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Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries

Baku, USSR, ~~20~~ 21 - 31 October 1969

PET.SYMP. A/3

DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN THE ECAFE REGION

by

G. S. Apte
Consultant
Economic Commission for Asia
and the Far East
(ECAFE)

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SUMMARY

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G.S. Apte

Economic Commission for Asia and the Far East

After an introduction showing the world position and the part played by the countries of the region covered by the ECAFE, the demand for petrochemical products in the latter group of countries is discussed in some detail. Petrochemical products are divided into monomers for plastics, fibres etc. general organic chemicals such as ethylene glycol, benzene, methanol etc, solvents such as toluene, acetone and chlorinated hydrocarbons.

In the next section, plastics and synthetic resin consumption is divided between countries and then between products. Synthetic fibre demands are next discussed followed by synthetic rubber requirements. Finally detergents, insecticides and carbon black are briefly mentioned.

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The paper next deals with the sources of raw material, crude oil and natural gas - the position in each country of the region is discussed in some detail.

Production figures are next discussed, plastics, synthetic fibers and synthetic rubber production figures being given for those countries in the region producing them. Following this the number of plants as well as their capacity in each country is given.

In the next section import and export figures for the more important countries in the region are given followed by a section detailing the plans for expansion where these have been announced.

The various factors affecting the development of petrochemicals are next discussed, demand for end products and the processing industries necessary, disposal of co-products, raw material availability, financial resources, engineering design, know-how, training of personnel.

The rate of expansion of consumption of end products expected in the period 1970 - 1980 is next discussed and the new plants necessary to meet this growth are forecast together with the anticipated costs of production and investment necessary. Attention is given to the possibility of developing countries being able to meet world prices for various petrochemical products. Grouping of the production of primary products at central locations is given consideration with some estimates of the transport costs involved.

Finally tables are drawn up for each country in the region showing the estimated demand in 1980 for the principal plastics, fibres and synthetic rubbers together with detergents and basic chemicals, capacity required by 1980, plant size, and number of plants. The possibility of joint ventures e.g. several countries sharing one plant is examined in detail and recommendations made.

I. Introduction

The world petrochemical industry has progressed very fast during the last few years and high growth rate has become synonymous with this newly developing industry. Having started from gas and naphtha as raw materials and developed the conversion processes of high temperature cracking and separation of basic products like ethylene, propylene, butadiene, aromatics like benzene, petrochemical industry found itself in a position to product many groups of products like plastics, synthetic rubbers, synthetic fibres and organic chemicals in much larger quantities and at competitive prices as compared to their production from other raw materials like fermentation alcohol, benzene from coal etc. These large production units were, however, beset with problems of disposal of a number of by-products simultaneously produced. Search for markets for these by-products was therefore pursued vigorously. The markets for many of the petrochemical products expanded rapidly due to increased availability, low prices and intensive market development The pressure of demand set the industry on a higher pitch of activity of increasing plant sizes, improved productivity and enabled it to offer larger quantities at more economic prices. These cycles have repeated in the past and despite some periods of static demands the net result has been growth at a very high rate in past few years and the indication for future point to wider horizons. Some of the indicators of the progress during the last four or five years are the growth of new petrochemical plants and rapidly increasing production in the petrochemical sectors. The growth of petrochemical plants since between 1964 and 1967 may be seen in table I-1.

Table I-1

World petrochemical plant construction

Area/Country	1964		1967	
	Plants in operation	Planned	Plants in operation	Planned
U.S.A.	511	60	551	36
North America	585	95	554	74
Western Europe	216	97	294	107
Africa/Middle East	6	22	12	21
Asia/East	65	72	94	[illegible]
South America	42	25	65	32
Total	914	311	1,11[illegible]	307

Source: World Petroleum - 1964, 1968.

It will be seen that there has been intense activity in the plant construction during the last few years in almost all the regions.

The world growth in some of the major sectors of petrochemical production may be seen from table I-2 below.

Table I-2

World production of major petrochemical groups

(Unit: 1,000 tons

Major Groups	1961	1962	1963	1964	1965	1966
Synthetic resins	7,600	9,210	10,710	12,700	14,690	16,570
Synthetic fibres	835	1,090	1,330	1,690	2,045	2,470
Synthetic rubber	2,125	2,400	2,610	3,000	3,235	3,575

Source: United Nations Statistical Yearbook, 1967.

The Asian developments have also moved along with the world trends in petrochemical manufacture and there have been substantial developments in this region. In this paper a brief outline of the progress and developments during the last few years in this region in the petrochemical field is given. Considerable data and information regarding developments in this connexion was supplied by the governments of the various countries to the Asian Industrial Development Council Fact Finding Team on Petrochemicals in 1968. The team visited many of the countries and had discussions with petrochemical manufacturers, government officials connected with the planning and development of these industries. Heavy reliance has been placed on this fund of information during the preparation of this paper. So far as Japan is concerned the data has been obtained from publications like Industrial Japan, Japan Plastics (organ of the Japan Plastics Industry Association) and Japan Chemical Annual. Data in respect of Australia and the Republic of China has been based on the information given by the Government to the ECAFE Secretaria

Since Japan is the only country in the region which has reached high level of petrochemical production comparable to developed countries a separate report on Japan is prepared and may be seen in Appendix I.

II. Demands for petrochemical products

The current demands of some of the major petrochemical groups are given below.

Monomers

The current demand for monomers may be seen in table II-1.

In connexion with the data in table II-1 it may be mentioned that data in respect of monomer as such was not available from many countries and the estimates given by them for manufacturing of polymer covered the monomer demands also. In such cases, calculations were based on demands for polymer.

(2) Organic chemicals and solvents

Current demands of the major organic chemicals are given in table II-2. Data regarding consumption of solvents was available from only few countries and may be seen in table II-3.

[illegible]

Demand for mon[illegible]rs in coun[illegible]ies of ECAFE region

(Unit: 1,000 tons)

	Australia 65/[illegible]	India [illegible]/69	[illegible] 68/69	Japan [illegible]	Korea 68	Pakistan 67/68	Thai-land 69	Philip-pines 69	Rep. of China
Acrylonitrile	1.1	3.5		[illegible]	14				
[illegible]	[illegible]	15		[illegible]	5.4			-	
[illegible]	-	7	5	[illegible]	14	1.5		2.5	55 3/
Ethylene	-	21 2/		1,474					
Propylene	-	12 2/		8[illegible]1 1/					
Styrene	15.8	18 2/		285	5			small	1.6
[illegible] Terphthalate	-	6	5	120			2.8		
Vinyl Acetate	4.5	3	1	273	11			small	
Vinyl Chloride	-	25 2/	-	7[illegible] 2/	14			6	106 1/

1/ Actual production
2/ Estimates based on [illegible] products
3/ Capacity [illegible] plant started in 1968

Sources: 1. Report of the AIDC Fact-Finding team on Petrochemical Industries
2. Japan Chemical Week, 19[illegible] July 25, October 12
3. Data supplies by Australia and Rep. of China
4. Bulletin of Japan Petroleum Institute May 1968
5. Japan Chemical Annual 1967.

Table II-2

Demands for organic chemicals in countries of ECAFE region (Unit: tons)

	Year	Urea non-ferti-lizer use	Phenol	Ethy-lene glycol	Propy-lene glycol	Phthalic Anhy-dride	Formal-dehyde	Acetic acid	Benzene	Xylene	Cyclo-hexane	Metha-nol
Australia	1965/66		3,500			[illegible]	24,[illegible] (1966/67)	12,000 (65/66)				
China, Rep. of			660	612		1,540	32,000					23,226
India	1968/69		10,000	2,500	-	8,000	16,000 to 20,000	[illegible]	30,000	1,[illegible]	1,000	10,000
Iran	1967/68			670		10	437	336				273
Japan	1967/68		110,600	130,600	20,065	135,600	-	-	643,200	193,900	295,000	570,000
Korea Rep. of	1968	2,508 (67)	614	18,501		[illegible],500	42,700	5,200			14,520	23,400
Pakistan	1967/68											2,000
Philip-pines			70	75		700		1,200				8,000
Singapore		1,400	400									1,500
Thailand	1967/69	824	16	1,000			107	767				1,527

Sources:
1. Report of the AIDC Fact-Finding Team on Petrochemical Industries, 1968
2. Japan Chemical Annual, 1967, Autumn Edition
3. Japan Chemical Week, [illegible] July 25
4. Information [illegible] by governments.

Table II-[illegible]

Demand for solvents in countries of ECAFE region

(Unit: tons)

	Toluene	Acetone	Ethanol	Carbon tetra-chloride	Methylene Dichlo-ride	Chloroform	Hexane
China, Rep. of		4[illegible]	-	-	-	-	-
India (66/67)	56[illegible] 1/	[illegible],617	[illegible],172 1/	[illegible]94	-	353	-
Iran (67/68)		394	900	150	-		
Japan (67)	323,200	99,0[illegible]	-	-	-	-	-
Korea, Rep. of (69)			58,000(kl)	-	-	-	-
Pakistan (67/68)		12,000	-	-	-	-	-
Philippines (67)		417	-	-	-	-	-
Thailand (67)	1,19[illegible]	66	94(kl)	38	-	31	-

1/ Imports.

Sources: 1. Information supplied by government
2. Japan Chemical Week, 1968 July 25
3. **Report of the AIDC Fact-Finding Study Team on Petrochemical Industries 1968.**

(3) Plastics and synthetic resins

Synthetic resin demand started in many countries of the region with pro-cessing of thermosets, manufacturing of electrical goods and plywood. Poly-styrene and PVC followed these and though polyethylene came later it has now reached a high level of consumption in almost all the countries. Polypropy-lene had also now been processed and consumed in sizeable quantities especi-ally in Japan and the Republic of China. Apparent consumption of plastics and synthetic resins in the region may be seen in table II-4.

An examination of the table II-4 will show that consumption of synthet[illegible] resins has increased from 1,[illegible]46 million tons in 1963 to 2,294 million tons [illegible] 1966. This shows a 19.5 per cent growth rate. The consumption in develop[illegible] countries has increased from .2[illegible] million in 1963 to .4 million in 1966. [illegible] 1966 consumption of developing countries was 17 per cent while Japan and Australia have accounted for 80 per cent of the regional consumption. Hong Kong, Republic of China, India, Philippines, Republic of Korea, Thail[and] and New Zealand consumed more than [illegible],000 tons each. Twelve out of eighte[en] countries in the region have crossed 10,[illegible] ton consumption levels in 196[illegible].

The consumption of individual resins in 1965 and 1966 in Japan and th[e] percentage consumption of some of the major resins may be seen in table II-[illegible]

Table II-4

Consumption/demand[a] of plastics and synthetic[b] resins in countries of the ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
Burma	2,994	2,480	3,686	1,914	939
Cambodia	1,270	800	1,470	1,690	2,996
Ceylon	1,938	1,987	2,000	3,300	4,791
China, Rep. of	19,372	47,679	63,954	68,427	108,021
Hong Kong	69,782	111,170	85,300	98,090	
India	28,306	35,394	43,020	46,154	57,300
Indonesia	6,487	[illegible],111	6,340	2,967	9,350
Iran	7,100	12,100	15,000	19,800	
Korea, Rep. of	14,180	17,780	23,300	39,400	57,300
Malaysia	4,677	12,569	5,41[illegible]	6,550	15,766
Pakistan	9,461	17,213	15,00[illegible]	16,890	19,400
Philippines	29,200	35,900	37,200	48,000	
Singapore	5,832	...	3,120	[illegible],65[illegible]	11,380
Thailand	14,012	17,530	23,995	35,33[illegible]	
Vietnam, Rep. of	5,017	7,50[illegible]	8,[illegible]	11,41[illegible]	1[illegible],721
Total Developing countries	221,648	[illegible]	[illegible]	[illegible]	[illegible],364
Australia	1[illegible],5[illegible]	151,[illegible]	17[illegible]	[illegible]	
Japan	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],316,771
New Zealand	1[illegible]	[illegible]	[illegible]	[illegible]	
Total Developed countries	1,124,[illegible]	[illegible]	[illegible]	[illegible]	2,316,771
Grand Total	1,346,[illegible]	[illegible]	[illegible]	[illegible],2[illegible],715	2,622,135

a/ Apparent consumption = production + imports - exports

b/ Plastics and synthetic resins under SITC 581

Sources:
1. Report of the AIPO Fact-Finding Team on Petrochemical Industries, 1968
2. UN International Trade Statistics, 1963-1966
3. UN Statistical Yearbook, 1967
4. ECAFE, Foreign Trade Statistics of Asia and the Far East, 1963
5. OECD Commodity Trade - Exports, 1964 - 1967
6. Japan Plastics - 1964, 1965 and 1967.

Table II-5

Japan: Demand of principal plastics and synthetic resins

(Unit: tons)

Type of resins	Demand		Consumption as percentage of total consumption in 1966
	1965	1966	
Phenolics	75,743	97,737	5.0
Urea	249,853	291,392	14.5
Melamine	44,096	57,070	2.8
Polyester (unsat.)	37,188	45,850	2.2
Phthalic	50,993	59,537	2.8
Urethane	39,361	47,194	2.3
Polyvinyl chloride	478,142	488,032	24.4
Low-density polyethylene	301,824	439,702	21.9
High-density polyethylene	96,295	122,325	6.1
Polystyrene	1[illegible]7,566	198,585	9.9
ABS	12,096	25,721	1.0

While the consumption thermosets have recorded slight increases during the last few years in Japan major strides have been made in high density and low density polyethylene, polystyrene and polypropylene. In 1966, the consumption of major resins was polyvinyl chloride 24.4 per cent, polyethylene 28 per cent, polystyrene 9.9 per cent and urea 14.5 per cent.

Other countries of the region namely India, Iran, the Republic of Korea, Pakistan, Malaysia and Thailand showed differential trends of consumption in 1966/67. These data may be seen in table II-6.

Table II-6

Demand of principal plastics and synthetic resins in selected ECAFE countries

Country	Year	Total plastic consumption (tons)	poly-ethylene (per cent)	PVC (per cent)	Polystyrene (per cent)	Polypropylene (per cent)	Thermosets (per cent)
Hong Kong	1966	[illegible]	43.0	19.0	22.0	8.0	2.0
India	1967	[illegible]	33.0	32.0	13.0	2.8	14.0
Iran	1967/68	[illegible]	38.0	38.0	9.5	...	4.6
Korea, Rep. of	1967	57,300	23.0	22.0	2.4	2.0	50.0
Malaysia	1967	15,760	36.0	13.0	7.0	6.0	30.0
Pakistan	1967/68	19,400	29.4	27.4	16.0	10.6	14.0
Thailand	1966	[illegible]	52.0	26	6	4	10

It will be seen that the percentage consumption of thermosets is high in countries like Korea with a sizable production of plywood where these resins are used as adhesives. In other countries the current demand for polyethylene, PVC, polystyrene, etc. shows that these mass produced plastics has now started coming up as principal products in market.

Information was available on the end-use pattern of various plastics in India and Japan. These may be of interest to the developing ECAFE countries and are therefore given below.

India: End use pattern of major plastics in 67/68 was as follows:

Polyethylene: Film for packaging of textiles, fertilizers, pesticides, etc. 65 per cent, moulded goods 20 per cent, pipes 5 per cent, monofilaments and cane 8 per cent.

[illegible]: Leather cloth 24 per cent, wire and cables coating 14 per cent, footwear 33 per cent, unsupported sheets 14 per cent, rigid pipes, sheets, etc. 9 per cent.

Polystyrene: Textile components 17 per cent, electrical and engineering goods components 11 per cent, household goods such as combs, soap boxes, domestic ware, etc. 41 per cent, foam 15 per cent, miscellaneous uses 15 per cent.

Japan: The pattern of end uses of various major plastics in Japan in 1967 was as follows:

Low density polyethylene: Film consumption was 63 per cent, sheets 14 per cent, electrical cable coating 7 per cent, injection moulding 11 per cent, blow moulding 3 per cent, miscellaneous 2 per cent.

High medium density polyethylene. Injection moulding 32 per cent, blow moulding 22 per cent, textiles 19 per cent, film 13 per cent, stretch tape 9 per cent, miscellaneous 5 per cent.

PVC: Rigid products such as corrugated and plain sheets, pipes, joints drainage pipes, etc. [illegible].6 per cent. This was due to a high spurt in the construction and housing. Films for agriculture, film for packaging extruded pipes and other packaging material accounted for 30 per cent, cable coating 8 per cent, floor tiles 3 per cent, fibres 1.1 per cent and blow moulding 3 per cent.

Polypropylene: Injection moulding accounted for 40 per cent, film 22 per cent, textiles 18 per cent, flat yarn 10 per cent, extrusion 7 per cent and blow moulding 2 per cent.

Phenolics: Ninety per cent of the phenolics were consumed for production of electrical goods. TV sets, radios, etc. Tableware is now being made of phenolic in place of wood. It is also finding greater use as a grinding wheel adhesive.

<u>Urea</u>: Fifty-five per cent of the urea resins consumption was as adhesive for laminated wood and board. Urea moulding is mainly table ware, container lids and equipment parts, etc. Twenty-five per cent of urea resins are used in the textile for anti-shrink finishes and paper processing.

<u>Polyester</u>: Resins are being widely used with glass reinforcement for fabrication of boats, tanks, bath tubs and the use of reinforced polyester has now gone up from 35 to 55 per cent.

(4) <u>Synthetic fibres</u>

From the time the synthetic fibres were first introduced in the market they caught the consumer appeal and preference which is growing. Some of the qualities of these films like water repellency, ease with which they could be washed and cleaned, crease resistance made them attractive. Durability and relief from laundrying made the use of the fibre economic inspite of high cost. These fibres also found wide usage mixed with natural and cellulosic man-made fibres. The limited availability of natural fibres, variation in quality from source to source made demands on synthetics and in quite a few countries of the region the textile industry already operating with natural fibres adjusted their production facilities to the processing of synthetic and mixed fibres. Table II-7 shows the consumption/demand of synthetic fibres in various countries of the region.

Table II-7

Consumption/demands[a/] of synthetic fibres[b/] in the countries of the ECAFE region

(Unit: tons)

Countries	1963	1964	1965	1966	1967
China, Rep. of	1,683	2,509	3,92[illegible]	6,252	-
Hong Kong	1,405	1,860	2,120	4,130	-
India	3,460	2,900	7,6[illegible]	9,300	10,900
Indonesia	60	-	65	-	76
Iran	1,415	2,696	3,406	[illegible],569	10,118
Korea, Rep. of	7,014	5,559	9,300	14,199	33,291
Malaysia	--	247	47[illegible]	517	165
Pakistan	670	1,[illegible]	1,965	5,174	5,000
Philippines	-	2,[illegible]	2,184	5,526	5,780
Singapore	-	-	--	154	172
Thailand	-	1,061	1,409	2,537	2,804
Vietnam, Rep. of	-	857	692	1,202	1,563
Total Developing countries	15,7[illegible]	21,[illegible]04	33,176	55,556	69,869
Australia	[illegible]	[illegible]	20,86[illegible]	22,600[8/]	27,600
Japan	223,[illegible]	[illegible]	275,000	350,600	456,400
New Zealand	1,[illegible]	1,[illegible]	3,000	7,729	-
Total Developed countries	[illegible]	[illegible]	[illegible]8,86[illegible]	380,929	484,00[illegible]
Grand total	[illegible]	[illegible]	[illegible]2,036	436,485	553,869

a/ Apparent consum[illegible] production + import - export
b/ Synthetic fibre under SI[illegible] 266.[illegible] and 651.6

Sources: 1. Repor[illegible] of the [illegible] Fact-Finding Study Team on Petrochemical Ind[illegible]stries, 1968
2. UN International Trade Statistics, 1963-1966
3. UN Statistical Yearbook, 1967
4. OECD - Commodity Trade Report
5. ECAFE Seminar on Development Prospects of the Man-Made Fibre Industry in Asia and the Far East, 1966
6. Textile Organon, 1968
7. Data furnished by governments
8. Including New Zealand.

