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1. GENERAL

1.1. THE GROWING IMPORTANCE OF THE PETROCHEMICAL INDUSTRY

The petrochemical industry was born at the end of the First World War, and developed gradually until 1940. By 1920, although production of crude oil had already reached 100 million tons, the first petrochemicals produced amounted to only a few hundred tons.

The car industry became the first consumer of petrochemical products, with a particular demand for new paints, anti-freeze and various additives. Later on, plastics and synthetic rubber and fibres came on to the market. The Second World War was a very powerful stimulus to the development of the petrochemical industry, which was then in a position to meet a demand far in excess of what could be supplied by traditional sources such as the coal industry or agriculture, both in terms of quantity and quality.

The petrochemical industry developed rapidly, thanks to the substitutes which became possible through the arrival on the market of products which were very competitive both in quality and in price.

World consumption of petrochemical products, which amounted to 3.5 million tons in 1950, is now close to 65 million tons, and the growth rate of the petrochemical industry, which has averaged over 14% a year since 1950, is one of the fastest in industry. Over the same period, the production of aluminium increased by 10% a year, and that of steel by 5.5%, while production of fertilizers, another rapidly growing sector, rose by less than 13% a year. Although spectacular results have been achieved in other fields, such as the nuclear industry, data processing and space exploration, it is the petrochemical industry which has most affected everyday life in the last 25 years, by making available to an ever-larger number of consumers, through mass production, new materials with properties often superior to those of natural products.

1.2. PRINCIPAL END PRODUCTS OF THE PETROCHEMICAL INDUSTRY

Plastics account for more than half of the petrochemical products under consideration, in terms of tonnage (see Table 1.1), and even so, the production of plastics is still expanding rapidly, on account of the enormous demand potential.

As far as the other end products, such as synthetic fibres, rubber and detergents, which came on the market more recently, are concerned, the substantial rise in production in the last twenty to thirty years can be attributed mainly to their having rapidly supplanted those products which were already on the market, i.e. cellulose fibres, natural rubber and soap.

Generally speaking, the substitution of synthetic products is not complete, but considering the extent to which they have already penetrated the market, production of the three groups of products mentioned, namely synthetic fibres, rubber and detergents can be expected to begin to decline in the near future.

TABLE 1.1

MAIN PETROCHEMICALS PRODUCTION (WORLD)

MILLION TONS

	1950	1960	1970	1974	1975
PLASTICS	1.5	7.0	30.2	44.6	38.5
SYNTHETIC FIBRES	0.1	0.7	5.1	7.5	7.5
SYNTHETIC RUBBERS	0.7	2.0	5.9	7.7	7.4
DETERGENTS	0.7	3.5	9.0	11.0	10.8
TOTAL	3.0	13.2	50.2	70.8	64.2

1.3. BASIC PETROCHEMICAL PRODUCTION

The main petrochemical base products are olefins, (ethylene, propylene, butadiene) aromatics, essentially benzene and xylenes, and methanol.

Two basic processes predominate, namely :

- steam cracking, which is the main source of olefins but which can also be used to produce aromatics
- catalytic reforming which, independently from its use in refining, produces aromatics for the petrochemical industry

In addition to these, steam reforming should be mentioned; it is used essentially for the synthesis of ammonia, but also for the synthesis of methanol.

The basic hydrocarbons resulting from these processes, i.e. ethylene, propylene, butadiene, benzene, xylenes and methanol are the key products of the petrochemical industry. The paths leading from these basic products to the end products are numerous, and complex (see paragraph 1.4.), but the main ones can be traced : ethylene and propylene serve as basic products for the most important plastics; aromatics form the basis for the synthesis of non-cellulosic fibres; butadiene is involved in the production of the principal synthetic rubbers. Methanol is used essentially for the production of formol, one of the constituents of adhesives.

Table 1.2 shows the relative importance of the basic hydrocarbons. World consumption of ethylene amounts to roughly double that of propylene or benzene.

TABLE 1.2

PRODUCTION OF BASIC PRODUCTS

10^3 T

	1965	1970	1976
Ethylene			
United States	4 600	7 700	9 900
Western Europe	2 000	5 950	9 600
Japan	900	3 050	3 800
Others	500	1 800	2 700 (1)
Total	8 000	18 500	26 000
Propylene			
United States	2 400	3 900	4 400
Western Europe	1 100	3 280	5 100
Japan	700	1 850	2 600
Others	200	500	1 600 (1)
Total	4 400	9 530	13 700
Butadiene			
United States	1 100	1 400	1 500
Western Europe	400	880	1 400
Japan	100	450	590
Others	300	400	1 400 (1)
Total	1 300	3 030	4 890
Benzene			
United States	2 700	3 900	4 500
Western Europe	1 450	2 750	4 100
Japan	380	1 570	1 900
Others	250	600	2 800 (1)
Total	4 780	8 820	13 300
P.xylene			
United States			1 500
Western Europe			750
Japan			550
Others			300
Total			3 100

(1) Estimated and including Eastern Europe production.

1.4. COMPLEXITY AND DIVERSITY OF THE PETROCHEMICAL INDUSTRY

The petrochemical industry is one which is relatively complex, in particular from the point of view of the many technical possitilities offered to a future producer. Several basic products are required for the production of some intermediates such as styrene or dimethylterephthalate. One intermediate may be used in the production of several end products, the uses of which may be very different : this is particularly so in the case of styrene, which is the raw material from which SBR rubber and polystyrene plastic are produced. The same intermediate, caprolactam for instance, may be derived from different basic products, i.e. benzene or toluene. One end product may be obtained in several different ways : for example, polyester fibres may be produced either from terephtalic acid or from dimethylterephtalate and ethylene

In addition, the basic materials, namely olefins and aromatics, may be produced in various ways. Production of benzene may be linked to that of ethylene, if it is extracted from pyrolysis gasoline; or on the other hand it may be independent, if a method involving catalytic reforming of naphtha and extraction from the reformate is chosen; the two may be combined, as one extraction unit may be fed both by a reformate and a pyrolysis gasoline.

It can be pointed out that production of ethylene from ethane does not lead to any petrochimical by-products; on the other hand, if heavier feedstocks such as naphta or gas-oil are used, this involves the co-production of other basic products, namely propylene, butadiene and benzene.

2. WORLD PRODUCTION OF PETROCHEMICALS

2.1. FACTORS AFFECTING THE PRODUCTION OF PETROCHEMICAL PRODUCTS

There are many different types of factors which affect the establishment and development of a given petrochemical industry ; they can be classified as geographical, human, economic, financial and technical.

1. EXISTENCE AND DEVELOPMENT OF A MARKET

The first condition for the setting up of an industry is the existence of a market, i.e. a demand, whether actual or potential. The rapid development of the petrochemical industry is due to the fact that it was able to supply at a competitive price, products with characteristics which were not only constant, but often superior to those of the products, generally natural, which they supplanted.

It should be added that :

- the availability of petrochemical derivatives on the market led to but a few new uses for these products; in fact its only consequence was that it made possible the growth of the demand as far as existing uses were concerned.
- the arrival of petrochemical products on the market had a twin effect on natural products :
  - as concerns prices : not only did prices fall, but the frequent fluctuations in the prices of natural products (for example, natural rubber) were reduced.
  - as concerns production : there was an improvement in the productivity of some natural products (e.g. planting of high-yield rubber) and also in the quality (e.g. quality label for wool and cotton).

These natural products in turn, having become competitive, have since recently been able to turn the tide of the development of petrochemical products :

e.g. an increase in the proportion of natural rubber used in blends for tyre manufacture ; and in the proportion of cotton in polyester/cotton mixtures (65/35 → 50/50).

For final products, the market is linked with other industries and final consumers. For basic and intermediate products the market is constitued by the petrochemical plants themselves.

2. AVAILABILITY OF PETROLEUM RAW MATERIALS

In order for a petrochemical industry to be set up, there must be petroleum raw materials available, either in the form of gas or petroleum fractions obtained through refining. The development and concentration of the petrochemical industry in such areas as North America, JAPAN, and EUROPE were largely due to the existence of suitably priced raw materials : ethane and LPG associated with natural gas in the UNITED STATES ; and naphtha, until recently in excess of the requirements of the petroleum products market, in EUROPE and JAPAN. In the past, a local supply of crude oil was not not a major factor in the development of the petrochemical industry, and with the exception of the UNITED STATES where the petrochemical industry is based on gas, most of the countries where the petrochemical industry is well developed are not themselves producers of crude oil. The existence of gas or of a refining industry which can supply gas oil or naphtha is much more important. The proportion of raw materials used in petrochemistry, out of the total crude oil and gas produced, although constantly growing, is still small. It was less than 1 % in 1950 and is now somewhere between 4.5 and 5 %.

3. EXISTENCE OF A REFINING INDUSTRY

The existence of a large-scale refining industry is an important factor as far as the petrochemical industry is concerned. On one hand it is an indispensable source of some raw materials : for instance, in order to produce 300,000 tons/year of ethylene, more than 1 million tons/year of naphtha are required, and such a quantity, unless it is imported, can only be obtained from a refinery with a capacity of 5-6 million tons/year. On the other hand the refining industry enables a large quantity of by-products from petrochemistry to be valorized. The production of 1 ton of ethylene by the steam cracking of naphtha automatically yields about 0.2 tons of LPG and 0.65 tons of gasoline, which can only be fully valorised through blending with refinery products. Finally, the refining and petrochemical industries rely on technologies which are in some respects fairly similar. The presence of personnel who are experienced in the operation and maintenance of refining plant is of great benefit to a petrochemical industry which is just starting up.

4. AVAILABILITY OF MANPOWER

The technology used in the petrochemical industry is in some respects very complex, involving the latest technical developments in several fields, including of course chemistry, but also metallurgy, mechanics and electronics. The personnel in charge of the operation and maintenance of plants is therefore made up essentially of a highly specialised work force. In view of the large sums invested and the effect of too frequent stoppages on the profitability of the plant, it is advisable that the operation and maintenance of petrochemical plants should be in the hands of very experienced personnel. The problems of training engineers, foremen, operators, maintenance specialists and chemists are a decisive factor, and training involves considerable expenditure.

The personnel requirements of the petrochemical industry, particularly the basic industry are, however, relatively limited in proportion to the tonnage produced and particularly to the amount of investment. A complex based on a steam cracker capacity of 400,000 tons/year of ethylene and producing 530,000 tons/year of plastics (polyethylene, PVC, polypropylene); 40,000 tons/year of polybutadiene rubber; 150,000 tons/year of aromatics; 40,000 tons/year of acrylonitrile and over 400,000 tons/year of petroleum products, and with investments approaching 1,000 million U.S. $ (1974 conditions) would require for operation, maintenance and general services a staff of 2,050 of whom only 30% could be classed as unskilled workers.

Personnel requirements are greater, compared to the tonnage produced, for end products than for basic products. This is illustrated by the following table which shows the personnel required for the operation of various petrochemical plants. A steam cracker which produces 400,000 tons/year of ethylene and also over 1 million tons of basic petrochemical and petroleum products has about the same operational manpower requirements as a polyethylene plant with an output of 220,000 tons/year. A PVC plant operates with twice the number of personnel required for the corresponding vinyl chloride unit, although the capacity is practically the same. Synthetic fibres constitute a special case in the petrochemical industry, for a very large staff is required for production, of the which the majority, who are engaged in handling, are unskilled.

5. MEANS OF FINANCING INVESTMENT

The petrochemical industry is a heavy industry requiring very considerable investment.

To give some idea of the order of magnitude of investments in the petrochemical industry it can be mentioned that in 1973 and 1975 Japan invested almost 2,000 million U.S. $ in their local petrochemical industry, and at the present day an integrated petrochemical complex centred around a steam cracker with a capacity of 400,000 tons/year of ethylene requires investments amounting to more than 1,000 million U.S. $. Access to means of financing these very high investments (ploughing back of profits, shareholders' contribution or external sources of finance through long-term loans) has been and will increasingly be a major element governing the development and setting up of the petrochemical industry.

TABLE 1.3

OPERATION MANPOWER FOR SOME PETROCHEMICAL UNITS

Unit	Capacity tons/year	OPERATING MANPOWER			
		Engineers	Foremen Technicians	Skilled workers	Unskilled workers
Steam cracking	400 000 (ethylene)	7	16	41	10
Vinylchloride	250 000	2	11	47	12
PVC	240 000	3	17	88	30
Low density polyethylene	220 000	2	11	60	20
Nylon filament	6 000	2	18	130	150

6. DEVELOPING A TECHNOLOGY - THE IMPORTANCE OF RESEARCH

The spectacular development of the petrochemical industry, due to the increasingly competitive nature of the products marketed, was made possible only through the continuous perfecting and improvement of a technology, thanks to particularly large sums being set aside for research. Between 1960 and 1970 the budget devoted by the leading chemical companies to the perfecting of existing techniques and the development of new processes was equivalent to 2-4% of their turnover in the United States and Europe. Companies engaged in production were not the only ones to undertake such research : engineering companies and companies specialising in the development of processes were also very active in this field, with a view to being able to offer more and more competitive techniques to their ever-growing clientele. This constant, sustained effort accounts on one hand for the relative complexity of the petrochemical industry, mentioned earlier, and on the other hand for the upheavals which take place within the industry whenever a new technique is perfected, as well as its capacity for adaptation to changing economic situations. Examples include the changeover from acetylene to ethylene as the main base material; the progressive replacement in the United States of the production of butadiene from butane by the extraction of C_4 cuts from steam cracking; the use of heavier and heavier feedstocks for the production of olefins; the construction of ever-larger production units. One of the most important fields of research concerned the continual improvement of the quality of end products, e.g. the mechanical properties of synthetic rubber and plastics; the solidity, homogeneity and greater receptivity of synthetic fibres to dyestuffs; the degree of biodegradability of detergents. The two main lines of research, lowering of production costs and improving the quality of products, led to the expansion of the market for petrochemical products, a major factor in the growth of the industry.

The amount of research and technological development achieved has of course only been made possible through the initial revenue realised by the petrochemical industry, particularly through having low-priced raw materials available, thus enabling this industry to compete from the very beginning with the natural products.

Of course as far as any company or country is concerned the development of a technology is not a prerequisite for the setting up of a chemical industry, since a new producer can have access to a production technology once the necessary licences have been acquired.

7. *EXISTENCE OF A PROCESSING INDUSTRY*

The end products of the petrochemical industry are not sold directly to the ultimate consumers. The petrochemical industry finds its outlets in other industries - the plastics processing industry, the textile industry, the tyre industry, the detergent industry. If these industries are not already present in a given country or area, there are no effective outlets for a petrochemical industry, even if there is a considerable market demand at the level of the ultimate consumers, for finished products such as tubes, films, material, tyres. The existence and development of a processing industry are indispensable where petrochemicals are to be produced. The processing industry must also be technically capable of using petrochemical products; some problems have arisen, in the textile and tyre industries in particular. Processing industries are very different in nature from the petrochemical industry : they do not require nearly such high investment, they employ a very large workforce, and their threshold of economical size is much lower. Their production capacity matches market growth fairly closely, on account of their relatively small unit size. The processing industries have in fact received a great deal of aid from the petrochemical industry, particularly in the industrialised countries, in the form of after-sales service, promotion of end products and constant improvements in the quality of petrochemical products.

The processing industry is the customer of end products petrochemicals, consequently, its existence or lack affects also basic and intermediate petrochemicals production.

2.2. RELATIVE IMPORTANCE OF THESE FACTORS

Actually the hereabove described factors affecting the production of petrochemical products are not of the same importance and their impacts can be different according to the petrochemical product considered. They can be classified in the following way :

1. *ESSENTIAL FACTORS*

- Existence of a market either domestic or resulting from either favourable production economy conditions or international agrements.
- Means of financing investment either from local ressources or from external cooperation or through foreign participation.
- Raw material availability. Gas or condensate ressources or refining industry processing domestic or imported crude. A basic petrochemical industry could be theoritically based on imported raw material (naphtha, gas-oil, condensate). Such an industry would be too much dependant of external circonstances. This availability is a need only as concerns basic products (olefins, aromatics, methanol)

2. *IMPORTANT FACTORS*

More specificly a present lack of these factors could be reasonably considered as possible to solve in the majority of the countries.

- *Existence of a processing industry*
  The existence of a processing industry is indispensable for a petrochemical industry turned towards domestic market. In the great majority of the countries,processing industry precede petrochemical industry. Nevertheless in some cases intensive must be given to the processing industries in order to eliminate this constraints.
- *Manpower availability*

  All the sectors of the petrochemical industry require a highly specialized work force. Their formation must be considered as soon as the decision of implementation is taken ; nevertheless the possibility of local manpower formation or availability is in many cases impossible in totality.

The solution is to call from external cooperation. There are in industrialized countries several companies specialized in providing people and teams able to operate or to participate to the operation of petrochemical plants.

3. *OTHER FACTOR*

Existence of a technology

Existence of a technology is not indispensable for the setting up or the development of a petrochemical industry.

The initial japanese and to a lesser extend West European petrochemistry have been based up on technology imported from the U.S. The totality of the petrochemistry set up in the developing countries uses technologies developed in United States, Canada, Japan and Europe. Of course, this obligation to buy licences representing in some cases notable amounts of money will have unfavorable impacts upon the profitability and mainly the foreign currency balance of the project. Due to the present spreading out of the petrochemical technology there is no monopolistic position as concerns the availability of technology relative to the different fields of petrochemistry.

2.3. LOCALISATION OF THE PETROCHEMICAL INDUSTRY

The main factors governing the existence and development of a petrochemical industry, which have been analysed in the preceding paragraph, have generally been present together in the industrialised regions, hence the privileged development and the concentration of the industry in these regions.

In fact plants in EUROPE, the UNITED STATES and JAPAN account for 92 % of world ethylene capacity, 97 % of world benzene capacity and 93 % of world butadiene capacity. The importance of these regions in terms of production capacity also extends to intermediates and end products, for in these regions are located more than 90 % of the facilities for intermediate products and for plastics and synthetic rubber production.

Very few of the developing countries in fact have a sizeable basic petrochemical industry in operation at present : those which do include BRAZIL, MEXICO, VENEZUELA, ALGERIA, the REPUBLIC of KOREA and TAIWAN. Some other countries have important projects in view, some of which are already at the implementation stage. Taking into consideration the projected plants that will start up before 1983, the share of the developing countries in the petrochemicals production will grow. The ethylene capacity in LATIN AMERICA, AFRICA (1), ASIA (2), will increase by about 2 times from now to 1983 ; during the same period the increase of the capacities in EUROPE, UNITED STATES and JAPAN will be lower than 40 %.

The capacities of production in 1977 of the main petrochemicals by region and by countries are given in the following tables.

(1) *Excluding* SOUTH AFRICA

(2) *Excluding* JAPAN.

Some of these data can be altered within a short range, as for instance :

- Capacities of production of ethylene and propylene which depend on the feedstocks used and the actual severities of the operation,

- Capacities of production for aromatics which relate to the processed crude and the operating conditions in the plant.

In some fields like synthetic fibres and detergents, from habits and because of small size and easy construction of additional production lines that are usually implanted inside existing factories,companies are not used to announce their projects, and the production capacities could be higher than indicated in the tables.

TABLE 1.4

EXISTING CAPACITIES

BASIC PRODUCTS

10^3 tons/year

COUNTRIES / PRODUCTS	Ethylene	Propylene	Butadiene	Benzene	P.xylene	O.xylene	Methanol
WESTERN EUROPE	14 165	8 020	2 153	5 802	1 220	848	3 920
EASTERN EUROPE	2 955	1 553	340	3 460	327	285	2 513
NORTH AMERICA	14 450	7 100	2 270	6 400	1 908	603	4 624
LATIN AMERICA	1 455	410	205	349	100	75	264
NORTH AFRICA	120	-	-	-	-	-	110
EAST AND WEST AFRICA	-	-	-	-	-	-	-
SOUTH AFRICA	200	-	20	-	-	-	17
MIDDLE EAST COUNTRIES	190	40	33	-	-	-	54
SOUTH ASIA	192	100	36	69	17	-	33
EAST ASIA (1)	480	215	77	134	42	-	585
JAPAN	4 510	2 800	872	2 550	636	315	1 164
PACIFIC AREA	290	80	34	-	-	-	33
WORLD TOTAL	39 007	20 306	6 040	18 764	4 250	2 126	13 317

(1) excluding JAPAN

TABLE 1.5

EXISTING CAPACITIES

INTERMEDIATE PRODUCTS

10^3 tons/year

COUNTRIES \ PRODUCTS	Ethylene oxide	Vinyl chloride	Styrene	MONOMER FOR SYNTHETIC FIBRES					
				Caprolactame	Acrylonitrile	DMT	TPA	ADIPIC ACID	HEXAMETHYLENE DIAMINE
WESTERN EUROPE	1 730	4 860	2 945	800	1 110	1 220	515	840	255
EASTERN EUROPE	302	1 195	164	419	275	667	45	9	n.a.
NORTH AMERICA	2 450	3 100	3 580	430	745	1 923	890	795	470
LATIN AMERICA	65	357	150	74	23	149	55	32	12
NORTH AFRICA	-	-	-	-	-	-	-	-	-
EAST AND WEST AFRICA	-	-	-	-	-	-	-	-	-
SOUTH AFRICA	-	42	18	-	-	-	-	-	-
MIDDLE EAST COUNTRIES	-	69	25	-	-	-	-	-	-
SOUTH ASIA (1)	12	191	36	20	-	24	-	-	-
EAST ASIA	-	166	100	80	102	77	-	-	-
JAPAN	490	2 290	1 535	460	675	740	750	30	5
PACIFIC AREA	15	47	30	-	-	-	-	-	-
WORLD TOTAL	5 064	12 317	8 557	2 283	2 931	4 800	2 255	1 706	> 742

(1) excluding JAPAN

TABLE 1.6

EXISTING CAPACITIES

PLASTICS

10^3 tons/year

COUNTRIES \ PRODUCTS	Ld polyethylene	Hd polyethylene	PVC	Polypropylene	Polystyrene
WESTERN EUROPE	4 920	2 055	4 710	882	2 831.5
EASTERN EUROPE	725	250	1 511	200	404
NORTH AMERICA	3 725	1 575	3 235	1 430	2 300
LATIN AMERICA	440	30	333.5	-	250
NORTH AFRICA	-	-	-	-	-
EAST AND WEST AFRICA	-	-	-	-	-
SOUTH AFRICA	70	50	40	22	7
MIDDLE EAST COUNTRIES	55	-	77	-	31
SOUTH ASIA	55	30	216	20	82
EAST ASIA (1)	245	-	190	30	86
JAPAN	1 300	630	1 833	960	900
PACIFIC AREA	100	70	47	28	55
WORLD TOTAL	11 635	4 690	12 200.5	3 582	7 034.5

(1) Excluding JAPAN

TABLE 1.7

EXISTING CAPACITIES

10^3 tons/year

PRODUCTS / COUNTRIES	SYNTHETIC RUBBERS		DETERGENTS		SYNTHETIC FIBRES		
	Styrene Butadiene Rubber	Poly-butadiene	Alkyl-benzene	Detergent range alcohol	Polyester fibres	Polyamide fibres	Acrylic fibres
WESTERN EUROPE	1 511	373	733	381.5	1 200	1 079	1 030
EASTERN EUROPE	1 097	310	15	≥ 37	429	426	203
NORTH AMERICA	1 790	405	400	355	2 200	1 303	307
LATIN AMERICA	227	58	605	-	410	194	75
NORTH AFRICA	-	-	-	-	-	3	-
EAST AND WEST AFRICA	-	-	-	-	5	-	-
SOUTH AFRICA	30	-	-	-	36	15	-
MIDDLE EAST COUNTRIES	32	13.5	10	-	69	31	31
SOUTH ASIA	30	-	> 27	4	204	65	1
EAST ASIA (1)	148	-	13	-	> 524	170	173
JAPAN	439	300	100	150	525	350	270
PACIFIC AREA	50	20	7	-	-	32	-
WORLD TOTAL	5 354	1 479.5	≥ 1 990	≥ 927.5	5 778	3 668	2 170

(1) excluding JAPAN

3. WORLD DEMAND FOR PETROCHEMICALS

3.1. FACTORS AFFECTING THE DEMAND

In this paragraph the principal factors responsible for variations in demand in the world's main consumer areas will be analyzed.

