions for Economic Comparison of International Competitiveness", the production costs, exfactory prices, fixed asset taxes, insurance, rates of long-term loans available in respective countries and interest rates on local loans have been assumed for the year 1980 concerning each process plant included in the whole complex.

The basic method for making such assumption was shown in Chapter 6, Part I (Volume II)on which the industrialization policies of the countries are reflected.

Further, in the case of Indonesia, it has been pre-designated that the rate of own-capital is at 30%, however, a tentative assumption of 100% loan accommodation for capital in other countries has been made in view of the fact that the own-capital rates for the other countries have not been made clear. Further considerations have been made to the differences amongst the subject countries in such factors as the stream factors, rates, project life (depreciation period), construction period, the rate of plant administration costs, etc. Concerning the exfactory prices, the inflation factor of 7% per year has been basically assumed and further, the internal rate of return of each process plant has been assumed as being at 15%.

Therefore, such calculated exfactory price is largely affected by the tax-holiday period and the taxation conditions incorporated in the industrialization policies of the subject countries. For instance, in the case of Japan, no tax exemption is allowed so that it would be necessary that the profit as against the production cost should be set higher than the other countries if the internal rate of return is to be taken on the same level for all the countries. It has further been deemed that the commencement of the commercial operation of the process plant will be made in September 1980.

5-2 Results of Comparative Calculations

On the basis of the prerequisite conditions stated in the foregoing 5-1, the results were obtained as shown in Figures AIX-5-1 through 8 regarding the standard production costs and the exfactory prices at 1980 with adequate profit rates.

The breakdown of the production cost consists of the variable costs, fixed costs (including plant administration costs), distribution costs (bagging costs) and the general administration costs.

Table AIX-5-1 Major Prerequisite Conditions for Economic Comparison of International Competitiveness

	Indonesia (a)	Indonesia (b)	Middle East	Japan	Singapore	Korea
Location Factor for Construction Cost	130.6%	Same as (a)	134 %	100 %	126 %	122.1 %
Rate of Operation	85 %		80 %	95 %	90 %	95 %
Raw Material	Light Gas Condensate		Light Gas Condensate	Light Naphtha	Light Naphtha	Light Naphtha
Price of Raw Material* $/t	68.3	43.5	28.8	150.8	140.0	150.8
Fuel Price* $/MMKCal	FG 5.95	FG 3.75	FG 2.26	FG 9.52	FG 9.24	FG 9.52
Labour Cost* $/y	2,240	Same as (a)	4,500	10,500	2,900	2,000
Tax: Tax Holiday	5 Years		5 Years		1-5 Years 0% 6-8 Years 4% Over 8 Years 40%	On Foreign Capital 1 - 5 Years
Tax on Profit	45 %		55 %	53 - 54%	40 %	40 %
Tax on Capital and Insurance	1.4%		2.5%	1.7%	2 %	2 %
Interest: Long term loan	7.5%		7.5%	8 %	9 %	10 %
Local loan	12 %		12 %	10 %	20 %	20 %
Project Life	10 Years		10 Years	9 Years	10 Years	9 Years

* Estimated on the basis of 1980

(1) Ethylene (refer to Figure AIX-5-1)

The price of ethylene which is the basic intermediate raw material is largely affected by the raw material cost and the fuel cost. The advantage of the cases of Indonesia and Middle East where the light condensate is used as the raw material is quite obviously superior over the cases of Japan, Korea and Singapore where naphtha is employed as the raw material. This advantage is the result of multiple effects of such facts that, on one hand, the raw material gas can only be assessed on a low level in view of transportation in the case of a gas-based olefin plant and, on the other hand, the ethylene yield is 40 to 80% so that requirement of the raw material amount is approximately 1/1.3 to 1/2 when compared with the naphtha-base case. Also, the amount of fuel which is required for the thermal cracking in an olefin plant is on a much lower level in the latter case; occasionally as low as 1/2 of the former. When the case of Indonesia is compared with that of Middle East, the Middle East case displays a high extent of construction cost and low degree

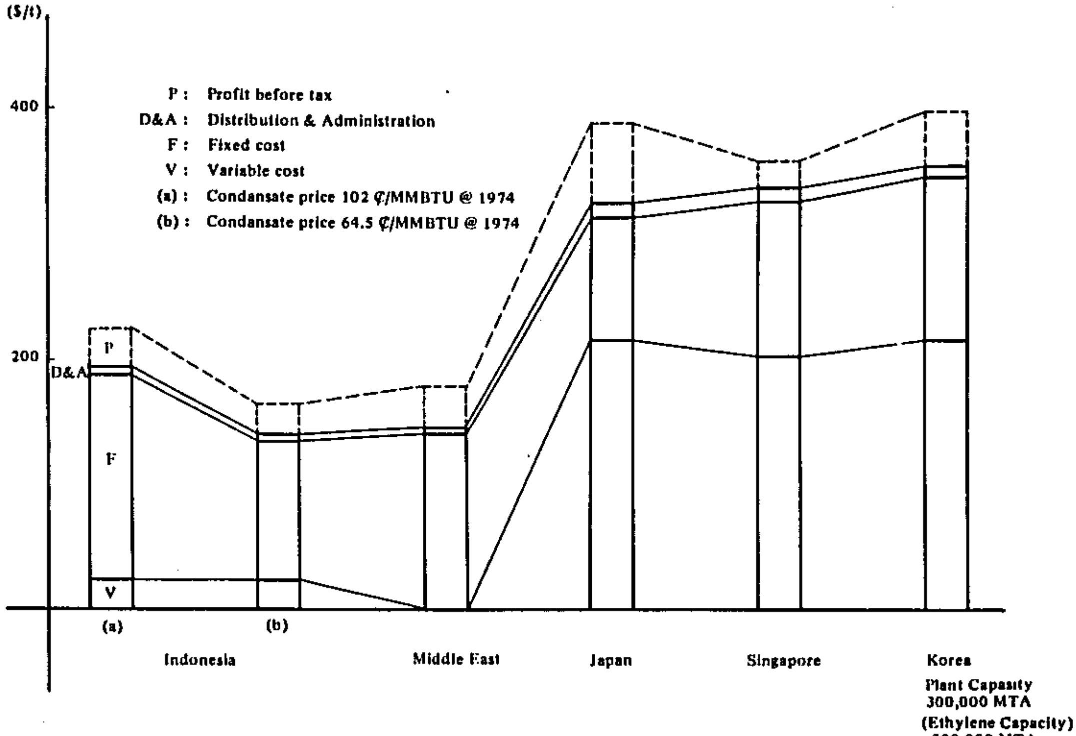

Figure AIX-5-1 Comparison of International Competitiveness (Ethylene) of stream factors and also, in the case of Middle East the fixed cost will be high due to the fact that a large number of expatriate skilled engineers will be necessary for technical assistance. This being the circumstance, the Middle East case displays a slightly higher level of the total cost when compared with the case of Indonesia (b) even the raw material cost is assumed lower but displays remarkably lower level of the total cost in comparison with the case of Indonesia (a) for which gas price is assumed as US¢100/MMBTU in 1974. In the case of naphtha-based plants, Japan displays a lower extent of production cost when compared with the case of Singapore due to a lower degree of fixed costs, however, the Japanese exfactory price is on a higher level than that of Singapore. This has been due to the fact that in Singapore, preferential policies such as tax exemption, etc. are being effected, whereas no such favour has been undertaken in Japan. Therefore, in the case of Singapore, it is possible to obtain the same level of profit rate as Japan on the side of producing enterprises even if the exfactory price of the products is made lower by squeezing the profit margin before tax.

(2) Chlorine and caustic soda (refer to Figure AIX-5-2).

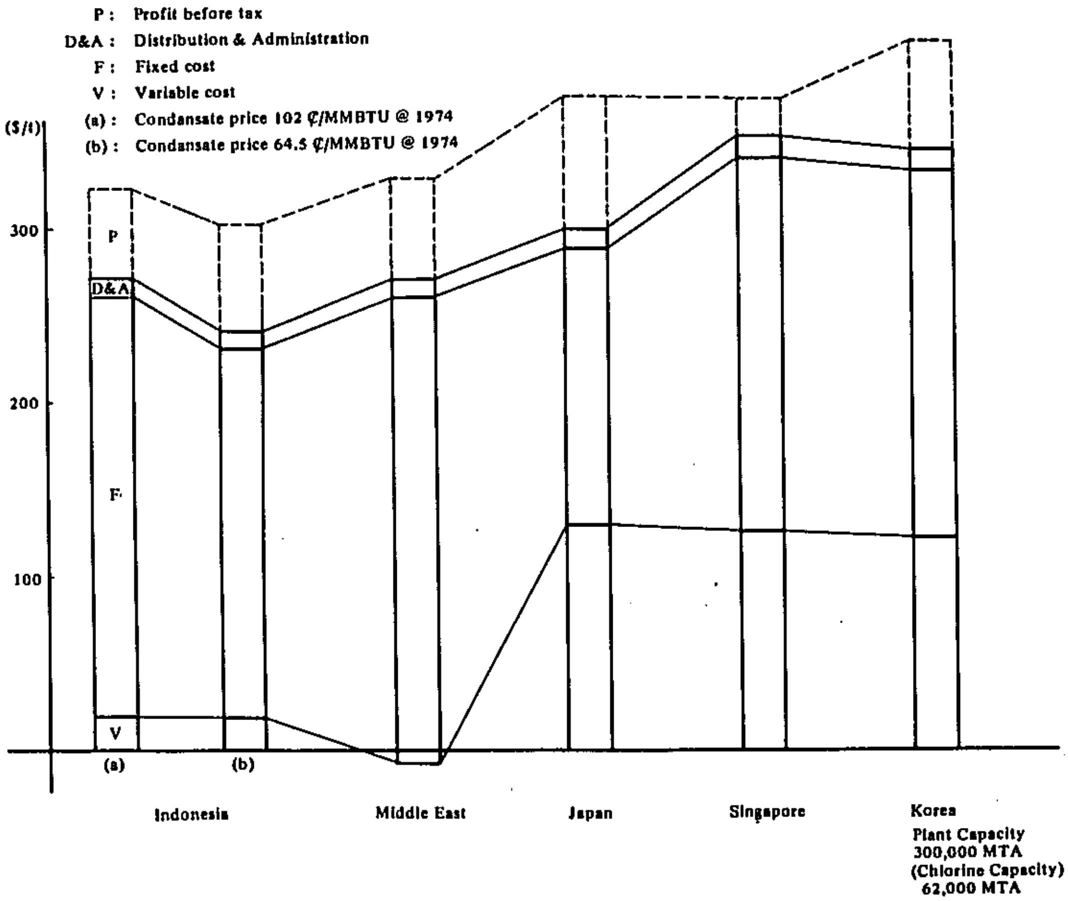

Figure AIX-5-2 Comparison of International Competitiveness (Chlorine)

The prices of chlorine and caustic soda depend largely on electric power cost. As far as electiricity is concerned, own in-plant power generation facilities on the basis of a boiler turbine has been assumed for all the subject countries. The construction cost for the power generation station is expected to largely increase from the present level in view of the currently prevailing inflation. Therefore, the power generation construction cost will be vastly affected by the construction cost so that the assumed level of the electricity cost seems abnormally high; however, no extreme discrepancy in the fuel cost levels will nevertheless emerge. Therefore, the prices of chlorine and caustic soda show a slightly lower level in the cases of oil producing countries where the electricity cost is comparatively low due to a lower level of fuel cost. (Refer to Figure AIX-5-2). However, in the actual practice, as has been studied in the Asahan Project stated in Part III, the possibility is great for the production of chlorine and caustic soda through electrolysis, utilizing lower-cost electric power by hydro-power generation, or even nuclear power generation which is amply expected to be employable during the decade of 1980s.

Therefore, it is possible that the relative positions of advantages in the international competition may vary depending upon the level of the cost of electric power generated in the future.

(3) Other ethylene derivatives (refer to Figures AIX-5-3/8)

Figures AIX-5-3 through 8 illustrate the comparison of olefin derivatives such as LDPE, HDPE, EG, PP, etc. and the derivatives of ethylene and chlorine such as VCM, PVC, etc. In the petrochemical complex comparison between the gas-based and naphtha-based complexes, the advantage is obvious for the gas-based complexes even the case of Indonesia (a).