Here again the consumption has increased considerably and the 1966 consumption stands at 436,485 tons against the 1963 figures of 253,121 tons. This represents an increase of 183,364 tons over the 1963 production and the rate of growth was 20 per cent. Japan accounted for 82 per cent of the regional consumption. Australia, Korea, India and Iran have now crossed 10,000 ton levels and could expect larger demands in future. The demand for different types of synthetic fibres in 1963 and 1966-67 in some of the countries of the region may be seen in table II-8.

Table II-8

Demand for different synthetic fibres in selected countries of ECAFE region

(Unit: tons)

Country	Year	Nylon	Polyester	Acrylic	PVA
Japan	1963	65,965	56,921	28,819	
	1966	110,674	90,655	73,789	
India	1963	2,320	1,140	-	
	1967	4,380	3,530	306	
Iran	1963	-	-	-	
	1967	8,000	1,000	1,000	
Korea, Rep. of	1963	5,004	627	979	404
	1967	18,187	4,277	9,851	673
Pakistan	1963	-	-	-	
	1967	3,200	1,500	300	
Philippines	1967	2,200	2,670	890	

Sources: 1. Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968

2. Industrial Japan, 1968.

Synthetic Rubber

ECAFE region has large resources of natural rubber. However, special properties of synthetic rubber enabled an increase in consumption inspite of easy availability of natural rubber. The low temperature and acid resistance of chloroprene rubber, abrasion resistance of polybutadiene rubber, non-permeability of butyl and oil resistance of nitrile rubber gave these new materials special scope of use for specific product manufacturing. Constant quality and lowering prices also had an impact. The consumption of synthetic rubber in the region can be seen in table II-9.

Table II-9

Apparent consumption/demand[a] of synthetic rubber[b] in countries of ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	1,251	1,814	3,047	3,047	4,010
India	[illegible]	[illegible]	15,268	16,572	22,963
Iran	[illegible]	931	1,043	-	9,275 c/
Korea, Rep. of	[illegible]	2,729	5,442	4,384	6,163
Malaysia	[illegible]	455	800	1,003	-
Pakistan	550	963	721	3,000	-
Philippines	4,814	6,790	5,659	7,449	7,621
Singapore	-	-	151	440	284
Thailand	76	292	600	866	143
Total Developing countries	[illegible]	29,528	32,731	36,761	41,184
Australia	[illegible]	22,?21	36,436	37,606	39,000
Japan	[illegible]	162,326	180,807	229,555	272,726
Total Developed countries	176,4[illegible]	195,647	217,243	267,161	311,726
Grand total	[illegible]	225,175	249,974	303,922	352,910

a/ Consumption = production + import - export
b/ Year beginning March
c/ 1968 demands

Sources:
1. Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968
2. UN Statistical Yearbook, 1967
3. OECD Commodity Trade: Exports, 1963-1966
4. Industrial Japan 1967/1968
5. Industrial Bank of Japan Petrochemical Industries, 1968.

An examination of the above table will show that the demand for synthetic rubber has gone up from 197,957 tons to 352,910 tons over the period 1963 to 1967. This represents growth rate of 15.6 per cent. The major consumers have been Japan, Australia and India. Consumption is also now increasing to appreciable extent in the Republic of Korea, Philippines and Iran. In 1967 in Japan SBR accounted for 65 per cent of the total demand for synthetic rubber and polybutadiene demand rose to 42,000 tons (14 per cent) whereas the demand for polypropylene remain more or less stationery at 31,000 tons. In India the major consumption was SBR which represented more than 95 per cent of the synthetic rubber demand.

Detergents

The current demand for detergents may be seen from table II-10 below.

Table II-10

Demand for detergents in countries of ECAFE region

(Unit: tons)

Country	Year	Demand
India	1967/68	18,000
Iran	1968	40,000
Korea, Rep. of	1968	5,100
Malaysia	1968	12,000
Pakistan	1967/68	2,500
Philippines	1966	34,516
Singapore	1968	6,000
Thailand		16,000
Viet-Nam, Rep. of	1967	1,059
Australia		100,000
Japan	1966	425,519

Sources: 1. Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968

2. Japan Chemical Annual, 1967.

Because of the problems in procurement of vegetable and animal fatty materials the soap is being replaced in a major way by the synthetic detergents in many developed countries. Similar trends are bound to come up in this region also and the demand of synthetic detergent is expected to rise quite steeply during the next 5 years.

Pesticides

Next to fertilizers, pesticides are now recognized as important inputs for intensive agricultural production and the pesticides demands for the region are likely to grow in the coming years. At the moment, Australia, India, Pakistan, Republic of China and Japan are the only producers of these chemicals and the demand of the other countries of the region are being met by imports. An idea of the total imports of all these countries can be had from table II-11 given below.

Table II-11

Import of insecticides, fungicides, disinfectants into the ECAFE developing countries

(Quantity in metric tons, value in US$1,000)

Country	1965		1967	
	Quantity	Value	Quantity	Value
Afghanistan	244	126	-	-
Burma	764	444	-	-
Cambodia	478	492	-	-
Ceylon	2,189	1,345	2,701	1,859
China, Rep. of	2,385	2,840	2,818	3,797
Hong Kong	1,316	975	1,121	888
India	12,946	5,058	6,898	3,186
Indonesia	1,515	1,349	4,772	7,073
Iran	6,663	3,598	6,332	5,982
[illegible]	[illegible]	1,994	1,562	1,639
Malaysia	[illegible]	[illegible]	3,896	3,213
Pakistan	7,598	[illegible]	[illegible]	5,830
Philippines	2,109	1,372	[illegible]	3,859
Singapore	-	-	683	802
Thailand	5,612	3,359	8,725	5,410
Viet-Nam, Rep. of	1,202	604	873	1,159
Total	51,804	35,242	55,077	44,697

Source: OECD Commodity Trade: Exports.

The total demand of pesticide in the region is estimated at 130,000 - 140,000 tons.

Carbon black

Demand for carbon black comes mainly from rubber and printing ink industries. The growth of this may be seen in table II-12.

Table II-12

Consumption of carbon black in the ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	955	1,245	1,8[illegible]	2,100	2,988
India	1,484	1,309	12,[illegible]	26,773	29,619
Iran					4,500
Korea, Rep. of		2,626	2,306	3,401	4,255
Malaysia	1,457	1,730	2,490	2,92[illegible]	[illegible],532
Philippines	4,008	5,501	3,558	4,412	4,[illegible]1
Singapore			704	1,192	1,7[illegible]4
Australia					33,400
Japan				119,260	149,390

Sources: 1. Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968

2. Japan Chemical Week 1967 September 14.

III. Survey of sources of raw materials for the petrochemical industry

ECAFE region has sizable petrochemical raw material resources in the form of oil and natural gas. An idea of the oil and gas production in some of the countries of the region can be had from tables III-1 and III-2.

Table III-1

Crude oil production in countries of ECAFE region

(Unit: 1,000 tons)

Country	1963	1964	1965	1966
Burma	636	556	545	568
China, Rep. of	3	9	19	32
India	1,653	2,212	3,022	4,647
Indonesia	22,275	22,919	23,319	22,455
Iran	73,557	84,612	94,126	105,445
Australia	-	190	335	431

Source: UN Statistical Yearbook 1967

Table III-2

Natural gas production in countries of the ECAFE region

(Unit: million cu meter)

Country	1963	1964	1965	1966
Burma	16	-	-	-
China, Rep. of	51	169	310	439
Indonesia	2,728	2,731	2,446	1,601
Iran	1,13[illegible]	1,192	1,230	1,386
Pakistan	1,18[illegible]	1,429	1,620	-
Australia	3	3	4	4
Japan	1,678	1,821	1,726	1,777

The natural gas and some light fraction of oil specially naptha available from refinery operation constitute essential and widely used feed stocks. The position of these raw materials in countries of this region is given below.

Australia

The Australian crude oil production in 1967 is estimated at 22,000 barrels per day against a 1966 production of 10,000 barrels per day according to the World Petroleum Report, 1968. Table III-3 gives the main sources of oil and the characteristics of the oil available from individual sources.

Table III-3

Australia: Analysis of oil

	Moonie	Barrow Island	Marlin*	Halibut*	Kingfish*
Gravity					
SG	0.804	0.835	0.773	0.814	0.797
API	44.5	38.0	51.5	42.2	46.0
Sulphur Wt. per cent	0.025	0.05	0.06	0.11	0.13
Distillation Vol. per cent					
C_4 and lighter	0.5	2.4	4.0	4.0	4.0
C_5 - 375°F	39.1	37.4	45.5	32.4	39.8
375°F - 450°F	10.5	12.4	13.5	7.7	7.9
450°F - 600°F	19.4	25.2	26.0	19.4	17.5
600°F - 1000°F	23.0	21.0	10.0	34.0	28.9
Residue	7.5	1.6	1.0	2.5	1.9

* Preliminary assay only.

Production from Moonie commenced in 1964, and from Barrow Island in 1967. Production from Bass Strait fields is likely to commence in 1969. Refining of future output is expected to give a range of products which could include some petrochemical feedstocks although present availability appears limited.

Natural gas

Gas is available at six locations and an analysis of this can be seen from table III-4 given below.

Table III-4

Australia: Analysis of natural gas

Field	Mereenie	Palm Valley	Gidgealpa	Gilmore	Gippsland Shelf	Roma
N_2 %	10	4	2	6	3	4
CO_2 %	0.5	0.5	16	2	1	1
CH_4 %	73	83	76	89	93	86
C_2H_6 %	11	10	4	2	2	5
C_3	4	2	1	0.5	0.5	2
C_4	1	0.5	0.5	0.5	0.5	1
C_5	0.5	0.5	0.5	0.5	0.5	0.5
C_6	0.5	0.5	0.5	0.5	0.5	0.5
Sulphur	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet
BTU/scf	1,290	1,310	1,020	1,210	1,280	1,280

The exploitation from Roma, Gidgealpa-Moomba and Gippsland Shelf is due to commence in 1969. A very small quantity of gas is used in Roma. Most of the gas is committed for supply to the cities of Brisbane, Adelaide and Melbourne.

China, Republic of

Natural gas reserves are estimated at 27,000 m. cu. metres and the present production is 2.7 m. cu. metre per day. The gas is used for manufacture of ammonia methanol and as fuel. The crude oil reserves are very limited. There is a refinery at Kao Hsing with a capacity of 120,000 BPSD using middle east crudes. The refinery products demand and supply pattern may be seen in table III-5.

Table III-5

Republic of China: Production and demand of petroleum products

(Unit: 1,000 kl)

	Present		Future (1972)	
	Production	Demand	Production	Demand
Fuel oil	1,300	1,800	2,700	3,700
Diesel	500	400	600	600
Gasolene	400	400	600	600
Kerosene	26	30	20	20

Availability of raw materials for further petrochemical manufacture appears to be limited. It is, however, understood that the naphtha requirements of cracker which has recently gone into production will be met by the refinery.

India

Oil

There are three major fields in Gujarat and four in Assam area. Crude reserve has been estimated at 141 million tons in 1967 and distributed between Assam fields and Gujarat field at 76 and 65 million tons respectively. The Indian crude meets 40 per cent of the demand and there is no possibility of surplus oil being used as a feedstock. Typical crude analysis is as follows:

Table III-6

India: Analysis of crude oil

	Gujarat (Ankleshwar)	Assam (Naharkotia)
Gravity API	48	32
Sp. Gravity	0.7868	0.8645
Pour point	-15°	-30°
Sulphur, Wt. per cent	0.05	0.28

Refinery through put in 1967 was 14.43 million tons and the refining is being carried out in 8 refineries. The production and demand pattern of various oil products is as per table III-7.

Table III-7

India: Production and demand of petroleum products

(Unit: 1 million tons)

	1967		1972	
	Production	Demand	Production	Demand
Light oil	2.5	1.6	4.3	5.3
Kerosene	2.5	3.0	4.4	4.0
Diesels	4.0	3.7	6.4	6.1
Heavy ends	4.4	5.6	8.1	7.6

At the present juncture there is a nephtha surplus but with heavy demand for fertilizer and petrochemical manufacturing, the surplus will be converted into deficit before 1972. The naphtha plan of consumption covers the petro-chemical and fertilizer demand.

Gas

Associated and non-associated gas resources in India are estimated in .;7 at 69 billion cubic metres. This is available from 2 fields in Gujarat and 3 in Assam. Production is 1,000 million cubic metres per year. The present production is committed for manufacturing of ammonia, domestic use and power generation. Typical gas analysis is given below.

Table III-8

India: Analysis of natural gas

	Ankleshwar Associated	Cambay Non-associated	Assam Lean	Assam Rich
Methane	66.6-68.4	75.7	92.0	80.0
Ethane	13.0-16.4	11.8	2.[illegible]	8.7
Propane	10.8-12.1	5.0	1.5	6.2
Butane (i)	2.0- 2.6	1.2	0.1	1.4
Butane (n)	3.[illegible]- [illegible]	1.5	0.1	1.6
Higher Hydrocarbons	--	.	0.1	0.9
CO_2	0.6- 0.8	1.0	2.6	0.6
N_2	-	--	0.8	0.6
Cali value net		-	931	1,144
Btu/cu ft gross			1,032	1,262

Indonesia

Oil

This country is a large producer of both oil and gas. Most important fields are Minas, Duri and Bekasap in central Sumatra and Rantan in north Sumatra. Oil production in Kalimantan mainly at Tandjung is large. Some oil also has been produced in Java. Besides these new fields are being explored. The oil production internal refinery delivers and exports are given in table III-9.

Table III-9

Indonesia: Production, export and refinery delivery of oil

(Unit: million tons)

Year	Production	Exports	Refinery deliveries
1960	20.606	10.[illegible]	9.748
1961	21.287	11.828	9.459
1962	22.747	12.623	10.124
1963	23.231	13.200	9.031
1964	26.851	17.728	9.123
1965	27.055	17.937	10.018
1966	26.778	17.568	9.210

An idea of the quality of crudes available can be had from the following analysis given in table III-10.

Table III-10

Indonesia: Analysis of oil

Source	API°	Sp. gr.	Pom pt.	Sulphur
North Sumatra				
Ratan	48.5	0.7861	-30	0.5
Central Sumatra				
Minas	35.8	-	95	0.06
Duri	22.2	-	35	0.18 parafinic
Bekasap	31.3	0.8687	38	0.11 naphthanic
Lirik	34.8	0.850	100	0.96
Kalimantan	40.2	0.824	105	0.20 parafinic

The Minas crude is very waxy and forms bulk of the export. There are 3 large refineries (2 government owned and one private Stanvac) with a capacity of 190,000 BPSD ~~and three~~ small ones with a capacity of 4,500 BPS aggregate. One more refinery of 150,000 BPSD is scheduled to go on stream by 1971 at Dumai. Production and demand for petroleum products in 1967 and 1972 has been assessed as per table III-11.

Table III-11

Indonesia: Production and demand of refinery products

(Unit: 1,000 barrels)

	Production (1967)	Demand (1972)
Aviation gasoline	128	182
Motor gasoline	10,229	12,599
Aviation turbine	1,135	610
Kerosene	12,235	16,002
Automotive diesel	6,400	8,001
Industrial diesel	2,421	4,403
Fuel oil	13,273	7,303

It will be seen from the above table that because of the high demand of gasoline compared to other products the naphtha is not likely to be surplus. Its price quoted is high for petrochemical operations.

Gas

There are number of gas deposits and recent discoveries at Tjeribon field ~~are promising.~~ Production in 1967 from the main areas may be seen from table III-12.

Table III-12

Indonesia: Natural gas production and reserves, 1967

(Unit: billion cubic feet)

	Production	Reserves non-associated	Associated
North Sumatra	9.3	-	-
Central Sumatra	8.8	-	-
South Sumatra	82.6	443.2	475.3
Java	0.3	-	-
Kalimantan	14.1	-	-
Total	115.1	443.2	475.3

A typical analysis of the Indonesian gas is given in table III-13.

Table III-13

Indonesia: Analysis of gas

	Gunung Kemala	Limau	West Java
C_1	22.0	62.3)	91.8
C_2	18.5	6.4)	
C_3	31.8	4.5	0.9
C_4	11.0	1.9	2.3
C_5	2.5	0.8	-
CO_2	14.2	24.2	0.8

The gas is likely to be used by the Palembang fertilizer plant. The reserves in Java field are being proved but it is probable that large quantities will be available. However, the reserves and prices will have to be properly estimated.

Iran

Oil

With a reserve of 5,200 million tons and an estimated production of 144 million tons in 1968 Iran is one of the world's largest producers of oil and could claim itself to have important sources of raw materials for petrochemical industry. A wide variety of oils are available from different sources in Iran and quite a few of these are light oils. However, as there is large availability of gas and naphtha it may not be necessary to use light oils as raw material.

Refineries

Refining capacity of the refineries at Abadan, Kermanshah and Tehran is about 524,000 barrels per day and the refineries use Ahwaz, Kage Safid, Lali and Naft-Shah crudes. By 1971-72 capacity will increase by 46,000 BPSD with commencement of production from Shiraz refinery and increase of capacity of Kermanshah. The Iranian demand for motor spirit is likely to be only a fraction of the total refinery capacity and the supplies of light fractions and naphtha may be considered high and would be able to sustain petrochemical production of a large magnitude. In view of the large surplus of light oil and naphtha the prices of naphtha were low. Recently prices have gone up but they may settle down at $15 per ton without discounts.

Gas

The associated gas availability is also very high in view of large oil production. The gas oil ratio varies from 480 to 1,000 cubic feet per barrel and 650 feet per barrel may be considered good average. Based on this associated gas production would be of the order of 1,700 m.cu.ft. per day. This will rise at the rate of 10-15 per cent per year with a proportionate yearly increase in the oil production. Thus by 1972 2,500 m.cu.ft. of gas may be available in Iran. The present gas consumption of 200 m.cu.ft. per day is expected to go up to 300 m.cu.ft. per day with various utilization schemes and proposals. An additional quantity of 600 to 1,000 m.cu.ft. per day will be supplied to Russia according to commitments already made. A pipe line of 1,100 km. is being laid to carry gas to Russia. In view of the above details it could be seen that Iran will have 1,000 to 1,200 million cu.ft. per day of gas even after meeting the internal and contracted export demands.

The gas available for internal consumption and supply to the Soviet Union will have the following analysis as shown in table III-14.

Table III-14

Iran: Analysis of natural gas

	Range (Volume per cent)	Analysis of gas to be supplied to USSR (Volume per cent)	Average gas analysis (Volume per cent)
C_1	67-85	83	80.3
C_2	7.23-11.43	12	9.73
C_3	3.40 - 5.0	3.5	4.4
$i\text{-}C_4$	0.34 - 5.0	1.5	0.47
$n\text{-}C_4$	0.90 - 1.50		1.17
$n\text{-}C_5$	0.24 - 0.38	-	0.29
$i\text{-}C_5$	0.22 - 0.35	-	0.28
C_6	0.22 - 0.30	-	0.25
C_7 plus	0.02 - 0.34	-	0.09
CO_2	0.45 - 5.20	1.0 max.	3.45

The supplies of natural gas to the Soviet Union would mean 96 m.cu.ft. of ethane equivalent but would still leave 146 m.cu.ft. per day for use in the country on the basis of average analysis. Even after making allowance for change in composition and variation in production of gas 3,500 to 4,000 tons of ethane would be readily available as ethane for conversion to ethylene. Iranian gas could therefore form a very large source of ethylene at very competitive prices. It has been estimated that liquified ethylene could be produced and be made available CIF South East Asian ports at less than US5 cents per lb.