1. EXISTENCE OF A MARKET

The rapid growth in the demand for petrochemical products since the end of the Second World War can be explained by the fact that these products :

- have properties, both physical and mechanical, which are perfectly suited to their uses,
- can easily be substituted for products already on the market,
- are sold at competitive prices.

In the early stages, the quality of the petrochemical products which came on the market was far from being perfect, and this in some cases was detrimental to the trade image of coal-derived and petroleum-derived substitutes, and thus held back market growth. Examples of this include the premature ageing of plastics (PVC) and more generally, a lack of constancy in the technical characteristics of the products sold.

These problems have now been resolved :

- either by incorporating additives into the end products,
- or, more often, by increasing the range of grades of products, each grade having its own particular specifications. Thus, the sales catalogue of one of the major polypropylene producers includes nearly 40 grades of this polymer (homopolymers and copolymers), without taking into account differences due to colour. It should be noted that the characteristics of the different grades of one product are determined not only by the properties of the end product to be obtained but also by the process method -injection moulding, extrusion

in case of plastics- and by the production rhythms. In view of the usual requirements of the users (transformers) that part of the production which does not meet the strict specifications -off-grade material- is sold more cheaply, generally without the manufacturer's brand name.

In several cases, inadequacy of the properties has limited the development of the demand for petrochemical products. Examples include :

- the poor receptivity of polypropylene to dyestuffs, which for a long time prevented this polymer from being used in the textile industry. This difficulty has now been overcome,

- their highly inflammable nature and the nocuous fumes given off during combustion have always been a barrier to the growth of the demand for polyurethane and PVC in the construction industry,

- the ability of a monomer (vinyl chloride, styrene) to migrate through the walls of the corresponding polymer has recently limited the use of the latter, particularly in the food industry. The harmful effects of these monomers first came to light in the factories where they were produced, where a relatively high concentration of monomers was found to be present in the atmosphere,

- docecyl benzene sulphonate -based detergents, the use of which leads to increased pollution of rivers, etc .., have now fortunately been replaced by biodegradable detergents (of the linear alkylbenzene type) in all areas where there is a high risk of increased water pollution.

All these examples are in fact merely exceptions. In most cases petrochemical products have been able to supplant the products already on the market, mostly natural products such as rubber, wool, cotton, wood, metal and soap, or artificial materials such as cellulose fibres, paper and cardboard. However, there are very few instances of total substitution, since :

- either a mixture of a certain proportion of petrochemical products with a certain proportion of natural products turns out to be best suited to the uses for which it was developed, e.g. :

  - rubber mixture used in tyre manufacture

  - polyester/cotton mixture for certain uses in the textile industry,

- or else, stimulated by the competition presented by petrochemical products, the productivity of natural resources has been improved (e.g. planting of high yield rubber) or in some cases, the quality of natural products has become established (quality labels for wool and cotton).

The competition between natural and petrochemical products is strongest at the level of the relative prices. For many years the lower price of petrochemical products forced producers of natural products to reduce their prices, for example natural rubber. Another effect of this competition was to stabilise the price of raw materials of natural origin.

Lately, however, the rising price of polyester fibres has led to the producers increasing the proportion of cotton in polyester/cotton mixtures (the proportion is now 50/50 instead of 65/35 as previously).

2. STANDARD OF LIVING

The main factor in the growth in the demand for petrochemical products is, as is generally so, the rising standard of living of consumers (hence the interest of a macro-economic approach in estimating future requirements) : this rise leads to a growth, at least equivalent and often considerably greater (1) in the demand in the various sectors of application e.g. construction, transport, packaging, clothing, etc...

(1) *positive elasticity (>1) in the case of most petrochemical products*

3. DEGREE OF PENETRATION OF PETROCHEMICAL PRODUCTS IN THE SECTORS OF USE

This is the second and important factor in the growth in the demand for petrochemical products. If the product marketed is well suited to the demand in its sector of application -as is the case for most of the major petrochemical products on the market at present- the initial rate of growth is rapid, with a subsequent tendency to slow down as a relative saturation point is reached. The growth in the demand for petrochemical products then resembles that of the sector of application as a whole.

It should be noted that market penetration may be either :

- partial, as in the case of synthetic rubber on the total rubber market. From observations made in those countries where the degree of penetration is greatest (the UNITED STATES, EASTERN EUROPE) this is seen to reach a ceiling at about 80 % of the total,
- or total, as in the case of low density polyethylene bags and, secondarily, woven polypropylene bags. These have entirely replaced the paper bags previously in use.

4. THE POTENTIAL MARKET FOR PETROCHEMICAL PRODUCTS

Even from a very long term point of view, the potential market for plastics appears to be practically unlimited, considering the many possible uses for these materials, particularly in packaging, transport and especially construction. Future consumption can therefore be expected to be in the order of hundreds of kg per head.

The potential market for synthetic rubber and fibers, on the other hand, is much smaller. It is in fact restricted respectively (limiting factor) to :

- uses in car manufacture and in industry, and a few domestic uses,
- clothing and one or two industrial or domestic applications (furnishings, etc..).

The demand in these fields of application cannot be expected to exceed some tens of kg per head.

The result is that the growth in the demand for synthetic fibres, which has been particularly pronounced in recent years in the industrialized countries, will soon be limited in these countries on account of :

- the present high degree of substitution of synthetic fibres on the total chemical fibres markets,
- the mediocre potential of the textile industry as a whole.

The same comment can be applied "mutatis mutandis" to synthetic rubber.

5. PRICES

As in the case for all consumer goods, the demand varies in inverse proportion to the price. Thus, the sustained fall in the price -expressed as a constant value- of plastics during the sixties and early seventies definitely encouraged the growth in demand in their various areas of use. Conversely, the considerable rise in the price of plastics and other petrochemical products would normally have resulted in a sharp drop in the demand for these products. However, this effect was limited due to the simultaneous rise, generally in at least equal proportions, in the price of rival products : wood, paper, cardboard, non-ferrous metals (in the case of plastics), natural rubber (in the case of synthetic rubber), natural fibres (in the case of synthetic fibers). Where the arbitrage, due to prices, between natural and petrochemical-derived products is not limited by technical considerations, it occurs readily (for example, variation in the proportions of the constituents of polyester/cotton mixtures : 65/35$\rightleftarrows$50/50).

In other cases, the requirements or the habits of the processors must be more closely adhered to (for example, slight variations in the proportion of natural rubber to synthetic rubber for each different type of tyre manufactured).

Since recently there has been a tendency towards savings in materials by avoiding wastage : this is so for all kinds of materials including, for instance, plastics used in packaging. The practice of excessive packaging in this sector has thus been checked.

In addition to variations in the price of petrochemical products compared to other rival raw materials, the part played by variations in the prices of petrochemical end products themselves should be mentioned. The most striking example in this respect is that of large tonnage polymers. As a result of differentiated price increased in recent years, the price of these polymers presently lies in the range of 25-30¢/lb. Over a large range of applications, with the exception of films, this is favourable in particular to the demand for Hd polyethylene and polypropylene, as these two polymers were previously dearer than the others.

6. LOCAL PRODUCTION

The setting up and subsequent development of a local petrochemical production plant undeniably leads to an acceleration of local demand. This effect is not always felt at once, however, on account of :

- import restrictions (customs barrier set up to protect a new industry)
- the problems of supplying the market at the moment of start-up
- the reluctance of manufacturers (processors) to use a locally made product, the specifications of which are often initially considered inferior to those of the products previously imported.

The existence of a national processing industry has a definite influence on the development of local demand :

- The presence of this industry, generally spread over the country, tends to make the product better known to the consumers than it would be if it were merely imported (effect of diffusion),

- Local processing with a high added value (especially in the case of textiles, less so for everyday plastics) means that local production shoul. be cheap compared with imported end-products, particularly if labour costs are also low.

The case of tyre manufacture, by far the largest user of rubber, is different : the setting up of such an industry, (usually controlled by large international companies) has no appreciable direct effect on the local market. Besides, any one plant, even a fair sized one, does not produce the whole range of tyres required by the consumers. The situation would be quite different in the case of a car assembly plant possibly using locally manufactured tyres.

7. THE LIFE CYCLE OF PETROCHEMICAL PRODUCTS

It is established fact that every product passes-through five schematic phases in the course of its economic life, and these phases are always the same :

- Phase 0 Discovery and experiment (or birth)
- Phase I Take-off (or childhood)
- Phase II Development and industrialization (or adolescence)
- Phase III Stabilization (or maturity)
- Phase IV Decline (or old age).

Phases I and II correspond to a rapid growth in demand, Phase III to a steady, generally regular growth, and finally Phase IV to a reduction in the volume of demand.

In the case of the petrochemical industry, which is still young, most products are in Phases II and III. Exceptionally, however, a few products have rapidly reached Phase IV. This is notably the case of dodecylbenzene sulphonate (a detergent base) which being non-biodegradable tends to increase water pollution. The perfecting of biodegradable detergents made it possible to impose a ban on the use of hard, DDB sulphonate-based detergents, at least in already heavily polluted areas. The use of DDT-based insecticides has rapidly declined for the same reason.

Conversely, as a result of unceasing research, numerous petrochemical products are still being developed and launched on the market (Phases I and 0).

These are usually very specific products, with a relatively high value compared to their weight but for which the market is very small.

The general feeling is that in the foreseeable future there is little likelihood of a major discovery in petrochemistry which would have an appreciable effect on the present pattern of the consumption of the major products (and the corresponding intermediates) at present on the market.

3.2. SIZE OF THE MARKETS - GEOGRAPHICAL BREAKDOWN

The following Tables show up the present (1973-1975) size and localization of the main types of petrochemical end-products.

1. PLASTICS (table 1.8)

In 1974* World consumption of plastics (excluding CHINA) reached nearly 45 MT of which around 90 % was used by industrialized countries.

World consumption breakdown is presented below :

. Western EUROPE	34.5 %
. Eastern EUROPE	10.0 %
. North AMERICA	31.0 %
. JAPAN	13 %
. South AFRICA, PACIFIC AREA	2 %

The share of the developing countries (excluding CHINA) in World market was successively from 1973 to 1975 : 9.2, 9.35 and 11.5 % of World total.

The following regional breakdown of World plastic consumption is obtained by comparing each region concerned to the developing countries total :

* *We refer to the year 1974 because of the drop in demand recorded during the following year in the industrialized countries. In most cases 1976 figures were again at 1974 level.*

TABLE 1.8

PLASTICS - WORLD DEMAND

Excluding Mainland China

Unit : 1000 tons

REGIONS OF THE WORLD	1973	1974	1975
WESTERN EUROPE	14 660	15 430	12 330
EASTERN EUROPE	3 803	4 500	5 150
NORTH AMERICA	14 036	13 872	11 185
LATIN AMERICA	1 634	1 923	1 907
AFRICA	632.5	724	810
NORTH AFRICA	199.5	220	240
WEST AFRICA	81.5	102	115
EAST AFRICA	99	108	120
CENTRAL AFRICA	52.5	64	75
SOUTH AFRICA	200	230	260
ASIA excl. CHINA	7 450	7 554	6 429
MIDDLE EAST	390	405	445
EAST ASIA excl. JAPAN	583	576	659
JAPAN	5 600	5 800	4 470
SOUTH ASIA	877	773	855
PACIFIC AREA	550	600	650
TOTAL WORLD	42 765.5	44 603	38 461
of which developing countries	3 916	4 171	4 416

- LATIN AMERICA 46
- AFRICA, excepting SOUTH AFRICA 12
- ASIA, excepting JAPAN 42

2. MAN-MADE FIBRES - SYNTHETIC FIBRES

The World demand for man-made fibres amounts to one quarter of World demand for plastics.

The share of the industrialized countries is around 80 % of this total, therefore considerably less important than in the previous case.

World breakdown of demand, not very different from that of plastics, is shown below :

- Western EUROPE 23.2 %
- Eastern EUROPE 16.7 %
- North AMERICA 28.3
- JAPAN 8.4 %
- South AFRICA, PACIFIC AREA 2.3 %

The share of the developing countries in World market was successively, from 1973 to 1975 : 18.75, 20.35 and 22.75 % of the total.

The regional breakdown is as follows :

- LATIN AMERICA 28.9 %
- AFRICA, excepting SOUTH AFRICA 10.0 %
- ASIA, excepting JAPAN 61.1 %

The very last figure is due to the influence of the local textile industry, heavily export-oriented, on the local market.

TABLE 1.9

MAN-MADE FIBRES - WORLD DEMAND

Unit : 1000 tons

REGIONS OF THE WORLD	1973	1974	1975
WESTERN EUROPE	2 790	2 570	2 231
EASTERN EUROPE	1 700	1 850	1 900
NORTH AMERICA	3 383	3 128	2 839
LATIN AMERICA	593.1	850.6	828.9
AFRICA	345.5	361.9	370
NORTH AFRICA	116.5	114.1	125
WEST AFRICA	45.2	51.3	55
EAST AFRICA	43.5	46.8	50
CENTRAL AFRICA	13.0	13.9	15
SOUTH AFRICA	127.3	135.8	125
ASIA incl. CHINA	2 370.4	2 308.6	2 410.0
CHINA	362.3	262.1	350.0
MIDDLE EAST	143.4	166.7	150
EAST ASIA excl.JAPAN	202	233	295
JAPAN	1 064.3	931.5	865
SOUTH ASIA	598.7	693.4	730
PACIFIC AREA	140.1	193.3	180
TOTAL WORLD	11 302	11 081	10 539
OF WHICH DEVELOPING COUNTRIES	2 117.4	2 251.8	2 398.9

TABLE 1.10

SYNTHETIC FIBRES - WORLD DEMAND

Unit : 1000 tons

REGIONS OF THE WORLD	1973	1974	1975
WESTERN EUROPE	1 930	1 770	1 840
EASTERN EUROPE	880	830	950
NORTH AMERICA	2 734	2 591	2 475
LATIN AMERICA	428.9	497.0	485.7
AFRICA	179.5	198.9	203.
NORTH AFRICA	48.3	50.8	57
WEST AFRICA	25.4	29.3	33
EAST AFRICA	18.8	21.3	24
CENTRAL AFRICA	8.7	9.4	11
SOUTH AFRICA	80.3	88.3	78
ASIA excl. CHINA	1 542	1 498.8	1 585.0
MIDDLE EAST	88.8	118.7	110
EAST ASIA excl. JAPAN	148.9	185.8	230
JAPAN	755.2	855.1	585.
SOUTH ASIA	319.2	382.7	380
PACIFIC AREA	109.7	155.4	(140)
TOTAL WORLD	7 804.1	7 538.1	7 478.7
of which developing countries	1 314.9	1 451.3	1 830.7

Synthetic fibres account for around 70 % of the man-made fibres world market. This figure keeps growing gradually. It is usually a little lower in the developing countries.

Differences between the geographical breakdown of the synthetic fibres market and the breakdown of man-made fibres market are due to the differences of penetration rates of synthetic fibres into the total man-made fibres market.

Industrialized contries (1974) : 81 % of World total :

. Western EUROPE	23.5 %
. Eastern EUROPE	11.0 %
. North AMERICA	34.4 %
. JAPAN	8.7 %
. South AFRICA, PACIFIC AREA	3.2 %

Developing countries alone (1974) :

. LATIN AMERICA	34.3 %
. AFRICA, excluding SOUTH AFRICA	7.6 %
. ASIA, excluding JAPAN	58.1 %

From 1973 to 1975 the share of the developing countries of World total was successively : 17.3, 19.25 and 21.8 %.

3. *SYNTHETIC DETERGENTS*

Data concerning world detergent market are lacking or often contradictory. Nevertheless the market can be estimated to reach around 12.5MT.This corresponds to a formulated detergent tonnage as delivered to industrial or domestic consumers.

These detergents take the form of :

- Surface active finished detergent powder (65-66 % of total for Western EUROPE, 70 % of total for JAPAN)
- Scouring powder (7-8 % of total)
- Liquid detergents (27 % of total for Western EUROPE, 23 % of total for JAPAN).

There are many constituants for formulated detergents ; the most used among them being phosphate builder (sodium tripolyphosphate which generally represents 30-35 % of formulations) and other soda salts : sulphate, perborate, silicate, carbonate, etc..

The petrochemical active material only accounts for an average fo 20 % of formulated product tonnage. This percentage fluctuates a great deal from one country to the other depending on washing habits.

The share of the industrialized countries in World market is 80 %.

World market breakdown is as follows :

Western EUROPE	30.4 %
Eastern EUROPE	13.8 %
North AMERICA	24.9 %
JAPAN	7.8 %
South AFRICA, PACIFIC AREA	2.5 %

TABLE 1.11

SYNTHETIC ORGANIC DETERGENTS - WORLD DEMAND

REGIONS OF THE WORLD	1973	1974	1975
WESTERN EUROPE	4 000		3 300
EASTERN EUROPE			1 500
NORTH AMERICA	3 000		2 700
LATIN AMERICA			900
AFRICA			250
NORTH AFRICA			110
WEST AFRICA			50
EAST AFRICA			40
CENTRAL AFRICA			25
SOUTH AFRICA			25
ASIA excl. CHINA			1 950
MIDDLE EAST			150
EAST ASIA excl.JAPAN			400
JAPAN	900		850
SOUTH ASIA			550
PACIFIC AREA			250
TOTAL WORLD			10 850
of which developing countries			2 225

3.3. DEVELOPMENT OF THE DEMAND FOR PETROCHEMICAL PRODUCTS BETWEEN 1965 and 1975

1. GENERAL

During the 1960's and up till 1973 world demand for petrochemical products grew considerably. By the end of this period, however, a certain decline in the growth rate was already being felt. 1974 was characterized by a slight but unprecedented drop in world demand followed in 1975 by a further appreciable decline. On the basis of preliminary results for 1976, world demand for that year regained a level close to the 1973 maximum.

The following table shows the growth rates of the demand for the main families of petrochemical products during the two successive periods 1965-70 and 1970-75 in the major areas. The growth rates of this demand for industrialized countries (where the drop in demand in 1974-75 was the sharpest) are indicated for 1970 to 1974 or 1976 so as to give a better idea of the trends in the medium or long run.

On the whole, we can note that the demand rose more sharply during the period 1965-70 than during the following period, especially in the case of plastics.

The growth rates of the demand for synthetic rubber and fibres were higher than those indicated for man-made fibres and rubber, in as much as the former penetrated the total market of the latter.

Also two types of growth in regional demand for petrochemicals can be distinguished : the industrialized countries growth and developing countries growth. The variations are obviously more accute at country level.

T[illegible]

AVERAGE ANNUAL GROWTH RATE OF THE DEMAND FOR PLASTICS, MAN-MADE FIBRES AND RUBBER OVER THE 1965-1975 PERIOD

REGIONS / PERIODS	PLASTICS		MAN-MADE FIBRES		RUBBER		SYNDETS	
	1965/1970	1970/1975	1965/1970	1970/1975	1965/1970	1970.1975	1965/1970	1970/1975
WESTERN EUROPE	15.2	4.8(1)	8.7	0.6(2)	8.3	0.9(3)		0.7
EASTERN EUROPE	-	-	7.8	6.6 (2)	5.3	10.2 (3)	-	-
NORTH AMERICA	9.7	3.4(1)	8.4	3.5(2)	3.9	0.8(3)	4.1	2.3(4)
LATIN AMERICA	21.3	15.7	10.8	12.8	10.95	9.75	12.7	8.45
AFRICA. excl. S.AFRICA	17.7	17.0	6.55	9.75	3.85	8.3	-	-
NORTH AFRICA	19.1	18.4	10.7	7.35	7.8	6.1	17.5	8.25
WEST AFRICA	19.8	16.8	7.4	21.6	0.0	5.8	-	-
EAST AFRICA	18.7	12.7	negative	7.5	4.85	14.6	-	-
CENTRAL AFRICA	9.4	20.9	10.0	6.8	4.6	14.9	-	-
SOUTH AFRICA	-	-	3.5	7.2	7.5	9.6	-	-
ASIA excl. JAPAN	22.2	11.65	7.93	13.9	10.0	7.85	-	-
CHINA	-	-	7.8	23.4	9.3	1.8	-	-
MIDDLE EAST	21.5	12.9	5.3	8.9	7.8	11.85	8.45	10.75
EAST ASIA excl. JAPAN	22.9	13.5	34.5	12.75	18.5	10.45	-	-
JAPAN	23.4	0.5(1)	9.45	3.85(2)	15.6	2.2(3)	-	-
SOUTH ASIA	22.1	9.6	8.8	12.0	9.6	9.6	25.6	17.1
PACIFIC AREA	-	-	5.1	6.2 (2)	3.85	0.5(3)	13.6	6.8

(1) *1970/74 : Western Europe : 12.1 ; North America : 10.25 ; Japan : 7.4*

(2) *1970/74 : Western Europe : 4.3 ; Eastern Europe : 7.6 ; North America : 7.0 ; Japan : 6.2 ; Pacific area : 16.8*

(3) *1970/74 : Western Europe : 2.95 ; Eastern Europe : 10.9 ; North America : 5.1 ; Japan : 4.45 ; Pacific area : 6.1*
1970/76 : Western Europe : 2.0 ; Eastern Europe : 9.4 ; North America : 2.85 ; Japan 3.55

(4) *Production - 1970/74 : Western Europe : 4.3 ; North America : 4.8*

- In the first case, the growth of demand is slow and steady, due to the stabilization of markets which are reaching a saturation level (particularly a high rate of substitution exists in these markets).

- The fall in the growth rate in 1974-75 due mainly to economic causes, also reflects a change of attitude on the part of producers and consumers towards petrochemicals.

- As was noticed previously the effect of the rise in the price of these products on the level of the demand has been limited by a simultaneous rise in the price of competing products. As for the future, as already confirmed by the first results recorded for the years 1976-1977, there will appear a new growth pace of demand for petrochemicals, in any case more moderate than before. The growth in demand in the developing countries is typically higher -after a "take-off" phase- but also irregular. However, it must be noted that in developing countries as a whole, the growth in demand was much less affected in 1974-75 than it was in the industrialized countries. This can be explain as follows :

  - economical growth was still generally sustained in developing countries,

  - potential demand remains by far <u>relatively</u> larger.

2. MAIN FEATURES OF THE DEVELOPMENT OF THE DEMAND OVER THE 1965-1975 PERIOD - REGIONAL ASPECTS

A particular attention has been given to the main characteristics of the regional demand for petrochemical products over the 1965-1975 period since these characteristics will still have a large effect upon the development of the demand in the next ten years.

Herebelow, we will successively consider the past evolution of the regional demand for the main types of products : plastics, man-made fibers, rubber with a special emphasis on macroeconomic approach and, then, we will consider the evolution of the main thermoplastics, synthetic fibers and rubbers.

As far as intermediate products and basic products are concerned, the volume and the variations of the demand are simply and directly brought about by final demand.