But the differences between Indonesia (a) and Singapore for LDPE, PVC and P.P. are not so big and other factors (for example, transportation cost etc.) should be considered for making comparison.

(4) Other points to be considered

The comparative calculations described in the foregoing have been made for the purpose of carrying out a comparative study of the advantages in the potential international competitiveness by comparing the site conditions, whilst basing the assessment upon the prerequisite conditions stated in Chapter 5, 5-1. Therefore, it must be noted here that the results of these calculations will be affected by the changes in the prerequisite conditions. The following paragraphs will describe the points to be noted when reviewing the results obtained through the above mentioned calculations.

a) Construction cost and total investment cost

Construction cost and total investment cost are estimated in such a manner that a complex including all the necessary auxiliary facilities such as jetty will be newly constructed in a grassroot site.

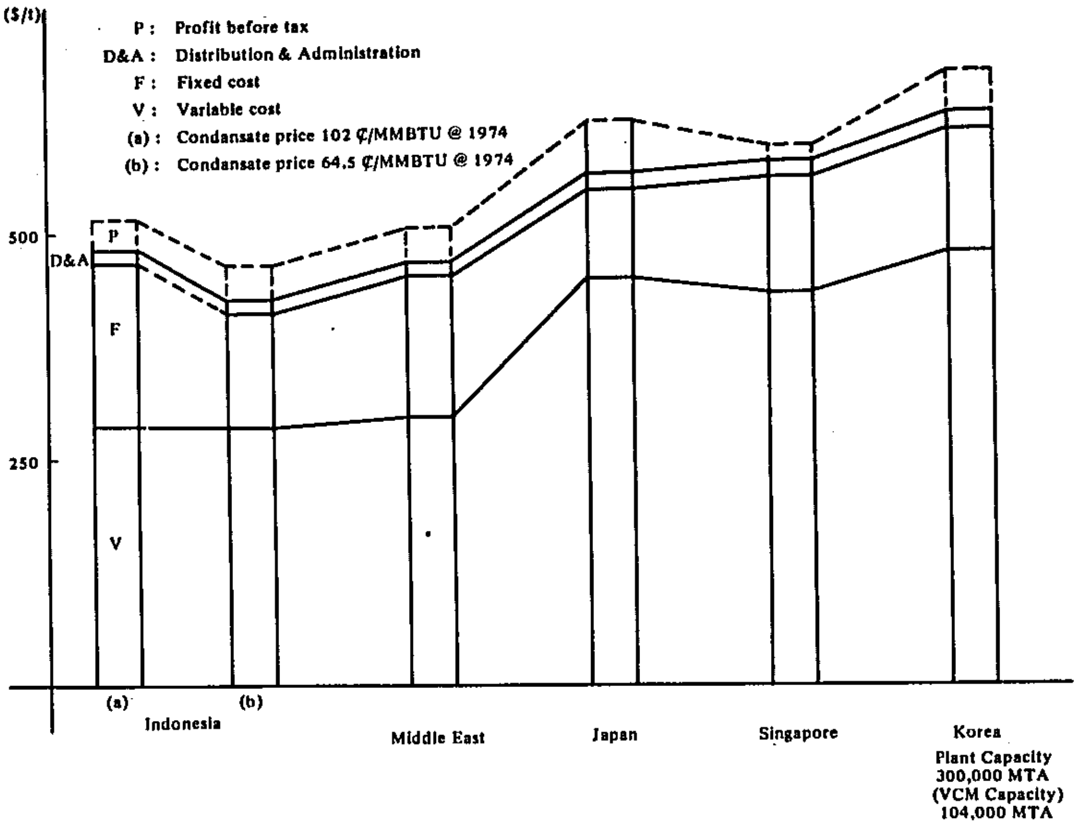

Figure AIX-5-3 Comparison of International Competitiveness (VCM)

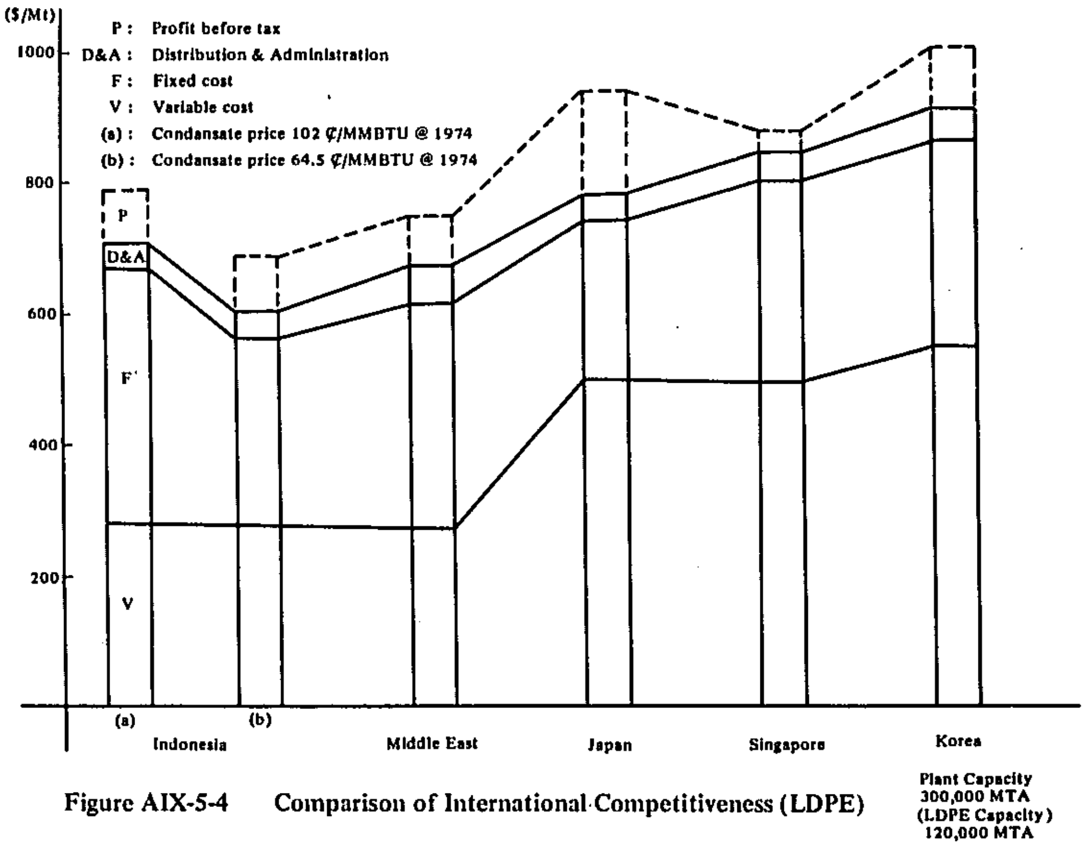

Figure AIX-5-4 Comparison of International Competitiveness (LDPE)

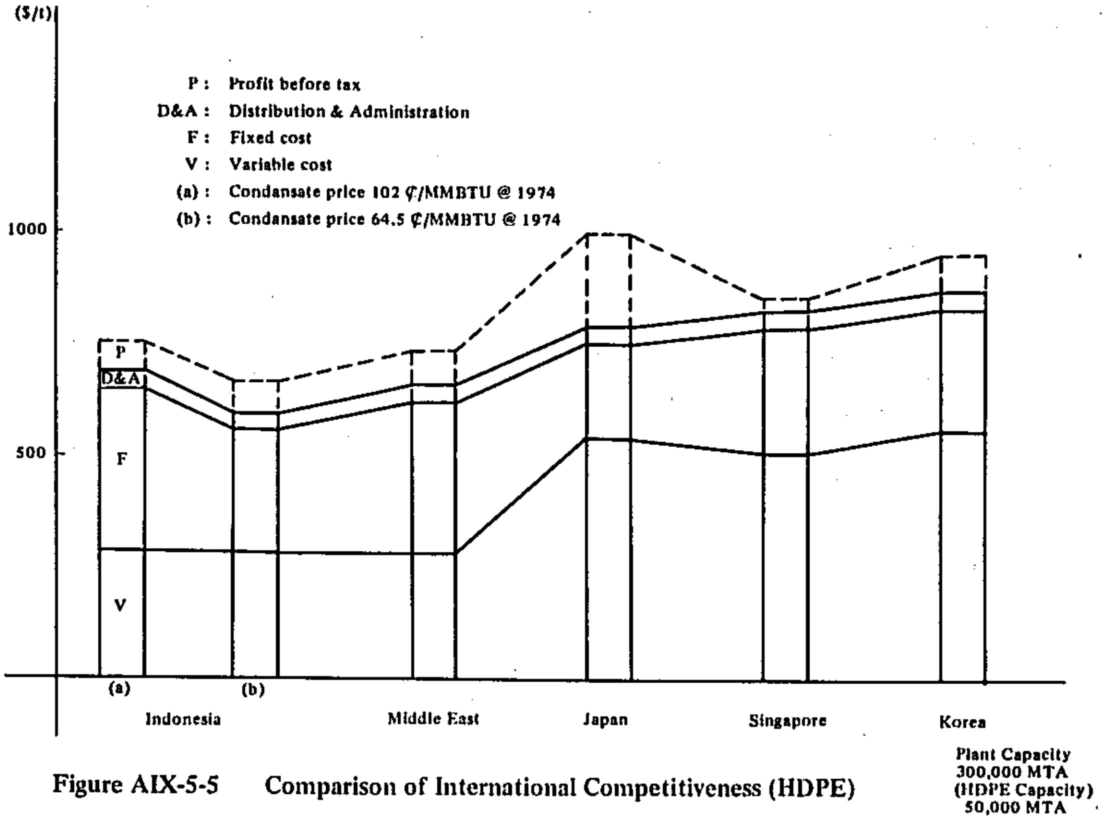

Figure AIX-5-5 Comparison of International Competitiveness (HDPE)

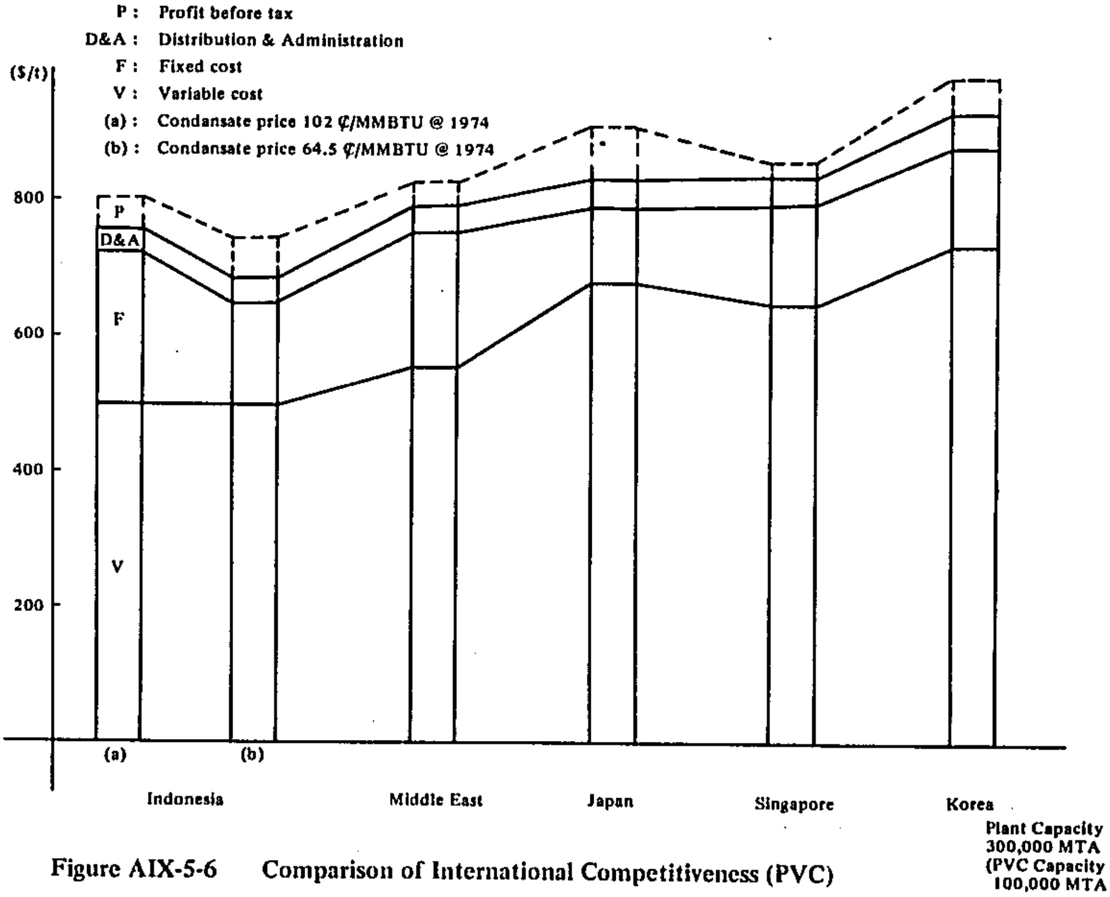

Figure AIX-5-6 Comparison of International Competitiveness (PVC)