Refinery gases are also available in large quantities containing propane, ethane and ethylene. These could also form another raw material source but it may not be necessary to turn to this in view of natural gas and naphtha availability.

Japan

Crude oil production in Japan dropped slightly during 1963 to 1966 from .875 million tons to .786 million tons in 1966. The proved reserves have also gone down. The gas production increased from 1,209 m.cu.m. in 1963 to 1,826 m.cu.m. in 1966. Due to limited availability from internal sources Japan has imported progressively larger quantities of crude oil for refining. Imports in 1966 were 101 million kilo litres. The crude oil imports are expected to increase at 9.6 per cent and may reach 167 million kilo litres by 1971. Imports of naphtha to cover the gap between projected domestic production and consumption is envisaged.

Korea, Rep. of

There are no oil or gas deposts - only petrochemical raw material available is naphtha from refinery.

There is one refinery at Ulsan. Production of various petroleum products and demand in 1968 and 1972 may be seen in table III-15.

Table III-15

Korea: Production and demand of oil products

(Unit: 000 barrels)

	Production 1968	Demand	
		1968	1972
Gasoline	5,100	4,879	7,936
Treated naphtha	156	90	120
Untreated naphtha	1,550	3,613	9,865
Kerosene	2,490	2,895	4,141
Diesel	9,500	9,693	10,867
LRFO	3,170	2,102	2,772
Bunker-A	133	216	600
Bunker-C	16,100	23,409	68,682

A naphtha cracker, an aromatic plant and ammonia production has already been planned and their requirements of naphtha may not be adequately covered from available naphtha. The cracker is planned near Ulsan refinery and expected to give ethylene, propylene, butadiene benzene and cyclohexane for further processing.

Malaysia

There are no oil or gas resources. There are 3 refineries with (two Shell and one ESSO) a combined capacity of 120,000 BPD. There is a heavy gasoline consumption and naphtha surplus limited to availability from ESSO (at present exported) which is committed for supply to an ammonia plant.

Pakistan

Oil

Oil is available only in West Pakistan near Attork in Potwar Basin. Oil production has been as follows.

Table III-16

Pakistan: Production of oil

(Unit: barrels)

Year	Production
1962	2,922,070
1963	3,137,731
1964	3,379,870
1965	3,48[illegible],895
1966	3,252,920
1967	3,178,782

The present production was considered adequate to meet 15 per cent of the countries' demands. Recently oil availability has improved and oil from new fields of Kot Sarang, Tut and Meyal finds could mean a higher percentage of indegeneous supplies. The total oil production even with these new finds will still be inadequate to meet the demand.

The present aggregate refinery capacity is 61,000 BPD. A lube oil plant of 550,000 tons/year capacity is being expanded to a 1.7 million tons/year capacity refinery. A refinery of 1.5 million tons has recently gone in production at Chittagong in East Pakistan. With these planned expansions a refinery capacity of 4 to 4.[illegible] million tons by 1970 are expected in West Pakistan and 1.5 metric tons in East Pakistan. The naphtha availability after taking into consideration demand for motor spirit blending JP-4 fuel blending and platforming will be of the order of 120,000 tons per annum and this could increase to [illegible],000 tons by 1970/71. Against this availability the requirements of naphtha for proposed petrochemical complex of Karachi would be 70,000 tons by 1972 and this may go up to 135,000 tons by 1975. Some naphtha will be required as fuel in East Pakistan and the surplus of naphtha will only be marginal.

Gas

Pakistan ~~gas fields~~ are rich ~~and the~~ gas resources are estimated at 20 million/million cu.ft. (600,000 million Nm^3). Against this the consumption is 300 m.cu.ft/day of 0.1 million/million cu.ft. per year. Thus there is scope for greater utilization of this gas as a feed stock. Price of the gas has been fixed by the ~~government at~~ 10.5 US cents per million BTUs purified ex Sui gas field in West Pakistan and Extitas field in East Pakistan. Analysis of gas from major fields and availability is as per tables III-17 and III-18.

Table III-17

East Pakistan: Analysis of natural gas

	Rasidper	Titus	Habi Ganj	Kailas Tila
Reserves 10^{12} cu.ft. balance as at 1 July 1968	1.06	2.25	1.28	0.6
C_1	98.2	97.2	97.8	95.7
C_2	1.20	1.8	1.5	2.6
C_3	0.2	0.5	-	0.9
C_4 and higher	0.1	0.5	-	0.4
Nitrogen	0.3	-	0.7	0.2
CO_2	-	-	-	0.2
Hydrogen Sulphide Grains/100 cu.ft.	-	-	-	-
Mervaptan Sulphur Grains/100 cu.ft.	-	-	-	-
Gross heating value BTU/cu.ft.	1,014	1,039	1,020	1,050

Table III-18

West Pakistan: Analysis of natural gas

	Sui	Mari	Uch.	Khairpur
Reserves 10^{12} cu.ft. balance as at 1 July 1968	5.86	3.90	2.50	1.00
C_1	88.52	66.2	27.3	12.2
C_2	0.89	0.2	0.7	0.2
C_3	0.26	-	0.3	0.1
C_4 and higher	0.37	-	0.3	-
Nitrogen	2.46	19.5	25.2	16.9
CO_2	-	0.3	44.7	46.2
Hydrogen Sulphide grains/100 cu.ft.	92.2	-	33.5	2.0
Mercaptan sulphur grains/100 cu.ft.	3.8	-	10.2	46.0
Gross heating value BTU/cu.ft.	933	674	308	130

The analysis, however, shows large availability of gases high in methane and low in C_2 + and these may be suitable for methanol, acetylene manufacture.

Philippines

There is a small oil field in Cebu which has not been commercially exploited yet. Supply of gas from IPIL field near Manila has been earmarked for local use.

There are 4 refineries with an aggregate capacity of 180,000 BPD of atmospheric distillation and 44,800 BPD of vacuum distillation. The demand and supply position of crude oil may be seen from table III-19 below.

Table III-19

Philippines: Production and demand of petroleum products

(thousand barrels)

	Production	Demand
Fuel oil	16,607	17,600
Diesel oil	9,426	9,500
Kerosene	2,862	3,000
Motor spirit/naphtha	13,911	15,700
Refinery gas	450	600
Others	657	1,300
Total	43,913	47,700

Singapore

There are no oil or gas deposits. There are, however, 4 refineries (2 by Shell, 1 by Mobil and 1 by BP). Large quantities of bunker oil are supplied to ships and there is a considerable surplus of naphtha (as may be seen from table III-20). The naphtha is being supplied to Viet-Nam but may become spare under normal conditions as a feed stock around US$17 per ton. This may be a good naphtha source in the region.

Table III-20

Singapore: Production and demand of petroleum products

	Present		Future (1972)	
	Production	Demand	Production	Demand
Fuel oil	3.0	20	50	30
Diesel	7.0	4.5	16	6
Kerosene	1.0	0.6	4	0.8
Gasolene	8.0	3.0	17	4
LPG	0.5	0.4	1	0.6

Some refinery gas may be available but may be expensive as a feed stock.

Thailand

There are two small deposits in Thailand but no gas field - oil deposits are at Mae Soon and Boh Ton Khan but only one is exploited since the refinery is designed to use asphaltic crude and produce heavy products according to the demand pattern.

Naphtha - 4 refiners (2 small and 2 big) with an aggregate capacity of 62,000 BPS are in production. Demand pattern data is not available with naphtha surplus is likely to be limited.

IV. Rate and pattern of growth

1. Production

Having examined the current consumption of various petrochemicals in th region it would be interesting to get an idea of the growth of production in the region and analyse trends in production into different groups of petrochemical products.

Plastics and synthetic resins

Production during the last four years may be seen in table IV-1 below.

Table IV-1

Production of plastics in countries of ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	16,800	22,300	25,500	45,600	63,40
India	24,800	31,100	40,400	39,400	47,70
Philippines	11,600	14,000	14,700	16,200	18,20
Total Developing Countries	53,200	67,400	80,600	101,200	129,30
Australia	86,500	100,300	107,900	123,600	145,40
Japan	1,061,800	1,367,700	1,601,300	1,989,800	2,675,40
Total Developed Countries	1,148,300	1,468,000	1,709,200	2,113,400	2,820,80
Grand Total ECAFE	1,201,500	1,535,400	1,789,800	2,214,600	2,950,10

Sources:
1. Japan Plastics - 1964/65, April 1967.
2. Statistical Yearbook, 1968, United Nations.
3. Data supplied by government.
4. Rubber and Plastics Age International, June 1968.

An examination of the above table will show the production of plastics in the region has risen quite fast and the growth rate during 1963-1966 was 23 per cent. The Japanese production has almost doubled during the period 1963-1966. In 1966, the Japanese share of the total regional production was 88 per cent. The growth rate between 1963 and 1967 is 26 per cent and the 1967 production has shown once more a big jump in Japan. Data regarding production of different plastics and resins was available only in respect of Japan, India, and Republic of China. The production of major thermoplastic and resins in the region may be seen from table IV-2 and thermosetting resins in table IV-3.

Table IV-2

Production of thermoplastic resins in the ECAFE region

	Japan	India	Rep. of China	Korea	Total
1963					
Polyethylene	223,400	7,923	-		231,323
Polyvinyl-chloride	348,900	3,906	16,751		369,557
Polystyrene	68,800	5,515	-		74,315
Polypropylene	21,200	-	-		21,200
1964					
Polyethylene	289,400	9,057	-		298,457
Polyvinyl-chloride	473,800	9,204	23,198		506,202
Polystyrene	100,400	4,815	-		105,215
Polypropylene	39,500				39,500
1965					
Polyethylene	396,300	13,508	-		409,808
Polyvinyl-chloride	483,000	12,179	25,305		520,484
Polystyrene	125,500	5,646	192		131,338
Polypropylene	57,500				57,500
1966					
Polyethylene	551,200	14,129	-	-	565,329
Polyvinyl-chloride	489,700	10,796	44,175	218	544,889
Polystyrene	199,000	5,791	1,450	-	206,241
Polypropylene	98,500				98,500
1967					
Polyethylene	747,764	9,751	-	-	757,515
Polyvinyl-chloride	697,967	14,000	61,775	7,000	780,742
Polystyrene	278,011	5,591	1,579	-	285,181
Polypropylene	192,318	-			192,318

Sources:
1. Japan Plastics, 1964/66.
2. Monthly Statistics of Japan Bureau of Statistics, Office of the Prime Minister.
3. Information supplied by governments.
4. Report of the AIDC Fact-Finding Study Team on Petrochemical Industries 1968.

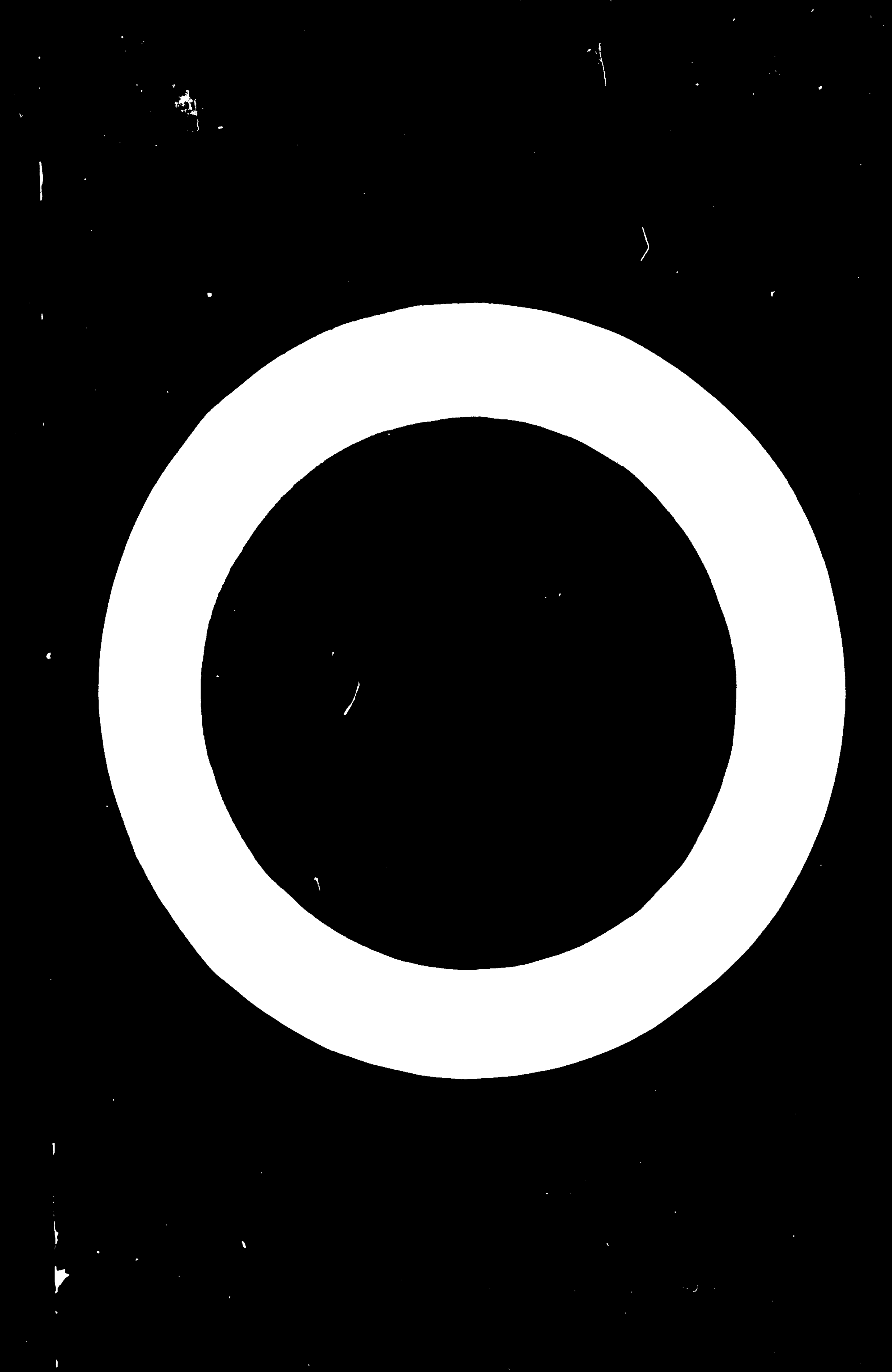
Table IV-3

Production of thermosetting resins in the ECAFE region

(Unit: tons)

	Japan	India	Rep. of China	Total
1963				
Urea	208,600	4,330	-	213,130
Phenolic	[illegible]	2,880	-	67,480
Melamine	27,800	-	-	27,800
Unsat. Polyester	[illegible]	-	-	27,800
1964				
Urea	242,500	4,803	22,885	270,188
Phenolic	77,800	3,225	372	81,397
Melamine	33,900	-	--	33,900
Unsat. Polyester	33,400		-	33,400
1965				
Urea	[illegible]	[illegible]	[illegible]	[illegible]
Phenolic	[illegible]	3,360	708	80,468
Melamine	[illegible]	-	-	44,000
Unsat. Polyester	[illegible]	-	-	37,500
1966				
Urea	[illegible]	[illegible]	27,602	324,817
Phenolic	[illegible]	[illegible]	1,448	[illegible]
Melamine	[illegible]	-	-	57,700
Unsat. Polyester	[illegible]	-	-	46,100
1967				
Urea	[illegible]	-	[illegible]	[illegible]
Phenolic	[illegible]	[illegible]	1,600	[illegible]
Melamine	[illegible]			74,981
Unsat. Polyester	[illegible]			57,969

Sources:
1. Jap[illegible] 1967 April.
2. Inf[illegible]mation supplied by governments.
3. Report of th[illegible] Fact-Finding Study Team on Petrochemical Industries 1968.



Synthetic rubber production has increased from 115,400 tons to 328,432 tons in 1967. The growth rate has been 26 per cent in this period. However, the number of countries producing rubber is only three. Japan accounted for 86 per cent of the 1967 production. Data regarding production of synthetic rubber is shown in table IV-4.

Table IV-4

Production of synthetic rubber in the ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
India	7,000	11,800	15,700	15,600	21,843
Total Developing Countries	7,000	11,800	15,700	15,600	21,843
Australia	17,400	18,500	21,100	20,100	26,000
Japan	102,600	122,000	161,3[illegible]	232,[illegible]	280,589
Total Developed Countries	[illegible]	140,5[illegible]	182,400	252,100	306,589
Grend Total	127,000	152,300	198,100	267,700	328,432

Sources: 1. UN Statistical Yearbook, 1967.
2. Bureau of Statistics of Prime Minister, Monthly Statistics 1968, September.

Out of three rubber producing countries India produces only SBR rubber. Japan produces a wide range of synthetic rubber. Data regarding production of these during the last four years may be seen in table IV-5.

Table IV-5

Japan: Production of synthetic rubbers by types

(Unit: tons)

	1963	1964	1965	1966	1967 (Jan-June)
High styrene	6,281	6,069	9,571	10,464	5,762
SBR Crumbs (oil Ext. excl.)	27,978	25,737	39,4[illegible]3	47,217	24,229
Oil Ext.	43,9[illegible]7	50,6[illegible]4	63,291	88,401	53,183
Latex	13,930	21,[illegible]	13,43[illegible]	22,091	14,744
NBR	4,238	5,4[illegible]6	6,063	8,151	4,884
Polypropylene, Polybutadiene	6,[illegible]	1[illegible],2[illegible]	29,46[illegible]	[illegible],371	30,887
Total	102,5[illegible]	123,056	161,320	232,695	133,689

Source: Reported in Industrial Japan, 1968, quarterly Spring Special [illegible].

Synthetic fibres are now produced in [illegible] countries, the production performance of these may be seen in table IV-6.

Table IV-6

Production of synthetic [illegible] in countries of the ECAFE region

(Unit: tons)

Country	[illegible]	[illegible]	1965	1966
China, Rep. of	230	[illegible]10	1,640	3,100
India	[illegible]30	1,1[illegible]0	2,[illegible]60	4,470
Korea, Rep. of	[illegible]0	1,410	1,830	2,230
Pakistan		.	[illegible]0	140
Australia	5,[illegible]	7,7[illegible]0	10,660	13,380
Japan	268,[illegible]	25[illegible],[illegible]	387,000	454,000
Total	2[illegible]	[illegible]	[illegible]04,040	477,320

Source: 1. UN Statistical Yearbook, 1967.
2. ECAFE [illegible] on Development Prospects of Man-Made Fibre Industry in Asia and the Far East, 1966.
3. Textile Organon.

The synthetic fibre production has increased at 22 per cent during 1963-1966. In this field also the major share of production is from Japan which accounted for 95 per cent of the regional production in 1966. The synthetic fibre production in all other countries is at present based on imported monomers.

Production of major synthetic fibres in Japan may be seen from table IV-7.

Table IV-7

Japan: Production of major synthetic fibres

(Unit: tons)

	1963	1964	1965	1966	1967 (Jan-June)
Nylon	80,052	119,121	117,992	146,022	89,128
Polyester	[illegible]	[illegible]	[illegible]	120,755	70,657
Acrylic	[illegible]	[illegible]	[illegible]	[illegible]	59,713
Vinylon	[illegible]	[illegible]	[illegible]	[illegible]	29,629

Source: Industrial Japan, 196[illegible].

In India in 1965 and 1966 polyester production accounted for 45 per cent and 57 per cent of the total production.

2. Production capacities in operation and underway

During the last one or two years a few countries have installed substantial production capacities for manufacturing of different types of petrochemicals. These capacities are now getting on stream and in the next year or two will reflect in increased production from these countries. Details regarding present installed capacities in different countries and expansion of these facilities underway is given hereafter.