In fact, the demand for the only 4 major groups of end-products (plastics, synthetic rubber, fibers and detergent) generally correspond to the bulk - in some cases almost the totality-of consumption of basic petrochemicals.

a) *Evolution of the demand for the 4 main groups of end-products : plastics, main-made fibre, rubber, detergents*

Preliminary considerations on interest of macroeconomic approach - especially graphic method - are given in a separate note.
All basic economic data (including forecast for 1980-1985) : population and per capita GDP by regions used for the macroeconomic approach are given in tables 1.13 and 1.14.
For the purpose of the present study, the evolution of the shares of the petrochemical markets held by the main countries in developing regions are indicated in the Table 1.15.

• PLASTICS

Industrialized countries (table 1.15 - fig. 1.1)

Over the 1965-1975 period demand for plastics grew at average rates in the range of 6.7 % p.a (N. America) to 11.4 % p.a. (Japan). This reflects the heavy drop in the demand registered in industrialized countries in 1974-1975. When considering only the 1970-1974 period, demand for plastics still rose by 12.1% p.a. in W. Europe and 10.3% p.a. in North America. In Japan, increase was only 7.4 %. However, in this country, the rate of increase was among the highest in the world over the 1965-1970 period.
At the beginning of the seventies it was already evident that the period of constant growth was coming to an end. Relative saturation of some markets (development expected in some sectors have not been achieved - e.g. building applications) and higher level of prices (although those of the most competitive materials have gone up, too) will be the decisive factors contributing to the slow-down in the expansion of plastic market in industrialized countries.
Referring to the levels of consumption versus income, major consuming areas are found in about the same situation, not far from the "master curve" (See Note). From this point of view, the chances of development of the demand for plastics are not different in the

TABLE 1.13 WORLD POPULATION BY REGION

Millions inhabitants

REGIONS OF THE WORLD	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976	1980	1985	2000
WESTERN EUROPE	323	328.8	330.7	332.8	334.6	338.2	340.1	342.2	343.9	343.9	350.7	359.9	387.3
EASTERN EUROPE	350.3	360.1	363.1	366	369.2	372.3	375.3	378.8	382.5	386.0	400.0	417.5	402.3
NORTH AMERICA	214	221.6	223.9	226.4	228.7	230.8	232.6	234.5	236.8	239.1	248.8	262.3	296.2
LATIN AMERICA	247.1	262.0	275.3	282.8	290.7	298.6	306.7	315.4	323.8	332.8	371.4	425.5	619.9
U.S.A.	194.3	200.7	202.7	204.9	207.0	208.8	210.4	211.9	213.9	215.8	224.1	237.5	264.4
AFRICA													
NORTH AFRICA	75.3	81.9	84.2	86.8	89.2	91.6	94.1	96.7	99.4	102.1	114.5	131.9	194.1
WEST AFRICA	89.1	95.7	98.0	100.34	103	105.7	108.5	111.3	114.2	117.4	131.0	151.4	189.5
EAST AFRICA	87.7	94.7	97.2	99.8	102.5	105.4	108.3	111.4	114.5	117.8	132.0	152.9	239.9
CENTRAL AFRICA	35.7	35.5	39.5	40.5	41.4	42.3	43.3	44.3	45.3	46.4	51.2	58.3	87.7
SOUTH AFRICA	20.8	22.8	23.5	24.2	24.9	25.6	26.2	26.9	27.7	28.5	31.9	36.8	55.7
ASIA													
CHINA	710.3	746.5	759.1	771.8	784.9	798.1	811.5	825.1	838.8	852.6	907.6	973.2	1 148.0
MIDDLE EAST	65.03	70.56	72.53	74.75	76.9	79.1	81.4	83.8	86.2	88.7	99.2	115.5	170.7
EAST ASIA (excl. JAPAN)	55.9	60.0	61.3	62.5	64.	65.3	66.8	68.	69.6	71.1	77.1	85.1	110.3
JAPAN	99.0	101.9	103.2	104.3	105.6	106.9	108.3	109.0	111.1	112.5	117.5	122.5	132.9
SOUTH ASIA	826.5	889.3	912	936.6	961.2	986.5	1 012.4	1 038	1 064.8	1 097.0	1 213.8	1 378.9	1 905.2
PACIFIC AREA	14.0	14.8	15.0	15.4	15.6	15.9	16.1	16.6	16.8	17.1	18.4	20.0	24.5
TOTAL WORLD	3 287 657	3 447 650	3 542 886	3 609 599	3 678 288	3 747 334	3 817 648	3 889 955	3 967 004	4 044 433	4 373 203	4 815 621	6 253 135

TABLE I.14- PER CAPITA GROSS DOMESTIC PRODUCT (G.D.P.) BY REGION

Unit : US $ (1971 Value)

Source : UNIDO (1965-1975)

REGIONS OF THE WORLD	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976	1980	1985	2000	1980/1975	1985/1980
WESTERN EUROPE	1.865	2.070	2.180	2.280	2.340	2.430	2.553	2.520	2.530	2.600	3.005	3.570			
EASTERN EUROPE	1.545	1.680	1.770	1.830	1.895	1.960	2.035	2.100	2.160	2.200	2.490	2.960			
NORTH AMERICA	4.220	4.695	4.780	4.760	4.860	5.100	5.350	5.240	5.130	5.400	6.090	7.235			
LATIN AMERICA	472	507	528	548	567	590	616	632	648		745	865			
AFRICA excl. S. Africa															
NORTH AFRICA	225	245	250	260	260	265	270	280	290		350	415			
WEST AFRICA	130	135	135	153	160	165	170	180	190		240	300			
EAST AFRICA	95	105	110	110	115	115	117	120	123		138	155			
CENTRAL AFRICA	136	140	145	153	157	162	168	174	180		210	242			
SOUTH AFRICA	630	675	705	715	725	730	745	765	780		860	950			
ASIA															
CHINA	188	205	215	225	235	257	270	280	290	302	355	432			
MIDDLE EAST	365	410	425	435	465	490	510	600	650		935	1.310			
EAST ASIA (excl. Japan)	175	220	250	260	270	285	310	330	350		470	625			
JAPAN	1.150	1.575	1.720	1.890	2.000	2.150	2.335	2.300	2.350	2.450	3.145	4.310			
SOUTH ASIA	110	120	125	127	129	130	135	140	145		165	190			
PACIFIC AREA	1.940	2.605	2.715	2.761	2.830	2.910	3.035	3.000	3.050		3.535	4.200			

TABLE I.15- DEVELOPING COUNTRIES - SHARE OF THE PETROCHEMICAL

MARKET HELD BY THE MAIN COUNTRIES IN EACH REGION - 1965 - 1975

Percentage	Plastics			Man-made fibers			Rubber		
	1965	1970	1975	1965	1970	1975	1965	1970	1975
LATIN AMERICA : TOTAL of which		100	100	100	100	100	100	100	100
. Argentina			16	17	10	10	-	15	13
. Brazil			34.5	27.5	31	30	30.7	34	42
. Mexico			21	20.5	22	26.5		23	20
. Andean countries			19.5	21	22	20		19	18
. Others : Caribbean,			9	8	9	5.5	10.5	9	7
Central America				6	6	8.5			
ASIA :									
EAST ASIA excl. Japan TOTAL	100	100	100	100	100	100			
. Hong-KOng	59	41	24	11	13.5	7			
. Taiwan	19	28	31	37	36	50			
. Korea Rep.	19	28	42	49	47.5	40			
. Others				3	3	3			
SOUTH ASIA : TOTAL of which	100	100	100	100	100	100	100	100	100
. India	28	20	17.5	32	34	21	45.5	42	34.5
. Iran	25	18.5	23.5	18	19	16	5.0	6.5	14
. Pakistan	3	4	7	6	4	4	-	-	5
. Indonesia	5.5	12	17	8.5	4	14	-	-	21.5
. Philippines	18.5	18.5	15	8.5	10	10	11	12	11.5
. Singapore	5	4.5	7	11	10	6	-	-	3
. Thailand	10	17.5	10	6	8	7	-	-	7
. Others	5	5	3	10	11	22	-	-	4.5

TABLE 1.15- DEVELOPING COUNTRIES - SHARE OF THE PETROCHEMICAL

MARKETS HELD BY THE MAIN COUNTRIES IN EACH REGION - 1965 - 1975 (CONTINUED)

Percentage		Plastics			Man made fibers			Rubber		
MIDDLE EAST of which :	TOTAL	100	100	100	100	100	100	100	100	100
. Iraq		6.5	4.5	5.5	20	20	17	-	-	5
. Lebanon		11	6.5	7	7.5	9	10	-	-	13
. Israel		38	39.5	31.5	13	11	10	-	-	18
. Turkey		33	39	40.5	25	39	44	-	-	36
. Syria		4.5	4.5	4.5	-	-	-	-	-	-
AFRICA										
NORTH AFRICA of which	TOTAL	100	100		100	100		100	100	100
. Others		10	10		34.5	16		-	-	-
. Algeria		23	34.5	-	6	35	-	50	39.5	33.5
. Egypt		37	18.5	-	21	15	-	22	19.5	20
. Morocco		26	30	-	38.5	34	-	11	13	14.5
. Tunisia		4.5	7	-	-	-		-	-	-
WEST AFRICA of which :	TOTAL	100	100		100	100		100	100	100
. Ivory coast		18.5	19	-	9	15.5	-	-	-	-
. Nigeria		51	47	-	37	47	-	54	48	48.5
EAST AFRICA										
CENTRAL AFRICA of which	TOTAL	100	100		100	100		100	100	100
. Angola		54	38	-	31.3	37	-	37.5	40.0	35

industrialized countries. The single exception concerns the East Europe an countries where the level of consumption versus income is by far lower than in the other industrialized countries. This has mainly resulted from other choices in industrial production by sector, trade policy etc.
But keeping in mind the present level of consumption versus income, in a very long term scope, potential development of the demand for plastics remains large in East Europe an countries.

Developing countries (Table 1.16 - Fig.1.1)

Over the 1965-1975 period, the demand for plastics kept growing at a very fast pace in developing countries. The rate of increase was in the range of 15-20 % p.a. in most of the developing countries.

As above indicated the development of demand was generally less rapid over the 1970-1975 period than it was over the previous 5 years period. In 1974-1975 fall in the demand, if any, was in most countries very limited, by contrast with the situation then observed in industrialized countries. This better strength against the fall in demand under less favourable economic circumstances shows up how high is still the potential demand in developing countries.

Referring to the level of consumption versus income, most developing countries are found in about the same situation, not very far from the "master curve" representative of developing countries. From this point of view, in Africa for example East- and Central Africa regions are found in a more favourable situation than West Africa : to this extent, the prospects of the market are likely better in the latter region.

Still referring to the level of consumption versus income, East Asia emerges among developing countries*. The existence of an export-oriented plastic processing industry (Hong-Kong, Taiwan, Korea Rep.) has undoubtly been a favourable factor of development of the local demand for these materials.

Another point is noteworthy : despite of a very favourable increase of income, development of the demand for plastics is not yet in relation with this increase. In addition, even with a very strong increase of income, consumption of plastics cannot long develop at a pace higher than -say- 25 % p.a.

*9 kg per capita against 3 kg for the other region having the same income

TABLE 1.16

PLASTICS - WORLD DEMAND BY REGION - 1965/1976

Unit : 1000 tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
WESTERN EUROPE	4 800	7 200	8 650	9 770	10 700	12 220	14 860	15 430	12 330	
FRANCE	680	1 038	1 290	1 454	1 693	2 021	2 242	2 407	1 904	2 500
GERMANY F.R.	1 440	2 178	2 646	2 962	3 247	3 662	4 161	4 348	3 546	
ITALY	635	1 037	1 250	1 446	1 507	1 762	2 045	2 051	1 559	
SPAIN							747	769	600	
UNITED KINGDOM	830	1 110	1 232	1 395	1 462	1 628	1 825	1 921	1 519	
E.E.C.										
EASTERN EUROPE						3 802			5 150	
U.S.A.	5 500	7 620	8 975	8 750	9 600	11 800	13 152	12 932	10 325	
JAPAN	1 520	3 174	3 615	4 354	4 442	4 748	5 600	5 800	4 470	

TABLE 1.1[illegible] (continued)

PLASTICS - WORLD DEMAND BY REGION - 1965/1976 (CONTINUED)

Unit : 1000 metric tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
ASIA : TOTAL	2 116	3 969	4 608	5 488	5 706	6 237	7 450	7 554	6 429	
(excluding Mainland China)										
EAST ASIA	1 825	3 445	3 945	4 705	4 840	5 202	6 183	6 376	5 129	
. Hong-Kong	75	145	165	150	180	155	180	145	165	
. Taiwan	125 {25	270 {60	330 {80	350 {100	400 {110	452 {120	583 {150	576 {170	659 {210	
. Korea Rep.	25	65	85	100	130	177	253	261	284	
. Japan	1 700	3 175	3 615	4 355	4 440	4 750	5 600	5 800	4 470	
SOUTH ASIA	199	343	461	540	628.5	724.5	877	773	855	
of which :										
. India	55	86	95.5	110	115.5	127.5	138.5	141	150	
. Iran	50	70	85	100	120	140	160	180	200	
. Pakistan	6	9	9	20	36	33	60	55	60	
. Indonesia	11	32	65	65	67	101	143	125	145	
. Philippines	37	61	82	100	125	123	146	117	125	
. Singapore	10	20	25	25	30	45	60	50	60	
. Thailand	20	50	80	95	110	125	140	80	90	
MIDDLE EAST	92	181	202	243	237	310	390	405	445	
of which :										
. Iraq	6.5	9	8	11	14	17	18	22	25	
. Lebanon	10	15	15	15.5	20.5	29	42	40	30	
. Israel	35	75	83	96	80	83	110	125	140	
. Turkey	30	65	75	95	105	135	180	165	180	
. Syria	4	7	9	11.5	13.5	35.5	29	14	20	

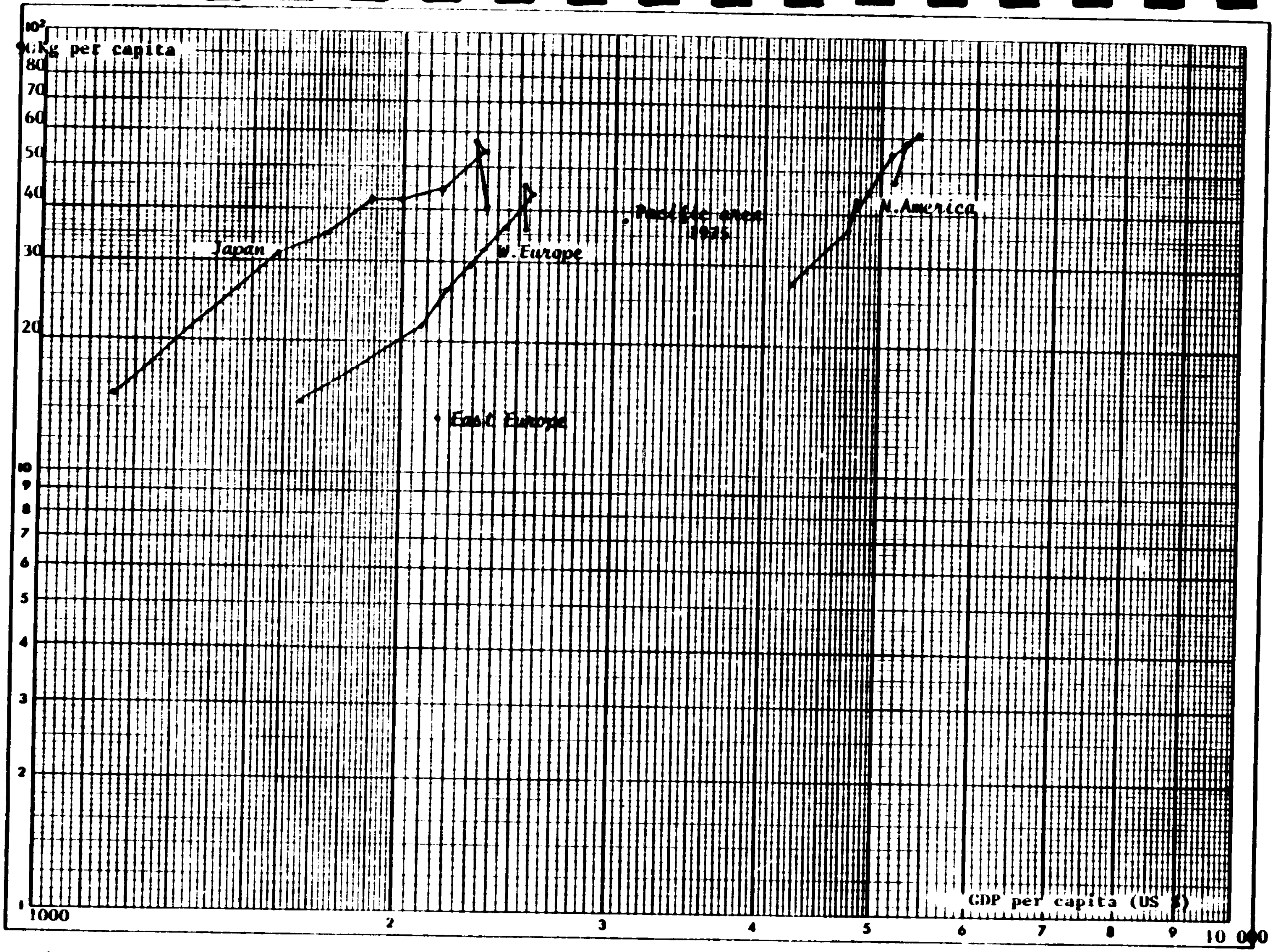

FIG. 1.1 - INDUSTRIALIZED COUNTRIES : Evolution of per caput PLASTIC Demand related to Gross Domestic Product (1965-75).

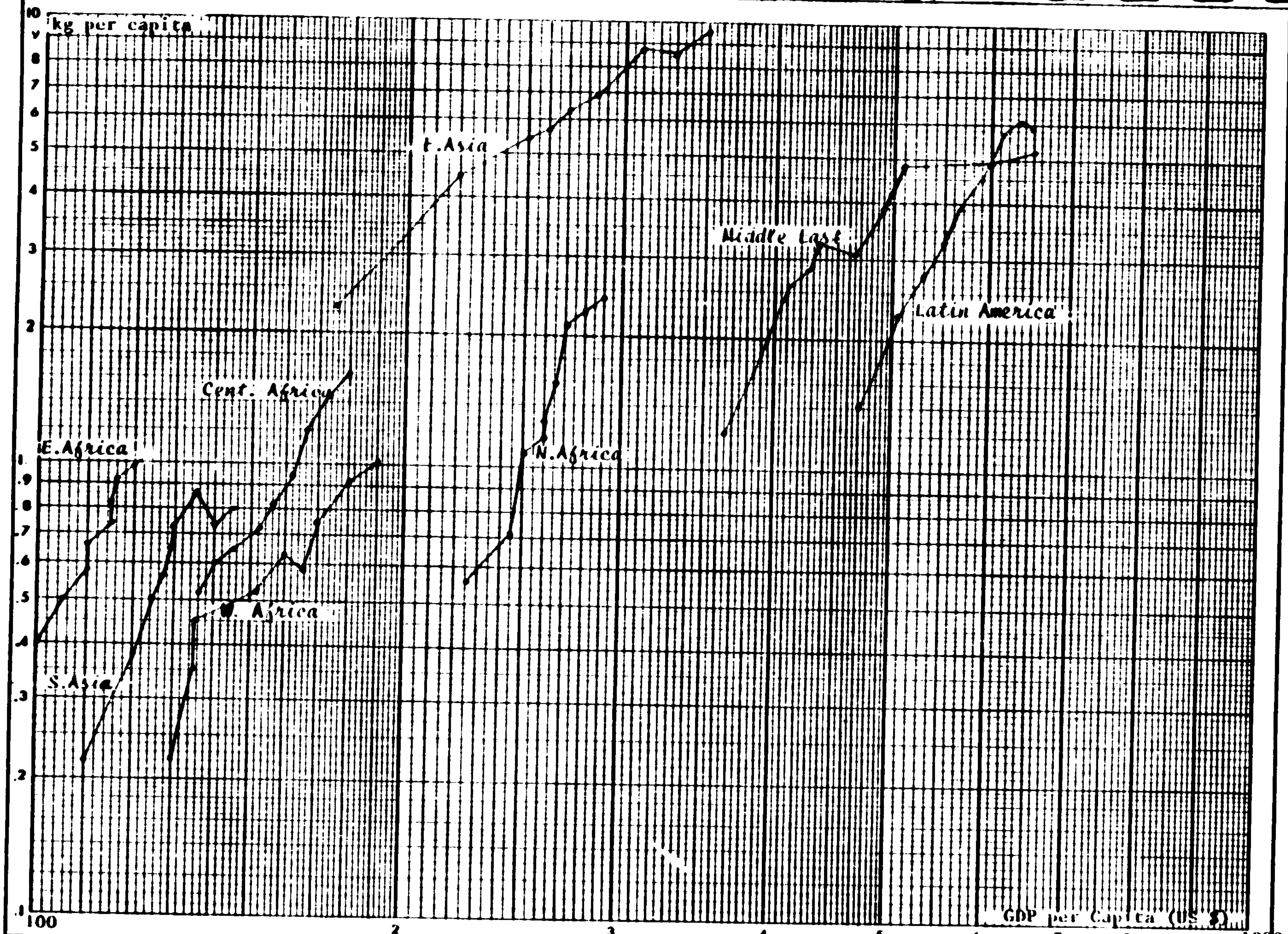

FIG.1 2 - DEVELOPING COUNTRIES : Evolution of per caput PLASTIC Demand related to Gross Domestic Product (1965-75)

MAN-MADE FIBRES

Industrialized countries (table 1.17, Fig. 1.3)

Over the 1965-1975 period, average growth rate of the demand for man-made fibers was in the range of 4.6 % p.a. (W. Europe) to 7.2 % p.a. As observed in plastic market, demand for man-made fibers heavily dropped at the end of the 10 years - period so that demand rose only by 0.7 % p.a. in W. Europe between 1970 and 1975, by 3,7 % in North America and Japan.

But basically, the slow-down in the development of the demand reflects the high degree of penetration of man-made fibers in textile market in industrialized countries.

In these countries, it was already more than 50 % of the total at the beginning of the seventies; it is expected to be as high as 70 % of the total in 1985 in WESTERN EUROPE and in NORTH AMERICA, and even 75 % of the total in JAPAN.

Referring to the level of consumption versus income, industrialized regions are found in about the same situation, not far from the "master curve". Again, the single exception concerns East Europe where, by contrast with the demand for plastics, the demand for man-made fibers has kept growing at a faster rate than in the other industrialized areas.

Developing countries (Table 1.17 - Fig. 1.4.)

Over the last past decade development of the demand for man-made fibers has been strong and irregular. This is typical of the countries where the level of consumption is still low : less than 1 kg per capita in Africa(excepting North Africa) 2 kg per capita in Middle East and in Latin America and,where the potential demand is still large. Again, East Asia with a level of consumption of 4 kg per capita is an exception to the rule. The export-oriented textile industry has undoubtly largely contributed to this situation.

By contrast with the situation observed in industrialized countries, the still moderate degree of penetration of man-made fibers in textile market (only 20-25 % of the total at the beginning of the seventies) will largely contribute to sustain the growth of the demand in these countries.