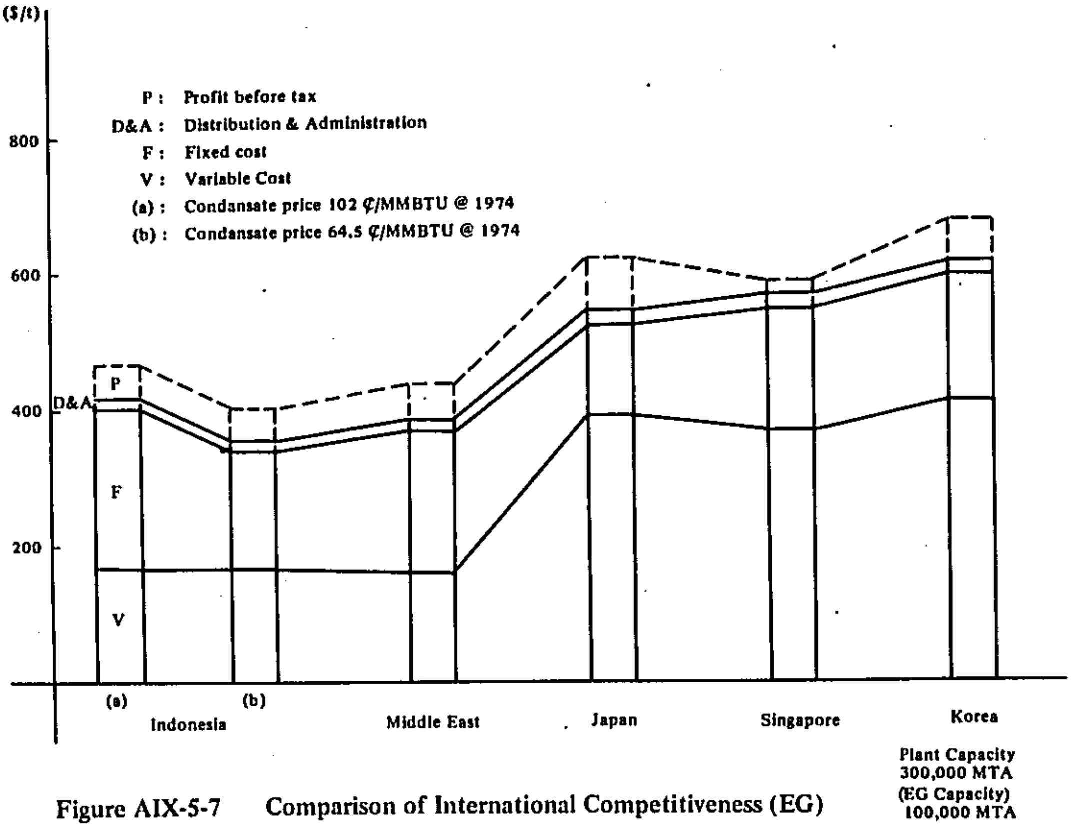

Figure AIX-5-7 Comparison of International Competitiveness (EG)

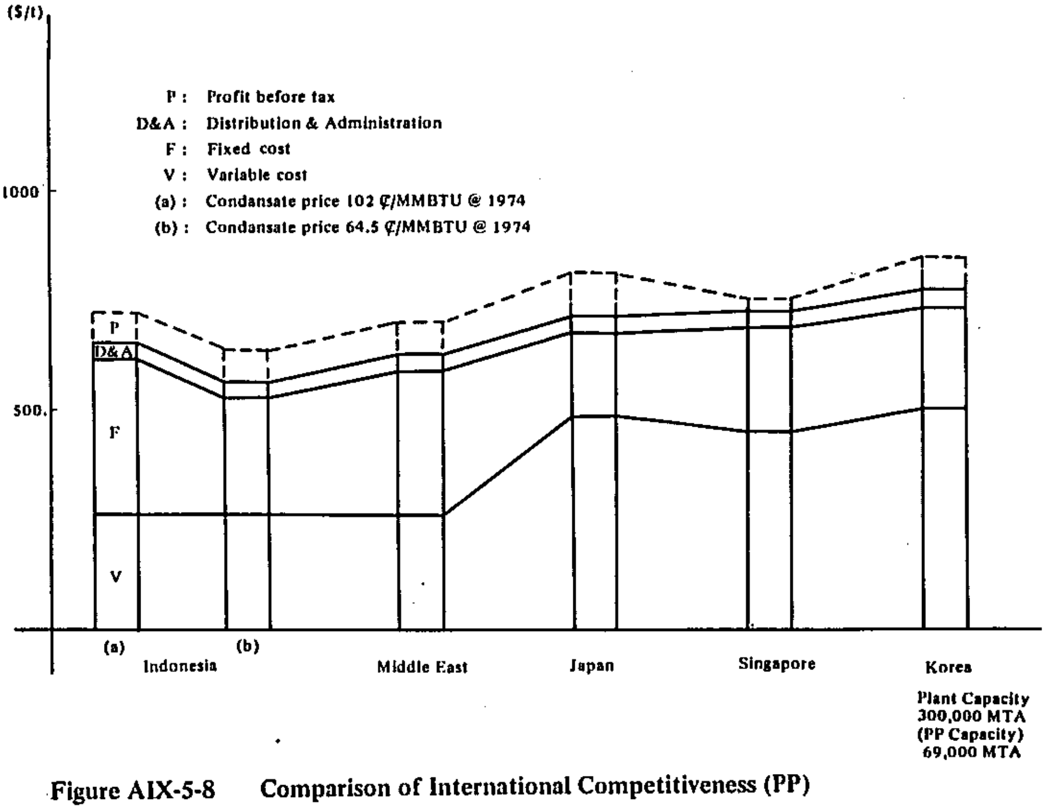

Figure AIX-5-8 Comparison of International Competitiveness (PP)

However, in developed industrial countries, some supporting facilities are already constructed and investment cost might be reduced by utilizing such facilities.

Also, there will be cases in which the license fee or know-how fee becomes unnecessary because of the accumulation of own technology or self-development of techniques. It should be noted here that no evaluation has been made to the possibility of potential saving in the amount of investment gained by the introduction of the latest technology and effective project controls. Also, for semi-advanced countries such as in the case of Korea, ample evaluation has not been made in a report done by Oil and Gas Journal Method concerning the effects of reduction in the construction costs because of a high level of workers' morale and of the construction administration technique. If such are to be also evaluated, investment cost in Japan and Korea, will be reduced.

b) Preferential policies by the government

The objectives of industrialization of petrochemical industry vary according to the countries in which the project is to be undertaken. The objectives will further vary even within the same country depending on the time of effecting such an industrialization. There are cases in which tax exemption is undertaken for the purpose of encouraging investment activities, i.e., for the introduction of foreign capital. In such a case, the intensification yield of the investment during the initial phase of industrialization is usually undertaken in order to reinforce the international competitiveness. Such a provision has also been taken into consideration as a prerequisite condition for the present calculation for assessing the international competitiveness. However, at the stage after the initial phase of industrialization, there are cases in which the tax exemption provision is abolished. Therefore, it may be necessary to evaluate the international competitiveness potential without considering the tax exemption provision, for the purpose of effecting a long-term and national economy rather than enterprise-oriented assessment.

c) Competitiveness in export markets and managerial policy of enterprises

For the managerial administration of a petrochemical complex, a wide range of freedom is available in the selection of the enterprise business policies and in many cases, the degree of export competitiveness depends on the nature of the policies selected. For instance, concerning the problems of establishing the optimum production scale, there are such possibilities as (1) to set the scale on a smaller side in order to satisfy the immediate domestic demand; (2) to pursue the scale merit by setting the production scale on a larger side, in which case the operational rate will remain on a low level during the initial stage until the demand grows substantially; (3) to set a large scale and the demand shortage portion, i.e., the production exceeding the domestic demand, shall be exported on a low price level in order to fully obtain the scale merit by improving the operational rate. Of these various cases, one of the most notable examples is the exportation carried out by Japan in the past at a price close to the marginal level as being one of the instances of the case (3) above. As has been described so far, the export price has a vast extent of flexibility and the determination of the level thereof largely depends on the nature of the policy adopted by the management of the enterprises. Further, the export competitiveness will become more flexible if governmental policies are reflected upon the enter-availability, in view of such circumstances as the raw material supply possibility to the plant site, the extent of necessity for the promotion of industrialization, the national needs for foreign exchange, etc. Considerations to a certain extent have already been made pertaining to these points by mentioning the availability of governmental tax exemption provisions.

Although it is highly difficult to estimate the real export competitiveness or the levels of export prices through simple comparative studies by setting a constant profit rate, etc., such scrutinizations will serve as the basis for a comparison of potential competitiveness of the subject countries.

ANNEX X

VARIOUS UTILIZATION APPLICATION OF NATURAL GAS

CONTENTS

Chapter 1. Various Utilization Application of Natural Gas

Natural gas has the following characteristics:

1. High calorie: The gross caloric value is 9,000 to 9,800 $Kcal/Nm^3$;

2. Cleanliness: Smoke-free, soot-free, ash-free and tar-free;

3. Simple composition: When compared with crude oil, coal, etc., the separation of the component substances can be comparatively easily carried out. The desulfurization is also easily undertaken;

4. Gas Status: The handling is made easy.

The effective utilization of natural gas can only be made by taking full advantage of the above characteristics.

In this sense, it is quite natural that in countries other than Japan, the utilization of natural gas, as a chemical industrial raw material or as a sub-raw material for steel and iron production has been increasing in the recent years, although the conventional utilization of natural gas has been heavily concentrated on the application for town gas, electrical power generation and for other so-called energy source. The following Table AX-1-1 shows the consumption break-down of natural gas in various countries of the world. The natural gas utilization can be broadly classified into two categories, i.e., for fuel application and for carbon source application.

Table AX-1-1 Country-wise Natural Gas Consumption Breakdown

(Unit: %)

	Italy (1968)	U.S.S.R. (1966)	France (1968)	Japan (1969)
Chemical Ind.	18.31	4.4	31.8	58.4
Gas Enterprise	21.03	11.1	25.5	21.6
Power Plant	11.93	28.3	21.8	10.2
Others	48.73	56.2	20.9	9.8

1-1 Natural Gas as Fuel

Because of the characteristics of natural gas such as the high gross caloric value, the simple composition consisting mainly of low extent of hydrocarbons, ease in desulfurization, smoke-free, soot-free and ash-free combustion performance, etc., it is widely utilized as town gas, for boiler fuel and electrical power generation as one of the typical clean energy sources. Particularly, in the field as the fuel for electrical power generation, it is expected that the consumption will grow in the future along with the development of high-capacity gas turbines and combined power generation systems. Further, natural gas can be used in the iron and steel industries and the ceramic industry as direct heating fuel.

1-2 Natural Gas as a Hydrocarbon Source

Natural gas is one of the most easily available hydrocarbon sources along with crude oil and coal. Natural gas is in a gaseous state and that greatly facilitates the transportation, storage and other handling, thereby expanding its field of application.