Australia

Existing capacities for manufacture of petrochemcial products are as follows:

Plastics and synthetic resins	No. of plants	Total capacity (tons per year)
Polyethylene	3	57,000
PVC	2	
Polystyrene	4	
UF resin	7	
PF resin	7	
Synthetic fibres		
Nylon 66 }	1	13,400
Polyester)		4,500
Nylon tyre cord	1	1,600
Synthetic rubber	2	60,000
Carbon black	3	62,500
Detergents	122	
Organic chemicals		
Vinyl chloride	2	35,000-40,000
Vinyl acetate	1	5,000
Phenol	2	11,000

Capacities for manufacturing of ethylene oxide, ethylene glycol, ethylene glychloride, butadiene, phthalic anhydride, methanol and formaldehyde have been established.

China, Republic of

Production capacities of various petrochemical products are as follows:

Synthetic resins and plastics	No. of plants	Total capacity (tons per year)
PVC	4	75,000
Polystyrene	1	1,600
Urea formaldehyde	2	-
Phenol formaldehyde	1	-
Synthetic fibres		
Polyester	1	2,640
Nylon	4	6,640
Acrylic	1	330
Carbon black	1	500

India

Synthetic resins

Installed capacities for manufacturing of different resins and expansions approved and being implemented are as follows:

Resins	No. of units	Total production capacity (tons per year)
Polyethylene	4	46,000
PVC	4	19,000 (expansion to 80,000 tons approved and being implemented)
Polystyrene	2	15,000 (expansion to 21,500 tons approved and being implemented)
Polyvinyl acetate	1	3,000
Urea	17	14,600
Phenol	4	3,330
Melamine	7	730
Unsaturated Polyesters	1	600 (to be expanded to 1,200 tons)
Epoxy	(plant under erection)	600

Solvents and plasticizers

The following capacities have already been installed and the production would be available from the four companies which have already started production.

Solvents	Total production capacity (tons per year)
Acetone	17,000
Diacetone alcohol	4,800
Butyl alcohol	11,000
Butyl acetate	2,800
Ethyl acetate	600
Ethyl hexanol	1,600
2 - Ethyl hexanol	8,000
Ethylene dichloride	3,000
Isopropanol	1,500
Methyl isobutyl ketone	3,700
Benzene	47,000
Toluene	14,000

Plasticizers (Phthalate type)

Number of units	Total production capacity (tons per year)
4	8,100

Synthetic fibres

Fibre	Number of units	Total production capacity
Nylon	8	12,230
Polyester	1	4,500
Acrylic	2	6,500

Synthetic rubber

Number of units	Total production capacity (tons per year)
1	30,000

Synthetic Detergents

Number of units	Total production capacity (tons per year)
6	18,000 (expansion to 22,000 tons/year approved and being implemented)

Pesticides

	Capacities installed	Under implementation	Total
B.H.C. 13 per cent	11,800	14,850	26,650
Lindane			
D.D.T.	2,800	1,400	4,200
Endrine	-	3,500	3,500
Parathion	700	2,500	3,200
DDVP		280	280
Carbaryl			
Thiocarbamates	4,300	1,220	5,520

Petrochemical complexes

Two naphtha crackers, with naphtha through put of 60,000 tons and 225,000 tons each have already been installed and gone into production in 1967 and 1968 respectively. The output of the first cracker at full capacity will be about 20,000-22,000 tons of ethylene and 10,000-12,000 tons of propylene and proportionate quantities of aromatics and other products. The ethylene from this cracker is being used for production of H.P. polyethylene in the same plant, whereas the propylene and aromatics are contracted for supply to other companies for manufacture of phenol and other products. The factories also produce solvents.

Second cracker will produce 60,000 tons of ethylene and 35,000 tons of propylene, 7,000 tons of butadiene, and 14,000 tons of benzene. Ethylene is being used for manufacturing PVC as well as for supply to an allied factory for production of high-density polyethylene. Production of solvents and petrochemical intermediates has already been started.

Iran

A plant with production capacity of 60 tons a day for manufacture of PVC is already under construction at Abadan, production would be based on natural gas. Similarly, a urea plant with a capacity of 500 tons a day based on natural gas and a dodecyl benzene plant with a capacity of 30 tons a day based on imported benzene are also under construction.

A plant for manufacture of 53 tons per day of polyethylene based on refinery off-gas has been ordered.

Japan

The capacity installed of the major petrochemcials in Japan in 1967 and 1968 and the operation rate may be seen from table IV-8.

Table IV-8

Petrochemical	Production capacity (ton/month)		Rate of increase (per cent)		Operation rate (per cent)	
	Mar.1967	Mar.1968	1967/1966	1968/1967	Mar.1967	Mar.1968
Ethylene	114,969	130,209	125.9	113.3	97	107
Propylene	80,526	93,206	128.5	115.7	110	114
Styrene monomer	24,300	28,870	115.2	118.8	109	104
Butadiene	15,423	16,323	103.4	105.8	112	121
Polyethylene	47,890	70,627	120.5	147.5	126	99
Polystyrene	25,715	31,505	142.8	122.5	85	83
Polypropylene	9,680	20,300	152.7	209.7	127	94
Ethylene oxide	14,220	14,220	208.5	100.0	97	90
Ethylene glycol	12,720	12,720	201.9	100.0	101	78
Propylene oxide	7,360	7,642	103.5	103.8	74	71
Polypropylene glycol	6,140	6,470	98.6	105.4	53	62
Acetone	7,651	9,651	119.8	126.1	109	93
Octanol	4,123	5,123	100.0	124.3	107	92
Butanol	7,850	8,100	101.3	103.2	103	80
Phthalic anhyride	13,265	15,885	122.7	119.8	87	81
Terephthalic acid	10,340	13,900	106.3	134.4	108	103
Benzene	27,470	46,790	100.1	170.3	98	93
Toluene	17,761	24,231	102.9	136.4	109	107
Xylene	12,296	22,356	110.3	181.8	107	111
Synthetic rubber	25,203	29,803	104.0	118.0	98	93

Source: Industrial Bank of Japan - Petrochemicals, 1968.

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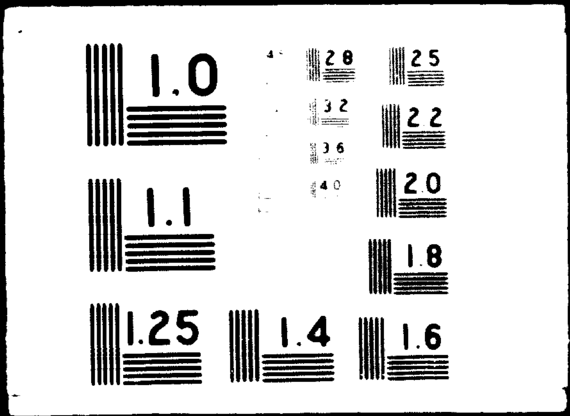

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

Korea, Republic of

Synthetic resins

Capacities installed for manufacturing of petrochemicals are given below.

Synthetic resins and plastics

	No. of units	Present capacity (tons/year)	Capacity under expansion	Final capacity
PVC	5	44,600	15,900	60,500
Urea Formaldehyde	7	26,640	-	26,640
Polystyrene	1	3,000	5,000	8,000

Synthetic fibres

	No. of units	Present capacity	Under construction	Under planning expansion	Total
Nylon	3	7,175	1,575	1,750	10,500
Polyester	6	2,100	7,000	16,100	25,200
Acrylic	3	4,725	8,750	19,600	33,075
PVA	1	700	1,750	-	2,450
Synthetic detergents	5	17,500	-	-	17,500

Philippines

The present production capacities are: 6,000 tons of PVC resin, 8,200 tons carbon black, 41,500 tons of urea formaldehyde resin and 37,000 tons of synthetic detergents. A nylon plant with a capacity of 2,500 tons a year is under construction and is expected to go stream by 1969.

Pakistan

Present position regarding capacities installed is as follows:

Synthetic resins

Capacity installed for manufacturing of polyethylene is 5,000 tons/year. Capacity of the urea resin manufacture is adequate to meet the current demand.

Synthetic fibres

Two plants together have a capacity of 1,200 tons/year. This is being expanded to 4,000 tons/year by 1970. A further 2,000 tons/year capacity has been licenced.

Pesticides

Two plants for manufacture of BHC (12 per cent gamma isomer) and three for manufacture of DDT have total capacities of 3,500 tons and 7,500 tons/year respectively.

Singapore

The present petrochemical capacity in existence is in the sphere of urea formaldehyde resins 4,800 tons and phenol formaldehyde resins 1,200 tons. There is also a detergent capacity to the extent of 6,000 tons per year.

V. Trade in major petrochemical products

With the development of petrochemical industries in Japan, Australia and other countries of the region and growth of processing industries in many countries of the region trade in petrochemical products increased in volume. An idea of the trade in major petrochemical products is given below.

Plastics and synthetic resins

Table V-1 shows the pattern of import trade in plastics and synthetic resins.

Table V-1

Import of synthetic plastics ~~and~~ resins in countries of ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
Burma	2,994	2,480	3,686	1,914	939
Cambodia	1,270	800	1,470	1,690	2,996
Ceylon	1,938	1,987	2,000	3,300	4,791
China, Rep. of	7,165	9,405	19,597	24,892	44,680
Hong Kong	69,886	121,930	97,140	108,560	-
India	12,700	16,300	15,943	15,834	30,640
Indonesia	8,487	5,111	6,340	2,967	9,350
Iran	7,100	12,100	15,000	19,800	-
Korea, Rep. of	13,091	13,050	14,051	17,234	21,796
Malaysia	4,677	12,569	17,700	11,423	13,594
Pakistan	9,481	17,213	15,009	16,890	17,286
Philippines	17,600	21,900	22,500	31,800	30,840
Singapore	-	-	151	440	284
Thailand	78	292	600	866	143
Vietnam, Rep. of	5,610	8,200	9,550	11,412	19,721
Total Developing countries	162,077	243,337	240,737	269,022	197,060
Australia	34,051	62,108	78,102	78,034	83,942
Japan	35,800	44,900	23,400	27,900	33,621
New Zealand	-	27,300	35,600	34,800	-
Total Developed countries	69,851	134,308	137,102	140,734	117,563
Grand Total	231,928	377,645	377,839	409,756	314,623

Sources:
1. UN International Trade Statistics.
2. Commodity Trade Exports - OECD.
3. Data supplied by governments.
4. Japan Plastics 1967.
5. Foreign Trade Statistics of Asia and the Far East, 1963.

Table V-2

Export of synthetic resins from countries of ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	4,593	8,181	6,406	31,140	30,513
Hong Kong	1,104	10,760	11,840	10,470	
Total Developing countries	5,697	18,941	18,246	41,610	30,513
Australia	-	10,900	10,550	4,990	
Japan	112,750	141,800	251,000	361,000	390,250
Total Developed countries	112,750	152,700	261,550	365,990	390,250
Grand Total	118,447	171,641	279,796	407,600	420,763

Sources: 1. Japan Plastics Annual, 196
2. Includes re-export.

An examination of the above tables would show that by 1966 the exports for the region as a whole were already at par with imports. The total imports increased from 231,928 tons in 1963 to 409,756 tons in 1966 whereas the exports increased from 118,447 tons in 1963 to 407,600 tons in the same year. The major importers were: Hong Kong 28 per cent, Japan 7 per cent, New Zealand 9 per cent, Philippines 8 per cent, China 6.5 per cent, and Australia 20 per cent. The major exporter of the region was Japan and in 1966 exports from Japan constituted 88 per cent of the total export.

Pattern of imports of plastic in Hong Kong in 1966 showed 36 per cent polyethylene, 17 per cent PVC, 19 per cent polystyrene, 7.5 per cent polypropylene and 4.5 per cent urea resins.

In the Republic of China in 1966 52 per cent of polyethylene, 17.5 per cent of PVC, 7.5 per cent of polystyrene and 6.6 per cent of polypropylene was imported.

Japan imports consisted of 5 per cent polyethylene, 6 per cent PVC, 10 per cent polystyrene, 5 per cent acrylics and 10 per cent of thermosets (UF and PF) while a number of other materials were imported in smaller quantities.

Australian imports in 1966 of the poly condensation and addition products (thermosets like urea and phenolic resin) formed 30 per cent of imports, the polymerisation and copolymerisation products formed 52 per cent, cellulosic plastic 15 per cent and other 1.5 per cent. Polyethylene imports were 11 per cent and PVC 13.5 per cent of the total.

Item-wise details of the export from Japan may be seen from table V-3 below.

Table V-3

Japan: Plastics export by material

(Unit: tons)

	1964	1965	1966	1967
Polyvinyl chloride resin	33,600	71,207	59,295	58,911
PVC film	11,000			
PVC sheet	14,800			
PVC leather	16,200			
PVC pipe	3,900	56,280	68,042	72,886
PVC plate	6,400			
PVC others	1,000			
Polyethylene	25,100	75,273	155,605	167,633
Polystyrene	2,000	4,725	15,584	22,364
Polyvinyl acetate	1,800	2,297	3,893	4,116
Polymethyl methacrylate	1,200	2,264	1,958	3,377
Polyvinyl alcohol	4,700	5,553	10,071	17,896
Others	4,200	10,728	11,731	16,530
Thermoplastics total	125,900	228,327	336,179	363,713
Melamine resin	1,800	1,668	1,956	2,949
Melamine decoratives laminates	1,600	2.9m.sq.m	4.5m.sq.m.	4.8m.sq.m.
Unsaturated Polyester resin	2,500	6,002	7,033	5,532
Phenolic resin	500	1,026	1,160	1,257
Urea resin	500	306	551	1,078
Others	1,600	3,412	4,624	5,285
Thermosetting total	8,500	12,414	15,324	16,101
Others	7,400	10,222	9,635	10,438
Grand Total	141,800	250,963	360,138	390,252

Source: Japan Plastics, Vol. 1, No.1 April 1967.
Rubber and Plastic International 1968.

Japanese polyethylene was the biggest export item from the region in 1966 and accounted for 37 per cent of the export while PVC from the Republic of China and Japan was the next biggest item in quantity accounting for 24 per cent.

Synthetic fibres

Exports and imports of synthetic fibres may be seen in tables V-4 and V-5.

Table V-4

Import of synthetic fibres

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	2,074	3,451	4,250	5,686	8,060
Hong Kong	1,405	1,860	2,120	4,130	10,377
India	-	2,700	6,500	5,900	4,830
Indonesia	60	-	65	-	76
Iran	1,415	2,696	3,406	6,565	10,118
Korea, Rep. of	6,526	4,175	7,496	12,144	28,671
Malaysia	-	247	473	517	165
Philippines	-	2,113	2,184	5,526	5,780
Singapore	-	-	-	154	172
Thailand	-	1,061	1,409	2,537	2,804
Vietnam, Rep. of	-	857	692	1,202	1,563
Total Developing countries	11,480	19,160	28,595	44,361	72,616
Australia	7,700	7,000	10,200		
Japan	2,000	1,000	1,000	600	680
New Zealand	-	1,500	1,500	800	
Total Developed countries	9,700	9,500	12,700	1,400	680
Grand Total	21,180	28,660	41,295	45,761	73,296

1/ Year ending June.

Sources: 1. Information supplied to AIDC Fact-Finding Study Team on Petrochemical Industries.
2. Seminar on Development Prospects of the Man-made Fibre Industry in Asia and the Far East, Tokyo, 1966.
3. International Trade Statistics.
4. Information supplied by governments.

The region has remained throughout the period exporter of synthetic fibres becausw of large exports from Japan. The imports in the region increased from 20,996 in 1963 to 55,805 in 1966 but the exports during the period also registered an increase from 47,614 tons to 106,534 tons. Japan and the Republic of China were the only exporting countries and in 1966 Japan accounted for 98 per cent of the export. Major fibres exported from Japan in 1966 were nylon 29 per cent, polyester 24 per cent, acrylic 22 per cent and vinylon 2 per cent.

Table V-5

Export of synthetic fibres from ECAFE region

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	614	1,352	1,967	2,534	3,984
Japan	47,000	68,000	113,000	104,000	112,900
Total	47,614	69,352	114,967	106,534	116,884

Source: 1. Textile Organon June 1968.
2. Data furnished by government.
3. Data submitted at ECAFE Seminar on Development Prospects of Man-Made Fibre Industry, Tokyo, 1966.

Trends in synthetic rubber - imports and exports - may be seen in tables V-6 and V-7 below.

Table V-6

Imports of synthetic rubber

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	1,135	1,674	2,500	3,863	5,000 (estimate)
India	5,738	3,752	975	990	1,126
Iran	-	-	-	-	9,275 1/
Korea, Rep. of	-	2,729	5,442	4,384	6,163
Malaysia	675	460	822	1,003	
Pakistan	550	963	721	6,247	2,229
Philippines	4,814	6,790	5,659	7,449	7,621
Singapore	-	-	304	584	511
Thailand	78	292	600	903	143
Total Developing countries	12,990	16,660	17,023	25,423	32,068
Australia	10,421	13,821	15,336	17,506	17,682
Japan	54,460	57,201	49,830	47,855	49,672
Total Developed countries	64,881	71,022	65,166	65,361	67,354
Grand Total	77,871	87,682	82,189	90,784	99,422

Sources: 1. Information supplied by governments to AIDC Fact-Finding Study Team on Petrochemical Industries, 1968.
2. UN International Trade Statistics.
3. OECD Commodity Exports.
4. Foreign Trade Statistics.
5. Information supplied by governments.

1/ 1968 imports.

2/ 1967/1968 data.

Table V-7

Export of synthetic rubber

Country	1963	1964	1965	1966	1967
Japan	8,417	15,875	30,323	50,300	57,535

Source: MITI as reported in

It may be observed that import of synthetic rubber has increased by 21,000 tons over the period while exports have increased by 49,000 tons during the same period. In spite of a large production of synthetic rubber, Japan is the principal importer accounting for 49 per cent of the regional imports. Australia with 17,680 tons accounts for 17.5 per cent of the imports followed by Philippines and China. Iran has also imported large quantities in 1968.

In 1966 import of SBR polybutadiene and butyl rubber was 34 per cent and 43 per cent respectively in case of Japan. In Australia in 1966 special types of SBR like latex, high styrene and general purpose SBR accounted for 40 per cent of import, polybutadiene for 19 per cent, butyl for 9 per cent and chloroprene rubber for 13 per cent. In Iran in 1968 SBR imports were 70 per cent, polybutadiene 24 per cent and butyl 6 per cent.

VI. Plans for expansion

Apart from the capacities already installed, licensed and under implementation or construction, the following plans for creating additional capacity for production of petrochemicals are under active consideration of the various countries.

Australia

Production of 5 million lbs. ABS plastics and styrene butadiene latex has been planned. Plans are expected to go into production by 1969.

India

Plans for the establishment of public sector naphtha cracker in Gujarat with a through put of 323,000 tons per year has reached an advanced stage. It is estimated that the project will be in operation by 1972-1973.

The following products would be available for sales to the units to be set up in private sector:

1.	Ethylene (polymer grade)	100,000 tons
2.	Propylene (polymer grade)	17,000 tons
3.	Propylene (92 per cent)	33,200 tons
4.	Benzene about	20,000 tons
5.	Butadiene	37,000 tons

Proposals for manufacture of petrochemicals from these primary products have been worked out in detail, with a number of firms and these will go in operation along with the naphtha cracker. The details of the products to be produced in the units is as follows:

	tons/year
Polyethylene (high pressure)	45,000 (to be expanded to 60,000 tons in second phase)
Styrene	30,000
Polyethylene (intermediate pressure)	27,000
Vinyl acetate	30,000
Acetaldehyde (by-products)	15,000
Polypropylene	15,000
Acrylonitrile	16,000
Stereo regular polybutadiene and butadiene-styrene synthetic rubber	25,000

It is also planned to supply 12,000 tons of butadiene from this cracker to an existing SBR plant.