TABLE 1.17

MAN-MADE FIBRES - WORLD DEMAND

Unit : 1000 tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
WESTERN EUROPE	1 431	1 825	2 136	2 168	2 251	2 403	2 790	2 570	2 231	
FRANCE	167	212	259	276	289	316	363	247	195	
GERMANY F.R.	373	447	526	488	550	538	588	558	452	
ITALY	173	231	314	320	314	355	434	338	284	
SPAIN	74	104	130	145	151	196	227	218	205	
UNITED KINGDOM	338	439	436	447	467	466	552	499	485	
E.E.C.										
Others E.E.C.										
EASTERN EUROPE	950	1 190	1 290	1 380	1 450	1 629	1 700	1 850	1 900	
U.S.A.	1 501	2 219	2 311	2 247	2 494	2 927	3 166	2 946	2 865	
JAPAN	466.5	624.8	643.9	732.2	678.6	566.7	1 064.3	931.5	855.0	

TABLE 1.17 (CONTINUED)

MAN-MADE FIBRES - WORLD DEMAND BY REGION - 1965-1976 (CONTINUED)

Unit : 1000 metric tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
ASIA : TOTAL	1 009.8	1 275.5	1 350.8	1 527.8	1 580.7	1 589.2	2 370.4	2 306.6	2 410.0	
(Including Mainland China)	83.8	80.3	85.5	122.1	166.6	245.7	362.3	282.1	350	
EAST ASIA excl. JAPAN	36.8	113	136.4	162	207	184.7	202	233	295	
. Hong-Kong	4.1	22.0	25.5	23.6	39.4	32.8	27.2	14.0	20.0	
. Taiwan	14.1	32.3	43.9	60.0	80.0	90.0	110.0	130.0	150.0	
. Korea Rep.	18.6	57.8	67.0	78.3	87.6	41.9	64.5	88.9	125.0	
. Japan	466.5	624.8	643.9	732.2	678.6	566.7	1 064.3	931.5	885.0	
SOUTH ASIA	271.3	352.9	377.6	413.7	430.4	488.0	598.7	693.4	730	
of which :										
. India	85.9	124.8	125.7	140.3	144.8	154.2	138.3	154.4	155	
. Iran	49.0	66.6	50.2	79.4	74.8	83.9	89.0	106.6	115	
. Pakistan	17.1	11.2	16.2	17.5	15.1	17.3	22.6	27.8	26.5	
. Indonesia	22.9	17.9	16.0	17.0	15.1	19.4	78.7	101.2	100	
. Philippines	22.6	40.4	50.1	40.7	56.4	57.2	58.3	67.9	70	
. Singapore	(30.0)	(35.0)	(40.0)	42.0	50.0	44.0	(45.0)	(45.0)	45	
. Thailand	15.4	24.2	28.9	34.1	35.8	59.4	50.7	49.2	50	
MIDDLE EAST	75.7	105.3	107.4	97.9	108.1	134.1	143.4	166.7	150	
of which :										
. Iraq	15.0	22.5	21.7	19.4	16.7	16.4	15.9	27.1	25	
. Lebanon	5.7	9.4	10.5	9.0	12.0	13.7	15.6	15.3	15	
. Israel	9.8	14.2	12.7	11.2	15.0	24.7	12.4	13.7	15	
. Turkey	18.7	35.0	35.2	38.1	48.4	55.9	70.2	82.6	66	
. Syria										

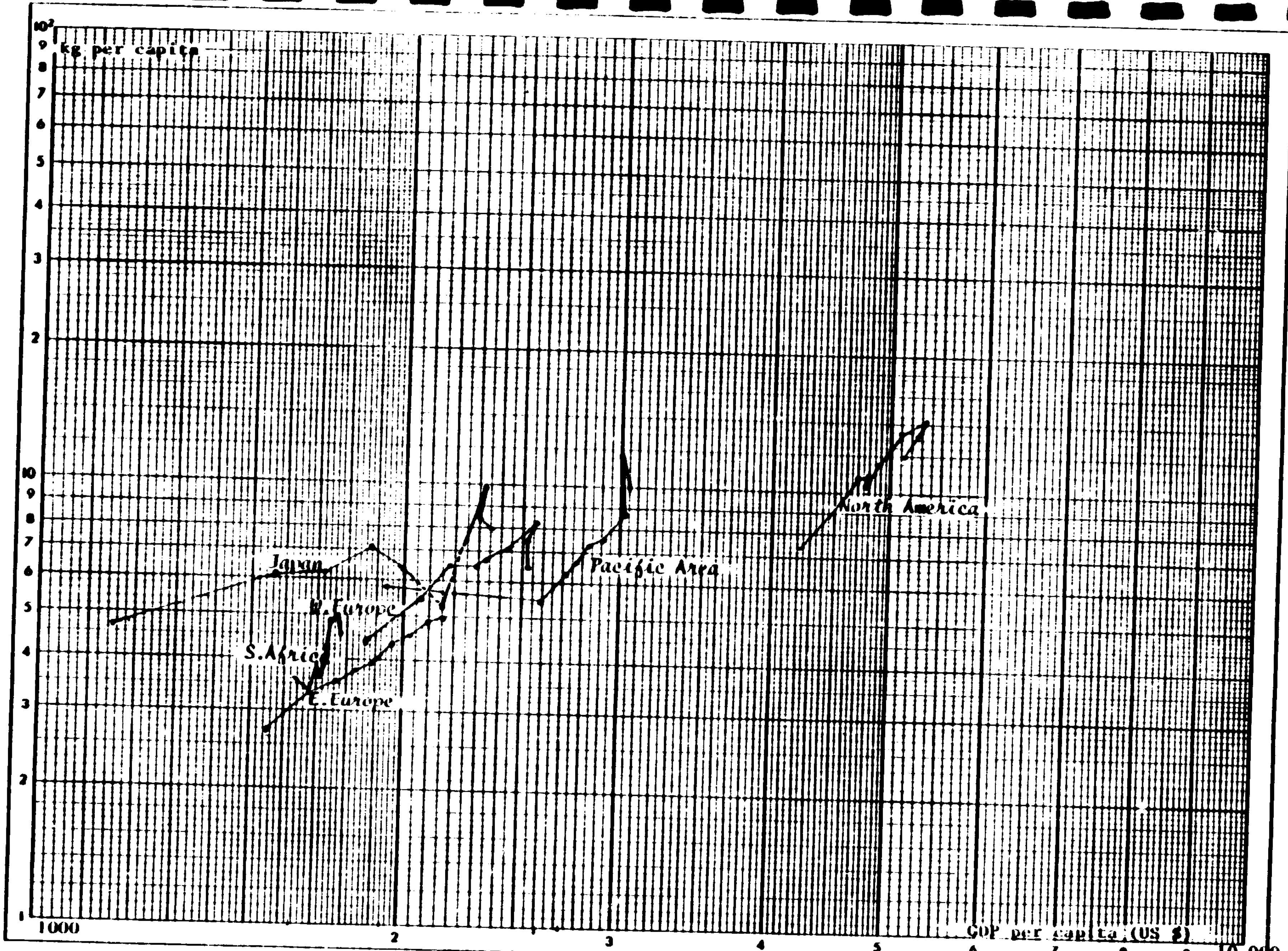

FIG. 1.3- INDUSTRIALIZED COUNTRIES : Evolution of per caput MAN-MADE FIBERS Demand related to GDP (1965-75)

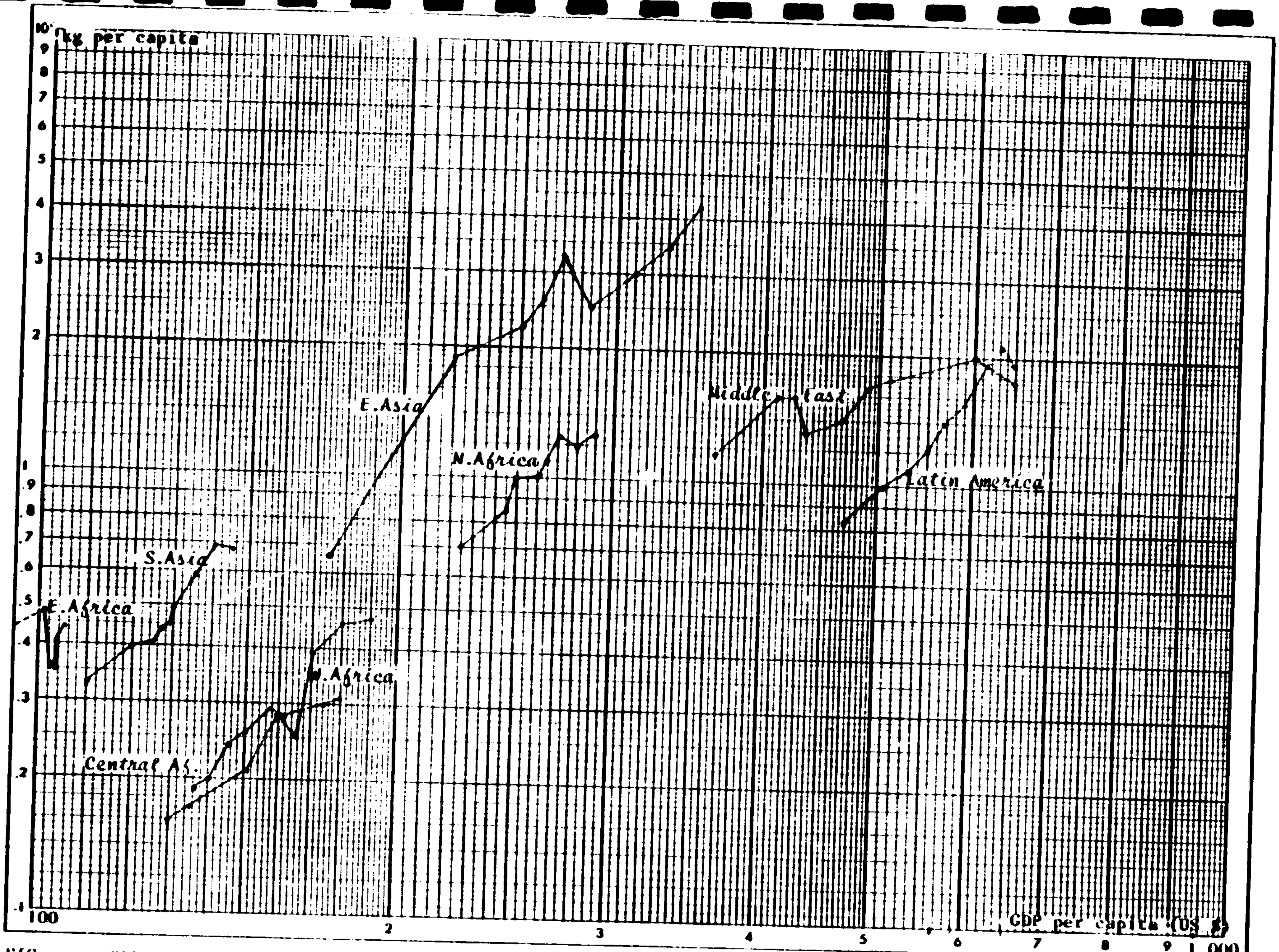

FIG. 4 - DEVELOPING COUNTRIES : Evolution of per caput MAN-MADE FIBERS Demand related to GDP (1965-75)

As far as the level of consumption versus income is concerned (reference to the master curve), the largest difference between regions are found in developing countries with a still low income (below $ 200). As for other petrochemical final products, both Latin America and Middle East are found in the same situation.

- DETERGENTS

Industrialized countries (table 1.18)

From the beginning of the seventies on, only a modest growth of the demand for detergents was observed in industrialized countries : the rates of increase did not exceed 4 % p.a. In 1974-75 demand was fairly static in industrialized regions chiefly because of the recession but also because other factors (changes in the behaviour of consumers).

The recent slowdown in the development corresponds to a deep penetration of syndets in the soap-detergent and cleaning agent market. This penetration seems to be achieved in the next coming years resulting in very moderate growth prospects. In other words, syndet market will likely develop at about the same pace as the soap-detergent and cleaning agent market as a whole.

Developing countries (table 1.19)

In developing countries, demand for syndets has been growing at still high yearly rates, comparable with those observed for other final petrochemical products.
This has mainly resulted from the following factors :

- strong development of the needs of soaps and detergents at this level of consumption

- still moderate degree of penetration of syndets in the above market.

On account of these factors, the prospects of the growth of syndet market remain favourable in most developing countries.

TABLE 1.18

SYNDETS - WORLD DEMAND BY REGION - ESTIMATE

Unit : 1000 t

	1973	1975
WESTERN EUROPE	4 000	3 300
of which E.E.C.	3 300	2 750
EASTERN EUROPE		1 500
NORTH AMERICA	3 000	2 700
of which U.S.A.	2 700	2 420

TABLE 1.19

SYNDETS - WORLD DEMAND BY REGION - 1965-1976 - ESTIMATE (CONTINUED)

Unit : 1000 metric tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
ASIA : TOTAL									1 100	
(excluding Mainland China)										
EAST ASIA									400	
. Hong-Kong										
. Taiwan									} 100	
. Korea Rep.										
. Japan							900	850	850	950
SOUTH ASIA	80	160	200	250	280	340	400	500	550	
of which :										
. India										
. Iran										
. Pakistan										
. Indonesia										
. Philippines										
. Singapore										
. Thailand										
MIDDLE EAST	60	80	85	90	95	115	125	140	150	
of which :										
. Iraq										
. Lebanon										
. Israel										
. Turkey										
. Syria										

NOTE

MACROECONOMIC APPROACH

Macroeconomic approach is usually used for situating and comparing the volume of the demand for the following classes of products :

- plastics
- man-made fibers
- rubber

As matter of fact, the widespread use of these classes of petrochemicals among the generality of consumers underlies the approximate relationship observed between the average consumption of these products and the average per capita income (GDP) in a given country or region.

With certain reserves explained later, such an approach can be a guidance for a forecast of the demand for the above classes of petrochemicals : a certain consumption of plastics or man-made fibers or rubber is likely to correspond to a given level of income; therefore, assuming a certain future income leads to an estimate of the probable consumption of these products.

This means a definite increase of demand is generally observed for a given increase of income : the ratio of demand increase to income increase defines the coefficient of elasticity.

With plastics for instance, this generally varies between 3 and 2 - a high value that has kept up in a large number of countries for a long time. This results from the action of economic incentives such as declining prices (as it was until 1973) and the gradual application of plastics to a wider range of uses, known as "diffusion effect". Owing to this effect, after ten years, the consumption of plastics might be up to twice what it is presently for the same income. Basically, coefficient of elasticity tends to decrease in course of time.

Even at a lower extent, this also applies to consumption of man-made fibers and rubber.

In order to take into account this influence, the trends have been studied over a long period in all regions in the world. However, from 1973 forward, some troubles occured in petrochemical markets the effects of which will somewhat change the long term trend previously observed.

It is noteworthy that macroeconomic approach is well adapted in the case of the plastics, the potential market of which still appears very large (including in industrialized countries). In contrast, the market of rubber (tyre and non tyre products) and man-made fibers (clothes, furnishing and some industrial applications) is undoubtly limited and the macroeconomic approach has to be used with some reserves, especially for the long term in the case of countries with a high level of consumption.

In order to set up the forecast of the demand for petrochemical products, very helpful indications are given by graphic method. In this method illustrated by figures 1 to 6, the consumption of plastics rubber, fibers per capita are plotted versus the GDP per capita (via arithmetic function) for regions or countries and for every year of a long period in the past (1965-1975 in the present case). The line representative of this evolution is generally well established - with the exception of 1973-1975 period - especially for the regions the level of consumption of which is high : say about 10 kg per capita in the case of plastics. For these regions, the representative lines tend to become parallel between themselves. This corresponds to the fact that elasticity coefficient of the demand versus income in these regions is then almost constant and often about the same.

Another point is noteworthy. Representative lines of the evolution of the demand over a long period in every regions or, indeed, in all countries in the world shape a "master curve" (not represented on figures 1 to 6). This master curve can be considered year by year as the reference line of the worldwide demand for a certain level of income *. The individual position of each region with respect to the master curve show up how can be appreciated the chances of the development of the demand for petrochemicals. However, as it appears in the figures 1 to 6, the discrepancies between the regions are only gradually reduced and furthermore over a long period.

* There is no discontinuity of this worldwide master curve between developing countries (GDP up to 600-800) and industrialized countries (GDP from 1000). However, for the purpose of the study, we will separately consider these two types of regions owing to the respective characteristics of development of the demand

b) ***Evolution of the demand for the main final products***
Major trends

- PLASTICS (table 1.20)

The major part of plastic market is held by thermoplastics : these resins generally account for 70 % to 85 % of this market. The lowest percentages are usually observed in industrialized countries, the highest in developing countries. This is explainable, since the thermoplastic resins (polyethylene, polypropylene, PVC, polystyrene...) all apply a wide range of uses and correspond to large tonnages. Their percentage has kept growing, especially during the last years (at least until 1974), reflecting falling prices on the market. However, their share is expected to never exceed 90 % of the total in any case in the foreseeable future.

Concerning the situation and the likely development of the main types of plastics, following remarks can be made :

. Polyolefins (i.e. low density polyethylene, high density polyethylene, polypropylene) now account for one third of World plastics market.

This position can be largely attributed to the very favourable price level brought about by cheap raw materials in the sixties and up to the beginning of the year 1974. Despite of the recent rise in the price of polyolefins, their share held in plastic market is expected to keep gradually growing, up to about 40 % of the total in 1985. This percentage will generally keep significantly higher in developing countries.

Taking into account the strong expansion of the demand expected for high density polyethylene and especially for polypropylene, demand for low density polyethylene will likely grow at about the same pace as that of demand for plastics as a whole. This will mainly result from the competition of both high density polyethylene and polypropylene in the field of some applications (e.g. injection molding) whereas film applications will become more and more the major outlet for low density polyethylene. In addition, the recent rise in the price of low density polyethylene has been stronger than

TABLE 1.20

STRUCTURE OF DEMAND FOR PLASTICS

Percentage

REGION	1973	1974	1975	1976	1980	1985
JAPAN						
Polyethylene ld	16.1	14.9	16.4			
Polyethylene hd	8.0	7.0	6.9			
Polypropylene	10.3	10.6	11.9			
PVC	27.2	19.9	26.0			
Polyetyrene	6.6	6.0	7.3			
ABS	4.0	9.1	4.5			
TOTAL	72.2	82.5	73.0			
WESTERN EUROPE						
Polyethylene ld	21.2	21.4	18.8			
Polyethylene hd	6.7	8.0	6.8			
Polypropylene	3.9	4.5	4.4			
PVC	23.7	22.6	22.9			
Polyetyrene	10.4	11.0	10.8			
ABS	2.0	1.9	2.1			
TOTAL	67.9	69.4	65.8			
EASTERN EUROPE						
Polyethylene ld			14.6			
Polyethylene hd			2.9			
Polypropylene			3.9			
PVC			18.1			
Polyetyrene			6.0			
ABS			1.2			
TOTAL			46.7			
U.S.A.						
Polyethylene ld	18.8	19.7	19.1			
Polyethylene hd	8.6	8.7	9.1			
Polypropylene	6.6	7.0	7.4			
PVC	15.6	15.5	15.8			
Polystyrene	13.5	13.1	14.5			
ABS	3.5	3.1	2.5			
TOTAL	66.6	67.1	68.4			

TABLE 1.20 (CONTINUED)

STRUCTURE OF DEMAND FOR PLASTICS

Percentage

REGION	1973	1974	1975	1978	1980	1985
LATIN AMERICA						
Polyethylene ld	25.1	26.0	24.7			
Polyethylene hd	8.2	7.0	7.7			
Polypropylene	4.6	4.9	5.6			
PVC	18.7	21.0	19.5			
Polystyrene	9.4	9.7	8.4			
ABS	1.3	1.2	1.3			
TOTAL	67.3	69.8	67.2			
ASIA						
CHINA						
Polyethylene ld						
Polyethylene hd						
Polypropylene						
PVC						
Polyetyrene						
ABS						
TOTAL						
EAST ASIA						
Polyethylene ld	26.9	26.9	26.8			
Polyethylene hd	9.1	9.0	9.1			
Polypropylene	9.9	10.1	10.0			
PVC	24.0	23.9	24.0			
Polyetyrene	8.9	9.0	8.9			
ABS	1.0	1.0	1.1			
TOTAL	80.8	79.9	79.9			
SOUTH ASIA						
Polyethylene ld	26.9	27.0	26.8			
Polyethylene hd	9.0	9.0	9.0			
Polypropylene	10.0	9.9	10.0			
PVC	23.9	24.1	24.1			
Polystyrene	9.0	8.9	9.0			
ABS	1.0	1.0	1.0			
TOTAL	79.8	79.9	79.9			

TABLE 1.20 (CONTINUED)

STRUCTURE OF DEMAND FOR PLASTICS

Percentage

REGION	1973	1974	1975	1978	1980	1985
ASIA (continued)						
MIDDLE EAST						
Polyethylene ld	26.9	27.1	26.7			
Polyethylene hd	8.7	8.4	8.5			
Polypropylene	5.1	5.2	8.5			
PVC	29.0	28.9	29.0			
Polystyrene	9.5	9.4	9.4			
ABS	1.0	1.0	1.1			
TOTAL	80.2	80.0	79.9			
PACIFIC AREA						
Polyethylene ld	20.0	22.0	21.8			
Polyethylene hd	8.0	8.0	8.0			
Polypropylene	4.9	5.0	5.1			
PVC	22.9	22.8	23.1			
Polystyrene	10.0	10.0	10.0			
ABS	2.0	1.8	2.0			
TOTAL	67.8	69.6	70.0			
AFRICA						
NORTH AFRICA						
Polyethylene ld	30.1	30.0	30.0			
Polyethylene hd	9.5	9.5	9.6			
Polypropylene	4.0	4.1	4.2			
PVC	29.1	29.1	29.2			
Polystyrene	9.0	9.1	9.2			
ABS	0.5	0.4	0.6			
TOTAL	82.2	82.2	82.6			
WEST AFRICA						
Polyethylene ld	30.7	30.4	30.4			
Polyethylene hd	9.6	9.6	9.6			
Polypropylene	4.3	4.4	4.3			
PVC	29.4	29.4	28.7			
Polystyrene	9.2	8.8	8.7			
ABS	0.8	0.5	0.9			
TOTAL	84.0	83.3	82.6			

TABLE 1.20 .(CONTINUED)

STRUCTURE OF DEMAND FOR PLASTICS

Percentage

REGION	1973	1974	1975	1976	1980	1985
AFRICA (continued)						
EAST AFRICA						
Polyethylene ld	30.3	30.5	30.0			
Polyethylene hd	10.1	10.2	10.0			
Polypropylene	4.0	4.2	4.2			
PVC	29.3	28.7	29.2			
Polystyrene	9.1	9.2	9.2			
ABS	5.0	0.5	0.8			
TOTAL	87.8	83.3	83.4			
CENTRAL AFRICA						
Polyethylene ld	30.5	29.7	30.7			
Polyethylene hd	9.5	9.4	9.3			
Polypropylene	3.8	3.9	4.0			
PVC	28.6	29.7	29.3			
Polystyrene	9.5	9.4	9.3			
ABS	-	0.8	0.7			
TOTAL	81.9	82.9	83.3			
SOUTH AFRICA						
Polyethylene ld	22.0	22.2	21.9			
Polyethylene hd	8.0	7.8	8.1			
Polypropylene	5.0	5.0	5.0			
PVC	23.0	23.0	23.1			
Polystyrene	10.0	10.0	10.0			
ABS	2.0	2.0	2.0			
TOTAL	70.0	70.0	70.1			

TABLE 1.20 (CONTINUED)

STRUCTURE OF DEMAND FOR PLASTICS

Percentage

REGION	1973	1974	1975	1978	1980	1985
NORTH AMERICA						
Polyethylene ld	18.3	20.0	19.4			
Polyethylene hd	8.6	8.7	9.1			
Polypropylene	6.8	6.9	7.3			
PVC	15.8	15.5	15.8			
Polystyrene	13.3	12.9	14.3			
ABS	3.8	3.2	2.7			
TOTAL	66.2	67.2	68.6			
WORLD TOTAL	*	*				
Polyethylene ld	19.7	20.2	19.0			
Polyethylene hd	7.1	8.1	7.1			
Polypropylene	5.9	6.4	6.4			
PVC	22.0	19.9	22.1			
Polystyrene	10.5	10.7	10.5			
ABS	2.8	2.6	2.3			
TOTAL	67.8	67.9	67.4			

* Excluding Eastern Europe

for both high density polyethylene and polypropylene so that the level of prices of the three polyolefins are not so different as it was some years ago.