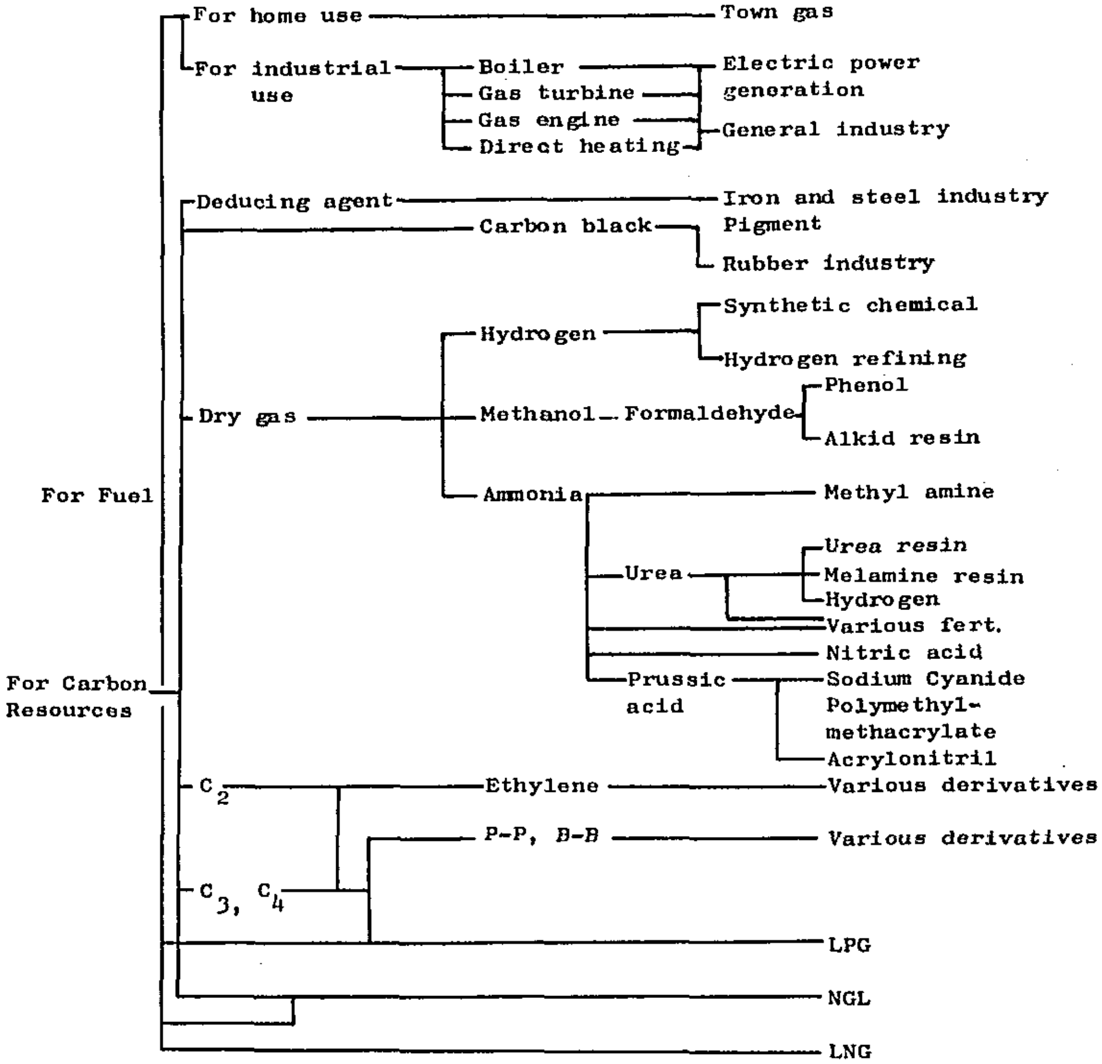

Figure AX-1-1 An Example of Natural Gas Utilization

1-2-1 As a reduction agent

Natural gas can be utilized as reduction agents in the blow-in into blast furnace, in the direct reduction process in iron and steel manufacture in general, and in the production of reduction pellets.

1-2-2 As a carbon source

Natural gas is also used in the production of carbon black, in the generation of hydrogen by means of steam reforming reactions and also in the utilization of the generated hydrogen, the production of methanol, ammonia and the prussic acid and the derivatives thereof, etc.

1-2-3 As a C_2 source

By means of the process described in the following chapter, the separation and recovery of the C_2 fraction contained in natural gas will be undertaken for the production of ethylene and the derivatives thereof.

1-2-4 As a C_3^+ source

The C_3^+ fraction which can be separated and recovered from natural gas is evaluated on the fuel basis as LPG and natural gasoline. Further, it is utilized as a raw material of petrochemical industries together with the above-mentioned C_2 fraction for the production of ethylene and the derivatives thereof, as well as for the production of propylene, butylene and their derivatives.

Examples of the above-mentioned various fields of applications will be described in Figure AX-1-1.

When utilizing natural gas the following points should be well taken into consideration.

(1) Study on the utilization scheme

Except for a case which the total amount of natural gas is used as fuel, care must be exercised to confirm the quantitative balance and the mutual correlation amongst the raw material gas composition, main products and by-products. The excess by-products will normally be consumed as fuel inside the complex, however, which sometimes causes the enhancement of the utility consumption of the production system.

(2) Study on the separation and recovery of each component in natural gas

For instance, in the case of ethylene production, the yield of ethylene and of the P-P and B-B fractions will be greatly affected by the composition of the employed natural gas. Therefore, it is necessary to integrally study the quantitative balance (including the fuel consumption) within the production lines as well as the separation cost of the components and the production cost.

(3) Scrutinization of the plant site

It is necessary to find the best relationship between natural gas producing area and the consumption area in terms of an over-all correlation among the quantity, method of transportation, destination, etc. of the raw gas, products, by-products, export fuel, etc.

Chapter 2. LNG Production Process and Separation/Recovery of Petrochemical Industrial Raw Materials

2-1 Production Process of LNG

The liquefying processes for natural gas can be categorized into three processes.

1. Mechanical refrigerating
2. Turbo-expansion cycle
3. Joule-Thomson cooling

The most prevailing method of liquefying process for base load, that is, propane-cooling mixed refrigerant method (Mechanical refrigeration) is explained in the following paragraph.

(1) Specifications of the plant

Main Equipment:

Acid gas removing equipment: Diethanol amine washing

Dehydrator: Molecular sieves

Cooling method: Propane pre-cooling mixed refrigerant process

Compressors: Propane compressor, 1 unit;
mixed refrigerant compressor, 1 unit

Main heat exchange: Wound aluminum coil, 1 unit

Utility facilities: Steam and power generators,
sea water intake facilities

The liquefying plant consists of the acid gas removing equipment, dehydrator, fractionator equipment, and the raw material gas and the mixed-refrigerant pre-cooling equipment, and liquefying equipment.

Explanations will be made here and in accordance with the attached flow sheet, (Figure AX-2-1).

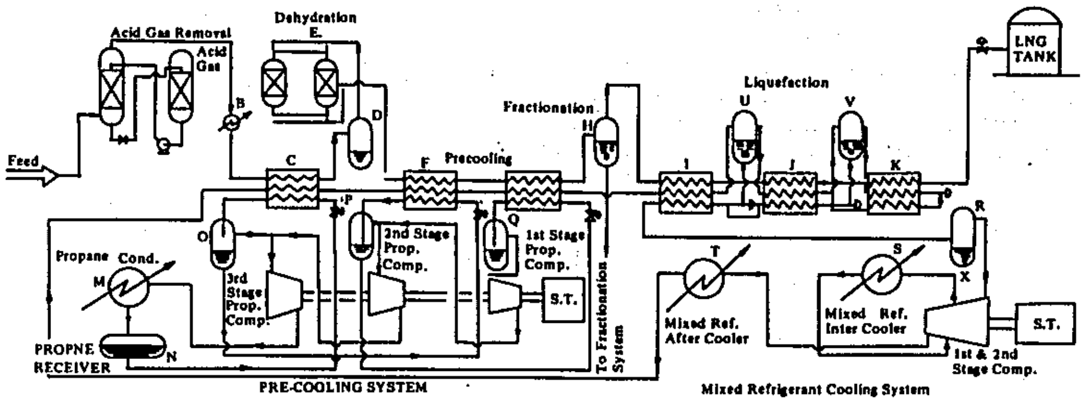

Figure AX-2-1 Flow Diagram of LNG Production

(2) Acid gas removing equipment (A)

The raw material gas containing such acid gas substances as CO_2, H_2S, S, etc. firstly is fed to the absorbing tower in which the concentration of CO_2 and H_2S in gas is reduced to less than 70 ppm in volume by Diethanol Amine. After the removal of the acid gas, the raw material gas is firstly cooled to about 32°C by sea

water cooler (B), and then cooled to 20°C by the 3rd stage cooler (C) of the propane refrigerator. By the above-mentioned cooling processes, dehydration is undertaken to reduce the load on the following dehumidifying equipment. The water is separated in the Drum (D) and then drained.

(3) Dehydrator (E)

After the completion of the primary dehydration at the drum (D), the gas is further fed into the dehydrator (E), in which molecular sieves are employed as the absorbing agent. Here, the water content is reduced to less than 0.5 ppm in volume. This process is undertaken to prevent freezing in the cold end of the heat exchanger in the liquefying equipment. Defrosting once every year will be necessary in this grade of dehydration. The molecular sieve is more suitable than the other desiccants in view of the prevention of change in the feed gas composition caused by the absorption of hydrocarbon.

(4) Fractionator

The raw material gas which has been dehydrated by the dehydrator (E) is cooled by the second stage of the propane cycle and then on the first stage thereof, thereby resulting in the liquefying of partially high-boiling point substances. The liquefied substances is separated at the separation drum (H), and further fractionated to be used as the make-up to the mixed refrigerants explained later.

(5) Pre-cooling equipment for raw material gas and the *mixed refrigerants*

The raw materials gas and the mixed refrigerants are precooled by the heat exchanger (C), (F) and (G) by means of a three-stage expansion propane refrigerant cycle. The approximate cooling temperature levels are respectively 20°C, -1°C and -30°C. Propane which has been concentrated at the propane condenser (M) by sea-water cooling is expanded in the heat exchanger (C) after passing through the liquid receiver (N), thereby carrying out the cooling. The evaporated gas and the flush gas are separated by the separator (O), and the gas portion is led into the third stage of the propane compressor from where it is returned to the condenser (M). On the other hand,the liquid portion is depressurized and expanded at the heat exchanger (F) and then led into the separator (P) in a gas/liquid mixed status after being cooled. Then, the gas portion is fed into the second stage of compressor, and the liquid is then fed to the heat exchanger (G). After cooling, the evaporation is completed and the gas portion is finally led to the first stage of the compressor. The expansion valve at the first stage is controlled by the in-take gas super-heating and the expansion valves of the second and the third stages would be respectively controlled by the liquid level of the separators (P) and (O).

(6) Liquefying equipment

The raw material gas which has been cooled to approximately -30°C is led into the heat exchangers (I), (J) and (K) which are cooled by the refrigerant cycle of the mixed refrigerant after a portion of the high-boiling point substances have been separated from the raw material gas in the separation drum (H). In the heat exchanges, the cooling is gradually undertaken and liquefying is complete. The LNG which has completely been liquefied is further super-cooled to below -162°C so that almost no flushing takes place even if the LNG is depressurized to the atmospheric pressure inside the LNG tanks. On the other hand, the mixed refrigerants (mixture of N_2, C_1, C_2 and C_3) is pressurized by the set two-stage compressor with intercooler (S), then is cooled by the sea water at the after cooler (T). Refrigerant is further cooled by the heat exchanger (I) by means of the above-mentioned propane cycle in which the partial liquefying is undertaken. The partially liquefied gas is led into separation drum (U).