The Government of India had concluded a technical know-how agreement with a German firm for establishing an aromatic project at Koyali, Gujarat. The following products will be manufactured:

Product	Tons/year
Ortho-xylene	21,000
Para-xylene	17,000
Mixed xylenes	2,500
Dimethyl Terphthalate	24,000

This project was expected to be on stream by 1970/1971.

A private sector plant for manufacture of caprolactum of 21,000 tons a year is in advanced stage of planning and is expected to be on stream by 1971.

Indonesia

A proposal for manufacture of 2,300 tons of PVC compound at the first stage and 8,000 tons of PVC resin three years thereafter has been submitted by a foreign company.

A project for manufacture of carbon black is being planned in north Sumatra which would take up 20 million SCF a day of LPG. This is planned in conjunction with 30 million SCF a day of LPG production.

Iran

Steps have been taken to acquire license and know-how for a 15,000 tons per year of carbon black plant.

Projects for manufacture of 25,000 DMT and 10,000 tons of TEL and/or TML are under consideration.

A feasibility study for manufacture of ethylene from associated gas have been carried out. If the project is taken up on a national basis the plant capacity will be of 100,000 tons per year of ethylene. There is a possibility of this being increased on the basis of joint venture with an international company. A 70,000 tons per year capacity ethanol plant would also be a part of the project.

Feasibility studies are being undertaken for a 600 tons a day methanol and 300,000 to 400,000 tons per year aromatic projects.

Plans for 20,000 to 25,000 T/Y capacity caprolactam plants are under consideration.

Korea, Republic of

The first naphtha cracker in the Republic of Korea will be established at Wulsan. It is expected that the project will be on stream in 1970. A list of products to be produced and production capacity for each are as follows:

Item	Production Capacity (tons/year)	Remarks
Ethylene	66,000	Expandable to 100,000-150,000 tons/year
Polyethylene	50,000	
Vinylchloride	40,000	
Polystyrene	6,000	
Ethylene oxide and ethylene glycol	12,000	
Acetaldehyde	26,000	
Polypropylene	20,000	
Alkyl benzene	6,800	Expandable to 10,000 tons/year
S.B.R.	15,000	
Caprolactam	33,000	
Acrylonitrile	26,700	Expandable to 52,000 tons/year
Methanol	45,000	

It is understood that with the exception of alkyl benzene and methanol, the production of other petrochemicals will be undertaken by joint-venture companies.

Pakistan

In West Pakistan a petrochemical complex having a capacity of 25,000 tons of ethylene, 10,000 tons of polyethylene, 15,000 tons of PVC, 5,000 tons of polypropylene and 5,000 tons of DDB are in advance stage of implementation. This complex will be based on naphtha. A complex based on natural gas to produce 15,000 tons of PVC resins and polyvinyl alcohol fibre is planned for East Pakistan.

A polyester fibre plant with a capacity of 7,000 tons of chips and 5,000 tons per year of fibre as a joint venture between Iran, Pakistan and Turkey is planned. This plant will be in operation in 1971/1972.

A joint venture plant between Iran and Pakistan for production of 5,000 tons per year of acrylic fibre is being planned. This will operate by 1972. Both the fibre plants will be based on imported intermediates.

A plant for manufacture of 10,000 tons a year of polybutadiene rubber is planned for Karachi. The production for this would cover the Pakistan requirement and some quantity will be available to Iran against some polyisoprene imports.

A detergent plant of 3,000 tons per year capacity in existence is being expanded to 5,000 tons a year. Additional new capacity for the total production of 20,000 tons a year to coincide with the DDB plant is being planned.

A BTX unit is being built at the national refinery. This will meet the toluene and xylene demands of the country but the benzene will not be adequately available from internal sources.

Philippines

The Board of Investment has approved a methanol plant with a capacity of 18,000 tons per year. A 2,500 T capacity nylon plant is expected to go on stream in 1969.

A formaldehyde plant with a capacity of 16,500 tons with provision for producing resins is under planning.

Setting up of a polyester fibre plant with a capacity of 4,700 tons per year is being considered.

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Future plans for expansion or creation of fresh manufacturing capacity have been indicated below.

Synthetic fibres

Nylon - 22,600 T/A capacity is under planning for 1970.

Acrylic - A plant for manufacture of 3,300 T/A has been recently completed and 16,500 T/A capacity is under planning for 1970.

Polyester - 27,000 T/A capacity is planned for 1970.

Synthetic rubber

20,000 T/A plant is planned for 1974.

Primary petrochemicals

Ethylene - 55,000 T/A has been completed recently.

Benzene - 20,000 T/A is being engineered for completion by 1969.

Toluene - 25,000 T/A is being engineered for completion by 1969.

Xylene - 24,000 T/A is being engineered for completion by 1969.

Singapore

A PVC resin plant with a capacity of 3,000 tons a year using imported EDC as raw material is being planned.

VII. Special features and factors initiating the petrochemical development and suggested solution

There are certain special characteristics of the petrochemical industry which have to be taken note of in order to examine the special features and factors affecting the growth of these industries. They are briefly enumerated here.

The petrochemical manufacture needs large initial investments and is highly capital intensive. In 1964 1/ investment of a naphtha cracker with 285 thousand ton naphtha throughput and a production of 80 thousand tons of ethylene was estimated at 15 million US dollars. There had been a tendency all over to construct larger units, and now 300,000 tons per year ethylene plants are being erected in Japan, Europe and United States. In a recent forecast 2/ for ethylene production and usage in the period 1970-1980 it has been estimated that the capacity of ethylene plants will go up from 225,000 tons in the sixties to 450,000 tons in the seventies. The cost of 450,000 tons per year capacity plants based on naphtha has been estimated at 35 million dollars.

The conversion of a composite feed stock consisting of several hydrocarbons is not selective and a number of other products are obtained along with ethylene. The economic working of the plants depend, to a large extent, on full utilization of all the products available.

The primary products available from the cracking reactions like ethylene, propylene are generally liquids and gases which are inflammable, explosive and difficult to transport. Their storage and transport is expensive. It is therefore economical and profitable to locate units consuming these primary products in close proximity to the main production centre.

1/ Petrochemical Industry and the Possibilities of its Establishment in Developing Countries - C. Mercier.

2/ Hydrocarbon Processing, 1969 January.

The research development efforts put in this industry have been very high and this has given rise to problems of obscelence of technology equipment and processes. Continuously newer raw materials and better processes are replacing the older ones making fresh investments necessary.

For the development of petrochemical industries it will be necessary to find markets for the following groups of products: (1) Synthetic resins and plastics; (2) synthetic fibres; (3) synthetic rubber; and (4) detergents.

The main markets which have been found for various groups in developed countries are:

Plastics: packaging materials - films, sheets, bags, plastic coated paper, plastic foam containers, injection and blow moulded containers and bottles.

Building materials: and components such as tiles, pipes, sheets (plain and corrugated) fittings, and others used in construction and housing.

Components or parts of radios, TV sets, electric fans, washing machines, household appliances and other durable consumption articles.

Components of automobiles, scooters, bicycles and transport vehicles.

Agriculture - film sheets etc. used in agriculture, canal lining, storage of grains, fertilizers and other products.

Synthetic rubber:

- Tyres and tubes of cars, trucks, motor cycles, bicycles etc.
- Cable and wire coating
- Hoses, pipes, belting
- Moulded goods
- Footwear
- Foam rubber cushions and mattresses

Synthetic detergents: - Replacement of laundry soaps for textile washing.

- Cleaning composition for industrial household and hospital use.

Synthetic fibres: - Apparel, cloth, knitted garments - fishing nets, ropes and industrial uses.

In the light of the above characteristics of the petrochemical industry the special problems of the region may be detailed as follows:

Demands:

The demands in the developing countries of the region for the petrochemical products are quite low. Limited per capita income has kept the consumption of many of the product groups at low levels. Because of large rural population and limited use of small packages for consumer articles, the packaging demands have not yet come up in large quantities. The use of other traditional materials like paper, glass is also common due to the cost consideration. The housing construction is proceeding at a slow pace because of the low income level. The use of materials like bricks, wood and metals, is more common due to a lack of adequate information regarding these new products and also due to the higher cost of these. The use of plastics in the construction field would require intensive marketing and extension work and the prices of the plastic materials would have to be competitive vis-à-vis other traditional materials available in the market. The acquisition of durable consumer goods like radios, refrigerators, air conditioners, automobiles etc. depends to a large extent on the availability of these goods at competitive prices as well as the requisite purchasing power. In many of the developing countries the manufacture of a number of these products is in the initial stage and the demands are small. These will have to come into market as mass produced items at competitive prices to ensure large sales. The demand for the plastic material as components would shoot up once these products find larger markets.

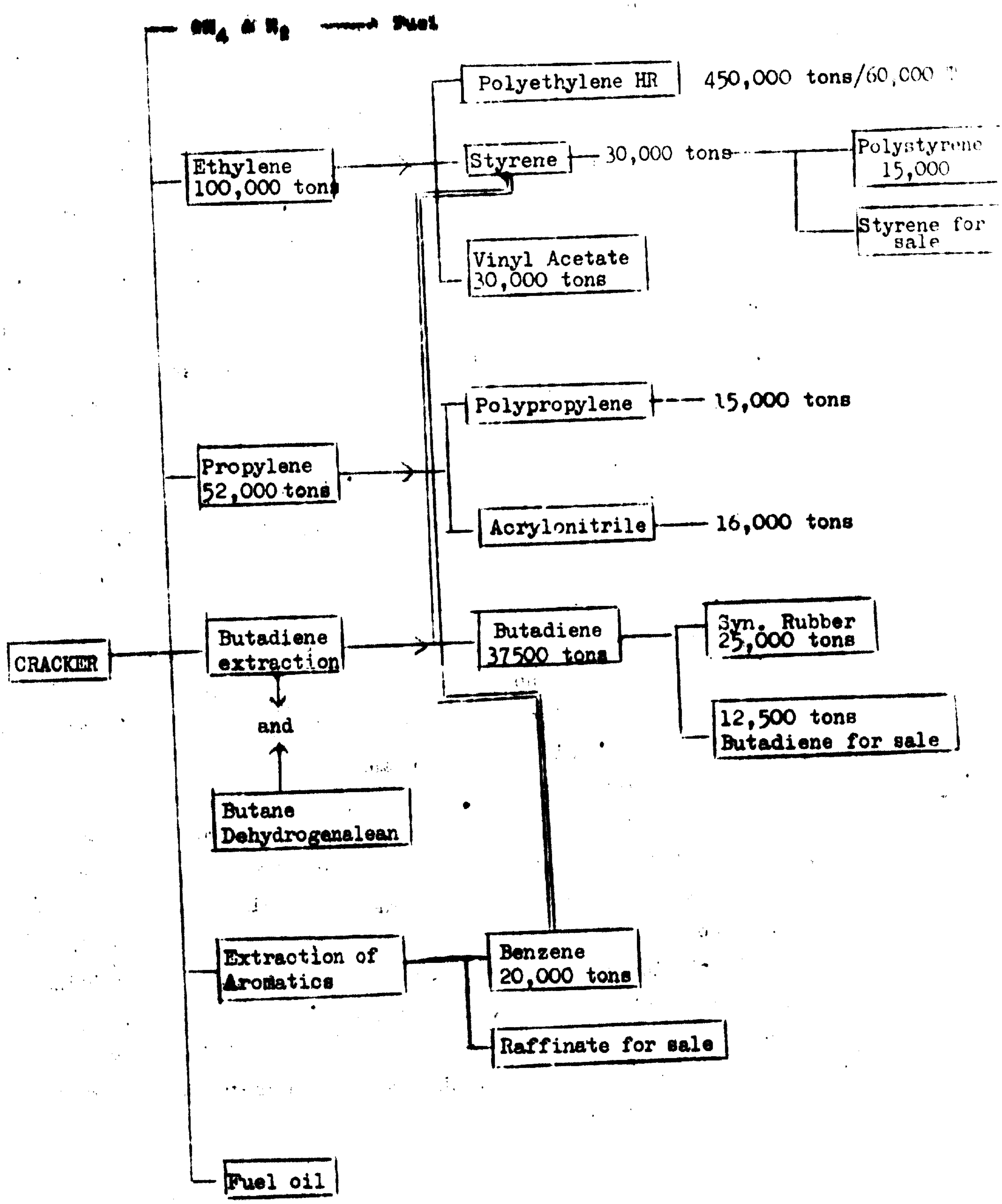
The major factors pending the growth of synthetic fibre demands are the high prices and the lack of processing facilities in some countries of the region. The region as a whole is short of the fibres and had to depend on imports. In 1966, it imported about 1.2 million tons of cotton alone. With the future growth of processing facilities and reduction in the cost of synthetic fibres, there should be no difficulties in finding bigger markets for synthetic fibres.

There is a large production of natural rubber in the region and the growth of synthetic rubber demand would affect the natural rubber industry unless both become complementary to each other and the use of rubber increases with larger production of rubber products.

The demands for synthetic detergents may go up. Availability of vegetable and animal fats for soup production will be limited because of demand for edible use; and soap may be replaced by detergents as in developed countries.

Finances

The financial outlay and investment required for petrochemical manufacture are very high even for individual units of production and since it is necessary to plan the production of petrochemicals around the basic facilities and the use of all the products, the investment becomes much larger because of the number of production units which will have to come up simultaneously. An idea of the production units which may have to be components of a complex and the financial outlays that may be necessary may be had from an outline of a new complex planned in the near future in one of the developing countries.


Polyethylene HR
450,000 tons/60,000
Ethylene
100,000 tons
Styrene
30,000 tons
Polystyrene
15,000
Styrene for sale
Vinyl Acetate
30,000 tons
Polypropylene
15,000 tons
Propylene
52,000 tons
Acrylonitrile
16,000 tons
CRACKER
Butadiene extraction
and
Butane Dehydrogenalean
Butadiene
37500 tons
Syn. Rubber
25,000 tons
12,500 tons
Butadiene for sale
Extraction of Aromatics
Benzene
20,000 tons
Raffinate for sale
Fuel oil

Investment for the cracker and the various downstream units listed above would be of the order of 130-135 million dollars and of this, a sizable portion (40 to 45%) would constitute the cost of imported equipment.

These investments are not inclusive of utilities which are being provided from existing facilities. Power, water and effluent disposal systems are already available and the land adjacent to a refinery has been developed for construction of the complex. Naphtha will be drawn from the refinery and all the products will be fed to the sown stream units with only limited storage facility investments.

Acrylonitrile and vinyl acetate will be further processed into actylic and PVA fibres respectively in plants for which separate and additional investments are planned.

Above details may give an idea of the magnitude of the investment involved. The financial problems likely to be encountered in the starting up of such a complex would fall in two broad groups.

Due to the lower level of industrialization there are very few industrialists or industrial organizations who might be able to muster and get the necessary finance on their own even for starting individual units for manufacture of petrochemicals. The development of joint stock companies in many countries of the region is not advanced enough and even in such countries where the joint stock companies are functioning the present capital formation may not be adequate for raising of the required funds for construction of such complexes. A large percentage of the necessary finance may have to come from financial institutions like banks, insurance companies and the government lending institutions. In view of the limitation of individual finances it may become necessary for a group of industrialists or organizations to pool their resources for starting a petrochemical complex and many problems of marketing, pricing of raw materials, sharing of utilities etc. will have to be sorted out to ensure the smooth working of the complex.

Table V-6

Imports of synthetic rubber

(Unit: tons)

Country	1963	1964	1965	1966	1967
China, Rep. of	1,135	1,674	2,500	3,863	5,000 (estimate)
India	5,738	3,752	975	990	1,126
Iran	-	-	-	-	9,275 1/
Korea, Rep. of	-	2,729	5,442	4,384	6,163
Malaysia	675	460	822	1,003	
Pakistan	550	963	721	6,247	2,229
Philippines	4,814	6,790	5,659	7,449	7,621
Singapore	-	-	304	584	511
Thailand	78	292	600	903	143
Total Developing countries	12,990	16,660	17,023	25,423	32,068
Australia	10,421	13,821	15,336	17,506	17,682
Japan	54,460	57,201	49,830	47,855	49,672
Total Developed countries	64,881	71,022	65,166	65,361	67,354
Grand Total	77,871	87,682	82,189	90,784	99,422

Sources:
1. Information supplied by governments to AIDC Fact-Finding Study Team on Petrochemical Industries, 1968.
2. UN International Trade Statistics.
3. OECD Commodity Exports.
4. Foreign Trade Statistics.
5. Information supplied by governments.

1/ 1968 imports.

2/ 1967/1968 data.

Table V-7

Import of synthetic rubber

Country	1963	1964	1965	1966	1967
Japan	8,417	15,875	30,323	50,300	57,535

Source: MITI as reported in

It may be observed that import of synthetic rubber has increased by 21,000 tons over the period while exports have increased by 49,000 tons during the same period. In spite of a large production of synthetic rubber, Japan is the principal importer accounting for 49 per cent of the regional imports. Australia with 17,680 tons accounts for 17.5 per cent of the imports followed by Philippines and China. Iran has also imported large quantities in 1968.

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	tons/year
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It is also planned to supply 12,000 tons of butadiene from this cracker to an existing SBR plant.

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In West Pakistan a petrochemical complex having a capacity of 25,000 tons of ethylene, 10,000 tons of polyethylene, 15,000 tons of PVC, 5,000 tons of polypropylene and 5,000 tons of DDB are in advance stage of implementation. This complex will be based on naphtha. A complex based on natural gas to produce 15,000 tons of PVC resins and polyvinyl alcohol fibre is planned for East Pakistan.