Despite of this price evolution, rate of penetration of high density polyethylene and polypropylene into polyolefin market will likely remain rather lower in developing countries than it will be in industrialized countries.

- PVC ranks first in the plastics World market (22 % of the total) before low density polyethylene. It has got a leading position with regard to the latter, especially in WEST GERMANY and in Socialist countries (EASTERN EUROPE), JAPAN and in many developing countries (ASIA, AFRICA).

  Volume of World demand for PVC is expected to grow at a rather lower pace as that of the demand for plastics as a whole. Consequently, PVC will keep holding its share in the total. This expansion will be mainly supported by the expected development for rigid applications, mainly pipes and other applications related to the building sector.

- Polystyrene accounts for 10.5 % of plastics World market and its share in this market is expected to keep nearly constant as it has been previously. It is noteworthy that about the same percentage applies in most regions. So, polystyrene demand alone can be considered as characteristic of the level of plastic consumption in a given area.

  There is a better prospect for ABS (acrylonitrile-butadiene-styrene) resins in terms of annual rates of increase, as it is for products recently introduced in the market and despite of price level 40-50 % higher than that for polystyrene and other large tonnage plastics.

  As it appears from historical series structure of the demand for plastics has gradually changed and the trends are generally well established.

• MAN-MADE FIBRES - SYNTHETIC FIBRES (tables 1.21 & 1.22)

In industrialized countries from the end of the last decade, demand for cellulosic fibers, after some years of stagnation was gradually decreasing. The major exception concerns East Europe where cellulosic fibers has still kept very slightly growing.

Future prospects of the demand for cellulosics are not favourable, although, especially in West Europe a part of the producing capacity is idle. Some plants have already been closed. There is no plant the construction of which is planned (The main reasons of this decline are : expensive raw material, qualities below those of synthetics).
By contrast, the development of the demand for cellulosics has been better in developing countries.
At a worldwide scale, volume of the demand for cellulosics is expected to be almost constant. Thus, from now on, synthetic fibers alone will be responsible of the expansion of man made fibers market as a whole.
However, the high degree of substitution of cellulosic by synthetic already observed in industrialized countries (72 % of the total) (in addition to the high degree of substitution of man-made fibers in textile market)will certainly be the limiting factor of the development of the demand for synthetics.

In developing countries, synthetic fibers account for 63 % of the total. In these countries, the development of the demand will mainly result from a deeper penetration of man-made fiber market in textile market (now 25 % of the total as against 50 % in industrialized countries) and overall from an increase in the level of textile demand.
Thus, a sustained growth of the demand for synthetics can be still expected in developing countries for the next ten coming years. However the yearly rates of increase of the demand will likely keep below those previously observed.

There are three main types of synthetic fibers : polyesters, polyamids and acrylics (table 1.23).
The pattern of the demand for these three main types of synthetic fibers has gradually changed for ten years, according to about the same scheme in major consuming areas, i.e. :

. the growing importance of polyesters in the total

TABLE 1.21

MAN-MADE FIBRES - WORLD DEMAND

Unit : 1000 tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
WESTERN EUROPE	1 431	1 825	2 136	2 168	2 251	2 403	2 790	2 570	2 231	
FRANCE	167	212	259	276	289	316	363	247	195	
GERMANY F.R.	373	447	526	488	550	538	588	558	452	
ITALY	173	231	314	320	314	355	434	338	284	
SPAIN	74	104	130	145	151	196	227	218	205	
UNITED KINGDOM	338	439	436	447	467	466	552	499	485	
E.E.C.										
Others E.E.C.										
EASTERN EUROPE	950	1 190	1 290	1 380	1 450	1 629	1 700	1 850	1 900	
U.S.A.	1 501	2 219	2 311	2 247	2 494	2 927	3 166	2 946	2 665	
JAPAN	466.5	624.8	643.9	732.2	678.6	566.7	1 064.3	931.5	855.0	

TABLE 1.21 (continued)

MAN-MADE FIBRES - WORLD DEMAND BY REGION - 1965-'976 (CONTINUED)

Unit : 1000 metric tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
ASIA : TOTAL	1 009.8	1 275.5	1 350.8	1 527.8	1 580.7	1 589.2	2 370.4	2 308.6	2 410.0	
(including Mainland China)	83.8	80.3	85.5	122.1	166.6	245.7	362.3	282.1	350	
EAST ASIA excl. JAPAN	36.8	113	136.4	162	207	164.7	202	233	295	
. Hong-Kong	4.1	22.0	25.5	23.6	39.4	32.8	27.2	14.0	20.0	
. Taiwan	14.1	32.3	43.9	60.0	80.0	90.0	110.0	130.0	150.0	
. Korea Rep.	18.6	57.8	67.0	78.3	87.6	41.9	64.5	88.9	125.0	
. Japan	466.5	624.8	643.9	732.2	678.6	566.7	1 064.3	931.5	885.0	
SOUTH ASIA	271.3	352.9	377.6	413.7	430.4	488.0	598.7	693.4	730	
of which :										
. India	85.9	124.8	125.7	140.3	144.8	154.2	138.3	154.4	155	
. Iran	49.0	66.6	50.2	79.4	74.8	83.9	89.0	106.6	115	
. Pakistan	17.1	11.2	16.2	17.5	15.1	17.3	22.6	27.8	26.5	
. Indonesia	22.9	17.9	16.0	17.0	15.1	19.4	78.7	101.2	100	
. Philippines	22.6	40.4	50.1	40.7	56.4	57.2	58.3	67.9	70	
. Singapore	(30.0)	(35.0)	(40.0)	42.0	50.0	44.0	(45.0)	(45.0)	45	
. Thailand	15.4	24.2	28.9	34.1	35.6	59.4	50.7	49.2	50	
MIDDLE EAST	75.7	105.3	107.4	97.9	108.1	134.1	143.4	166.7	150	
of which :										
. Iraq	15.0	22.5	21.7	19.4	16.7	16.4	15.9	27.1	25	
. Lebanon	5.7	9.4	10.5	9.0	12.0	13.7	15.6	15.3	15	
. Israel	9.8	14.2	12.7	11.2	15.0	24.7	12.4	13.7	15	
. Turkey	18.7	35.0	35.2	38.1	48.4	55.9	70.2	82.8	66	
. Syria										

TABLE 1.22

WORLD DEMAND FOR SYNTHETIC FIBRES

Unit : 1000 tons

	1972	1973	1974	1975
WESTERN EUROPE : TOTAL	1 810	1 930	1 770	1 840
of which :				
. Belgium	137	172	159	144
. France	183	245	228	187
. Germany	374	424	409	340
. Italy	238	307	223	215
. Netherlands				
. Spain	140	184	150	154
. United Kingdom	316	400	368	339
. Others	222	218	235	261
EASTERN EUROPE : TOTAL	557	880	830	950
. Bulgaria	29			
. Czechoslovakia	41			
. East Germany	50			
. Hungary	18			
. Poland	83			
. Rumania	33			
. U.S.S.R.	270			
. Yugoslavia	35			
NORTH AMERICA : TOTAL	2 429	2 734	2 591	2 475
. Canada	135	154	144	148
. U.S.A.	2 294	2 580	2 447	2 327

TABLE 1.22 (CONTINUED)

SYNTHETIC FIBRES - WORLD DEMAND BY REGION - 1965-1976 (CONTINUED)

Unit : 1000 metric tons

	1965	1968	1969	1970	1971	1972	1973	1974	1975	1976
ASIA : TOTAL	330.7	608.1	688.5	880.5	943.7	904.4	1 542.0	1 498.8	1 585	
Mainland China	9.2	12.1	18.6	57.4	93.0	160.8	230.1	177.7	200	
EAST ASIA excl. JAPAN	20	71.5	99.3	124.4	162.	112.5	148.9	185.6	230	
. Hong-Kong	2.0	8.3	12.6	12.1	23.3	19.8	15.6	4.1		
. Taiwan	7.7	17.5	32.3	44.5	59.0	67.0	82.0	97.0	113	
. Korea Rep.	10.3	45.7	54.4	67.8	79.7	25.7	51.3	84.5		
. Japan	221.5	347.4	363.6	476.8	429.3	(321.7)	755.2	855.1	585	
SOUTH ASIA	62.4	128.0	154.0	165.1	194.5	226.2	319.2	362.7	380	
of which :										
. India	9.1	13.9	17.2	21.5	27.0	26.6	27.9	25.5		
. Iran	2.3	19.8	17.6	27.3	23.5	36.1	45.3	52.3	55	
. Pakistan	2.8	0.7	4.1	6.2	6.3	7.0	8.8	14.4		
. Indonesia	0.1	11.2	10.2	11.6	10.7	14.0	75.2	95.7		
. Philippines	6.5	18.1	24.2	20.5	32.8	34.0	38.3	46.2		
. Singapore	(30.0)	(32.0)	(35.0)	37.0	44.0	40.0	(42.0)	(42.0)		
. Thailand	7.0	20.1	25.3	23.6	27.2	44.6	50.5	47.9		
MIDDLE EAST	17.6	49.1	53.0	56.8	64.6	83.2	88.6	116.7	110	
of which :										
. Iraq	-	4.0	6.9	8.1	3.6	3.1	4.7	12.1		
. Lebanon	1.7	4.6	5.3	5.7	9.4	11.7	14.0	13.3		
. Israel	4.5	10.5	8.9	7.8	11.3	21.5	11.2	12.1		
. Turkey	8.7	23.0	21.4	26.4	33.1	36.8	49.4	62.6		
. Syria										

TABLE 1.23

STRUCTURE OF THE DEMAND FOR SYNTHETIC FIBRES

Percentage

	1973	1974	1975	1980	1985
WORLD, TOTAL					
Acrylic	19.2	18.3	18.2		
Polyamide	38.5	35.3	33.9		
Polyester	42.3	44.4	48.3		
Other	1.0	2.0	1.8		
TOTAL	100	100	100		
WESTERN EUROPE					
Acrylic	28	27.5	29	27	25
Polyamide	35	35	34	30	28
Polyester	36	36.5	36	42	48
Other	1	1	1	1	1
TOTAL	100	100	100	100	100
EASTERN EUROPE					
Acrylic	22	21.5	21.5	20.5	20
Polyamide	43.5	38.5	37.5	34.5	32
Polyester	30.0	36	37	41	44
Other	4.5	4	4	4	4
TOTAL	100	100	100	100	100
U.S.A.					
Acrylic	12.5	11	10	10	10
Polyamide	37.5	37	34.5	32	29
Polyester	50	52	55.5	58	61
Other	-	-	-	-	-
TOTAL	100	100	100	100	100
JAPAN					
Acrylic	27	24.5	24	23	21
Polyamide	27.5	28	27.5	25	23
Polyester	38.0	41.5	43.5	47	51
Other	7.5	8	5	5	5
TOTAL	100	100	100	100	100

TABLE 1.23 (CONTINUED)

STRUCTURE OF THE DEMAND FOR SYNTHETIC FIBRES (CONTINUED)

Percentage

	1973	1974	1975	1980	1985
LATIN AMERICA					
Acrylic	14	18.5	19.5	19	17
Polyamide	36	32.5	30		
Polyester	50	49	50.5	55	60
Other				1	2
TOTAL	100	100	100		
ASIA					
CHINA					
Acrylic	18	17.5	17		
Polyamide	43.5	38.5	37.5		
Polyester	38.5	44	45.5		
Other	-	-	-		
TOTAL	100	100	100		
EAST ASIA					
Acrylic	16	16	16		
Polyamide	38	34	31		
Polyester	46	50	53		
Other	-	-	-		
TOTAL	100	100	100		
SOUTH ASIA					
Acrylic	15	15	15		
Polyamide	40	36	33		
Polyester	45	49	52		
Other	-	-	-		
TOTAL	100	100	100		
MIDDLE EAST					
Acrylic	10	10	9.5	10.5	11
Polyamide	53	50	47.5	37	29.5
Polyester	37	40	42.5	51.5	57.5
Other	-	-	0.5	1.0	2.0
TOTAL	100	100	100	100	100

TABLE 1.23 (CONTINUED)

STRUCTURE OF THE DEMAND FOR SYNTHETIC FIBRES (CONTINUED)

Percentage

	1973	1974	1975	1980	1985
AFRICA					
NORTH AFRICA					
Acrylic	15	15	15		
Polyamide	36	35	34		
Polyester	49	50	51		
Other	-	-	-		
TOTAL	100	100	100		
WEST AFRICA					
Acrylic	10	10	10		
Polyamide	40	38	35		
Polyester	50	52	55		
Other	-	-	-		
TOTAL	100	100	100		
EAST AFRICA					
Acrylic	10	10	10		
Polyamide	40	38	35		
Polyester	50	52	55		
Other	-	-	-		
TOTAL	100	100	100		
CENTRAL AFRICA					
Acrylic	10	10	10		
Polyamide	40	38	35		
Polyester	50	52	55		
Other	-	-	-		
TOTAL	100	100	100		
SOUTH AFRICA					
Acrylic	21	19.5	19		
Polyamide	35.5	35	33.5		
Polyester	41.5	43.5	46		
Other	2	2	1.5		
TOTAL	100	100	100		
PACIFIC AREA					
Acrylic	21	19.5	19		
Polyamide	35.5	35	35.5		
Polyester	41.5	43.5	46		
Other	2	2	1.5		
TOTAL	100	100	100		

of synthetic fibers

- to the same extent, the decreasing importance of polyamid fibers
- the almost constant share of synthetic market held by acrylics : about 20 % of the total.

As a result of this evolution, polyester fibers account now for 46.0 % of the World synthetic fibers market, nylon for 33 % and acrylics for 18.2 % (see Table 1.23). By contrast, USA are found in a more advanced stage of the foreseeable evolution in other consuming areas, especially concerning the share of the market held by polyesters : 55 % of the total.

- SYNTHETIC DETERGENTS (table 1.24)

Volume of the demand for synthetic detergents in the world can be estimated at about 10.8 million tons of which 2.2 million tons for developing countries.

Alkylbenzene sulfonates are by far the main active material used for the preparation of detergents. In 1975, volume of the worldwide demand for alkylbenzenes amounted to 1.2 millions tons of which 0.33 m. tons for developing countries. The relatively high volume of alkylbenzene used in the latter countries partially results from a higher rate of utilization of sulfonates (versus formulated detergents), a problem linked with the washing habits : hand washing with cold water (whereas machine washing with hot water requires significantly less of active material).
Assuming lower rate of utilization of sulfonates in these countries -- this being to some extent balanced by the fact that zero-phosphate and reduced phosphate detergents manufacture requires greater amounts of surface active detergent -- and especially, a further substitution of other detergents, alkylbenzenes would be in the region of 2. m.t. in 1985.

TABLE 1.24

WORLD DEMAND FOR SURFACTANTS BY TYPES - ESTIMATE

Unit : 1000 tons

	1 9 7 3				1 9 7 5			
	Cationic	Non ionic	Anionic	DDB incl. linear	Cationic	Non ionic	Anionic	DDB incl. linear
WESTERN EUROPE	80	300	730	420	75	265	505	270
of which E.E.C.	65	250	600	345	60	220	420	225
NORTH AMERICA	140	600	1 570	370	105	510	1 500	280
of which U.S.A.	125	540	1 420	330	95	460	1 360	250
JAPAN	24	150	160	170	22	137	172	130
INDUSTRIALIZED COUNTRIES					250	1 100	2 800	850
DEVELOPING COUNTRIES					25	100	1 000	350
WORLD TOTAL					275	1 200	3 800	1 200

Thus alkylate sulfonate will continue to develop at a moderate growth rate and will keep its leading position in detergent market, principally because no other surfactant can match this material on a cost performance basis for spray-synthetic detergents.

Due to the recent regulations on water pollution brought in industrialized countries, biodegradable detergents based on linear alkylate sulfonate have largely displaced "hard" detergents based on branchedchain dodecylbenzene sulfonate. E.g. : in U.S.A., linear detergent alkylates capacity amounts to 290,000 t, that of branched chain still in place amounts to 110,000 tons; the proportion is even higher at the level of the market.

Alkylbenzene sulfonates face long term threats from alpha olefin sulfonates and alcohol based surfactants, at least in industrialized countries. In these countries a continuing trend towards liquid detergent, could alter the nature of the market and linear alkylate sulfonate dominant position in it.

Detergent-range alcohols, (non ionic surfactant) second in importance as surface active material in industrialized countries (capacity : 350,000 t in WESTERN EUROPE, 360,000 t in U.S.A. and 155,000 t in JAPAN) have no very large prospects in other consuming areas, in terms of tonnage.

c) *Major trends in sectorial demand for final products*

1. PLASTICS

Demand for plastics by sectors

Despite of the strong expansion of the demand for plastics registered over the two last past decades, penetration of these materials is still limited in sectors with a large potential, namely construction and transportation.

In the USA for example, among the more advanced as for level of plastic demand, construction of a new house requires only 1 ton of plastics, a small quantity when compared with the total volume of building materials needed for this construction. In transport sector, plastics account for a modest 3,5 % of materials used for the manufacture of a car, this percentage being close to that of aluminium (current competitor of plastics in many applications).

On this basis, a further penetration of plastics in these two large sector of applications can be still expected as recently forecast for transportation sector by International Research and Technology in a report to the Government. Table 1.25.

They estimated conservatively the average car in 1980 will contain 6,7 % plastics and 6,3 % aluminium and the 1990 car will include 9,2 % plastics and 11,9 % aluminium.

Mass production of car bodies has been under consideration for years but, contrary to expectations, there have been yet no major developments for this applications.

Penetration of plastics in medium-size market of packaging is generally deeper than for the 2 above sectors. In France, for instance, the volume of the demand for plastics in this sector corresponds to about 15 % of that of paper and paper board used in the same sector. In the US market, this percentage is only 6 %. The above percentages, depend to a large extent, on relative prices and availability of paper products.

For the other sectors of applications with a more limited potential : appliance and furniture, penetration of plastic materials is usually still deeper.

Referring to the US market, the breakdown of the demand for plastics by major end-uses sectors is as follows (percentage) :

YEARS	1975	1976
Packaging	43	42
Building and construction	33	35
Transportation	13,5	13
Furniture	5,5	6
Appliances	4	4

In following tables are presented the demand for individual plastics in the U.S.A. For simplifying, only the "large tonnage" plastics the present study dealt with have been presented in the tables. These have generally better prospects than many others, namely thermosettings, including in developing countries.

As it appears from these tables, large tonnage plastics meet 93 % of the needs in packaging field,53 % in building sector, but only 28 % in transportation. The percentage amounts to 36 % for furniture and 53 % for appliances.

Demand for individual plastics

Structure of the demand for large tonnage plastics under consideration in the present study are indicated in the following tables 1.31 to 1.34..ll of them concern West Europe but there are no large differences between the large consuming areas. At least, the trends are basically similar.

As it appears from these tables, the changes in the structure in industrialized countries are generally gradual, reflecting,to some extent,the maturation of the markets.

As a general rule, there are one or two major outlets for these plastics, the share of the total remaining more or less constant. For example : film and sheet used for packaging for low density polyethylene, hollow articles, containers in the case of high density polyethylene.

More precisely, taking polyolefins (polyethylenes and polypropylene), the generally most promising class of large tonnage plastics as an example, the future development of such plastics can be appreciated as follows :

TABLE 1.25

MATERIALS COMPOSITION FOR AVERAGE COMPOSITE AUTOMOBILE*

	1975	1980	1990
PLASTICS	3,5 %	6,7 %	9,2 %
ALUMINIUM	2,9	6,3	11,9
LOW-CARBON STEEL	55,2	50,4	46,3
HIGH-STRENGH, LOW-ALLOY STEEL	6,0	6,5	7,9
CAST IRON	16,2	13,8	7,9

* Source : International Research and Technology

TABLE 1.26

PLASTICS IN PACKAGING

MATERIAL	1975	1978
	1000 metric tons	
COASTING (FOR PAPER, FILM, FOIL, METAL) :		
. POLYETHYLENE HIGH DENSITY	18	19
. POLYETHYLENE LOW DENSITY	184	214
. POLYPROPYLENE	3	4
. POLYVINYL ACETATE	17	18
. PVC	8	9
SUBTOTAL	230	264
OTHERS	75	77
TOTAL	305	341
CLOSURES :		
. POLYETHYLENE HIGH DENSITY	23	25
. POLYETHYLENE LOW DENSITY	9	10
. POLYPROPYLENE	25	35
. POLYSTYRENE	23	25
. PVC (GASKETS AND LINERS)	9	11
SUBTOTAL	89	106
OTHERS	10	12
TOTAL	99	118
CONTAINERS AND LIDS :		
. POLYETHYLENE HIGH DENSITY, BLOW MOLDED UP TO 2 GAL.	315	378
. POLYETHYLENE BLOW MOLDED 2 GAL. OR MORE	35	42
. POLYETHYLENE INJECTION MOLDED	90	93
. POLYETHYLENE THERMOFORMED	27	28
. POLYETHYLENE LOW DENSITY BLOW MOLDED	18	23
. POLYETHYLENE INJECTION MOLDED	70	72
. POLYPROPYLENE BLOW MOLDED	13	16
. POLYPROPYLENE EXTRUDED (DRINKING STRAWS)	13	14
. POLYPROPYLENE INJECTION MOLDED	25	34
. POLYPROPYLENE THERMOFORMED	7	10
. POLYSTYRENE BLOW MOLDED	12	14
. POLYSTYRENE MOLDED : CRYSTAL	52	55
FOAM	38	40
IMPACT	45	47
. POLYSTYRENE THERMOFORMED : FOAM	81	87
IMPACT	120	124
ORIENTED	58	70
OTHER	45	47
. ABS	18	18
. PVC : BLOW MOLDED	25	38
THERMOFORMED (INCL. BLISTER PACKS)	34	35
SUBTOTAL	1145	1261
OTHERS	60	86
TOTAL	1205	1347

TABLE 1.26 continued

MATERIAL	1975	1978
	1000 metric tons	
FILM :		
. POLYETHYLENE HIGH DENSITY	31	43
. POLYETHYLE LOW DENSITY	677	824
. POLYPROPYLENE	64	82
. PVC	55	80
. POLYSTYRENE	15	16
SUBTOTAL	842	1045
OTHERS	38	39
TOTAL	880	1084
GRAND SUBTOTAL	2306	2696
OTHERS	218	232
GRAND TOTAL	2524	2928

TABLE 1.27

PLASTICS IN BUILDING AND CONSTRUCTION

APPLICATION/MATERIAL	1975	1978
	1000 metric tons	
FLOORING : PVC	131	155
INSULATION : POLYSTYRENE FOAM	18	20
LIGHTING FIXTURES :		
. POLYSTYRENE	11	12
. PVC	6	16
PANELS AND SIDING : PVC	32	42
PIPE, FITTINGS AND CONDUIT :		
. ABS	91	114
. HDPE	70	113
. LDPE	10	15
. POLYPROPYLENE	5	7
. POLYSTYRENE	15	9
. PVC	480	658
PROFILE EXTRUSIONS (INCL. WINDOWS RAINWATER SYSTEMS ETC...)		
. PVC (INCL. FOAM)	63	89
. POLYETHYLENE	2	3
VAPOR BARRIERS :		
. POLYETHYLENE	51	74
. PVC (INCL. SWIMMING POOL LINERS)	23	24
WALL COVERINGS AND WOOD SURFACING (INTERIOR) :		
. POLYSTYRENE	2	2
. PVC	45	47
SUBTOTAL	1035	1370
OTHERS	855	1009
TOTAL	1890	2379

TABLE 1.28

PLASTICS IN TRANSPORTATION

MATERIAL	1976, 1000 metric tons		1977, 1000 metric tons	
	Passenger car	Trucks, buses	Passenger car	Trucks, buses
ABS	68	1.5	70	2
POLYETHYLENE : high density	5	2	11	3
POLYPROPYLENE AND COPOLYMERS	130	6.8	140	7
POLYSTYRENE ; high impact	2	N	2	N
POLYVINYL CHLORIDE	120	10	130	11
SAN (STYRENE ACRYLONITRILE)	4	N	5	N
SUBTOTAL	330	20.3	228	23
OTHERS	398	56.7	587	65
TOTAL	728	77	815	88

TABLE 1.29

PLASTICS IN FURNITURE

MARKET	1975	1976
	1000 metric tons	
ABS	4	5
POLYETHYLENE	9	11
POLYPROPYLENE	11	13
POLYSTYRENE	28	34
POLYVINYL CHLORIDE	90	95
SUBTOTAL	142	158
OTHERS	237	281
TOTAL	379	439

TABLE 1.30

PLASTICS IN APPLIANCES

MATERIAL	1975	1978
	1000 metric tons	
POLYETHYEENE	2.0	2.2
POLYPROPYLENE	35.0	40.0
POLYVINYL CHLORIDE	20.0	20.0
STYRENICS :		
. POLYSTYRENE	55.0	70.0
. ABS	39.0	48.0
. SAN	5.0	8.0
SUBTOTAL	156.0	188.2
. OTHERS	98.5	132.6
TOTAL	254.5	320.8

- LOW DENSITY POLYETHYLENE (ldPE)

There is a definite trend towards the production of plastic film. About 2/3 of the total production of this plastic now go into plastic film and sheets. Trough a second production process, various packaging materials are obtained (bags, carrier-bags, sacks).