The gas portion is led to the main heat exchanger (J) in which it is cooled and partially liquefied and then led to the subsequent stage. The liquid portion undertakes the cooling of the main heat exchanger (I) by being depressurized and desuperheated by expansion valve and then is fed to the suction drum of the compressor. The refrigerants which have been liquefied at the main heat exchanger (J) undertakes cooling of (J) by means depressurizing and desuperheating at the expansion valve. Then, it merges into the expanded gas of the main heat exchanger (I) and is led to the drum (R) together. The gas in the drum (V) is cooled and liquefied in the main heat exchanger (K), and cools (K) by the depressurizing by expansion. The evaporated gas merges into the gas from the second stage and further into the gas from the third stage. The cold heat is recovered at each stage to decrease temperature to approximately -37°C. Thereafter, the gas is compressed at the compressor after going through the suction drum (R). The same cycle is repeated to carry out the cooling and liquefying of the fed gas. The composition of mixed refrigerant shall be determined to minimize the efficiency deterioration by thermodynamics irreversible characteristic, by keeping the constant temperature difference between the cooling curve computed on feed gas composition and the vaporization temperature curve computed on mixed refrigerant. Calculations by a computer must be undertaken to the composition of the mixed refrigerant in accordance with the composition of the fed gas and must thereby be determined in such a manner that a predesignated temperature difference will be constantly maintained between the cooling curve of the fed gas and the vaporization curve of the mixed refrigerant in order to minimize the efficiency deterioration caused by the thermodynamic irreversibility.

(7) Utilities

Utilities requirement for the production of 2 million t/y of LNG production is as follows:

Fuel (Natural Gas):	354 thousand t/y(15% of the fed gas)
Cooling water(Sea water):	20 thousand t/y
Industrial water(Fresh water):	850 thousand t/y

2-2 Separation and Recovery of Petrochemical Industrial Raw Materials

As has been briefed in the foregoing chapter (various utilization application of natural gas), the application fields of natural gas cover a wide range including the use as fuel up to the application as the petrochemical industrial raw materials of various types. However, if natural gas is utilized as carbon sources or hydrogen sources (for instance, for the production of carbon black, ammonia, methanol, etc.), it is possible to utilize the natural gas as it is without carrying out the separation into various components. (It must be noted here that the carbon/hydrogen ratio in the raw natural gas will affect to a certain extent the operation of the subsequent processes.) However, in the case of utilizing carbon chains, more than two carbons, the subject substances must be separated and recovered from the raw natural gas. Table AX-2-1 shows the ratio between the raw material status and the yield of ethylene and by-products for ethylene production.

When considering the recovery of various hydrocarbons contained in natural gas, it is imperative to undertake the most effective utilization of the limited resource of natural gas by integrally studying the possible recovery rate and purity as well as the utilization possibility of the remaining substances on the basis of the amount and composition of the available natural gas. Table AX-2-2 shows an example of a certain gas-chemical complex and the gas balance thereof. In this example, the raw material balance inside the complexes are designed on the basis of the ethane recovery by the employment of absorption process at 80% C_2 recovery rate of 90% purity.

Table AX-2-1 Effect of Feedstock on Ethylene Production

Feed Stock		Ethylene Yield Wt. %	Propylene plus By-products Wt. %
Components	Kg/m^3		
Ethane	374	78	6
Propane	508	43	28
Butane	584	32	44
Pentanes - Heptanes	659	30	50
Naphthas	731	28	56
Gas Oil	875	25	61
Crude Oil	875	20	65

The following paragraphs will briefly explain the recovery processes of various hydrocarbons contained in natural gas.

(1) Flash separation with refrigeration

This is a process to improve the yield of NGL gas using the refrigeration process adopted to the NGL separation (and dehydration) process which is normally undertaken at the gas well. The structure of this processes is rather simple and it can be adopted when the raw gas is comparatively wet and further the demand for dry gas, particularly as the fuel is high. However, it must be noted that the ethane yield in this process is low.

Table AX-2-3 shows the ethane recovery rate by propane refrigerant cycle.

(2) Absorption process

The process flow is shown in Figure AX-2-2. In this process, the circulation of heavy gasoline or light oil is made at an operation temperature level of -20 to -45°C as the absorbing oil. This process is suitable for the recovery of C_3^+ substance and is popularly employed in the U.S.A. for the recovery of ethylene plant feed gas. However, if the C_2 recovery is intended, the necessary amount of the absorbing oil will drastically increase. Table AX-2-4 shows an example of corelation between the C_2 yield rate and the absorbing

Table AX-2-2 Feed Gas Composition

Acid Gas	0.162	Mol. Fract.
C_1	0.550	"
C_2	0.177	"
C_3	0.076	"
C_4	0.025	"
$C_{5}+$	0.010	"
Total	2,400,000	t/y

Gas from Separator						Products		
CO_2	482,000	t/y	To. ATM.	482,000	t/y	-		
H_2S	94,000	"	S. Recov.	94,000	"	Sulfur	84,000	t/y
C_1	1,069,000	"	NH_3 Plant	304,000	"	NH_3	320,000	"
			Plant Fuel	765,000	"	-		
C_2	325,000	"	Ethylene Plant	325,000	"	Ethylene	250,000	"
C_3	255,000	"	LPG plant	375,000	"	LPG	375,000	"
C_4	120,000	"						
$C_{5}+$	55,000		Gasoline Plant	55,000	"	Gasoline	55,000	"
Total	2,400,000	"		2,400,000	"			

Table AX-2-3 Feed Gas Composition

CO_2	0.0084	Mol. Fract.
N_2	0.0007	"
C_1	0.6747	"
C_2	0.1176	"
C_3	0.0780	"
C_4	0.0473	"
C_5+	0.0733	"
Total	1.0000	"

Vapor-Liquid Separation & C_2 Recovery

Operating Temperature = -38°C				
Operating Press.	(Kg/cm^2G)	20	40	60
Liq. Yield	(% on Feed)	29.8	40.7	55.0
C_2 Recovery	(% on Feed)	47.9	68.2	81.5

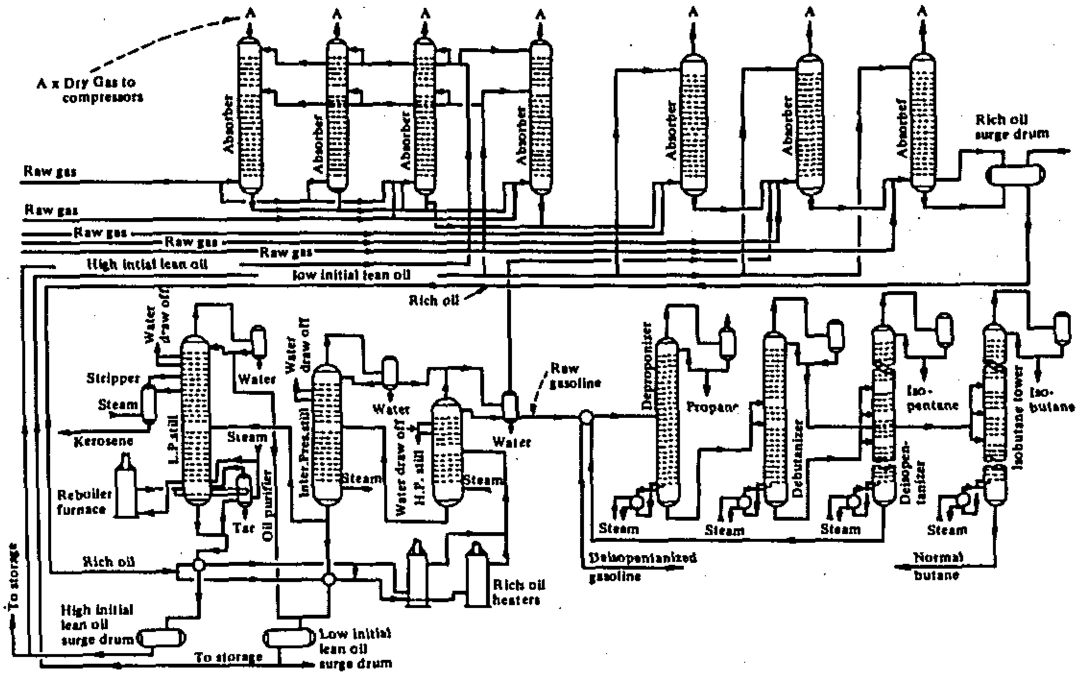

Figure AX-2-2 Flow Diagram of Absorption Process

Table AX-2-4 Effect of Oil Circulation Rate on Ethane Recovery

Ethane Recovery, %	Oil Circulation, Gpn
25	800
40	1,350
60	2,200
80	3,500

T = -40°F, P = 900 psig, Inlet Gas Rate = 500 MMscfd

Table AX-2-5 Cost for Ethane Recovery

Plant Capacity	
Feed Gas	2.155 $10^3 Nm^3/d$ (200 MM SLFD)
Annual Production of Ethane	110,000 t/y
Yield of Ethane Recovery	75 %
Investment (10^6 $)	
ISBL	29.00
Off-Site	11.00
	40.00
Production Cost (Ethane t/$)	
Feed Gas (50 ¢/MM BTU)	337.50
Cat. & Chem.	0.73
	338.23
Fuel Gas (50 ¢/MM BTU)	34.90
Boiler (10 ¢/Ton)	0.32
Cooling Water (0.7 ¢/t)	6.40
	41.62
Labour (@10,700$ x 44)	2.12
Cost for Fixed Investment	73.82
Profit & Loss	35.70
	111.64
Total	491.49
By-Product Gas	△ 412.90
GRAND TOTAL	78.59

circulation amount. When the C_2 recovery rate is more than 30%, the recovery rate for C_3^+ substance is almost 100%. This process is also suitable for the separation of each substance in the subsequent fractionations processes. Table AX-2-5 shows one example of the ethane recovery cost incurred by the employment of this process.

(3) Direct condensation process

In this process, the raw gas is cooled down to below the boiling point of the subject hydrocarbon to be recovered to carry out liquefying and separation of the desired substance. When the LNG production from the remaining gas is planned as the optimum utilization of the gas, the recovery of such gas can be undertaken by adding separation process of the gas to be separated to the raw gas liquefying process (refer to the previous chapter) (normally, a simple addition of a separation drum will be sufficient for this purpose). Therefore, this process can be considered as being one of the simplest process which can be adopted. However, when no LNG project is contemplated, a certain provisions should be made in order to obtain the coolant source necessary for the liquefying of the subject substance. This necessity has been impeding upon the actual industrialization of this process. In the recent years, a large-capacity Turbo-Expander has been developed, thereby making it comperatively easy to carry out direct cooling to -135°F to -150°F. This being the circumstance, this process has become highly interesting as one of the ethane recovery processes on a high efficiency rate.

(4) Direct utilization of the mixed gas (raw gas)

If the feed gas is wet and the same time when the ethylene plan is projected, this process is worthy of scrutinization. Figure AX-2-3 shows one of the examples of the cases in which this process is incorporated into an ethylene plant. This gas separation section in an ethylene plant will necessarily increase its through-put. However, this process can be employed depending upon the feed gas composition, the amount processed and the nature of the utilization project for the remaining gas.