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Demands:

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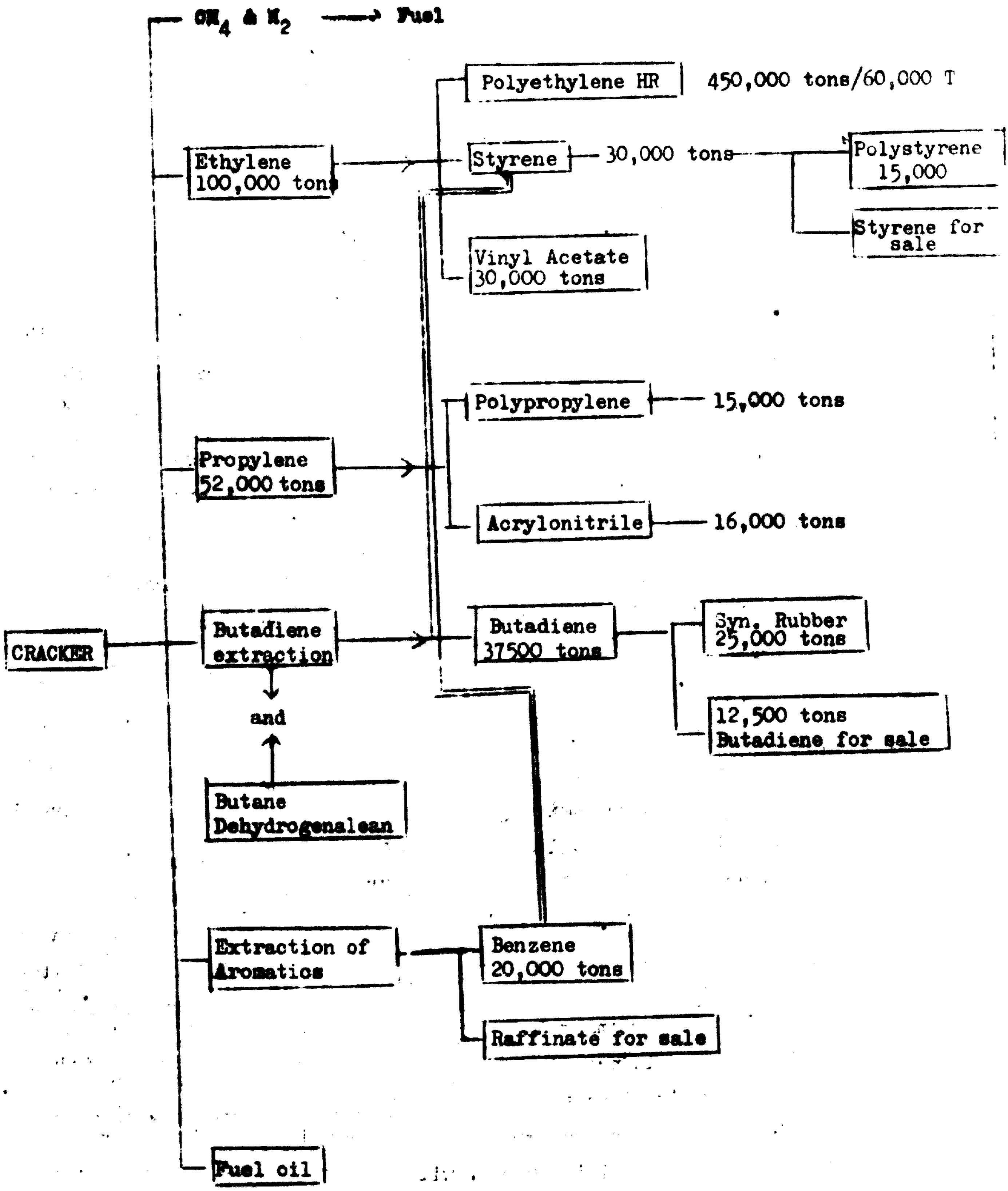
CH4 & H2
Fuel
Polyethylene HR
450,000 tons/60,000 T
Ethylene
100,000 tons
Styrene
30,000 tons
Polystyrene
15,000
Styrene for sale
Vinyl Acetate
30,000 tons
Polypropylene
15,000 tons
Propylene
52,000 tons
Acrylonitrile
16,000 tons
CRACKER
Butadiene extraction
Butadiene
37500 tons
Syn. Rubber
25,000 tons
12,500 tons
Butadiene for sale
and
Butane
Dehydrogenalean
Extraction of Aromatics
Benzene
20,000 tons
Raffinate for sale
Fuel oil

Investment for the cracker and the various downstream units listed above would be of the order of 130-135 million dollars and of this, a sizable portion (40 to 45%) would constitute the cost of imported equipment.

These investments are not inclusive of utilities which are being provided from existing facilities. Power, water and effluent disposal systems are already available and the land adjacent to a refinery has been developed for construction of the complex. Naphtha will be drawn from the refinery and all the products will be fed to the sown stream units with only limited storage facility investments.

Acrylonitrile and vinyl acetate will be further processed into actylic and PVA fibres respectively in plants for which separate and additional investments are planned.

Above details may give an idea of the magnitude of the investment involved. The financial problems likely to be encountered in the starting up of such a complex would fall in two broad groups.

Due to the lower level of industrialization there are very few industrialists or industrial organizations who might be able to muster and get the necessary finance on their own even for starting individual units for manufacture of petrochemicals. The development of joint stock companies in many countries of the region is not advanced enough and even in such countries where the joint stock companies are functioning the present capital formation may not be adequate for raising of the required funds for construction of such complexes. A large percentage of the necessary finance may have to come from financial institutions like banks, insurance companies and the government lending institutions. In view of the limitation of individual finances it may become necessary for a group of industrialists or organizations to pool their resources for starting a petrochemical complex and many problems of marketing, pricing of raw materials, sharing of utilities etc. will have to be sorted out to ensure the smooth working of the complex.

Many of the petrochemical projects require complicated and specialized equipments and it will be necessary to import from other countries that portion of the equipment of the complex. The requirements of imports may vary from country to country but generally these may be estimated to range between 35-60% of the total project cost. Raising of external finances or the necessary foreign exchange for purchases of this imported part of the equipment could be one of the major problems in planning of the petrochemical complexes due to balance of payment problems in many developing countries. The foreign exchange in many cases may have to be obtained in the form of loans or as foreign investments and the terms of repayment, rate of interest and many other details have to be worked out before the imports can be arranged.

Technology and engineering design facilities

Due to the lack of the technical knowledge for the detailed production processes and engineering design facilities in many countries, these will have to be obtained from outside licensing and engineering firms having the necessary know-how. At present many petrochemical plants and processes for each of the products are available from a number of licensing and engineering firms in developed countries. It would therefore be necessary for prospective manufacturers in the individual countries to evaluate the merits and demerits of each of the processes and to select the most suitable for the specialized needs of the country. Agencies for evaluation and detailed feasibility studies of projects before investments are made are necessary. Lack of suitable organization for this work would mean delays or faulty decision which may hamper growth along right lines.

The fabrication of equipment and designing of petrochemical plants require engineering skills and fabrication facilities and the extent to which these are available, the building of petrochemical complexes becomes more economical. The import of heavy equipments if not available locally also involves payment of freight and insurance charges which increases the plant cost. The engineering skills are required for subsequent operation of the plant and looking after the maintenance of the equipment installed.

A number of processes and plants are now available from the process licensers and engineering companies as turn-key jobs and if there is availability of requisite foreign exchange it is possible to start up the manufacturing units. However, it would be for every manufacturer to develop his own research facilities in order to keep pace with the modern developments. The necessary research facilities and skills have to be developed in most of the countries.

Training of personnel

The training of personnel to look after the production, engineering, management and marketing is necessary. The facilities for such training are not likely to be available in developing countries due to the lack of necessary industrial development. It would therefore be necessary to ensure that adequate training facilities are arranged so that the petrochemical units will be run efficiently and smoothly once they are set up.

Processing industries

The petrochemical products by themselves serve as raw materials to many other industries and reach consumer only after they have been processed further. Markets for many petrochemical products will have to be developed and stimulated by intensive work in product development application, research and extension work for the processing industries. Inadequate facilities and skills in conversion industries may affect the growth of petrochemical industries.

The synthetic fibres have to be spun, woven or knitted into cloth or other articles of apparel or converted into industrial products like fishing nets, ropes etc. These conversion units are developed in some of the developing countries of the region. In other cases the development of these facilities will have to be encouraged so that they can take up the fibres which may be available and convert them into various end products. In the plastic processing industry the conversion of the resins into different articles is carried out by processes such as extrusion, injection moulding, coating etc. The development of these processing industries depends on the availability of necessary machines, raw materials, moulds and dies and the required skills. In many countries the machines and raw materials may not be available in adequate quantities for developing markets. It will therefore be necessary to plan for development of the processing industries in individual countries of the region so as to ensure progressively higher consumption of the plastic materials. Production of films, pipes, footwear, electric groups etc. has started on a limited scale in many countries but a sustained effort on the part of all the agencies, like the government departments, the entrepreneurs, the resin manufacturers is necessary to ensure the rapid growth. To develop markets for products made from many new resins the import of the resins themselves will be necessary since these will not be available in the countries. The foreign exchange problems may make such imports difficult. It would therefore be necessary to find ways and means of getting initial quantities of resins for development of processing industries and for creating the markets initially.

The rubber industry in many countries finds major markets in production of tyres, tubes and these are connected with the transport development in the country. Production of other rubber goods like footwear, belting, moulded goods etc. would be at different stages of development in many countries. The use of synthetic rubber will depend on the availability of natural rubber and the prevailing prices of both categories of rubber. The development of the processing industry in this case also is essential to ensure greater consumption.

Some of the problems and features which may affect the development of petrochemical industries have been listed above. The problems are complicated and definite solutions may be difficult to suggest. Some ideas and suggestions to resolve these may be considered along the following lines:

(1) The development of petrochemical production should be taken up in the form of integrated complexes in such countries where the demands of individual products would justify setting up of such a complex. Location may be carefully chosen to get the advantages of raw materials and to avoid cost of inland transport of heavy equipment.

(2) In such cases where the markets are limited in the initial stages the petrochemical production may be taken by a group of countries as a joint venture so that the economic sized units can be set up and these can cater to the demands of the concerned countries.

(3) Suitable organization for choice of the most useful process from those offered by different process licensing and engineering firms and preparation feasibility studies to decide on the pattern of development may be evolved. Experts from some of the developing countries where petrochemical industries have come up may be able to assist other countries in the region due to their knowledge of local problems and conditions.

(4) The development of processing industry consuming the petrochemical products is necessary. Integrated efforts to develop these industries in individual countries which have limited current markets should be taken care of immediately so as to ensure larger markets for the products to be manufactured.

(5) To enable processing industry to be developed co-operation between the developing and the developed countries for import of the equipment and loan of products necessary for creating markets may be considered.

(6) The foreign exchange component of the plant and machinery could form a sizable amount in any petrochemical plant. Suitable arrangements for financing this either as joint ventures or loans from the developing countries may be considered.

(7) In view of the considerable cost of and essential needs to foster research and development, the developing countries could consider planning joint research programmes thereby reducing the cost and sharing the benefits of the technological improvements.

(8) On the same basis as joint research, the manufacture of heavy and complicated machinery could be planned and considered.

(9) Training of personnel in technology, engineering, research management and marketing may be possible only in developed countries and may be an important and purposeful field of mutual co-operation between the developed and developing countries.

VIII. Development prospects and investment needs in the petrochemical industry in the developing countries of ECAFE region during 1970-1980

Demand estimates for the period 1970-1980

The petrochemical demands during the next decade will depend on a number of factors such as population, national income growth rate and production in each country as well as special characteristics and properties of individual petrochemical products or product groups concerned. The factors which would normally influence demands of products in any country or area may be briefly mentioned as under:

- Purchasing power in the past, at present and in the period for which estimation is sought to be made.
- Volume of imports.
- Competitive position of the products. An assessment of the alternative products available in the market. Extent to which substitution of these by products under consideration is possible and likely. An extent of captive market.
- Current and future price trends of products. Influence of protective or restrictive duties taxes, import and export restrictions and such other factors.

An assessment of the estimated demand would be possible by an understanding and examination of the above factors.

The petrochemical markets have grown very fast in USA, Europe and Japan. Some of the important factors which have been responsible for the high growth rates are mentioned below:

- High income elasticity of demands for a number of petrochemical products.
- Substitution of traditional products like wood, metals, paper with petrochemical products like plastics has contributed to their market growth. Similarly substitution of natural rubber by synthetic rubber and natural fibres by synthetic fibre and soaps by detergents

has been responsible for the fast growth of these petrochemical sectors partially at the cost of traditional items mentioned above.

- Improvement in the properties of the newer products which substituted older. Thus for instance qualitatively and quantitatively detergents achieve better results as compared to soap.
- Introduction of new products with specialised properties suitable for specific end uses.
- Extensive promotional activities and application research for the benefit of industrial users and consumers.
- A gradual declining price in absolute terms also as well as in comparison to the prices of the materials which were being substituted.

It is quite likely that these factors and characteristics of petrochemical demand growth will evince themselves in the future years in Asian markets as has happened in the case of developed countries. However, the data in respect of various factors mentioned above being available to a very limited extent in different countries of the region, the demand estimates have been made on the basis of past trends in individual countries, taking into consideration the growth of demands of these products vis-à-vis gross national product. The estimates have been made in the following manner:

Equation given below has been used for estimating future demand in individual countries:

$$D_n = D_o (1 + Ng)^n$$

In the above equation N is the regression coefficient representing elasticity of demand of individual product groups with respect to growth of gross national product and this is assumed as constant. The connotion of individual terms in the above equation is as under:

D_n = Demand in the year of projection (1980)

D_o = Demand in the base year (1965)

N = Coefficient of elasticity

g = Annual rate of growth of gross national product in each country

n = Number of years between the base and projection year.

The growth rates of gross national product in the period 1960-1980 used for projections are given in table 1 below:

Table 1

Growth rates of gross national product of the countries in the ECAFE region, 1960-1980

Country	Rate of Growth (%)
Burma	4.0
Cambodia 1/	4.0
Ceylon	3.6
China, Rep. of	6.0
India	3.5
Indonesia	2.5
Iran	5.0
Korea, Rep. of	5.0
Malaya, Fed. of	3.5
Pakistan	3.0
Philippines	4.5
Singapore 1/	6.25
Thailand	5.0
Viet-Nam, Rep. of 1/	4.9

1/ Current rates assumed for future.

Sources: 1. ECAFE Seminar - Development Prospects of Man-Made Fibre Industry in Asia and the Far East.

2. OECD -

The elasticity coefficient of demand N was obtained for three major product groups namely, plastics, synthetic fibres and synthetic rubber from the growth rates of demand of these products and the growth rate of gross national product in the base years for the developing countries in the region and the value of N in each group has been determined.

The coefficients were on the high side and this is attributed to the high growth rates of these products as compared to gross national product when the demands were building up. This is likely to effect the projection figures and give them on the high side in many cases. Comments in respect of the observed future demand estimates of each group have been given separately. The anticipated demand in these three groups is given below:

Plastics

The 1980 demand for plastics may be seen in table 2 below.

Table 2

Projected demand for plastics and synthetic resins of the countries in the ECAFE region in 1980

(Unit: tons)

Country	Demand	
Burma	34,000	
Cambodia	15,000	
Ceylon	16,000	
China, Republic of	1,750,000	(440,000-460,000)*
India	325,000	(620,000)*
Indonesia	28,000	
Iran	223,000	
Korea, Republic of	358,000	
Malaysia	41,000	
Pakistan	87,000	
Philippines	464,000	
Singapore	87,000	
Thailand	352,000	
Viet-Nam, Republic of	134,000	

* Ref. - Comments on page 83.

The following comments are offered in respect of the above demand estimates.

China

The demand estimates obtained are very much on the high side. This is attributed to the high growth rate of gross national product and high demand in the base year. On the basis of the highest per capita consumption in the region as observed in Japan, it is felt that the Chinese demand is likely to be around 440,000 tons to 460,000 tons.

India

The estimates are on the low side because of low gross national product growth rate as well as the base year demand. According to the information available from the report of the Asian Industrial Development Council Study Team on Petrochemical Industry, 1968, by 1978-1979 the demand has been estimated by the Indian Government at 620,000 tons. These are probably based on more detailed information at the national level and therefore have been accepted instead of the observed figures.

Synthetic fibres

The demand estimates for 1980 for synthetic fibres may be seen in table 3 given below.

Table 3

Demand estimates for synthetic fibres in 1980 in the ECAFE region

(Unit: tons)

Country	Demand
China, Republic of	141,000
India	80,000 (186,000)*
Iran	64,000
Korea, Republic of	186,000
Pakistan	14,000
Philippines	34,000
Thailand	29,800

* Ref. - Comments as follows:

The following are observations in respect of the above estimates.

India

The observed figures are on the low side as in the case of synthetic resins. The national estimates for 1978-1979[1/] are 186,000 tons and this has been taken to represent 1980 demand instead of the observed figures.

Synthetic rubber

The synthetic rubber demand requirements are only limited to only a few countries. In many countries the use of this was very small. The data for 1980 demands for the rubber may be seen in table 4 given below.

Table 4

Anticipated demand for synthetic rubber in 1980 of selected countries in the ECAFE region

(Unit: tons)

Country	Demand
China, Republic of	38,000
India	69,000 (205,000)*
Korea, Republic of	44,000
Pakistan	10,200
Philippines	38,000

* Ref. - Comments below.

India

The national demand estimates[1/] for 1979-1980 are represented at 205,000 tons and have been accepted.

Synthetic detergents

The information available regarding current consumption of this group is very limited and on that basis it will be very difficult to estimate the demands. However, it has been observed that in countries like the Philippines and Thailand where the detergents usage has now caught up, the per capita demands are approaching 1 kg per annum. Since the

1/ Report of the AIDC Study Team on Petrochemical Industry, 1968.

availability of other washing materials like soap is likely to be restricted because of the lack of vegetable and animal fats in many countries, it is assumed that by 1980 the per capita demand would be around 1 kg in the countries of the region and estimates of requirements have been made on that basis.

Pesticides

The current requirements of pesticides have already been earlier indicated. Pesticides form an important agricultural input along with fertilizers. In developed countries the pesticides use has increased with modern agricultural techniques and use of high yielding seed varieties, high inputs of fertilizers and better water management. Since considerable emphasis is given on agricultural developments in the region the demand for pesticides would go quite high. These can be assessed by detailed examination of various features such as soil conditions, crops under consideration, type of diseases etc. The demand for specific insecticides can be determined thereafter. It is quite likely that demand may double and may be of the order of 300,000 tons by 1980. Detailed study is called for to enable an exact assessment of individual pesticide demands.

Necessity of further studies of demand estimates

The above demand estimates have been made on the basis of very limited information and data and these require to be followed in depth in order to arrive at an accurate and specific idea of the demand in individual spheres.

Plastics constitute major product group among petrochemicals and these are used as materials for further conversion before they reach the consumer. The estimation of demands has to be based on a close examination and analysis of the industries which use these materials. The major plastic demands in developed countries have come up in the field of packaging materials, as parts and components of construction and housing and as components of many machines like automobiles, refrigerators and other durable consumer articles. The market survey of plastic demand therefore requires an intimate knowledge of the trends in production and demand in these consuming industries as also the trends in the use of plastics in individual items produced. Such a study would require a continuing effort both at national and regional level but the data which would be available will be of enormous interest and would enable proper planning and development of this product group on a scientific basis. It is therefore felt that the demand estimates should be studied in depth by study of end use pattern at regional levels to refine the very broad estimates which have been arrived at so that more clear indications are made available for planners and producers in the petrochemical field. Similar studies may be very useful in synthetic fibres, rubber and detergent fields also.

Availability of raw materials

Detailed position regarding availability of raw materials in each of the countries of the region has been discussed under survey of sources of raw materials earlier. An examination of the data shows the following position.

Iran has both oil and natural gas available in large quantities as raw materials for petrochemical manufacturing. The natural gas in Iran contains ethane and propane and is suitable for manufacture of ethylene and petrochemicals. The Iran naphtha will also be a source of raw material for manufacture of various petrochemical products. Both gas and naphtha prices are likely to be competitive.

Pakistan has a considerable availability of gas rich in methane which could be used for manufacture of acetylene, methanol and ammonia. Availability of naphtha is enough for the cracker planned.

In India and Republic of China naphtha provisions have been made to cover the planned production of petrochemicals. There is availability of gas in both countries. This is mainly used for production of ammonia in India and ammonia and methanol in the case of China. The Korean requirement of naphtha is likely to be partly met from the internal production.

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Singapore will have a large surplus of naphtha which could form a major source of raw material for petrochemical manufacture in the Southeast Asian region.

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In other countries of the ECAFE region, petrochemical production may have to be based on imported feed stock according to the current information of gas and naphtha availability.

First generation intermediates

These may be considered as products directly produced from gas and naphtha and which act as building blocks or primary products for further conversion into secondary intermediates. In some cases certain end products like polyethylene can be made from the first generation intermediates also. In many other cases these are converted into secondary intermediates. The main products in these categories are:

Acetylene

This was initially produced from calcium carbide. Recently many other methods of manufacture are in vogue. The more important of these are: thermal cracking by Wulff process; partial oxidation of methane by flame process and arc process. These are intricate processes worked under vigorous conditions and large size plants of 30,000 to 45,000 tons capacity are installed in developed countries to ensure economic production. Due to complex process of manufacture elaborate recovery systems necessary for separation and purification of acetylene and high wear and tear, even with 30,000 to 45,000 tons capacity plants acetylene has been found to be expensive as a raw material and is being gradually replaced by ethylene. The major uses of acetylene of interest in this region are manufacture of vinyl chloride, acrylonitrile and vinyl acetate. All these products are now made more economically from ethylene and propylene as starting materials which are replacing acetylene. The development work for manufacture of acetylene by plasma process could reinstate acetylene as a petrochemical raw material provided the cost can come nearer to 3-4 cents per lb level.