The fast growing supply of ready-packed articles in supermarkets has recently contribued greatly to the vast expansion of plastic film.

However, this expansion is in strong dependence on private consumption expenses. Apart from plastic films for packaging, considerable quantities of LD polyethylene are used in the building, agriculture and horticulture industries.

In industrialized countries, all end-uses areas are still growing at respectables rates and better than average growth is expected from garbage bags, agricultural films, pallet shrink wrap, stretch film and other film packaging uses.

All other fields of application have for some time been losing their share of the total LD polyethylene consumption at the advantage or other thermoplastics (mainly H.D., polyethylene, polypropylene).

- HIGH DENSITY POLYETHYLENE (hdPE)

Blow molding has become the most dominant market of HD polyethylene. This corresponds to the development of all sorts of bottles of various sizes, cans, barrels and other large containers. the significant progress registered last years in the processing techniques have been a contributing factor of this expansion.

In the large blow molding sector, outstanding growth is seen for food and beverage containers. New process technology can unlock potential markets such as auto fuel, tank and shipping material.

Injection molding applications are the second outlet for HD polyethylene. It corresponds to production of household articles (like buckets, bowls, tanks, baskets, etc...) and various articles used in the packaging sector (boxes, containers transportation and storage crates).

These injection molded articles, as well as pipes and profiles, have been continually losing their share of the total HDPE consumption or only just holding their position. Concerning the pipe sector, its share will again increase in the future (large diameter pipe). Film is a modest but fast expanding market for HDPE.

For the future, whereas HDPE will continue to make gains in paper and glass replacement, penetration of some traditionally secure HDPE market by other plastic is expected (mainly polypropylene but some others too, having become competitive in specific end-use area).

- POLYPROPYLENE (PP)

Moulded parts for technicals applications are still dominating PP market. Polypropylene fibers have intruded heavily into the domain of jute, replacing jute fibers in carpet backing and shipping sacks. The tendency of a further increased share of fibers and film applications which was expected some years ago has been effectively realised (as contrary to the situation observed in Japan which, however, has the most developed PP market).

For the future, higher market share for fibers and related items and for films and sheets are foreseen in relation with their uses in packaging field.

Bottles, a modest outlet for PP show much promise. As compared with other thermoplastics, market maturity of polypropylene is still a long way off. In addition, polypropylene now enjoys the advantage of being the lowest priced thermoplastic resin (U.S. market). As for PVC and polystyrene, the salient features and trends of sectoral demand are as follow

- POLYVINYL CHLORIDE (PVC)

PVC applications usually fall into 2 categories :

- rigid PVC applications
- soft PVC applications. In this case, PVC resins contain plasticizers (mainly phtalates) in various proportions - up to 50 % of the total in a few cases -.

The major outlet for rigid PVC is found in the manufacture of pipes and extruded profiles, mainly used in building sector. Other uses of rigid PVC include : film and sheets (packaging sector), bottles (an application well developed in some West European countries, France, for example).

As a general rule, the rigid uses has showed higher growth rates than flexible ones.

Flexible application consist of coated (leather-like) fabrics, film and sheets, flooring (e.g. tiles) wire and cables shoes is still an appreciable outlet for flexible PVC in some developing countries.

For the next coming years, a good growth is foreseen for rigid extrusion products, especially in the construction industry where pipes fittings have already taken one third of production (in the US market Flooring, window components profiles, siding (in the US market) are being touted as areas open to extensive penetration by PVC.

The auto sector is expected to show moderate growth due to shrinking cars and to competition from polyurethane for leather-like applications.

Some smaller end-uses, such as records, apparel and sporting goods are not expected to show significant growth.

In short, predicted growth of the demand for PVC to a large extent depend on a development of the construction industry tied to a healthy economy. A further penetration of PVC in this sector will certainly occur, since the PVC industry has solved many of the technical and regulatory problems of recent years. On the other hand, aluminum is a severe competitor for rigid PVC in many applications of the building sector (especially profiles) as already seen in the case of automobile industry.

- POLYSTYRENE (PS)

Packaging is the main outlet for polystyrene. In this sector, polystyrene is mainly used for the production of various containers. Packaging is still the most promising market for polystyrene, as it has been for many years. In this field, PS enjoys the properties being rigid and being able to be processed in thin walls (for disposable wrapping).

Other applications of polystyrene include : appliances housewares, refrigerators and toys. A moderate (resulting from competition of polypropylene) but sustained growth is generally expected for these applications.

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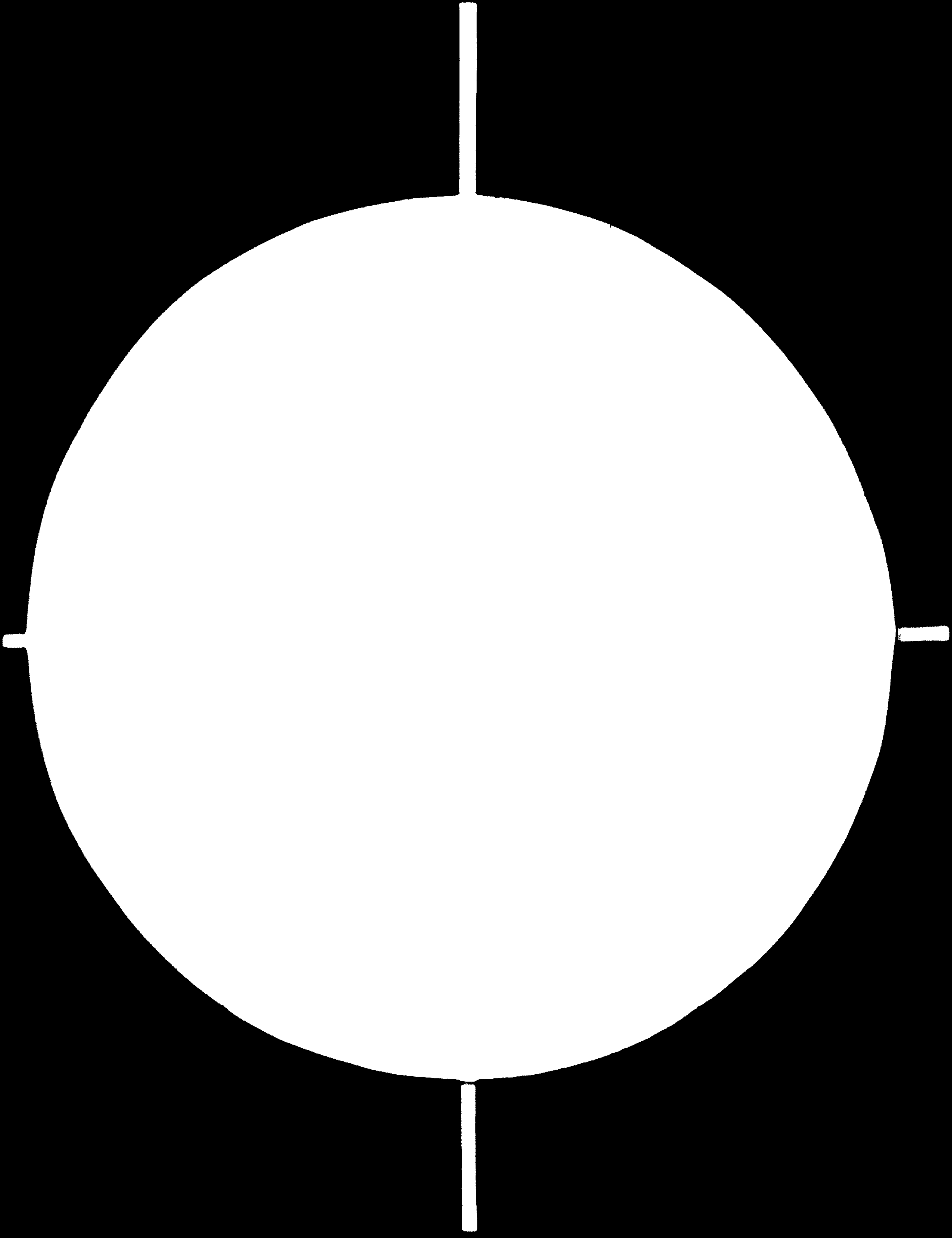

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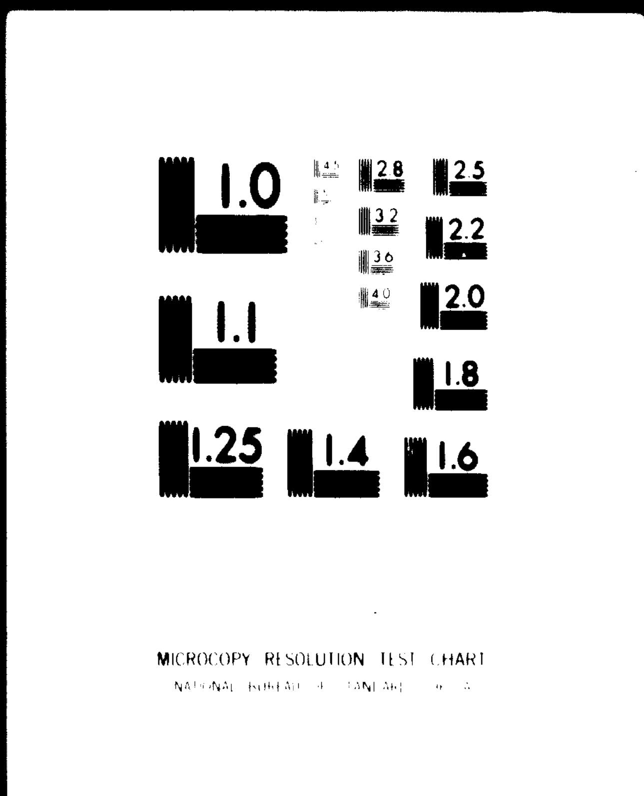

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There are pratically only two fields of applications for expandable polystyrene (foam) : building (insulation) and packaging.

In West Europe, the percentage of the total are respectively 49 % and 42 %. The expected growth of polystyrene foam market is no more than that of styrenic resins as a whole.

TABLE 1.

W. EUROPE H.D. POLYETHYLENE

PATTERN OF CONSUMPTION (PERCENTAGE)

Market / Years	1971	1972	1973	1974	1975	1976
Blow Moulding (hollow articles, containers)	40.1	41.3	42.7	41.0	45.2	46.0
Injection Moulding (packaging household, mechanical goods)	46.5	42.8	40.8	40.0	39.9	39.1
Pipe and conduit	4.5	5.9	4.9	5.2	4.3	4.5
Film and Sheet (packaging)	2.3	3.1	3.9	4.3	4.8	4.7
Wire and Cable	0.8	0.9	1.5	1.8	1.0	0.9
Other extruded Products*	4.4	4.0	4.9	5.5	4.3	4.2
Others	1.4	2.0	1.3	2.2	0.5	0.6
TOTAL, %	100.0	100.0	100.0	100.0	100.0	100.0

* Monofilament and slit film

TABLE 1.32

W. EUROPE POLYPROPYLENE

PATTERN OF CONSUMPTION (PERCENTAGE)

Market / Years	1971	1972	1973	1974	1975	1976
Injection Moulding and extrusion	56.0	56.0	47.0	45.8	53.3	51.8
Film (packaging)	10.6	10.4	12.5	12.5	10.8	11.9
Flat Yarn (raffia etc ...)	21.4	21.4	23.3	23.6	25.0	25.8
Monofilament fibers	12.0	12.2	17.2	18.1	10.9	10.5
Others	-	-	-	-	-	-
TOTAL, %	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 1.33

W. EUROPE P . V . C

PATTERN OF CONSUMPTION (PERCENTAGE)

Market \ Years	1971	1972	1973	1974	1975	1976
Bottles	5.1	5.6	6.5	6.1	7.3	7.4
Film and Sheet	9.7	9.4	9.4	10.2	9.1	9.3
Injection Moulding	1.7	2.3	2.4	2.5	2.2	2.2
Pipe and conduit	18.4	23.5	24.6	25.1	23.2	23.6
Profile Extrusion	9.4	10.5	11.3	11.7	13.3	13.4
Records and Others	3.2	2.4	2.6	2.8	3.8	3.9
Total, Rigid	(47.5)	(53.7)	(57.3)	(58.3)	(58.9)	(59.8)
Leather (isated fabrics)	8.5	9.0	8.6	7.9	6.8	6.8
Film and sheet	10.0	10.2	9.4	9.0	10.2	9.8
Flooring	7.0	6.8	6.0	5.5	6.2	6.1
Tubing (and profiles)	5.0	4.5	4.2	4.4	4.7	4.4
Wire and Cable	10.0	9.8	8.9	9.3	10.9	10.6
Others, Adhesives, Coating	12.0	6.0	5.6	5.5	2.2	2.5
Total, soft	(52.5)	(46.3)	(42.7)	(41.6)	(41.1)	(40.2)
TOTAL, %	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 1.3[illegible]

W. EUROPE POLYSTYRENE

PATTERN OF CONSUMPTION (PERCENTAGE) EXCLUDING EXPANDABLE POLYSTYRENE (BUILDING, PACKAGING)

Market \ Years	1971	1972	1973	1974	1975	1976
Appliances		9.4	10.0	9.7	10.2	9.7
Housewares		11.6	12.0	12.0	13.3	13.7
Packaging		41.4	42.3	42.6	42.8	44.0
Refrigerators		8.9	9.2	9.2	8.2	8.4
Automotive		2.0	1.9	1.9	1.5	1.8
Toys		6.4	5.8	5.3	5.1	4.8
Others (including furniture, shoe heels)		20.3	18.8	19.3	18.9	17.6
TOTAL, %		100.0	100.0	100.0		

2. SYNTHETIC FIBRES

Synthetic fibres by types

Concerning the main types of synthetic fibers, polyester fibers has gained the largest share of synthetic market everywhere in the world.

Polyester fibers have still a large potential growth as 100 percent synthetic fiber fabrics as well as in blends with the natural fibers, especially cotton.

The apparel market is generally the largest market for polyester fibers where they have equal acceptance by both men and women. For some apparel applications (hosiery etc...) polyester yarns can be textured, a feature that gives the finished fabric a more natural feel resembling that of fabric made from spun yarn, yet maintaining the economics of continuous filament yarns.

Polyester fibers are used by men for light weight suits, sometimes alone but more often blended with wool and likewise for slacks. They are used as well for shirts by men when blended with cotton and for blouses for women, in dresses suits and slacks.

The main reason for this acceptance is convenience because blends of polyester with natural fibers are the best for accepting the comparatively new permanent press and crease resistant finishes.

Among household goods, polyester is well accepted for curtaining again because of its convenience and confort. When blended with cotton, there is a major market developing in sheets for bedding.

Industrial uses of polyesters are a major market that has been developing. Other industrial markets in include reinforcement of rubber goods, cordage and in webbing.

An important point to be noted is that the development of polyester fibers is to a large extent linked with the relative prices of these fibers with cotton.

In the apparel market, polyamide fibers continue to hold a share of women's lingerie but have been outpaced by other fibers in women's dresses and outerwear.

Carpets form the major outlet of polyamides in the household sector. There is fierce competition in this market between all fibers. Although, polyamides are expected to hold a large share of the market, the real growth lies with the other fibres (especially polypropylene).

Industrial uses for polyamides include : tyre cord (almost only for the replacement market in the USA), automotive upholstery, tenting, tarpaulins, nets cordage and as reinforcement in hose belting and similar products. They are not very good prospects for these kinds of uses, especially for the former one.

This review of the main end-uses sector of polyamide shows that the long term development of this kind will be in any cases more limited than for other synthetic fibers.

The main outlet of acrylic fibers are found in sweaters but also in dresses, suits ans slacks, usually blended with wool. In suits and slacks, the acrylics are feeling the pressure of the polyester fibers.

In household products, the acrylics have made excellent penetration into blankets and also into rugs and carpets.

They are only few industrial outlets for the acrylics (e.g. covers for paint rollers).

The following table summarizes the expected development of synthetics in their various end-uses according to ENKA GLANZSTOFF.

TABLE 1.35

DEVELOPMENT OF VARIOUS END-USES FOR SYNTHETICS

(IN W.EUROPE)

Source : ENKA GLANZSTOFF

NYLON	Increasing :	carpets, home furnishings, pantyhose
	Decreasing :	tires
	Constant :	warp knitting, power nets, linings, ropes, nets.
POLYESTERS	Increasing :	men's and women's outerwear, underwear, shirts, workclothing, bed linen, tires, coated fabrics, carpets, carpet backing.
	Decreasing :	-
	Constant :	rainwear, curtains, anoraks.
ACRYLICS	Increasing :	knitted outerwear, draperies upholstery fabrics, blankets, carpets,
	Decreasing :	men's and women's outerwear
	Constant :	-

In industrialized countries, the slow down in the growth of demand for synthetic detergents observed for some years, to a great extent correspond to a deep penetration of these materials in the soap - detergent market. This penetration is expected to be achieved in the next coming years.

In addition, since the beginning of the seventies, there have been basic changes in the behaviour of consumers which have been important in restricting demand : e.g. consumer price resistance under the influence of consumer organisations (as observed in the USA) and saturation of the washing machine market.

On the other hand, another factor is able to sustain the growth of the demand for syndets : this is the elimination of phosphate builders which complement the detergent action of surfactants (acting primarily as water softeners). Phosphate builders make up a large part (traditionally about 30 %) of formulations but their uses has been questioned since the early seventies because of the algae growth problems which the high nutrient value phosphate causes in waste water streams.

Phosphate builders have already been banned in some states in the USA, resulting in an increasing need of surfactant to compensate. Europeans have taken longer to consider the problem. However, West Germany is already limiting phosphate contents and will enforce their replacement when alternative are available. In some other European countries, the alternative approach has been taken : most municipal sewage plants are equiped to precipitate phosphate from all sources.

4. RECENT DEVELOPMENTS AND FUTURE TRENDS IN THE PETROCHEMICAL INDUSTRY

Over the past few years some important developments have taken place which, although they do not directly concern the petrochemical industry, are likely to have an effect on it ; these include :

- a general slowing down of industrial activity, essentially in the industrialized countries,
- the rise in the cost of energy,
- a major increase, especially in 1973 and 1974, in plant construction costs,
- growing awareness of the problems of pollution, and the introduction of restrictions.

These external factors had an immediate impact on the petrochemical industry, and moreover are likely to have a great affect on its development in the coming years.

4.1. IMPACT ON THE PETROCHEMICAL INDUSTRY

1. *INCREASED PRODUCTION COSTS*

The rise in the cost of energy, particularly oil, led to a considerable rise in the cost of the raw materials and utilities used in the petrochemical industry, and this rise in turn naturally had a direct impact on the production costs of chemicals, an impact which is felt less as are moved towards more elaborated products . This effect was reinforced in the case of new plants, by the rise in construction costs. Moreover, in some countries anti-pollution measures resulted in additional investment costs.

It can be seen that the effect of the rise in the price of raw materials, and energy in particular, has been to increase olefin production costs by

350 % between 1972 and 1977.

2. SLOWER MARKET GROWTH

The general decline in industrial activity and the sharp rise in production costs, which was naturally reflected in selling prices, coincided with a slowing down of market growth. The set back of the petrochemicals demand brought about by their price increase has still be limited due to the simultaneous and in many cases higher cost increase of the competitive products (wood, paper, cardboard, non ferrous metals). See fig. 1.5, table 1.37).

In some fields, consumption has been kept lower avoiding wastage (excessive packing for example), Nevertheless, the stagnation and even the decrease of the purchasing power, have been the main reason of a parallel decline of the petrochemicals demand in the industrialized countries.

3. DIFFICULTY IN OBTAINING RAW MATERIALS - TREND TOWARDS FLEXIBILITY

The increased importance of the raw material as an element of the cost price of petrochemical products acted as an incentive to petrochemists to concentrate on the supply of raw materials as a priority. Futhermore, in some areas specific circumstances such as a reduction in natural gas reserves in the UNITED STATES, the need to import naphtha in JAPAN, the tendency in the West European petroleum products market to release less and less naphtha for the petrochemical industry have accentuated the problem of the supply of petrochemical raw materials. This factor will become increasingly important in the coming years. A general trend towards flexibility, eventat the price of high investments, is evident on the part of petrochemists.

4. SURPLUS PRODUCTION CAPACITY

On account of the sudden decline, difficult to predict, in the consumption of petrochemical products since 1973, chiefly in the industrialised countries, the industry as a whole is generally in a surplus situation. The development of production units can therefore be expected to slow down and the changes which might be expected as a result of developments affecting petrochemical production will be somewhat delayed.

The most pressing problems at the moment are those of outlets and competition, and no major new investments will be approved until the present uncertainty about renewed expansion is removed, and the supply/demand situation becomes more balanced.