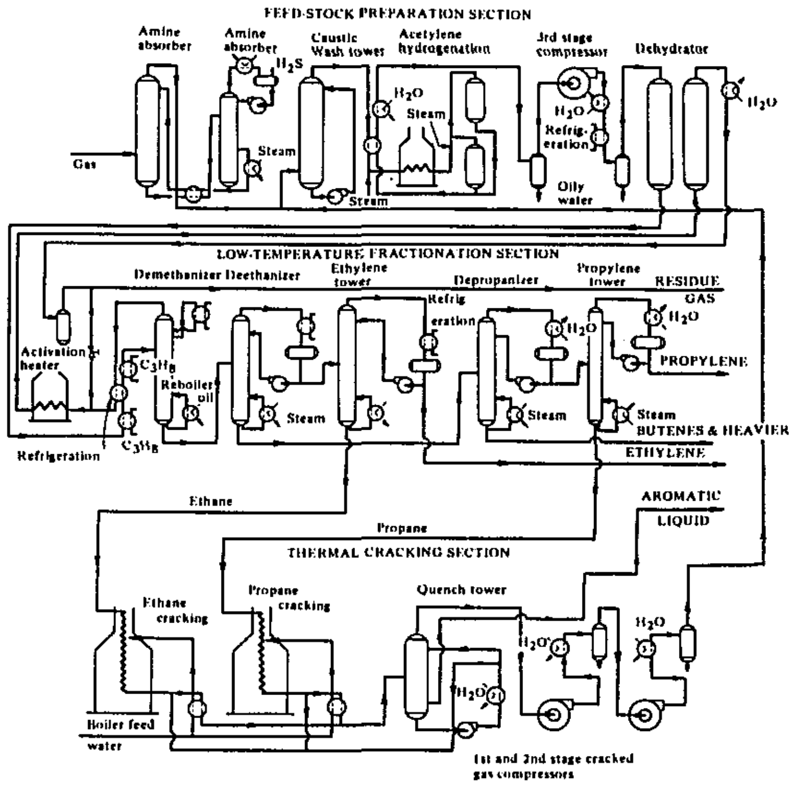

Figure AX-2-3 Direct Extraction of Mixed Gas (Raw Gas)

ANNEX XI

FEASIBILITY OF METHANOL PRODUCTION

CONTENTS

In Chapter 1 of this Annex the applicable usage of natural gas will be described regarding the case in which the component methane is used as the raw material. By so doing, the significance of methanol synthesis in a methane complex will be clarified. Chapter 2 will treat the evaluation of the present supply capacity and a forecast on the future demand of chemical industry-use methanol in Southeast Asia. Chapter 3 will discuss and observe the competitiveness of large-scale methanol plant in Indonesia by carrying out a comparative study with the cost factors involved in such an operation. Chapter 4 will summarize the conclusions drawn from the preceding chapters.

Chapter 1. Utilization of C_1 (methane)

Detailed explanation have already been made in the main volume regarding the olefin complex using C_2^+ contained in natural gas as a raw material. In this chapter, the effective utilization of C_1 (methane) as is shown in Figure AXI-1-1 will be observed. A simple application of natural gas is the direct utilization as fuel in various fields such as town gas and electric power generation. However,in this application consumption areas are to exist in the vicinity of the natural gas production site. The natural gas production sites, in general, are located away from consumption areas, thereby making it considerably difficult to readily undertake the utilization. Although an abundant amount of natural gas is reserved in North Sumatra and East Kalimantan, there is no consumption area in the vicinity where ample extent of natural gas consumption for fuel or electricity generation exists. In the U.S.A., natural gas transportation from the reserve up to the consumption areas through long pipe lines is being undertaken. In the case of Indonesia which consists of more than 3,000 islands, however, such a method is not necessarily effective. Further, it must be noted that for sometime to come it is difficult to expect Indonesia to enjoy demand corresponding to the high extent of the reserved gas.

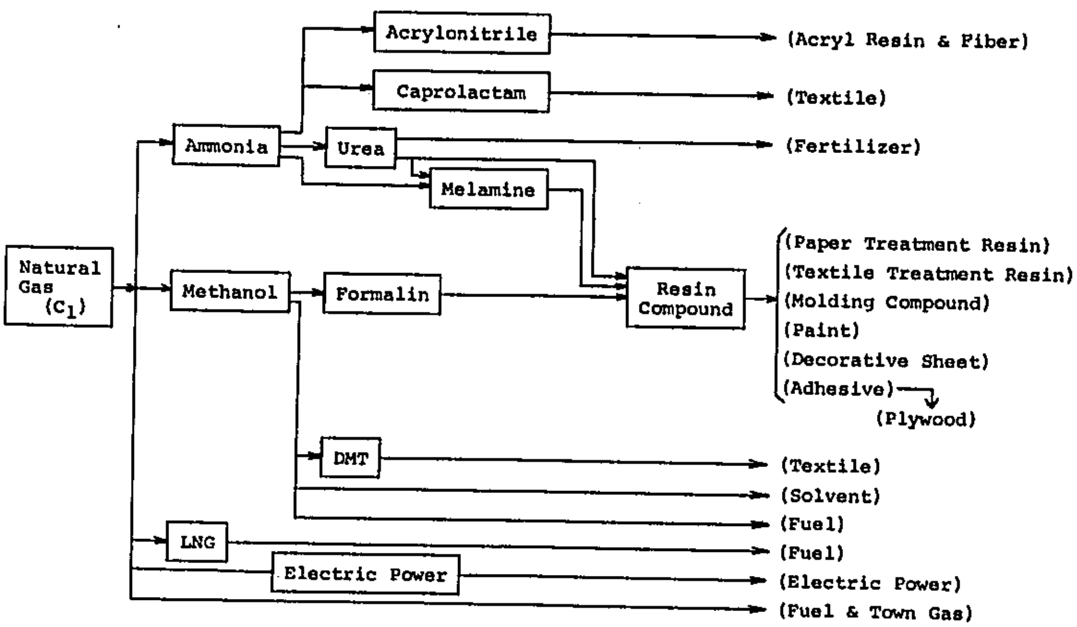

Figure AXI-1-1 Natural Gas (C_1) Complex Flow Scheme

Another possible means for effective utilization of methane is to convert it into a commodity with more additional values and a better aptitude for transportation by primary processing natural gas. By this method, it would be possible to export such a commodity to overseas market where a high extent of the demand already exists. Ammonia synthesis, methanol synthesis and LNG conversion fall under this category. In view of the fact that the LNG conversion projects are already progressing in North Sumatra and East Kalimantan, no particular explanations seem necessary to be made in this chapter.

The synthesized ammonia by fixing the atmospheric nitrogen is the main raw material of chemical fertilizers and because of the globally tight supply/demand position of fertilizers in the recent years, it seems that the ammonia synthesis is one of the most effective means for the utilization of methane. In Indonesia, the further development of agriculture is the very foundation for the development of the industry and therefore, the utilization of methane in this direction is a significant project in view also of the necessity to maintain a long-term stable supply of fertilizers. Ammonia is also a raw material of acrylonitrile and caprolactam which are raw materials for the production of synthetic fiber. Ammonia synthesis is, therefore, indispensable along with the development of the textile industry in Indonesia.

But in considering the ammonia industry in Indonesia, it seems that the production scale and time of construction should be determined on the basis of the agricultural policy and its long term development schedule. Therefore, the subject of the ammonia industry development should be treated by separate and independent studies and surveys.

The effective utilization of methane gas by means of carrying out methanol synthesis is as important as ammonia synthesis in view of the application of methanol as raw materials for various resins and DMT which is a raw material for synthetic fiber production. It will be also important as fuel methanol which has recently been attracting the world-wide attention. The above-mentioned various resins include adhesive materials which are important raw materials for the plywood industry. Methanol is the raw material for formalin which is in turn a raw material of these resins and almost 1/2 of the methanol produced now is being consumed in the formalin synthesis. Indonesia has abundant forest resources, so the wooden product industry has an extremely high potential for the future development.

Particularly, the plywood industry enhances the value of the forest resources through processing products to higher extent. It is expected strongly that the demand for plywood will increase rapidly both domestically and internationally. The industries using the forest or fishery resources as raw materials are the fields which developing countries can comparatively easily take up, and in this respect, the plywood industry is becoming one of the most important Indonesian industrial sectors.

In the recent years, the conversion of natural gas into methanol as fuel is attracting the world-wide attention and the relative research and developments are actively undertaken. This is due to the fact that methanol as well as LNG does not contain sulfur, thereby being considered as one of the pollution-free fuels under the present situation of increasing strict control on sulfur content rate, and, what is better, methanol as fuel has the following merit. Specially designed tankers are necessary for the transportation of LNG, whereas, generally use tankers of normal pressure and temperature can be employed for methanol. Also, the handling of methanol is easy and does not involve the danger of explosion during the transportation. When burnt, methanol does not generate any soot or fume, and furthermore makes it possible to reduce easily the emission of NO_x which has been considered as a major cause of air pollution. Methanol does not care for a re-gasifing process or a process to utilize the heat of the vaporization which is indispensable in the case of LNG. This signifies that methanol can freely adapt itself to the fluctuation of load.

However, the extent of the waste of natural gas to produce methanol is higher than to produce LNG, from the point of fuel efficiency.

To elaborate on this point further, the following can be stated. If a LNG plant with a capacity of 5,000,000 t/y is constructed by utilizing natural gas with heating value of 10 Kcal/l, the consumption of natural gas per unit heating value of LNG will be 0.14 l/Kcal. In the case of a methanol plant of 35,000 t/day (consisting of 7 lines of 5,000 ton capacity each), however, the consumption of natural gas per unit heating value of methanol will be 0.23 l/Kcal. Also, it must be noted that there have been no actual record of stable supply of methanol as fuel technically so that the utilization of methanol as fuel will be strongly high-lighted in the future when the production of chemical industry-use methanol achieves a progress of the scale expansion and stable operations, because the production process of fuel methanol is virtually the same as that of chemical industry-use methanol. The production of fuel methanol simply consists of parallel installation of several production lines each of which has the equivalent capacity to a large-scale plant for the production of chemical industry-use methanol without the distillation process. In the future, when the utilization of methanol as fuel is realized, the production of methanol for chemical industry-use can be simply carried out by distilling the produced fuel methanol.

This signifies that the accumulation of the actual records of operations in a large-scale plant for chemical industry-use methanol will be a valuable preparation for its smooth adaptation to the operations of fuel methanol production.

Chapter 2. Supply and Demand of Methanol for Chemical Industry-use

2-1 The Supply Capacity in Southeast Asia

The total production capacities of methanol in the ECAFE region in 1972 were 65 thousand t/y in Korea, 115 thousand t/y in Taiwan and 28 thousand t/y in the Philippines. The capacity in Japan at the end of 1973 was 1,335 thousand t/y (including the recovered methanol). The above figures total to 1,543 thousand t/y. Those countries have scarce resources of natural gas or oil and have mainly to depend on the importation of such resources. As has been manifested in the recent energy crisis, it has become impossible to expect to obtain ample supply of crude oil at as low prices as before. And prices of LPG or naphtha, either of which can produce methanol, have also been showing a rapid and drastic rise. It is now expected that the prices of the energy sources such as crude oil, LNG, LPG, etc. will be well balanced internationally per heating value. Therefore, if countries having no energy sources within themselves intend to expand or build the facilities for methanol production, they will be compelled to import one of the above mentioned energy sources at the well balanced international prices.

As will be shown in the following chapter, although Japan has the most advanced technology and complete infrastructures in Southeast Asia and furthermore the actual records of constructions and operations of methanol production plants are highly sufficient in Japan, it is impossible for her to cope about the cost price of methanol with Indonesia where the resources are available.

Therefore, it is necessary for Indonesia where the energy sources are richly available to set up the methanol industry corresponding to the newly grown demand of methanol in future, to maintain and develop the industries of Southeast Asia as a whole.

2-2 Demand Forecast

In view of the fact that the demand forecast for plywood is extremely significant in Indonesia where the forest resources are rich, the demand for methanol in Southeast Asia had better be analyzed by deviding it into two categories, the methanol consumption forecast in the plywood industry and that in the rest of the industrial sectors. According to the "Asian Industrial Survey for Regional Co-operation", the Proposal for Regional Co-operation in the Field of Plywood Manufacture, Study Number 7 by ECAFE, the demand of plywood in the AIS Region * has been estimated as is shown in Table AXI-2-1.

Also, an estimate is made as shown in Table AXI-2-2, concerning the demand for imported plywood by Japan, the U.S.A. and European countries which are the major consuming countries of plywood and the obtainable share of the AIS Region in the demand. As of 1973, the major plywood exporting countries in Asia were Korea, Japan, the Philippines, Singapore and Malaysia. In Korea, Japan and Singapore, the processing into plywood is undertaken by importing wood. However, the plywood industry in these countries is now suffering from the increase of raw material cost caused by the increase of transportation cost of wood, etc. So it seems reasonable that the growth of the future demand of plywood in Japan will have to be covered by the importation. In the case of the Philippines, due partly to the excessive utilization of the forest resources and also to the inherent shortage of the raw material wood with the appropriate quality for plywood, the importation of the wood materials for plywood from Kalimantan has been undertaken. Therefore, if Korea, the Philippines and Singapore are to expand the plywood production to meet the increase of the imported demand in future in the U.S.A., Europe and Japan, the merit by the expansion is becoming lower.