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Ethylene, propylene and butadiene

Ethylene is produced by pyrolysis of natural gas containing ethane and higher hydro carbons. Naphtha and light oils can also be used as feed stock for the manufacture of these products. In all cases high temperature non-catylic cracking is the main reaction involved in the manufacture. Except in USA the recent trend is in the direction of use of naphtha as a major feed stock. The ethylene propylene yields vary with the source of raw materials used. The recent tendency has been to operate under conditions which give maximum production of ethylene as this is main material required for many subsequent processes. The yields for different sources are as under:

Feed stock	Ethylene (%)	Propylene (%)
Ethane	80-85	1-2
Propane	40-45	15-20
Naphtha	27-30	12-16

These yields have been improved recently to the extent of 10 per cent by computer control of furnace operation, decoking of tubes and hydrogeneration of acetylene. The ethylene to propylene ratio can vary from 1:1 to 3:1 depending upon the degree of severity of cracking. Butadiene is also obtained as a co-product from the naphtha cracking. Conditions which give high yield of ethylene also improve the butadiene yield and 10-12 per cent of butadiene yield based on ethylene could be obtained.

Naphtha crackers of different size have been in operation right from 20,000 tons to 450,000 tons. The recent tendency however, has been to use large size crackers and operate them at the 100 per cent capacity. At this full utilization the cost of ethylene could vary from 7.5-12 cents per kg depending upon the cracker size, the price of naphtha, value of the by-products realized and several other factors. The cracker investments may vary from 8 to 35 million dollars.

Paraffins

Straight chain paraffins of C_{12} range available in the gas and oil fractions now constitute an important source of raw material for manufacture of soft detergents alkylates. They are replacing in many countries, the propylene tetramer because of the ability to give biodegradable foams. Molecular sieves using vapour or liquid phase absorption and recovery systems are used. The isolated paraffins are chlorinated and are used for manufacture of alkylates. Plant costs are estimated at 2.2 million dollars for a 40,000 tons a year plant for separation of C_{12} straight chain paraffin.

Secondary intermediates

These can be described as products which are obtained from primary or first generation intermediates by subsequent processing or chemical reactions. The size of the economic unit for manufacture of these will vary from location to location and several factors like raw material availability, finished product prices which can be obtained with duty protection etc. will have a bearing on the size of minimum economies. However, the scale of manufacture of intermediates and the prices at which these are made available for the manufacture of end products will considerably influence the cost of marketed petrochemicals. One of the major growth factors in petrochemicals has been progressively reducing prices at which these are offered for sale. These lower prices of end products can be achieved only if primary and secondary intermediates are available at cheap and competitive prices. For the development of petrochemicals markets it will therefore be necessary that these primary and secondary intermediates are available at as competitive prices as possible and the choice of production units, location and all other relevant factors should be given most detailed consideration. Although small sized plants could be considered economic in protected markets with high duty structure such units may not be able to help the industry in marketing end products in large quantities and at lower prices. It may therefore be worthwhile to install optimum sized units for manufacture of these key products to ensure sound long-term growth. Some observations regarding the size of units for manufacture of secondary intermediates are as follows:

Plastics and synthetic resins:	-	Styrene
	-	Vinyl chloride
	-	Methanol
Synthetic fibres:	-	DMT
	-	Caprolactam
	-	Acrylonitrile
	-	Vinyl acetate
	-	Ethylene glycol
Synthetic rubbers:	-	Styrene
	-	Butadiene
Detergents:	-	Dodecyl benzene
	-	Soft alkylates

The plant size which could give intermediates at comparable to prevailing world prices are given below.

Styrene

According to the recent data furnished[1/] a 24,000 ton per year plant in the region would be able to produce styrene at 11-12 cents per lb. The prices of styrene in developed countries are around 8-9[2/] cents per lb.

VC monomer

A 48,000 tons plant[3/] using ethylene as a raw material would be able to produce VC at 12 to 13 cents per kg and with 100,000 tons plant the VC cost would come to 11 cents per kg. This is based on 11.1 cents per kg of ethylene and 5 cents per kg of chlorine cost. Depending upon other factors VCM units should be of this order to ensure economic manufacture. In some cases an integrated PVC/VCM plant may have to be considered if the imported cost of monomer at a location is likely to be very high or there are other factors which may require such a choice.

1/ Report of the AIDC Fact-Finding Team on Petrochemical Industries.

2/ European Chemical News, October 1968.

3/ "Petrochemical Industries", M. Honda, September 1966.

Methanol

The minimum economic plant size is 45,000 tons per year. However, since methanol is a low boiling liquid with difficulties involved in transportation smaller capacity plant of 30,000 ton size in specific area of limited consumption may have to be considered.

DMT

The world prices are around 20-21[1] cents per lb and plant size smaller than 20,000 tons per annum may not be able to produce material competitively.

Caprolactam

In the manufacture of caprolactam a substantial quantity of ammonium sulphate is obtained as a by-product. The prices of both ammonium sulphate and caprolactam have been showing a downward trend and a 20,000 ton per annum plant will be required to offer material at these declining prices of, for example, around 22-24 cents per lb of caprolactam.

Vinyl acetate

The manufacture is now based on ethylene by one step conversion to vinyl acetate and a 30,000 ton per year plant would be required in order that vinyl acetate may be offered at competitive prices around 12 cents[2] per lb.

Dodecyl benzene

The estimated cost of dodecyl benzene from a projected plant in the region is around 12.3 cents per lb which is slightly on the high side as compared to the cost in USA of 10 cents per lb.

Linear alkylates

The present cost of soft alkylates is 10-12 cents per lb in developed countries and to be able to produce the soft alkylates at comparable price a plant of 10,000 tons per year capacity would be necessary.

1/ European Chemical News, October 1968.

2/ Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968.

Manufacture of monomers at central location

The cost of monomer manufacturing plant as well as cost of the monomer itself shows a definite downward trend with increasing plant size. This is now accepted as a general principle but the benefits of these have been mostly derived by developed countries where plants serve large markets. Effect of cost on different sizes of vinyl chloride[1] and styrene plants given below will serve as a guide:

Styrene monomer:

Plant size	12,000	24,000	48,000	96,000
Investment (million US dollars)	3.34	5.0	7.5	11.1
Styrene monomer cost (US cents per kg) (Ethylene cost 8.3 and benzene cost 6.95 cents/kg)	18.16	16.38	15.0	14.3
Styrene cost (Ethylene cost 11 cents and benzene cost 9.73 cents/kg)	21.35	19.55	18.25	17.26

In case of vinyl chloride the data was as under:

Plant size	48,000	100,000
Investment (million US dollars)	3.6	5.64
VC monomer cost (based on ethylene cost 11 cents and ethane cost 5 cents/kg)	12.1	11.0

The transport cost of monomer like ethylene[1] by ship has been estimated as under:

1/ Petrochemical Industries - Honda (ECAFE), 1966 June.

Distance to be transported (km)	50	600	[illegible]
Pressure tanker	30 kg/sq.cm.	Medium pressure	1 atmos. pressure
Temperature	– 13 or medium	medium to low	very low
Quantity transported	100 ton/ship 60,000 ton/year	310 tons 60,000 ton/yr.	20,000 ton/ship 200,000 ton
Cost of ship required to transport (US dollars)	.33 million	1 million	9.2 million
Transportation cost (US cents)	0.56 cent/kg	1.47 cent/kg	

Ethylene, vinyl chloride and styrene can be transported by ship and monomers produced at a central plant of large size could be made available for polymerization in comparatively small sized plant in individual countries. A compromise of 20,000 ton vinyl chloride[1/] and PVC plant costs have been estimated at 7 million dollars and the PVC cost at 15 cents per lb in a recent study. The cost of 5 such units would therefore come to 35 million dollars. Costs of 5 polymerization plants and one central monomer plant will however come to 21 million dollars. Similar economies in the cost of the styrene and polystyrene are also likely. It may therefore be worthwhile considering a central plant to manufacture vinylchloride and styrene for a number of countries in the region and only polymerization plants in individual countries.

Investment for petrochemical plants

The cost of plant required for manufacture of petrochemical and products as well as intermediates would vary depending on the location, available infrastructural facilities, degree of industrialization already achieved and other factors. Generally a new plant in an industrial area where facilities are already developed would be less costly than a plant where these facilities have to be simultaneously provided for. Since the position

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1/ Report of the AIDC Fact-Finding Study Team on Petrochemical Industries, 1968.

of this will vary from individual country to country and also from specific areas of each country, it would be difficult to estimate the investments without adequate background information regarding the exact conditions in each case. The cost of the process units and plant and equipment necessary for the manufacture of each project in US dollars has therefore been given in the data below. Apart from the cost of plant and machinery, other investments which are likely to be involved are given as a general guide only. Based on the plant and machinery cost at 100 the general magnitude of these costs in a developing country would be of the following order:

Plant and machinery	100
Export packing for plant and machinery, freight and insurance	12
Erection supervision	5
Off sites (storage tanks, services)	40
Financing	15
Miscellaneous	8
	180

The total investment for a plant including facilities in a developing country may be of the order of 180 per cent of the cost of plant and machinery. The investment normally described as "inside battery limits costs" in a developed country for the same plant may be 120-125 per cent of the process units investment. The investment requirements in a developing country would therefore be about 45-50 per cent higher than those of a similar plant constructed in a developed country. To illustrate the costs as an example a nylon plant with a 5,000 ton per year capacity may be considered. Cost of process units have been given at 3,100 dollars per ton of annual capacity. The total investment for plant and machinery would come to 15.5 million dollars. The battery limit cost of such a plant in a developed country would be 19.4 million dollars (125 per cent of 15.5) whereas the cost would come to 28 million dollars in a developing country. In the above calculation no provision has been made for local expenses such as customs duties,

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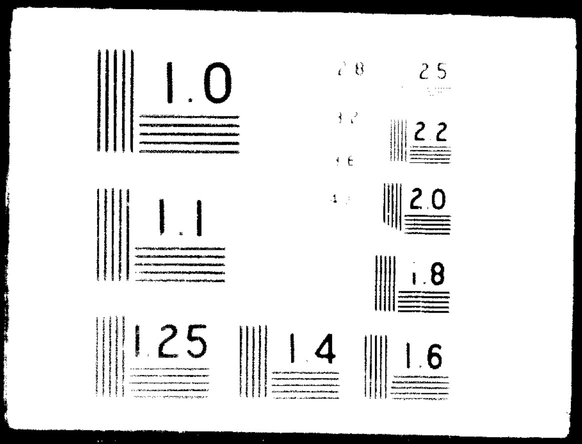

inland freight and such other costs which would vary materially from one country to another. The financing cost included in the above calculation may not be necessary where borrowed capital is not required. Similarly where services are available to an appreciable extent the off site cost could be lower.

The process units cost of various types of petrochemical plants are given as under:

Name of the product	Capacity ton/year	Cost in US$ per ton of annual capacity
I. Plastics		
Polyethylene	16,000	458
	32,000	340
	50,000	306
PVC	6,000	336
PVC (polymerization only)	20,000	180
PVC (with vinyl chl chloride and chlorine manufacturing)	20,000	610
Polystyrene	7,500	256
Polypropylene	15,000	945
Polypropylene	20,000	870
II. Synthetic fibres		
Nylon	1,650	6,050
	5,000	3,100
	10,000	2,420
Polyester	1,000	3,380
	5,000	2,180
	10,000	1,750
Acrylic	50,000	2,000
	120,000	1,115

continued

... of the product	Capacity ton/year	Cost in US$ per ton of annual capacity
III. Synthetic rubber		
	15,000	565
	30,000	434
	60,000	370
IV. Synthetic detergents		
	1,000	124
	10,000	82.5
	65,000	36.0
V. Intermediates		
Vinylchloride	48,000	90
	100,000	66.5
Styrene	24,000	254
	48,000	188
Acrylonitrile	30,000	499
Caprolactam	20,000	650
DMT	10,000	1,200
DMT (with xylene separation plant)	24,000	778
Ethylene (propylene)	100,000	99.5
Butadiene recovery	16,000	155
Aromatic (benzene extraction) toluene	30,000 100,000	97
Methanol	45,000	95
Butadiene (butane butene/dehydro-generation)	40,000	236

Investment needs for petrochemical industries in countries of the ECAFE region

On the basis of estimated demand by 1980 and on the basis of the plant cost data, the investment estimates in respect of countries are given below. Following general comments are made in respect of these:

- While arriving at the estimate of production the capacity in operation and under implementation has been taken into consideration and provision has been made for such balance capacity as may be necessary to achieve the above estimated targets of production. Unless otherwise stated in individual cases the estimates are for new plants.

- The estimates are demand based in the sense that they represent investment requirements to fulfil the demands as anticipated. They do not take into consideration the financial limitations that may be involved in raising the necessary internal or external funds or any other problems for construction of the above-mentioned plants.

- In certain cases more than one plant of the same capacity has been considered. The demand for individual products is likely to build up gradually over the decade and it may be necessary to build two plants of smaller size to meet the demands as they grow. A large size plant to cover the full 1980 demand installed earlier may have to be worked at capacities lower than economic presumably in the initial period of the lower demands. It is also felt that investments at different periods may be easier though slightly costlier.

For the purposes of estimating investments in the plastic groups a broad assessment of the demands of major individual plastics of each country has been made. This is based on the data available regarding the current demands in countries where this was available. For other countries the product pattern is based on average current demand in the countries of the region. On the basis of the product demands the investment estimates have been calculated. It is however quite likely that the internal demands for each product may be at variance in some countries with those expected, in which case there may be changes in the investment and in the light of these the investment may only be considered to represent the broad order of magnitude of estimates.

The synthetic fibre demands have also been calculated on the basis of current and anticipated demands in individual countries where this data was available. In other countries the product pattern is based on the regional demands with due reference to the needs of areas depending on climatic condition and other factors.

The synthetic rubber demand has been considered only in respect of SBR and investment figure has been arrived at. In cases where different types of rubber are to be produced investments may change.

It has been estimated[1/] that for every dollar invested in the synthetic fibre industry an equivalent investment is required in the textile sphere for conversion of these fibres. It is beyond the scope to go into the textile regional investment in these calculations. This broad indication has been given since this may be of interest for future planning.

It has been assessed on the basis of experience in few countries that investment for the conversion cost of plastic into end products ranges between 60-80 dollars per ton of conversion capacity. In very broad terms this may come to 20-25 per cent of the investment required for construction of polymer plant cost. Estimates for conversion equipment for each country have been indicated.

The investment needs of individual countries of the region are given as follows:

1/ Seminar on the Development Prospects of Man-Made Fibre in Asia and the Far East, 1966.

Burma

The demand for petrochemicals in Burma during the past few years has been fluctuating and limited. The demand for different petrochemical groups and the plants size is given in table 6 below:

Table 6

BURMA: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics and Synthetic Resins					
Polyethylene	11,500	-	11,500	-	-
Polyvinyl-chloride	10,600	-	10,600	6,000	2
Polystyrene	2,400	-	2,400	-	-
Synthetic Fibres					
Nylon	1,650	-	1,650	1,650	1
Synthetic Detergents					
	31,000	-	31,000	13,000	3
Intermediates/ Monomers					
Vinylchloride	13,000				
Caprolactam	1,815				
Dodecyl Benzene	6,000				

Taking into consideration the limited demand of individual major plastics and the minimum economic plant sizes, two polyvinyl chloride plants of 6,000 ton capacity have been considered.

The demand for synthetic fibres has been limited but it is considered that during the seventies at least one plant for the manufacture of nylon will be established. Similarly three plants for the manufacture of synthetic detergents have been considered. The monomers in all cases will be obtained from outside.

The investment requirements for the above plants are estimated as under.

	US million dollars
Plastics	7
Synthetic fibres	10
Detergents	2.5
Plastic processing machinery	21.5

Cambodia

The petrochemical demands for different groups are mentioned in table 7 given below.

Table 7

CAMBODIA: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics and Synthetic Resins					
Polyethylene	5,000	-	5,000	-	
Polyvinylchloride	4,400	-	4,400	6,000	1
Polystyrene	1,200	-	1,200	-	-
Synthetic Fibres					
Nylon	1,650	-	1,650	1,650	1
Synthetic Detergents	7,000	-	7,000	10,000	1
Intermediates/Monomers					
Vinylchloride	6,500				
Caprolactam	1,815				
Dodecyl Benzene	2,000				

In view of the limited demands for individual products and the minimum economic size, only one plant for polyvinyl chloride, one for nylon and one for synthetic detergents have been considered. The manufacture will be based on monomers/intermediates to be obtained from an outside plant.

The estimated investments are as under:

	US million dollars
Plastics	3.5
Synthetic fibres	10.0
Synthetic detergents	0.8
Plastic processing machinery	1

Ceylon

The anticipated demands for petrochemicals are limited and may be seen in table 8 given below.

Table 8

CEYLON: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plant
Plastics and Synthetic Resins					
Polyethylene	5,200	-	5,200	-	-
Polyvinylchloride	4,640	-	4,640	6,000	1
Polystyrene	1,280	-	-	-	-
Synthetic Fibres					
Nylon	1,650	-	1,650	1,650	1
Synthetic Detergents	19,000	-	19,000	10,000	2
Intermediates/Monomers					
Vinylchloride	6,500	All to be imported			
Caprolactam	1,815	All to be imported			
Dodecyl Benzene	4,000	All to be imported			

In view of the small quantities required one plant for polyvinyl chloride resin manufacture has been considered. Similarly one plant for manufacture of nylon and two for manufacture of detergents have been included. The monomers/intermediates will be obtained from outside.

The total investment required will be as under:

	US million dollars
Plastics	3.5
Synthetic fibres	10.0
Detergents	1.7
Plastic processing machinery	0.9

China, Republic of

The Chinese petrochemical demands have grown very fast during the last few years. The internal consumption as well as exports have grown considerably during this period. Substantial steps for erecting petrochemical manufacturing capacity have been taken recently. The detailed estimated demand, capacity in operation or under implementation and the new capacity required for meeting the demands by 1980 may be seen in table 9 given below.

Table 2

REPUBLIC OF CHINA: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics					
Polyethylene	100,000	20,000	80,000	50,000	1
				32,000	1
Polyvinylchloride	240,000	75,000	165,000	20,000	6
Polystyrene	18,000	1,600	16,400	7,500	2
Polypropylene	40,000	-	20,000	20,000	2
Synthetic Fibres					
Nylon	53,000	28,600	24,400	10,000	2
Polyester	35,000	29,600	5,400	5,000	1
Acrylic	53,000	23,100	29,900	10,000	3
Synthetic Rubber	38,000	20,000	-	Exp. to 30,000	
Synthetic Detergents	20,000	-	20,000	10,000	2
Intermediates/Monomers					
Vinyl chloride	260,000	110,000	150,000	100,000	1
				48,000	1
Styrene	24,600	-	24,600	24,000	1
Ethylene*	190,000	55,000	135,000 }	100,000	1
Propylene*	12,700	25,000	112,000 }	exp. of existing	
Acrylonitrile	52,000	-	52,000	30,000	2
Caprolactam	57,000	-	57,000	20,000	3
Dimethyl Terephthalate	38,500	-	38,500	24,000	2
Methanol	45,000	16,500	28,500	expansion	
Butadiene*	19,000	-	19,000	10,500	2
Dodecyl benzene*	4,000	-	4,000	10,000	1
Ethylene Glycol	14,000	-	14,000	20,000	1
Benzene	80,000	-	80,000	20,000	2

* From naphtha cracker.

The requirements of ethylene will be met by expansion of cracker which has recently gone into operation as well as by setting up a new cracker when necessary. The butadiene requirements will be obtained by extraction of the available by-products from the cracker.