5. CHANGES IN THE PRODUCTION COST STRUCTURE

A dramatic change has taken place in recent years in the production cost structure of petrochemical products, the chief cause of this change being the rising cost of raw material and energy. There has been a considerable decline in fixed costs, essentially related to investment, in favour of variable costs, particularly raw materials and utilities. This can be illustrated by the manufacturing costs of olefins, shown in table 19. In 1972 the proportion of the manufacturing cost represented by raw materials was 42 %. Under present-day conditions this proportion has reached 78 %. The proportion represented by amortization and return , on the other hand, has dropped from 40 % to 12 %. This very important change will affect the petrochemical industry principally in two ways :

1. Those countries or regions where raw materials are cheaply available, due to natural reserves, the favourable structure of the petroleum products market, or government aid to the petrochemical industry, will have a very great asset as far as petrochemical production is concerned ;

2. Economy of scale will become less important, with variable costs being the predominating factor, and the effect of market limitations as a barrier to the development of petrochemical

TABLE 1.36

OLEFINS MANUFACTURING COST

		Naphtha Steam cracking	Naphtha Steam cracking	Naphtha Steam cracking
Capacity tons/y ethylene		300 000	300 000	300 000
Economic conditions		Prevailing in 1972	Prevailing in 1977	Prevailing in 1977. Unit erected in 1972. Investment in 1972
Fixed capital cost MM $		104	184.3	104
Manufacturing cost MM $				
Raw materials		21 150	129 600	129 600
Utilities		1 080	2 200	2 200
Catalysts & chemicals		520	1 000	1 000
Manpower		700	1 100	1 100
Other charges (1)		750	12 000	12 000
Amortization & return		19 800	35 000	19 800
Total manufacturing cost		50 100	180 900	165 700
Products prices & sales	10^3t/y	$/ton	$/ton	$/ton
Ethylene	300	90	315 (2)	280 (2)
Propylene	139	55	193 (2)	172
Butadiene	38.2	150	520 (2)	465
Propane LPG	12	32	130	130
Butane LPG	44.2	32	130	130
Gasoline	195.8	45	168	168

See remarks on next page.

NOTES TO TABLE 1.36

(1) Maintenance, overhead expenses, insurance, general facilities, interest on working capital.

(2) Ratio of olefins prices have been kept constant in the table. In fact, ratio between ethylene and propylene prices is slightly decreasing from 1972 (1.6) to 1978 (1.4). Ratio of ethylene versus butadiene prices is now close to 0.9.

production will be diminished. Steam cracking economics for capacities of 150,000 and 300,000 t/year of ethylene, under 1972 conditions and present-day conditions, are shown in table 21. In 1972 doubling the steam cracker capacity would lead to a 20 % reduction in olefin production costs, but today the reduction would be no more than 6 %.

TABLE 1.37

ENERGY REQUIREMENTS

FINAL PRODUCTS

	Tons oil equivalent required for *
	1 million fertilizer bags
Polyethylene bags	470
Paper bags	700
	100 kilometers of 1 inch diameter service pipe
Polyethylene pipe	57
Copper pipe	86
Galvanized steel pipe	232
	100 kilometers of 4 inch diameter drainage pipe with fittings
P.V.C. pipe	360
Asbestos cement pipe	400
Cast iron pipe	1 970
Clay pipe	830
	1 million liters
PVC	37
Glass	230

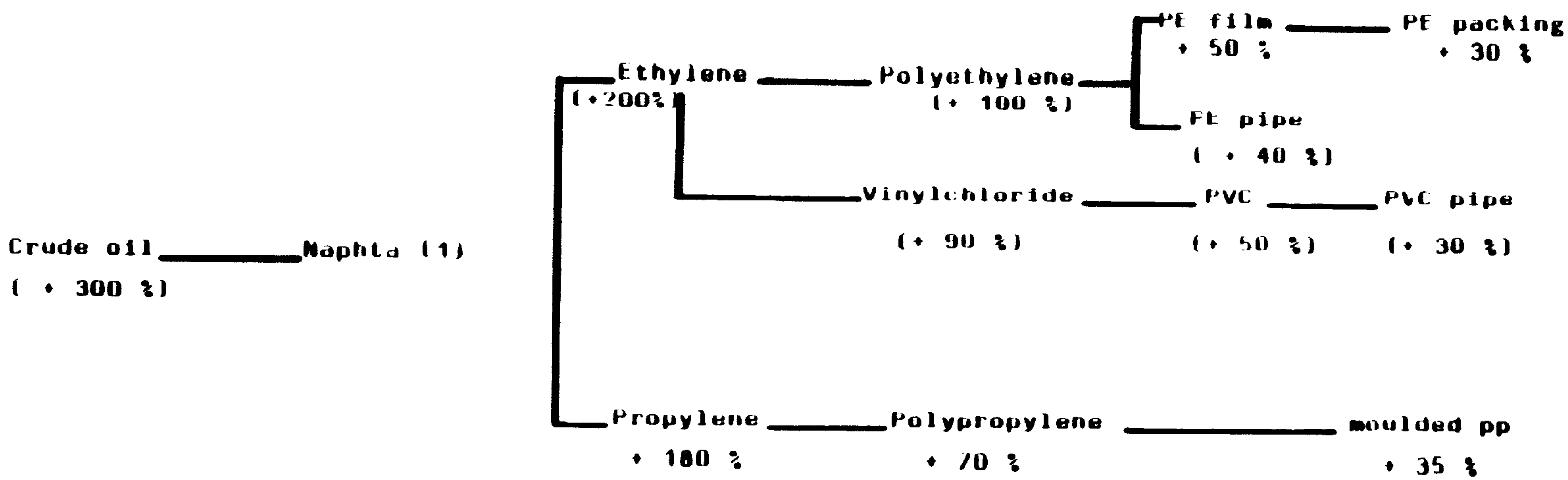
* including both raw material and energy for processing

source : ICI Plastics Division

FIGURE 1.5

Impact of the crude oil cost increase, on petrochemical products cost between June 1973 and June 1974.

(Source NEDO, Increased cost of energy - Implication for UK industry)



(1) Naphta price is dependant to offer and demand situation; it can vary up to some extend, independantly from the crude price. During the considered period, the naphta price increase amounted 400 %.

2. PETROCHEMICAL CONSUMPTION AND PRODUCTION IN VIETNAM - FORECASTS

1. General
2. Plastics demand in VIETNAM
3. Fibres demand in VIETNAM
4. Detergents demand in VIETNAM

1. GENERAL

The previous chapter contains data on world petrochemical consumption and production over the 1965-1975 period. The world petrochemical market has been seen to be characterized by fairly high growth rates in industrialized countries, and again high though often irregular rates in developing countries. These features are unfavourable to the design of econometric forecasting models.

Several methods may be used for forecasting :

a) ECONOMETRIC MODELS

There have been many attempts to design forecasting models, but these have turned out somewhat unsatisfactory in that they cannot be generalised but vary according to the country, products and period studied.

The tendency therefore is towards simple formulae with only one variable - income, either GNP or GDP. This gives an order of magnitude for future petrochemical demand.

One of the advantages of this method is that it illustrates the effect on petrochemical consumption of future income fluctuations.

Models take the form of log c = A log "GNP" + b. This formula works best in the case of industrialised countries or those with a sufficiently high level of consumption (e.g. 5 to 10 kg/head for plastics) and a regular demand growth pattern.

In developing countries on the other hand where consumption is still low and the rate of growth typically fast and irregular, a number of simple formulae based on GNP can be applied. When so many features are indeterminate such formulae are evidently valid only as a rough guide.

b) GRAPHIC METHOD

Another possibility involves graphic methods - a comparison of established trends in more developed but comparable countries - though these are perhaps more valid where a certain level of consumption has already been reached.

There is also some value in representing demand over a given period, for example a five-year span, as a function of income within a homogeneous group of countries, industrialized or non-industrialized. The corresponding curves move more or less in parallel through time. Plastics and fibres curves were shown in Chapter 1.

The position of any given country in relation to these master curves - either behind or ahead at the same income level - can be taken by gradual adjustments in relation to the curve (making up leeway or reducing lead), but substantial gaps are always found between countries with a comparable income level, even among the industrialized countries.

c) FLUCTUATIONS IN DEMAND ELASTICITY IN RELATION TO INCOME

The notion of elasticity was introduced in the remarks on the macro-economic approach. There is another method involving study of fluctuations in demand elasticity in relation to income.

Such fluctuations generally take the form of a regular decrease and can thus be forecast.

These various methods are applicable to product groups, i.e. plastics, fibres, rubber. The next step is to forecast demand growth for each product with reference to prospects in each of the main outlets.

Such methods can of course be applied only to countries for which a certain amount of statistical data is available.

In the case of VIETNAM where no statistics can be obtained the method used for plastics, fibres and rubber is as follows :

Firstly, to situate VIETNAM within a group of countries in the same region with similar income levels, and then to make a study of selected cases in those countries for which full statistics are available.

By using the econometric model together with the graphic and elasticity variation methods, and cross-checking the results, an order of magnitude is obtained which can then be applied to the countries in the group.

The group of countries chosen for the purposes of this study in SOUTH ASIA, which includes AFGHANISTAN, INDIA, PAKISTAN, BURMA, INDONESIA, LAOS, the PHILIPPINES, MALAYSIA, SINGAPORE, THAILAND and VIETNAM.

As to economic indices, no official figures exist for GDP. It is generally taken as being around 150$/capita, but this estimate is to be considered with certain reservations as many consumer goods are State-subsidised.

The table which follows shows the GDP of the major countries within the group.

From this table VIETNAM's placing in the group can be seen to be average.

TABLE 2.1

GROSS DOMESTIC PRODUCT

	1974 $/capita	1977 $/capita	% growth 1975-1980 UNIDO $ constant	1980 $/ capita (est.)
VIETNAM	-	150		200
THAILAND	300	360	2.	-
INDONESIA	175	200	4.	-
MALAYSIA	600	800	4.5	-
PAKISTAN	130	160	1.5	-
INDIA	130	160	1.5	-
BURMA	100	120	1.0	-
BANGLADESH	90	120	-	n.a
PHILIPPINES	310	400	3.5	-
CHINA	n.a	300	-	n.a

2. PLASTICS DEMAND IN VIETNAM

a) DATA SUPPLIED BY PETROVIETNAM

- Plan objectives

Plan objectives	1980	1985
Low density polyethylene	20,000	25,000
High density polyethylene	20,000	25,000
Polyvinyl chloride	90,000	100,000
Polypropylene	20,000	30,000
Polystyrene	10,000	(15,000)

- By 1980, consumption and the processing industry are both expected to show the following structure :

	%
Fertilizer bags	7.5
Kaolin bags	0.5
Export packaging	2.5
Feed packaging	20.0
Foodstuff packaging	9.8
Packaging	1.5
Electrical equipment	1.0
Vehicle spare parts	0.5
Construction	29.5
Footwear	6.0
Waterproof clothing	6.0
Artificial leather	6.0
Toys	0.6
Office equipment	0.6
Containers	5.0
Other	3.0.

b) CONSUMPTION FORECASTS

Growth rates (%/year) in South ASIA over the 1965-1970 and 1970-1975 periods were 15.7 %/year and 9.8 %/year respectively.

The 1975 regional consumption level was 0.8 kg/capita which corresponds to the master curve (see Chapter 1, paragraph 3.3, page 48.)

Consumption (kg per capita) in neighbouring countries is shown below :

	kg/capita	1976 GDP/capita US$
THAILAND	2.76	340
INDONESIA	1.03	190
INDIA	0.29	150
PAKISTAN	0.62	150
PHILIPPINES	2.61	380
MALAYSIA	8.0	750
VIETNAM	n.a	n.a

The 1980 forecast for the same countries is as shown below :

	kg/capita	1980 forecast GDP/capita US$	tons
THAILAND	3.6	400	
INDONESIA	1.49	220	232,000
INDIA	0.38	175	260,000
PAKISTAN	0.8	175	66,000
PHILIPPINES	3.66	430	190,000
MALAYSIA	10.6	870	148,000
VIETNAM (plan objective)	3.1	200	160,000

A preliminary comparison of neighbouring countries, e.g. THAILAND and INDONESIA, reveals that when the GDP is in the order of 200 US$ plastics consumption -chiefly thermoplastics- is in the region of 1.5 to 2 kg per capita at most, which represents as far as VIETNAM is concerned consumption of some 75 000 to 100,000 tons at most by 1980 and not the 160,000 quoted in the Plan objectives ; the latter figure would be valid for a country with a GDP of 350 US$ per capita.

Taking the growth rate to be the same as in the 1976-1980 period, total consumption in 1985 will be somewhere between 140,000 and 190,000 tons.

c) COST OF DEVELOPING PLASTICS DEMAND

Assuming the Plan objectives to be reached in 1980, i.e. with 160,000 tons of plastics consumed, this quantity would have to be imported until domestic production starts-up, representing an annual cost of 88 million dollars if resins cost 550 US$/ton on average.

Furthermore, since such products are not in their final form ready for sale to consumers, they require to be processed. In view of existing processing capacity in VIETNAM - under 50,000 tons - processing capacity in the order of 100,000 to 110,000 tons would require to be set up, costing some 100 to 120 million dollars.

If the 1980 Plan objectives are to be reached, this outlay would have to be made before the end of that year.

A resin and finished products distribution network would also have to be set up, as well as delivery storage units.

In view of all these considerations, we feel that the Plan objectives are over-optimistic, and that it would be more realistic to plan to spread these costs over the 1980-1985 period, particularly as to these figures must be added investment costs for resin production.

d) DEMAND STRUCTURE - COMPARISON WITH NEIGHBOURING COUNTRIES

The general structure of demand for the main thermoplastics in the South-East ASIA region is as follows :

Low density polyethylene	25-30 %
High density polyethylene	10-15 %
PVC	25-30 %
Polypropylene	10-15 %
Polystyrene	5-10 %

The structure forecast under the Plan objectives is the following :

Low density polyethylene	13 %
High density polyethylene	13 %
PVC	56 %
Polypropylene	13 %
Polystyrene	6 %

The exepcted share taken by PVC, 56 % in 1980 and 51 % in 1985, seems far too large, even if it is to be developed preferentially. In Eastern EUROPE where this has been the case, the share taken by PVC in total thermoplastics is no more than 38 %. Similarly in IRAQ where PVC is being strongly developed, the corresponding share of total thermoplastics is not likely to exceed 30 %.

The total for low density polyethylene and PVC together is 69 %, which can be compared to the figure of 60 % in the South ASIA region.

In PETROVIETNAM's proposed demand structure the item "construction", made up for the most part by PVC seems to be too large. If a level of 50,000 tons of PVC is to be realistic it must be warranted by major water purification programmes, irrigation programmes and other projects.

We propose the following main sectors of consumption :

Rice, fertilizer and flour bags	ldPE, polypropylene
Electric cable	ldPE, PVC
Footwear	PVC
Pipe	PVC, hdPE
Containers, drums, bottles	PVC, hdPE
Bottle crates, fish and fruit crates	hdPE
Household appliances	hdPE, polystyrene
Toys	hdPE, ldPE, PVC
Rope, fishing nets, mosquito nets	polypropylene
Packaging film	ldPE
Insulating	polystyrene

To sum up the following remarks can be made :

- Total thermoplastics demand is more likely to be

  80,000 tons by 1980
  160,000 tons by 1985

- The PVC share is too large and should be reduced to no more than 30-35 % of the total, i.e. 50,000 to 60,000 tons by 1985.

- As far as the other resins are concerned, the Plan objectives appear reasonable ; however, the share taken by low density polyethylene could be larger.

- A possible consumption structure for 1985 would be as follows :

Low density polyethylene	15-20 %
High density polyethylene	20-25 %
Polyvinyl chloride	30-35 %
Polypropylene	10-15 %
Polystyrene	5-10 %.

3. FIBRES DEMAND IN VIETNAM

a) DATA SUPPLIED BY PETROVIETNAM

Present consumption

Natural fibres, cotton	50,000 t/yr
Artificial fibres	30,000 t/yr

Plan objectives for 1985 (in tons)

	Natural fibres	Synthetic fibres	Cellulose fibres
Polyester filament		10,000	
Polyamides		25,000	
Acrylics		3,000	
Viscose			25,000
Other polyester		40,000	
Polyester/ cotton mix	13,200	26,800	
T O T A L	13,200	104,800	25,000
		143,000	

Plan objectives for 1980 in terms of total length of manufactured cloth amount to 450.000 metres.

b) CONSUMPTION FORECAST

The same forecasting methods and hypotheses were used as in the case of plastics (see 2.1.).

Artificial fibre consumption growth rates in the South ASIA region over the 1965-1970 and 1970-1975 periods were 10.3 %/year and 11.9 % /year respectively.

The 1975 regional consumption level was 0.68 kg per capita, slightly higher than the corresponding figure on the master curve.

Consumption (kg per capita) in the South ASIA group of countries is indicated in the table which follows. Figures are taken from the FAO report entitled "Per caput Fibre Consumption", covering 1973/1974.

Assuming no major variations in consumption between then and now, present consumption of total fibres in VIETNAM can be estimated at 1.6 kg/capita, a figure in accordance with the present 80,000 tons/year consumption level.

Taking the same GDP growth hypothesis as in the case of plastics, i.e. 200 US$ per capita by 1980, consumption of artificial fibres in VIETNAM in the same year may be put at 1.1-1.3 kg/capita, giving a total of 60,000 to 70,000 tons/yr.

c) GROWTH RATE

A reasonable growth rate forecast for South East ASIA over the 1980-1985 period would be around 11-12 % per year.

In the case of VIETNAM with a planned economy and established planning objectives, consumption of cellulose and synthetic fibres together can be expected to reach between 105 and 120,000 tons by by 1985.

d) COST OF DEVELOPING TEXTILE FIBRES DEMAND

Again as in the case of plastics, fibres are not sold as such directly to the consumer but first must be processed. The textile industry involves not only polymerization and spinning plants but also weaving and knitting units.

The textile industry appears already fairly well established in VIETNAM, in both the North and the South, but in order to meet 1985 consumption forecasts the industry will require to be considerably developed, implying high investment.

TABLE 2.2.

CONSUMPTION - SOUTH ASIA - KG/CAPITA

	1973/1974 Synthetic fibres kg/capita	1973 Total fibres kg/capita
THAILAND	1.2	3.1
INDONESIA	0.3	1.3
INDIA	0.3	2.2
PAKISTAN	0.2	4.3
PHILIPPINES	1.3	2.0
MALAYSIA	1.0	3.0
NORTH VIETNAM	0.2	0.7
SOUTH VIETNAM	0.9	2.4

e) DEMAND STRUCTURE - COMPARISON WITH NEIGHBOURING COUNTRIES

The average structure of synthetic fibre demand in South ASIA is as follows :

- Acrylics 15 %
- Polyamides 33 %
- Polyesters 52 %

In the next few years some modification of this structure can be expected with a higher share being taken by polyesters.

A possible 1980-1985 synthetic fibre demand structure in South ASIA might be as follows :

- Acrylics 15 %
- Polyamides 23 %
- Polyesters 62 %.

The Vietnamese plan envisages the following breakdown :

- Acrylics 3 %
- Polyamides 24 %
- Polyesters 73 %.

The polyester share seems too high, even with preferential development.

As regards acrylics, their share seems too low, particularly since acrylic fibre is a good substitute for wool, a natural fibre of which little or none is produced in VIETNAM.

The following are the main consumption sectors :

- Weaving : linings : cellulose fibres
  other materials : synthetic fibres
  clothing : cotton, wool
  household fabrics : artificial fibres, cotton
  industrial fabrics : artificial fibres, cotton

- Knitting : footwear, underwear : synthetics, blankets, sweaters cotton, wool

To sum up, the following assessments may be made :

1. Total artificial fibre demand can be estimated to some 115,000 tons by 1985, with synthetic fibres accounting for 95 to 100,000 tons.

2. The share taken by polyesters is over large and should be no more than 65 %, while that taken by acrylics is too small and should be over 10 %.

3. A possible 1985 consumption structure would be as follows :

   - Acrylics 10-15 %
   - Polyamides 20-25 %
   - Polyesters 60-65 %

4. DETERGENT DEMAND IN VIETNAM

a) DATA SUPPLIED BY PETROVIETNAM

Present demand for total soap + detergents is 0.5 kg/capita with an average breakdown of 50/50 % between soap and detergents.

Plan objectives for total soap + detergents are as follows :

1980	1985
100,000 tons/yr	210,000 tons/yr

The synthetic detergent forecast is 1 kg/capita by 1980 and 1.5 kg/capita by 1985.

b) SYNTHETIC DETERGENTS : SOME GENERAL REMARKS

The composition of household detergents may vary from one manufacturer to another and from country to country, but it varies above all according to the use to which the powder is put ; thus a powder designed for use in a washing machine will have a relatively higher proportion of perborate than an ordinary powder and will contain long chain fatty acids, the function of which is to minimize frothing.

The average composition of household detergents powders in developing countries can be taken as the following :

. Active ingredient (dodecylbenzene, sodium sulphonate, LAS and non-ionic surface-actives)	20 %
. Sodium tripolyphosphate	30-35 %
. 45 % sodium silicate	7-10 %
. Sodium perborate	12-15 %
. Sodium sulphate	16-18 %
. Various : sodium carbonate, soap carboxymethylcellulose blue	2-15 %

However, in industrialized countries - in EUROPE, for example - the total active ingredient level is lower (between 10 and 15 %) but the tripoly-phosphate level is 30 to 50 %.

The petrochemical industry is concerned with the manufacture of the active ingredients only, i.e. dodecylbenzene and linear alkylbenzene.

c) <u>CONSUMPTION FORECAST</u>

The average detergent demand growth rate in South ASIA, in %/year, was 25 % over the 1965-1970 period and 17 % from 1970 to 1975. Detergent consumption in the same countries was 0.5 kg/capita in 1975.

The figure of 0.5 kg/capita given by PETROVIETNAM for the soap + detergent total seems rather low, and would appear to refer rather to synthetic detergents alone.

d) <u>GROWTH RATE</u>

A reasonable growth rate for the South ASIA region over the 1980-1985 period would be in the area of 12-13 % per year, and 100,000 tons/yr seems a realistic synthetic detergent consumption level for 1985.

e) <u>DETERGENT DEMAND DEVELOPMENT</u>

According to the PETROVIETNAM data, detergent processing capacity in SOUTH VIETNAM is 50,000 tons/year, which corresponds to the synthetic detergent consumption capacity quoted in the Plan objectives.

If this data is accurate, the detergent formulating and processing industry has already reached the required capacity, and it will be sufficient to double this capacity in order to meet the 1985 Plan objectives.

6) CONCLUSION

The Plan objectives put forward by PETROVIETNAM, i.e.

	1980	1985
Soaps	50,000	100,000
Synthetic detergents	50,000	110,000
	100,000	210,000

are realistic as far as the soap + detergents total is concerned, but the breakdown between detergents and soaps (50/50) might show a shift in favour of synthetics by around 1985.

It should be remembered, however, that only the active ingredients, i.e. about 20 % of synthetic detergents, are petrochemicals. In the case of VIETNAM total active ingredient consumption will be around 20,000 tons by 1985.

3. PROPOSED PLAN FOR PETROCHEMICAL INDUSTRY DEVELOPMENT IN VIETNAM

1. General
2. Petrochemical industry development plan
3. Plan for petrochemical industry development in VIETNAM - Stage 1

1. GENERAL

There are many different types of factors which affect the establishment and development of a petrochemical industry. These can be classified as geographical, human, economic, financial and technical. They have been discussed in paragraph 1.2. The essential factors are the existence of a market, the means of financing investments and a supply of raw materials. Less essential but important factors are the existence of a processing industry and manpower resources.

There follows an attempt to analyse the situation in VIETNAM with reference to the above factors.

a) *EXISTENCE OF A MARKET*

The present market for petrochemicals in VIETNAM, i.e. plastics, fibres and detergents, is not very developed but middle and long term prospects, considering the large population and the forecast increases in national income are bright enough.