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* = AIS Region: Indonesia, Khmer, Korea, Laos, Malaysia, Philippines, Singapore, Sri Lanka, Thailand and Vietnam.

Table AXI-2-1 Projected Plywood Demand -Per 1,000 Capita & Totals- by Country (1969-1985)

	Demand per 1,000 capita (m^3)				Total Demand						
					1000 m^3				Index (1969=100)		
	1969 1/	1975	1980	1985	1969 1/	1975	1980	1985	1975	1980	1985
Indonesia	0.07	0.36	0.53	0.76	7.9	50.5	85.5	139.7	639	1,082	1,768
Khmer Rep.	0.43	1.37	1.73	2.26	2.9	11.3	16.8	25.6	390	579	883
Rep. of Korea	4.52	3.48	5.67	9.34	140.6	126.0	231.5	429.1	90	165	305
Laos	0.14	0.21	0.24	0.28	0.4	0.7	0.9	1.3	175	225	325
Malaysia	5.40	10.02	16.52	22.90	57.1	124.7	236.9	376.5	218	415	659
Philippines	7.00	4.45	5.64	7.58	260.0	195.9	296.2	471.2	75	114	181
Singapore	41.61	79.85	89.46	100.24	84.0	185.6	232.7	291.7	221	277	347
Sri Lanka	2.25	1.58	2.15	2.86	27.5	23.1	35.2	54.6	84	128	199
Thailand	0.99	2.43	3.50	5.12	34.4	101.3	170.8	288.8	294	497	840
Rep. of Vietnam	0.41	0.56	0.70	0.95	7.4	11.1	15.2	22.7	150	205	307
TOTAL REGION	2.18	2.44	3.38	4.68	622.2	830.2	1,321.7	2,101.2	133	212	338

1/ Actual Demand

Source: AIS Projections

Table AXI-2-2 Estimated Extra-Regional Market Volume for AIS Plywood (1970-1985)

MARKET	Demand for Imported Plywood	AIS Share	
		1000s of m^3	%
1970 (actual)			
USA	1,812	1,721	95
Japan	27	27	100
Europe	1,958	98	5
Total	3,797	1,846	49
1975			
USA	2,904	2,759	95
Japan	1,715	1,715	100
Europe	2,933	440	15
Total	7,552	4,914	65
1980			
USA	3,666	3,116	85
Japan	2,852	2,852	100
Europe	4,757	1,189	25
Total	11,275	7,157	63
1985			
USA	4,425	3,319	75
Japan	4,129	4,129	100
Europe	6,276	2,197	35
Total	14,830	9,645	65

Source: AIS estimates

Therefore, ECAFE recommends that the most economical solution is to construct new plywood mills in Indonesia and Malaysia in order to cover the increment portion of the demand beyond the plywood manufacturing capacity presently available in the AIS Region. Furthermore, ECAFE recommends that 90% of the newly built plywood mills in AIS Region to meet the increment be taken up by Indonesia and 10% by Malaysia in 1985.

In other words, the amount of plywood supply covered by Indonesia, the volume of its domestic market and the volume of exportation to extra-region in comparison with the other countries in AIS Region are as shown in Table AXI-2-3.

The amount of adhesive materials to be consumed in this plywood industry varies depending on the technical level of the operators and the number of the ply.

The amount of adhesive materials varies also depending on the types of the materials to be utilized. The average consumption of an adhesive is, however, approximately 55 kgs for one m^3 of plywood produced.

In a plywood plant with a capacity of 22 thousand m^3 per year will therefore require 1,210 t/y of adhesive materials.

The available lives of adhesive materials are short. The longest life of an adhesive material is approximately 3 months and the shortest is only 3 weeks.

It is also known that a synthetic adhesive material plant will not be viable economically unless it has at least a production capacity of 300 t/month.

Therefore, several plywood mills should be constructed in one limited area and one adhesive material plant should produce all the adhesives to be consumed by all these mills. The most commonly employed synthetic resin which are used as the adhesive materials in this industry are urea resin, phenol resin and melamine resin.

The urea resin type adhesive which is the most popularly used material includes 50 to 60% of urea resin and appropriate quantity of flour (wheat powder), water and ammonium chloride. Urea resin is produced from urea and formalin with the blending ratio of 3:7. Formalin is made of the oxidation of methanol. Approximately 500 kgs of methanol is consumed for the production of one ton of 37% formalin. Therefore, the required amount of methanol per ton of the adhesive materials is, by assuming the utilization of urea type adhesives, approximately 230 kg.

The minimum capacity of 30 t/day is necessary for a plant of formalin synthesis and a preferable production capacity of a plant is considered to be about 100 t/day. Therefore, one plant of formalin synthesis will be able to supply sufficient formalin to several adhesive material plants.

In view of the above, the necessary amount of methanol will be 12.7 kg to produce one m^3 of plywood by using the most popular urea type adhesive materials.

The calculation of the required amount of methanol for the accommodation of the plywood industry expansion projects shown in Table AXI-2-3, results as in Table AXI-2-4.

Table AXI-2-3 Expansion Scheme for Plywood Industry in Indonesia & in Other AIS Region by the ECAFE report

(Unit: 10^3 m^3)

		1973	1975	1980	1985
Indonesia	Supply	10	1,259	3,535	6,298
	Domestic Demand		51	86	140
	Exportation to Extra-Region		1,208	3,449	6,158
Other AIS Region	Supply	4,097	4,486	4,944	5,450
	Domestic Demand		780	1,236	1,963
	Exportation to Extra-Region		3,706	3,708	3,487
Total Supply			5,745	8,479	11,748

Table AXI-2-4 Methanol Consumption for Plywood Industry on Table AVII-4

(Unit: t/y)

	1975	1980	1985
Indonesia	16,000	45,000	80,000
The other AIS Region	57,000	63,000	69,000
Total	73,000	108,000	149,000

AIS Region: Indonesia, Khmer Republic, Republic of Korea, Laos, Malaysia, Philippines, Singapore, Sri Lanka, Thailand, Republic of Viet-Nam

The amount of methanol consumed for the production of plywoo in Indonesia in 1980 will be 45 thousand tons, and 80 thousand to... in 1985. As far as the whole AIS Region is concerned, the methanol consumption in the plywood industry will be 108 thousand tons in 1980 and 149 thousand tons in 1985.

On the other hand, the methanol demand in the fields other than the plywood industry is assumed to grow with an annual growth rate of 5% in the AIS Region and in Japan.

Table AXI-2-5 shows the estimated market volume of methanol in the ECAFE Region compiled on the basis of this assumption. Production in the Japanese plywood industry is assumed to be on a constant level from 1973 onward and it is also assumed that the increment of the domestic demand inside Japan thereafter will be covered by the importation from AIS Region, therefore the consumption volume of methanol in the plywood industry in Japan has been set on a constant level.

Table AXI-2-5 Estimated Market Volume of Methanol in South-East Asian Countries (Unit: t/y)

		1973 (Actual)	1975	1980	1985
AIS Region[1]	for Plywood[2]	52,000	73,000	108,000	149,000
	for Others	130,000	143,000	183,000	234,500
Japan	for Plywood[2]	97,000	97,000	97,000	97,000
	for Others[3]	1,078,800	1,189,000	1,518,000	1,937,000
Total		1,357,800	1,502,000	1,906,000	2,417,500

1) AIS Region: Indonesia, Khmer Republic, Republic of Korea, Laos, Malaysia Philippines, Singapore, Sri Lanka, Thailand, Republic of Viet-Nam
2) : Estimated value from ECAFE Report
3) : 5% growth per year
Included market of Methanol In Taiwan

For reference, the past demand for methanol (including the consumption for the plywood industry) in Japan is as shown in Figure AXI-2-1.

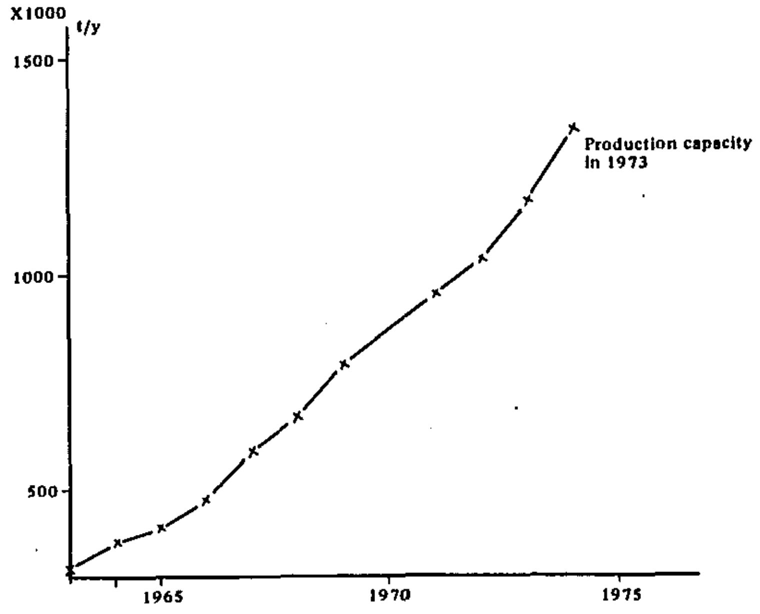


Figure AXI-2-1 Methanol Market in Japan (1963 - 1973)

The demand of methanol has grown on an average growth rate of 14% per year for ten years from 1963 to 1973.

This growth rate is expected to be gradually reduced in future. An assumption is made, that the average growth rate of methanol demand in Japan for the forthcoming decade will be 5% per year excluding the demand of methanol in the plywood industry in Japan.

On the other hand, the annual growth rate of 5% which is estimated in this report for the demand of methanol in the other industries than plywood in AIS Region seems to be rather conservative estimation, if a large-sized industry which consumes a lot of methanol is to be developed. For an instance, the volume of methanol consumed by the DMT plant of 100 thousand t/y which is now being projected in Palembang for 1977 onstream will be 41 thousand t/y. And when producing polyester fiber by polymerizing this 100 thousand tons of DMT, approximately 35 thousand tons of recovered methanol will be generated.

However, in order to re-utilize such recovered methanol, it is necessary to carry out distillation. If the polymerization plants are scattered in several sites, the distillation cost and transportation cost will become higher. Therefore, in order to carry out the re-utilization of the recovered methanol within the DMT plant, it is necessary to consider the layout of the plants on the basis of an integrated design of the polymerization plants and the DMT plant. Even if the recovery is fully undertaken, approximately 6,000 tons will be waisted within the DMT polymerization process per year.

If the existing capacity of methanol production at present in Southeast Asia is compared with the volume of the methanol demand in the same area estimated in the above paragraphs, approximately 360 thousand tons of methanol shortage will be inevitable in 1980 and approximately 880 thousand tons of the shortage will be in 1985.

Chapter 3. International Competitiveness

In the same manner as the plywood industry is expected to evolve towards a new balance of powers amongst the various countries in Southeast Asia on economical reasons, the methanol supply/demand in the same area is also expected to shift towards a new power-balance position in economical sense.

The supply of methanol cover the new methanol demand generated from the future economical development will be undertaken by a country or countries in which the methanol production cost is the lowest.

As has been discussed in Chapter 2, unless a new energy source with lower cost can be substituted by existing energy sources presently used, all the energy sources will attain balanced international prices.

The raw material of the methanol presently utilized is natural gas, LPG or naphtha, and the construction cost of a methanol plant utilizing natural gas as the raw material is the cheapest, followed by LPG and then naphtha.

The raw material is treated by a steam reforming process first, where methane is the most prone to be reformed, and higher hydrocarbons becomes gradually difficult to be reformed as the carbon number of hydrocarbons increases.

In this chapter, a comparative study will be conducted between the production cost of methanol by newly constructed plant in Japan utilizing LNG as the raw material imported from Indonesia, and the cost price of the methanol transported to Japan after being produced by a newly built plant in East Kalimantan utilizing NG available there as the raw material.