The investment requirements for creation of the new capacities mentioned above are as under.

	US million dollars
Plastics	93
Synthetic fibres	87
Synthetic rubber	15
Synthetic detergents	1.7
Intermediates and monomers	157
Plastic processing machinery	27.6

India

The Indian petrochemical demands during the sixties were depressed due to severe restriction on imports and limited domestic availability. With the production of a number of petrochemicals within the country and development of processing capacity for a number of end products, the demands are now fast growing. A sustained effort to increase the petrochemical production is being made. The objectives of these efforts are presumably full utilization of petrochemical feed stock likely to be available. The petrochemicals are also expected to augment supplies of many products or materials like fibres, rubber, leather etc. by partial substitution or as complementary materials to be used in conjunction with other available materials. The position in respect of petrochemical demands and requirements of capacity may be seen in table 10 below.

Table 10

INDIA: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics					
Polyethylene	210,000	46,000	165,000	50,000 exp. of one plant	3
Polyvinylchloride	200,000	80,000	120,000	20,000	6
Polystyrene	70,000	21,500	48,500	24,000	2
Polypropylene	25,000	-	25,000	20,000	1
Synthetic Fibres					
Nylon	70,000	12,000	58,000	10,000 exp. of existing plants to 5,000 tons	4
Polyester	76,000	12,000	54,000	10,000	5
Acrylic	18,000	6,500	11,500	5,000	2
Others	22,000	-	22,000	14,000)	1
				8,000)	1
Synthetic Rubber	205,000	30,000	175,000	60,000	3
Synthetic detergents	150,000	22,000	128,000	65,000	2
Intermediates/Monomers					
Vinylchloride	216,000	80,000	136,000	100,000	1
				480,000	1
Styrene	94,000	30,000	64,000	24,000	3
Ethylene	360,000 - 380,000	92,000	268,000 280/-	100,000 exp. of existing	2
Propylene	70,000	20,000	50,000	(from crackers)-	
Caprolactam	77,000	-	77,000	20,000	4
Dimethyl Terephthalate	84,700	-	84,700	24,000 exp. of one plant	3
Acrylonitrile	24,000	-	24,000	30,000	1
Ethylene Glycol	30,000	12,000	18,000	20,000	1
Butadiene	127,000	7,000	120,000	12,500	3
				40,000	2
Soft Alkylates	30,000	-	30,000	30,000	1
Methanol	45,000	33,000	12,000		
Benzene	160,000	53,000	108,000	20,000	4

Part of the requirements of benzene and butadiene will be met by setting up recovery units with each of the crackers. Additional quantities of butadiene will be made available by setting up two dehydrogeneration units as the demand develops. The unit for manufacture of DMT will include facilities for manufacture of para-xylene required. It is presumed that the requirements of ethylene will be met by expansion of the existing crackers as well as by erection of two new crackers of 100,000 tons capacity. It is understood that soft detergents alkylates may be produced by cracking of slack wax. It is presumed that requirement of additional quantity of methanol will be obtained by extension of an existing plant.

The investment estimates for the different petrochemical production capacity which will be required are as under.

	US million dollars
Plastics and synthetic resins	97.0
Synthetic fibres	268
Synthetic rubber	67
Synthetic detergents	4.7
Intermediates and monomers	23.7
Plastic processing machinery	37.2

Indonesia

The current demands have been limited. The estimated 1980 demands for different groups and the capacities required to meet this demand may be seen from table 11.

Table 11

INDONESIA: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics					
Polyethylene	9,250	-	9,250	-	-
PVC	8,100	-	8,100	6,000	1
Synthetic Fibres					
Nylon	1,650	-	1,650	1	1,650
Synthetic Detergents	50,000	6,000	44,000	10,000	4
Intermediates/Monomers					
Vinylchloride	6,500	-	-	-	-
Dodecyl Benzene	10,000	-	-	10,000	1
Caprolactam	1,815	-	-	20,000	1

Taking into consideration the minimum economic size plants one unit of polyvinyl chloride resin and nylon and four units for the manufacture of detergents have been recommended. It will be assumed that production based on monomers will be obtained from outside, except DDB which may be produced from LPG when adequate demand develops.

Investment requirements for the different petrochemical production capacity are as under.

	US million dollars
Plastics	3.5
Synthetic fibres	10.0
Synthetic detergents	3.3
Plastic processing machinery	1.7

In case a joint-venture for caprolactam is considered the investment will be $13 million.

Iran

The petrochemical demands have grown rapidly in Iran during the recent years. With large availability of petrochemical feed stocks developments could be sizeable. An idea of the demands and the capacity required to cover these may be seen from table 12.

Table 12

IRAN: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional capacity required to meet 1980 demand in tons	Plant size in tons	No. of plants
		ton/yr.	ton/yr.	ton/yr.	
Plastics					
Polyethylene	85,000	18,000	67,000	50,000	1
Polyvinyl Chloride	85,000	19,000	66,000	20,000	3
Polystyrene	21,000	-	21,000	7,500	3
Synthetic Fibres					
Nylon	51,200	-	51,200	10,000	5
Polyester	6,400	-	6,400	5,000	1
Acrylic	6,400	-	6,400	5,000	1
Synthetic Detergents	35,000	-	35,000	10,000	3
Intermediate/Monomers					
Vinyl Chloride	92,000	20,000	72,000	48,000	1
Ethylene*	100,000	18,000	82,000	100,000	1
Styrene	22,000	-	24,000		1
Caprolactam	56,000	-	-	20,000	3
Dimethyl Terephthalate	7,000	-	-	24,000	
Dodecyl Benzene	10,000	-	10,000		1
Ethylene Glycol	2,500	-	-	-	-

* From a naphtha or ethane propane cracker.

* May cover Pakistan and other countries' needs.

Table 11

KOREA: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastic					
Polyethylene	86,000	50,000	36,000	32,000	1
Polyvinylchloride	83,000	60,000	73,000	20,000	1
Polystyrene	9,000	8,000	1,000	-	-
Polypropylene	20,000	20,000	-	-	-
Synthetic Fibres					
Nylon	52,000	10,500	41,500	10,000	4
Polyester	48,000	25,200	22,800	10,000	2
Acrylic	75,000	33,000	42,000	20,000	2
Synthetic Rubber	44,000	15,000	29,000	30,000	1
Synthetic Detergents	42,000	17,500	24,500	10,000	2
Intermediates					
Vinylchloride	88,000	40,000	48,000	48,000	1
Styrene	18,000	-	18,000	24,000	1
Ethylene	146,000	66,000	76,000	expansion of existing cracker	
Acrylonitrile	75,000	26,700	48,300	30,000 expansion of existing cracker	1
Caprolactam	57,200	-	57,200	20,000	3
Dimethyl Terephthlate	52,800	-	52,800	24,000	2
Ethylene Glycol	20,000	12,000	-		
Butadiene	28,000	-	28,000	18,000	1
Methanol	15,000	45,000	-	-	
Propylene	140,000	35,000	110,000	45,000	
Dodecyl Benzene	10,000	10,000	-	-	

The ethylene requirements is assumed to be covered by expansion of the crackers from the initial capacity of 66,000 tons to 150,000 tons. It is assumed the acrylonitrile demands will be met by initially expanding the plant under construction and when additional demand requires the production will be obtained from a new plant. Butadiene will be obtained by extraction

It is assumed that the vinyl chloride requirements will be met by expansion of the existing plant as well as by setting up of a new plant.

The investment estimates for the above capacities are as under.

	US million dollars
Plastics	36.5
Synthetic fibres	141.9
Synthetic detergents	2.5
Intermediates	84.5
Plastic processing machinery	13.4

Republic of Korea

The Korean petrochemical industry has been developing rapidly to cater to the increasing internal and export demands. A number of petrochemical plants are being constructed and are underway and future demands would be met from these as well as new capacities which may have to be constructed. Idea of the demands and the capacities required may be seen from table 13.

of the available quantities of by product from the cracker. The thermo-setting resin production in Korea is likely to be substantial. The requirements of methanol for this could be of the order of 65,000 - 70,000 tons and these can be met by expansion of the methanol plant when necessary.

The investment requirements for the above capacities are as under.

	US million dollars
Plastics	14.3
Synthetic fibres	177.8
Synthetic rubber	13
Synthetic detergents	1.7
Intermediates and monomers	126
Plastic processing machinery	21.5

1980 demands and capacities required in Malaysia may be seen in table 14 below.

Table 14

MALAYSIA: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional capacity required to meet 1980 demand	Plant size	No. of plants
		ton/yr.	ton/yr.	ton/yr.	
Plastic and Synthetic Resins					
Polyethylene	13,500	--	13,500	16,000	1
Polyvinylchloride	900	-	11,900	6,000	2
Polystyrene	3,300	-	3,300	-	-
Synthetic Fibres					
Nylon	1,650	-	1,650	1,650	1
Synthetic Detergents	13,000	12,000	-	-	-
Intermediates					
Ethylene	17,300	to be imported			
Vinyl chloride	13,000	to be imported			
Dodecyl Benzene	2,500	to be imported			
Caprolactam	1,815				

The requirements of ethylene may be obtained from Singapore crackers. The investments in different groups are estimated as under.

	US million dollars
Plastics	140
Synthetic fibres	100
Plastic processing machinery	2.5

Pakistan

The petrochemical products demands are growing and capacities for certain types of products are being set up. The demands and requirements for capacities to meet this are given in table 15.

Table 15

PAKISTAN: Petrochemical demands capacities and plants required

Name of the products	1980 Demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastic					
Polyethylene	25,600	15,000	10,000	-	expansion
Polyvinylchloride	24,800	30,000	-	-	
Polystyrene	14,000	-	14,000	7,500	2
Synthetic Fibres					
Nylon	70,000	4,000	3,000	1,650	2
Polyester	3,500	-	5,000	5,000	1
Acrylic	4,200	-	5,000	5,000	1
Synthetic Rubber	102,000	10,000	-	15,000	-
Synthetic Detergents	50,000	25,000	30,000	10,000	3
Intermediates/Monomers					
Vinylchloride	26,800	30,000	-	-	
Ethylene**	35,000	25,000	-	-	
Butadiene**	11,000	-	-	12,500	1
Styrene	14,500*	-	-	-	-
Dimethyl Terephthalate	3,850*				
Caprolactam	7,700*				
Acrylonitrile	4,200*				
Dodecyl Benzene**	10,000	15,000	5,000	-	expansion
Methanol	45,000	4,500	-	-	-
Ethylene Glycol	1,400	-	-	-	-

* to be obtained from outside

** from the naphtha cracker

The capacities being set up for ethylene and vinyl chloride would be adequate to meet the requirements of the respective polymers. The butadiene requirements are expected to be obtained by extraction of the available by-products from the cracker. Some of the intermediates/monomers may be obtained from outside.

The investment requirements for various groups are as under.

	US million dollars
Plastics	5.8
Synthetic fibres	40.9
Synthetic rubber	8.5
Synthetic detergents	2.5
Intermediates and monomers	4.0
Plastic processing machinery	5.2

Philippines

The anticipated demands for various products and capacities required for meeting these may be seen in table 16 given below.

Table 16

PHILIPPINES: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional capacity required to meet 1980 demand in tons	Plant size in tons	No. of plants
		ton/yr.	ton/yr.	ton/yr.	
Plastics					
Polyethylene	106,000	-	106,000	50,000	2
Polyvinyl Chloride	70,000	6,000	86,000	20,000	4
Polypropylene	40,000	-	40,000	20,000	2
Synthetic Fibres					
Nylon	17,000	2,500	14,500	10,000 5,000	1 1
Polyester	17,000	-	17,000	10,000	2
Synthetic Rubbers	38,000	-	38,000	30,000	1
Synthetic Detergents	46,000	37,000	9,000	10,000	1
Intermediates/Monomers					
Vinyl Chloride	90,000	-	99,000	100,000	1
Ethylene	160,000	-	160,000	100,000	2
Butadiene	19,000	-	19,000	18,000	1
Propylene	44,000	-	40,000		1
Dimethyl Terephthalate	18,700	-	18,700	24,000	1
Caprolactam	18,700	-	18,700	20,000	1
Dodecyl Benzene	10,000	-	10,000	10,000	1
Benezene	22,000	-	-	20,000	1
Ethylene glycol	7,000				
Styrene	6,000				
Methanol	45,000	-	45,000	45,000	1

The current demand for thermosetting resins has been substantial and requirements of methanol to meet these on the present basis may be of the order of 65,000-75,000 tons. This could be met by expansion of the methanol plant capacity at a later date when required. It is expected that the requirements of ethylene will be met by installation of a 100,000 ton of naphtha cracker and its expansion to 166,000 tons as the demand develops.

The investment requirements for the above are estimated as under.

	US million dollars
Plastics	79.4
Synthetic fibres	74.7
Synthetic rubber	13.0
Synthetic detergents	0.8
Intermediates and monomers	63.1
Plastic processing machinery	27.8

Singapore

The estimated demands for the petrochemical products may be seen in table 17 as follows:

Table 17

SINGAPORE: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of plants
Plastics					
Polyethylene	33,500	-	33,500	50,000	1
Polyvinylchloride	17,000	-	17,000	20,000	1
Polystyrene	6,000	-	6,000	7,500	1
Synthetic Fibres	1,650	-	1,650	1,650	1
Synthetic Detergents	3,000	-	-	-	-
Intermediates/Monomers					
Vinylchloride	18,300	-	18,300	48,000**	1
Ethylene*	78,000	-	80,000	100,000	1
DDB*	10,000	-	10,000	10,000	1
Caprolactam	1,815	-	-	-	-

* From a naphtha cracker.

** It appeared as a joint venture for supply of vinyl chloride.

*** 17,400 tons of ethylene may be supplied to Malaysia and Republic of Viet-Nam for polyethylene manufacture in those countries.

The investment requirements for the petrochemicals are estimated as under:

	US million dollars
Plastics	20.7
Synthetic fibres	10
Intermediates and monomers	17.7
Plastic processing machinery	7.3

Thailand

The demands for various petrochemical groups especially have been increasing rapidly. The demand by 1980 and the production capacities required for meeting this may be seen from table 18.

Table 18

THAILAND: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation/ under implementation	Additional capacity required to meet 1980 demand	Plant size	No. of plants
		ton/yr.	ton/yr.	ton/yr.	
Plastics 352000					
Polyethylene	184,000	-	184,000	50,000 32,000	3 1
Polyvinyl chloride	92,000	-	92,000	20,000	5
Polystyrene	21,000	-	21,000	7,500	3
Synthetic Fibres 29800					
Nylon	12,000	2,000	10,000	10,000	1
Polyester	17,000	-	17,000	10,000	2
Acrylic	800	-			
Synthetic Detergents	52,000	16,000	36,000	10,000	4
Intermediates/Monomers					
Vinyl Chloride	100,000	-	100,000	100,000	1
Ethylene*	250,000	-	250,000	100,000	2
Styrene	23,000	-	23,000	24,000	1
Dimethyl Terephthalate	18,700	-	18,700	24,000	1
Caprolactam	13,200	-	13,200	-	1
Dodecyl Benzene*	10,000	-	10,000	-	1

* From a naphtha cracker.

The investment requirements for the petrochemicals are estimated as under:

	US million dollars
Plastics	80
Synthetic fibres	59
Synthetic detergents	3.3
Intermediates and monomers	60
Plastic processing machinery	21

Viet-Nam Rep. of

The estimates of demands and capacities required may be seen in table 19.

Table 12

REPUBLIC OF VIET-NAM: Petrochemical demands, capacities and plants required

Name of the products	1980 demand estimate in tons	Capacity in operation-under implementation	Additional cap. required to meet 1980 demand in tons	Plant size in tons	No. of Plants
Plastics					
Polyethylene	43,000	-	43,000	16,000	1
Polyvinylchloride	39,000	-	39,000	20,000	1
Polystyrene	10,000	-	10,000	7,500	1
Synthetic Fibres					
Nylon	1,650	-	1,650	1,650	1
Intermediates/Monomers					
Ethylene	17,100*	-	-	-	-
Vinylchloride	20,800	-	-	-	-
Styrene	7,800	-	-	-	-
Caprolactam	1,815	-	-	-	-

* To be obtained from Singapore cracker.

Due to uncertain conditions it is expected that investments in the initial periods may be as given in the table. The requirements of monomers and intermediates are anticipated to be met from outside.

The investment requirements for the above plant are estimated as under:

	US million dollars
Plastics	12.7
Synthetic fibres	10
Plastic processing machinery	8.2

Possibilities of joint ventures

In order to make monomers available at economic prices it may be advantageous to produce them at central locations to cater to the needs of a number of plants producing end products. These plants have already been indicated in countries with limited demands in the field of plastics and synthetic fibres. The requirements of monomers for some of these plants are as under.

Caprolactam

Based on the proposed nylon yarn plants in different countries, requirements of caprolactam of such countries are as under.

Country	Demand (tons)
Burma	1,815
Cambodia	1,815
Ceylon	1,815
Indonesia	1,815
Malaysia	1,815
Pakistan	7,700
Singapore	1,815
Viet-Nam, Republic of	1,815
Thailand	13,200

The total requirement works out to 33,000 tons. It has been proposed[1/] that a plant to produce 20,000 tons per annum of caprolactam to cater to the demand of the countries in the region may be located in Indonesia. This suggestion is based on the likely markets for ammonium sulphate available as a by-product from caprolactam manufacture. This proposal could perhaps be followed up and the joint venture idea worked out in detail. The capacity of the plant could be expanded at a suitable time when the demand goes up.

1/ Report of the AIDC Fact-Finding Study Team on Petrochemical Industry, 1968.

Vinyl Chloride

In a number of countries polyvinyl chloride plants have been suggested based on monomer to be purchased from outside sources. The requirements of vinyl chloride monomer in these countries may be seen below.

Country	Demand (tons)
Burma	13,000
Ceylon	6,500
Cambodia	6,500
Malaysia	13,000
Indonesia	6,500
Singapore	18,300
Viet-Nam, Republic of	21,600

The requirements of monomer could be met by a joint venture plant having substantial capacity. In the initial period a plant with a capacity of 48,000 tons could be set up and this could be expanded as the additional demand builds up. Singapore or Thailand could be possible locations for such a joint venture. However, detailed studies regarding the suitable location should be undertaken if the proposal to manufacture vinyl chloride monomer at a central plant and to carry out polymerization in units in different countries is considered.

Styrene

The requirements of styrene monomer of different countries may be seen below.

Country	Demand (tons)
Iran	22,000
Pakistan	14,500
Philippines	6,000
Singapore	7,800

It has been proposed that styrene should be manufactured at a central plant in Iran as a joint venture. This could be followed up by an agreement between the consuming countries and the capacity of the monomer plant increased when the demand goes up.

Methanol

According to the current consumption pattern in a number of countries in the region the demand for thermosetting resins has been estimated at approximately 20 per cent of the total plastics and synthetic resins demand. Total consumption of plastics and synthetic resins may be seen below.

Country	Total plastic and synthetic resins demand by 1980 (tons)
Burma	31,000
Cambodia	15,000
Ceylon	16,000
Indonesia	28,000
Malaysia	41,000
Viet-Nam, Republic of	134,000
Singapore	87,000
	352,000

Consumption of thermosetting resins at 20 per cent of the above would amount to 70,000 tons. Taking into account the consumption of thermosetting resins in Thailand which was estimated to be of the order of 35,000 tons, the total demand would be about 110,000 tons. This would be equivalent to a demand of about 40,000 tons of methanol in the above countries which do not have production facilities. A methanol plant of 45,000 tons is proposed in Pakistan to cater to the requirements of a number of countries in the region. This plant may therefore be able to look after the demand of these countries.

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