3-1 Prerequisite Conditions

a) Inflation factor: 7%/y

b) In view of the fact that the plant construction cost in Japan has become higher internationally, an assumption is made that the necessary machinery and equipment to build a plant will be procured from the U.S.A.

c) The engineering, supervision, etc. pertaining to the plant construction in East Kalimantan are assumed to be accommodated by developed countries and also, it is assumed that several experts will be despatched to Indonesia from the developed countries for conducting the operations training, etc.

d) Capacity: 2 thousand t/day (660 thousand t/y)

e) The machinery and equipment are ordered in 1979, the commencement of the test operation is undertaken in mid 1980, and the full commercial operation is started in 1981.

f) Ten years for depreciation and no salvage value is assumed.

g) LNG cost (100% CH_4): US$1.80/MMBTU delivered to users in Japan as of 1974, price increase rate, 7%/year.

h) The natural gas price at East Kalimantan has been calculated by subtracting from the Japanese LNG price, the storage cost, the freight cost, the insurance premiums and the liquefying cost.

i) The labor cost is estimated from the number of people needed in the head office works, operations and administration of the plants, general administration, maintenance department, general affairs department and service (shipment and warehousing) departments. Total number of 120 persons is in the case of Japan, while in the case of East Kalimantan, the total number of personnel is 180 (including 12 expert engineers despatched from developed countries).

An assumption is also made that all the above-mentioned personnel will be accommodated in the company housing facilities.

j) Maintenance cost is assumed to be 3% of the cost of ISBL in Japan. In the case of East Kalimantan, 4% of the cost of ISBL is incorporated. Also in the case of East Kalimantan, the number of workers needed for the annual maintenance is assumed as 500 persons, of which 250 persons are to be employed in the company and provided housing facilities, and therefore, the housing costs and the salaries for the people employed for the maintenance were added to the calculation. In the case of Japan, an assumption is made that the amount of workers can be recruited from outside at the time of the annual maintenance.

k) The interest payable is estimated as 10% on the total investment in Japan, while 7.5% in Indonesia. This assumption is made on the basis of the consideration that borrowings on a lower rate will be possible in Indonesia.

3-2 Results

The results of the above calculations are shown in Table AXI-3-1. When the methanol production is undertaken in Japan by using LNG as the raw material, the cost price of methanol will be US$141.2/t while the cost price becomes US$133.3/t if NG is used as the raw material in a plant in East Kalimantan and then the product is to be transported to Japan. This signifies that the cost reduction can be achieved by US$7.9 per ton of methanol in the case of constructing a methanol plant in East Kalimantan.

As long as LNG can be sold on a price level which is competitive with other energy sources, this cost advantage of US$7.9 per ton will exist, no matter how high the price level happens to be.

The Southeast Asian countries other than Japan can obtain cheaper methanol by importing it from Indonesia than from Japan. This signifies that Indonesia will assume an important position to supply enough and cheaper methanol for the industries in Southeast Asia.

In the following paragraphs, a comparative study will be conducted in view of the investment efficiency between the methanol project in East Kalimantan and in Japan.

In spite of the fact that US$35.07 million will be additionally required as the initial investment of the project in East Kalimantan when compared with the project in Japan, the cash flow of US$15.5 million will be saved more on the project in East Kalimantan than in Japan during the first year.

On the assumption that this saving amount will also be increased by 7% per year due to inflation and also on the assumption that the project life is ten years, the internal rate of return (IRR) is approximately 55% for this additional investment of US$35.07 million.

This signifies that if the site selection is made for East Kalimantan for the methanol production project, although the initial investment will exceed that in the case of Japan by US$35.07 million, such an excess investment will be recovered by the 55% interest rate during ten years.

Generally, the minimum attractive rate of return is approximately 15% and therefore, the investers will prefer Indonesia to Japan when they select a plant site for methanol production in the Southeast Asia.

The following paragraph will show a comparative competitive study of methanol made in East Kalimantan and in Persian Gulf by the plants which are built at the same time with the same capacity, if it is supplied to the market in Southeast Asia. If an assumption is made that the construction cost and production cost in Persian Gulf will be on a comparable level as those in Indonesia, the great difference will be in the aspect of the transportation cost.

Table AXI-3-1 Comparison of Cost Price of Methanol between Plant Sites in Japan and in East Kalimantan

(Price in 1980) (Unit: 10^6 $)

Investment Cost	Japan	East Kalimantan
Plant Cost		
I.S.B.L.	59.18	83.47
O.S.B.L.	17.75	25.04
Land Cost	1.69	--
Housing	7.20	10.60
Working Capital	3.93	5.42
Contigency	7.69	10.85
Total	89.70	124.77

	Japan		East Kalimantan	
Cost Price	$ (x 10^6)	@ $/t	$ (x 10^6)	@ $/t
Variable Cost				
NG or LNG		96.90		30.66
Cat. & Chemicals		4.46		5.13
Utilities		3.4		1.89
Sub-total		104.76		37.68
Fixed Cost				
Labor	1.44		1.61	
Maintenance	1.78		3.65	
Depreciation	9.69		13.54	
G & A Cost	1.44		1.61	
Interest	9.69		10.15	
Sub-total	24.04	36.42	30.56	46.30
Freight to Japan			(10,000 ton as one rot)	20.00
Insurance				0.33
Storage Cost				29.00
Cost Price		141.18		133.31

If methanol is produced in the Persian Gulf area, it will be necessary to add into the production cost the transportation cost from the Persian Gulf to Singapore. The cost increment for that transportation will be approximately US$26 per ton of the product in 1980. (10 thousand ton per lot)

Therefore, it would be necessary for the Persian Gulf-made methanol to reduce the production cost by US$26 in order to compete the Indonesian-made methanol in the market of Southeast Asia.

As is shown in Table AXI-3-1, natural gas cost is assumed to be US$30.66 per ton of methanol for the year of 1980 in East Kalimantan.

It would be required for the Persian Gulf methanol to reduce US$26 from the cost of the raw material in order to intrude effectively into the market of Southeast Asia, in other words, the raw material cost per ton of the Persian Gulf methanol is limited to only US$4.66 for that intrusion. This signifies that it is comparatively easy for Indonesia to expel the Middle East made methanol from the market of Southeast Asia.

Chapter 4. Conclusion

The main volume of this report recommended that there is an ample economical viability in the construction of an olefin complex in Indonesia in 1979 by utilizing C_2^+ contained in natural gas as the raw material.

The summary of the study made in this Annex has shown the significance of additional project to construct methanol synthesis plant of two thousand t/day (660 thousand t/y) inside the same olefin-based petrochemical complex site, and the said methanol synthesis plant can use as the raw material the remaining methane after the separation of C_2^+ for olefin complex from the natural gas. From the estimated methanol supply/demand balance in Southeast Asia mentioned in Chapter 2, the onstream of a plant with the capacity of two thousand t/day in mid 1980 seems to be sufficiently adequate both in capacity and construction timing.

The estimated volume of methanol demand in Southeast Asia in 1980 amount to 1,906 thousand tons and the present capacity to supply methanol in the same area is 1,543 thousand tons.

The shortage portion of 363 thousand tons will be partially covered by the proposed project of methanol synthesis in Indonesia.

By 1983, the shortage portion will amount to 600 thousand tons, so that the proposed methanol plant which by then will have attained an approximately full commercial operation will be able to dispose of the total amount of the products within the market of Southeast Asia. For both 1981 and 1982, it would be necessary to export products in addition to the ECAFE Region and Japan. The markets of China and India will be within the coverage of such an exportation. Approximately 20 thousand tons of methanol was imported in India in 1973, and China inquired of Japan about the possibility of the importation of 30 thousand tons of methanol. On an assumption that these demands will also grow on an annual growth rate of 5%, the methanol demand of these two countries will attain

70 thousand tons by 1980 and 90 thousand tons by 1985. By the year 1985, the shortage of methanol in the ECAFE Region and Japan will attain a level of 875 thousand tons so that even if the new plant is fully operated, it will still be impossible to fulfill the volume of the methanol market in the ECAFE Region and Japan.

Furthermore, as sufficiently substantiated infrastructures are not available yet in the areas where a large extent of natural gas can be produced in Indonesia so far, an advantage is evident in the construction of the methanol plant within the site of the olefin-based petrochemical industry complex, thereby making it possible to use the same utilities and the same port facilities in common.

The future of the plywood industry in Indonesia is extremely bright, and the forecast will be made even brighter if the basic raw material, methanol, is secured within the country. The securing of methanol will become more reliable by implementing the above project and it would also become possible to supply from the year 1981 onward, 41 thousand t/y of methanol to the DMT plant with 100 thousand t/y capacity which will be onstream in 1977 in Palembang. Approximately 35 thousand t/y of methanol by-produced from the process of DMT polymerization will be provided for the demand near the sites of the polymerization plants in various locations. For the plywood industry in Indonesia, approximately 52 thousand t/y of methanol will be supplied in 1981 from the newly built plant and 80 thousand t/y in 1985.

All of the product besides for the domestic use can be exported almost entirely to the market inside of Southeast Asia. It has also been described in Chapter 3 that the methanol plant to be constructed in Indonesia will have the strongest competitive power in Southeast Asia.

Furthermore, even the oil producing countries in Middle East will not be able to easily intrude into the Southeast Asian market in competition with the Indonesian methanol, unless they estimate the raw material cost on an extremely low level in order to establish a competitive level of selling price. In the future, if the era of fuel methanol arrives, the experiences accumulated through the operations of this new methanol plant will be a valuable springboard for the technological advantage.

In view of the above discussion, it is considered to be the most adequate to add to the project of the olefin-based petrochemical industry the project of methanol production with the capacity of two thousand t/day and a target commencement of test operation in the mid 1980.

Chapter 5. Process Description

5-1 Licensor List

High Pressure Process

BASF
Chemical Construction
Commercial Solvents
Foster Wheeler
Girdler Corp.
Imperial Chemical Industries
Vulcan-Cicinnati
Montedison-Mitsui-Toatsu

Low Pressure Process

Imperial Chemical Industries
Lurgi

5-2 Process Description

From natural gas

The process is divided in three steps:

1) Reforming of natural gas by steam to water gas

$$C_nH_m + n\ H_2O \longrightarrow n\ CO + (n + \tfrac{1}{2}m)\ H_2$$

$$CO + H_2O \longrightarrow CO_2 + H_2$$

There is obtained synthetic gas for methanol. If carbon peroxide is contained in the natural gas, it is naturally a good source. Even if the synthesis gas from natural gas by steam reforming does not contain enough carbon for methanol synthesis, operations have no difficulties. When sulphur is contained in natural gas, it must be removed before the reforming.

2) Synthesis of methanol

$$CO + 2\ H_2 \longrightarrow CH_3OH$$

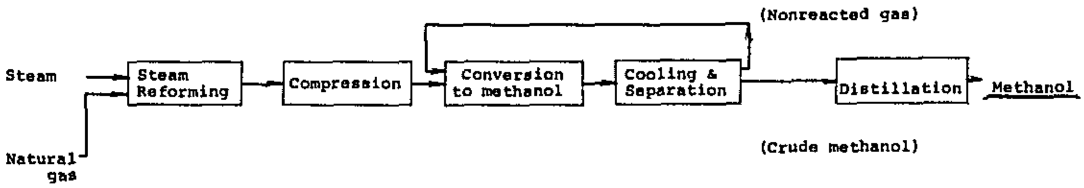
$$CO_2 + 3\ H_2 \longrightarrow CH_3OH + H_2O$$

Many kinds of catalysts for methanol are proposed, and oxide of chromium and zinc is usual for high pressure synthesis and copper based oxides for low pressure synthesis.

3) Purification of methanol

The crude methanol from the synthesis reactor contains dimethylether, methyl-formate, water and trace of other impurities. The distillation systems are used for the removal of the impurities.

5-3 Flow sheet for synthetic methanol



	Unit Consumption	
Carbon dioxide	150 Nm^3	99 x 10^6 Nm^3/y
Natural gas CH_4	1,060 Nm^3 (757 kg)	700 x 10^6 Nm^3 510,000 t/y (1,510 t/d)
Methanol	1,000 kg	660,000 t/y