Table 3.1. forecasts for 1985 and 1990 consumption of intermediates such as ethylene, propylene and benzene.

These ethylene, propylene and benzene consumption figures fall short because certain products derived form ethylene, propylene and benzene have not been included, e.g. ethylene glycol, polyvinyl acetate, propylene oxide ; hence it is necessary to multiply these values by factors to arrive at a potential consumption figure closed to reality. Table 3.2. gives an estimated value for total potential consumption of intermediates.

TABLE 3.1

CONSUMPTION FORECAST : BASIC INTERMEDIATES

IN 10³TONS

	QUANTITE	ETHYLENE	PROPYLENE	BENZENE	P.XYLENE	QUANTITE	ETHYLENE	PROPYLENE	BENZENE	P.XYLENE
PLASTICS										
. Polyethylene	65	67				125	130			
. P V C	56	28				110	57			
. Polypropylene	24		26			60		65		
. Polystyrene	15	5		15		30	10		30	
FIBRES										
. Nylon	25			27		40			43	
. Acrylics	15		17			30		34		
. Polyesters	60				45	120				90
DETERGENTS *	20		14	6		40		28	12	
T O T A L		100	57	48	45		197	127	85	90

* *for detergents the active material was assumed to be dodecylbenzene sulphonate but it may possibly rather be linear alkylbenzene, which would reduce the propylene balance.*

TABLE 3.2

TOTAL ESTIMATED CONSUMPTION OF INTERMEDIATES IN VIETNAM (10^3 TONS)

	1985	1990
ETHYLENE	125	245
PROPYLENE	70	150
BENZENE	55	95
PARAXYLENE	45	90

b) MEANS OF FINANCING

The petrochemical industry is a hevay industry requiring very considerable investments. It can be assumed that up to 1985 almost all the financing potential i.e. international loans, will be totally used for the fertilizer complex, the refinery, the processing industry and initiating petrochemical production such as PVC plant. It would be better to delay heavy petrochemical industry construction until 1990.

c) RAW MATERIAL SUPPLIES

In order, for a petrochemical industry, to be set up, there must be petroleum raw materials available, in the form of either gas, or petroleum fractions obtained through refining.

The raw materials situation in VIETNAM is at present not yet defined.

The petrochemical complex could evidently rely on certain petroleum fractions, as raw materials since it will be established after the start up of a refining industry, but the possibility of natural gas resources must also be considered - either ethane or ethane/propane, a very attractive raw material for an ethylene-based petrochemical industry.

d) EXISTENCE OF A PROCESSING INDUSTRY

As specified in paragraph 2.2. and 2.3. the existence of a processing industry is indispensable for a petrochemical industry oriented towards a local market. A petrochemical industry cannot start up without some processing industry but it is possible during start up to build up this processing industry.

e) MANPOWER AVAILABILITY

All sectors of the petrochemical industry require a highly specialized work force. It is possible during unit start up to call on external cooperation.

2. PETROCHEMICAL INDUSTRY DEVELOPMENT PLAN

If we take into account the factors discussed in the previous paragraph and the idea of economic capacity the development of the petrochemical industry must be envisaged in several stages.

For the first stage, the only unit which seems to be of suitable size is the PVC unit. The ethylene unit is too small and cannot be justified, and the polyethylene units are also too small.

In subsequent stages, a 250,000 ton ethylene steam cracker can be set up, as well as a high density polyethylene unit, a low density polyethylene unit, a polypropylene unit and another PVC unit. Construction of an aromtics-based complex for nylon and polyester must also be planned.

The development of the petrochemical industry, i.e. the type of complex, will depend mainly on the raw material.

If the raw material available for the steam cracker is a mixture ethane and propane, the complex based on ethylene, and the complex based on aromatics could be separate and even situated in different places.

If gas is not available it will be necessary to plan for the utilisation of naphtha or gas oil and in this case the two complexes would be integrated and located in the same site.

Several scenarios are possible. The variable which differentiates them is the steam cracker feedstock. The first scenario is based on an ethane steam cracker, the second on an ethane/propane steam cracker and the third on a liquid feedstock steam cracker. Each scenario will comprise several stages of development.

The various scenarios are presented in the table which follows.(table 3.3.)

For each of these scenarios, it is possible, of course to phase some productions using ethylene by operating the steam cracker at a reduced capacity - all will depend on the availability of financing, because the total investments for each of these scenarios, without taking into account inflation will be higher than one milliard US$.

It is not possible at this stage to study each of these scenarios in more detail owing to uncertainties as to the steam cracker feedstock.

TABLE 3.3

SCENARIO 1 : FEEDSTOCK ETHANE

	FIRST STAGE	SECOND STAGE	THIRD STAGE	FOURTH STAGE
IMPORT	Vinyl chloride	DMT and ethylene glycol	Propylene Ethylene glycol	
UNITS	P V C	Ethane steam craker salt electrolysis VCM - PVC Ld polyethylene Hd polyethylene Polyesters	Aromatic reformer Benzene Paraxylene - Styrene Polystyrene - DMT	Ethylene oxide Acrylonitrile Acrylic fibres Caprolactam - Nylon 6 detergents

SCENARIO 2 : FEEDSTOCK ETHANE-PROPANE*

	FIRST STAGE	SECOND STAGE	THIRD STAGE	FOURTH STAGE
IMPORTS	Vinyl chloride	DMT Ethylene glycol	Ethylene glycol	
UNITS	P V C	Steam cracker Salt electrolysis VCM - PVC Ld polyethylene Hd polyethylene Polypropylene Polyesters	Aromatic reformer Benzene Paraxylene - Styrene Polystyrene - DMT	Ethylene oxide Acrylonitrile Acrylic fibres Caprolactam - Nylon 6 Detergents

SCENARIO 3 : FEEDSTOCK NAPHTHA

	FIRST STAGE	SECOND STAGE	THIRD STAGE	FOURTH STAGE
IMPORT	Vinyl chloride	DMT - Ethylene glycol	Ethylene glycol	
UNITS	P V C	Steam cracker electrolysis VMC - PVC Ld & Hd polyethylene Polypropylene Polyesters	Aromatic reformer Benzene Paraxylene - Styrene Polystyrene - DMT	Ethylene oxide Acrylonitrile Caprolactam - Nylon 6 Detergents

* *In the case of scenario 2, the quantity of propylene produced depends upon the propane-ethane ratio of the feedstock. For the fourth stage, it will be necessary to increase the ratio of propane to ethane in order to produce propylene required for the production of acrylonitrile.*

3. PLAN FOR PETROCHEMICAL INDUSTRY DEVELOPMENT IN VIETNAM - STAGE 1

3.1. INTRODUCTION

Plastics consumption forecasts for 1985 are as follows : PVC 56,000 tons, low density polyethylene 35,000 tons high density polyethylene 30,000 tons, polypropylene 25 000 tons and polystyrene 15 000 tons.

The only economic capacity is PVC ; a 60 000 tons/year PVC unit is profitable and can be considered. PVC can be produced using either imported or locally produced vinyl chloride monomer, but in this hypothesis, it is necessary to import ethylene and to produce chlorine by salt electrolysis.

It seems preferable in the first state to import vinyl chloride monomer instead of producing it for the following reasons :

- Investment for chlorine and VCM production are very high compared to those for PVC alone
- Importing ethylene requires more expensive storage tanks than those for the import of VCM
- The production cost of VCM depends to a great extent on unit capacity and it seems better to build a bigger unit in the second stage than a small unit in the first stage and a second small one in the second state.
- The size effect is much less marked in the case of PVC.

The following chapter contains a preliminary definition of a PVC unit.

3.2. DESCRIPTION OF DIFFERENT TYPES OF PROCESSES

The three main techniques used to polymerise vinyl chloride into PVC are :

- Suspension polymerisation
- Emulsion polymerisation
- Liquid phase bulk polymerisation

a) *Suspension polymerisation*

Polymerisation unit

Vinyl chloride polymerisation into PVC takes place batchwise in large autoclaves (several for each line).

After nitrogen purging each polymeriser is fed with VCM from storage, demineralized water, suspending agents, catalysts and initiator previously weighed. Steam or hot water is then introduced into the reactor jacket to start polymerisation. Since the reaction is exothermic, the temperature is maintained constant at about 50-60°C by circulating cooling or chilled water in the jacket.

During the reaction, the mixture is continuously agitated. Each grade or resin is determined by quantities of reactants and additives, reaction time, reaction temperature, etc..

The end of the reaction is shown by a drop in pressure to less than 5 atm. Yield of conversion is then about 80-85 %. A slurry, i.e. a suspension of solid PVC in water, is finally obtained.

Monomer recovery

The slurry is degassed in the autoclave or in a separate degasing vessel and can then be continuously sent to a stripping column, where VCM is stripped.

After separation from steam, VCM vapour is sent to a gas holder together with unconverted VCM from autoclaves, then compressed and liquefied.

Liquid VCM is further purified in a column, and recycled after intermediate storage to the VCM feed tanks.

Slurry dewatering and drying

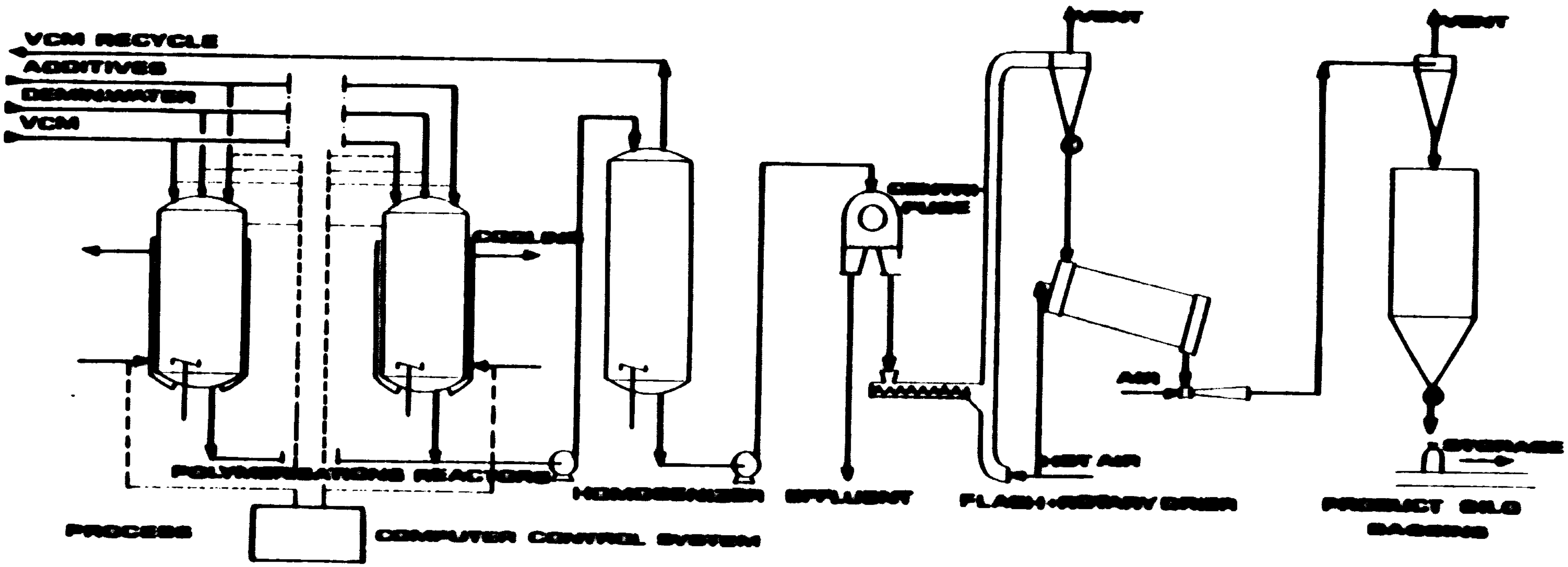
Stripped slurry from several batches is fed to a storage tank for homogeneisation, together with slurry recovered from washing out the reactors. The slurry consists of PVC grains dispersed in polymerisation water which also contains residues of the additives used in the reaction. PVC is usually separated from additives and from most of the water by centrifugation, which can be accompanied by water washing, and filtration.

The polymer cake is then dried and transported pneumatically to a screen, where any oversized particles are removed, then goes to a product hopper before being bagged or shipped in bulk.

This section is operated continuously.

Completion of the whole operation requires several hours. Construction material is relatively costly, since stainless steel or resin-coated steel is used for all equipment in contact with raw materials and for equipment in contact with PVC.

SUSPENSION-PVC PRODUCTION PROCESS FLOW DIAGRAM



b) *Emulsion polymerisation*

Until 1950, this type of polymerisation was used on a larger scale than other processes. But after the rapid development of suspension polymerisation, the number of plants using it has dwindled. Nevertheless, the process remains irreplaceable for production of certain resin grades used for coating and plastisol manufacture. In the U.S., emulsion polymerisation products account for about 13 % of total PVC production.

Polymerisation

This is usually carried out in batches in large jacketed autoclaves. An emulsifier creates micelles where polymerization is initiated, stabilizes monomer droplets in the emulsion and protects polymer particles from coagulation during the reaction. At the beginning of the reaction, a stable emulsion of vinyl chloride in water is thus created.

Emulsifier, initiator and buffer agent dissolved in demineralized water (cold water is often used to prevent initiator decomposition) are fed to the purged autoclave. Vinyl chloride monomer is then added. An emulsion is created by agitation, and heated by steam circulating in the reactor jacket to the desired polymerization temperature (40-55°C).

The end of the polymerization is indicated by a drop in pressure ; after 12 to 18 hours, 90 to 95 % of the VCM feedstock is polymerized. A PVC latex is finally obtained.

Reactors are periodically washed as in the suspension process.

Monomer recovery

The autoclave is degassed to remove most of the monomer. In recent processes, the PVC latex is then sent to steam stripping to eliminate the last traces of monomer.

Monomer is subsequently recovered in the same way as in the suspension process.

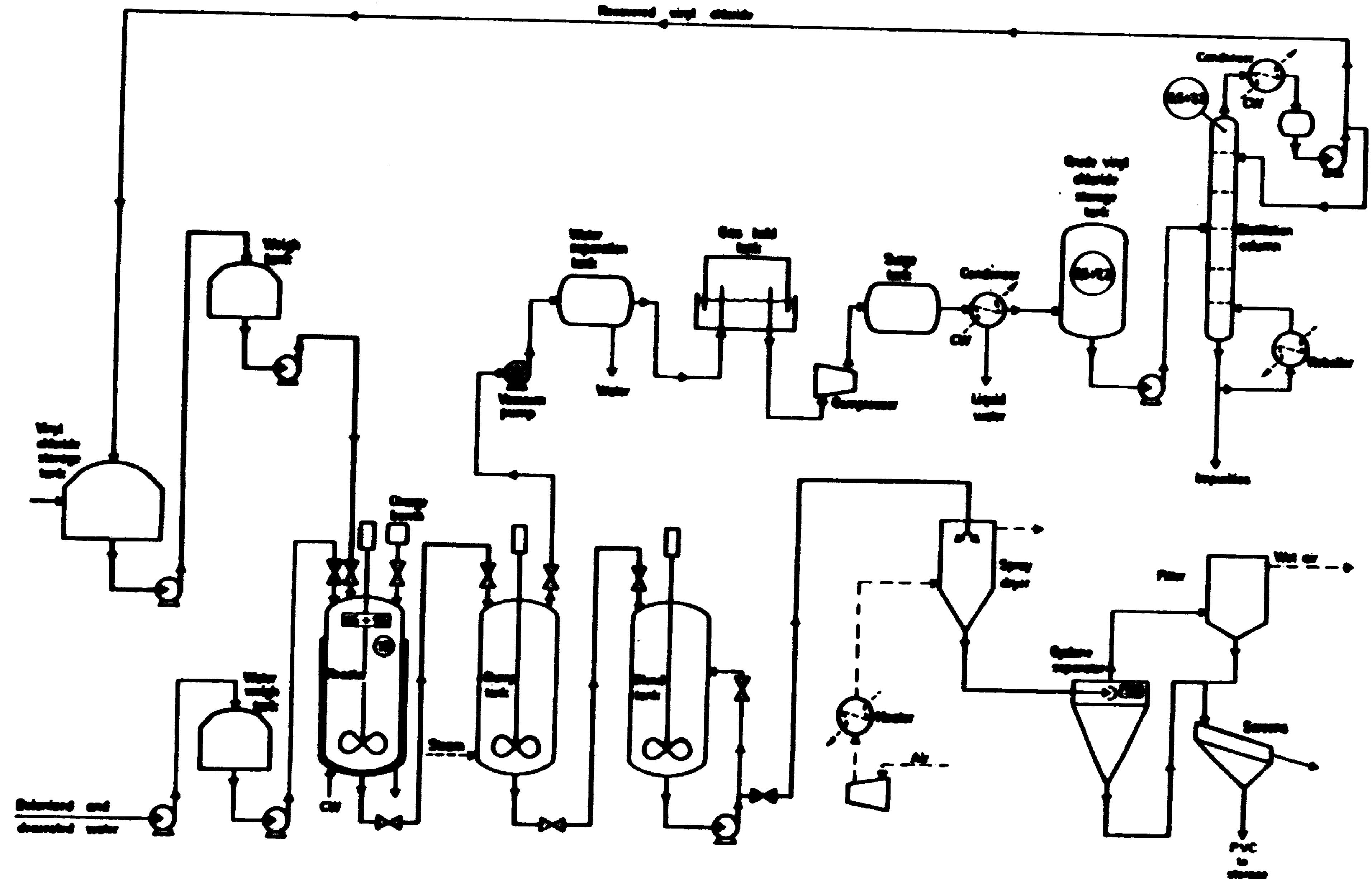
Latex drying and product finishing

Emulsion from several batches is fed to a blending tank for homogenisation.

Latex (concentrated or not) is then pumped into a spray dryer where circulating hot air vaporizes water still contained in fine latex particle.

The air-product mixture leaves the dryer and passes into filters where dried PVC is separated from the drying air and flows to a classifier. Air can be vented to the atmosphere, but part of it is sometimes recycled to the air blower.

Product from filters goes to a magnetic separator and a vibrating screen and is then crushed to yield a fine powder which is bagged or shipped in bulk.



P V C EMULSION POLYMERISATION PROCESS

c) *Bulk polymerisation*

Vapour phase bulk processes still being in the development stage, liquid phase polymerisation is the only bulk process used industrially. Polymerisation is performed in two stages, i.e. prepolymerisation and polymerisation.

Prepolymerisation

The operation is carried out in a jacketed autoclave fitted with an agitator and topped by a reflux condenser.

After purging with nitrogen, initiators are introduced then part (about 50 %) of the total liquid feedstock is added.

The initiator consists of a mixture of organic peroxides. Cooling water is used to regulate the temperature. When the desired transformation ratio -8 to 12 % of monomer converted into PVC seed- is achieved, the mother batch load is transferred to secondary polymerization autoclave.

A single prepolymerizer is designed to feed several autoclaves.

Polymerisation and degassing

Autoclaves are fitted with agitator, jacket for water circulation, and reflux condenser.

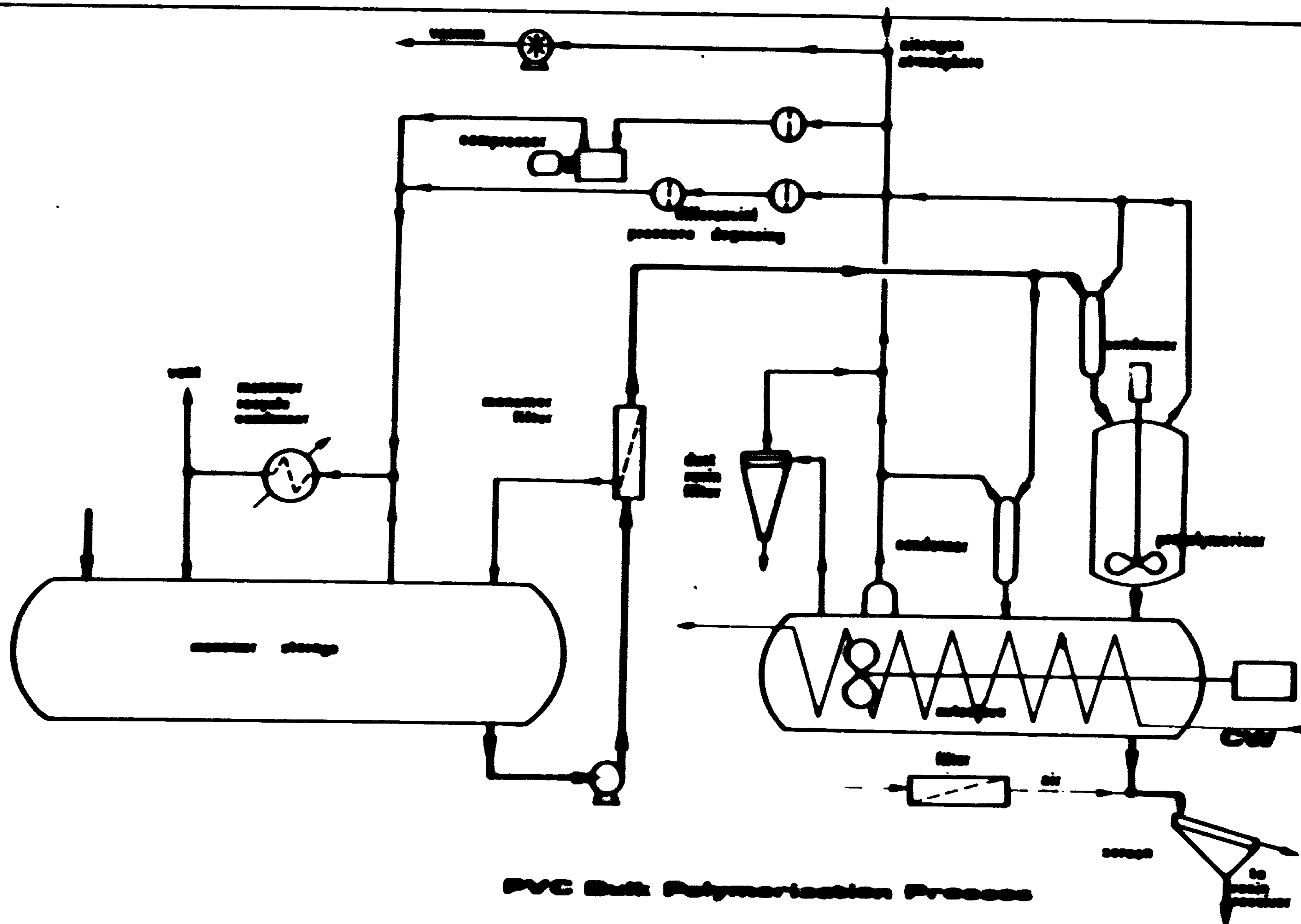
Liquid vinyl chloride monomer and the partially polymerized vinyl chloride (mother batch) are charged after degassing and initiator introduction. The autoclave is heated by hot water to about 70°C. When a 80 to 85 % transformation ratio is achieved, according to the desired PVC grade, the autoclave is degassed, and the non-converted monomer is recovered by condensation.

The unreacted monomer at the end of the cycle being completely adsorbed on the polymer beads, monomer is recovered in two stages ; the first stage includes heating and condensation, and the second stage is achieved by means of a vacuum pump and a degassing compressor.

Autoclaves are solvent - cleaned about every 10 batches.

Product finishing

The pulverulent polymer is discharged pneumatically to a receiving hopper, then fed to a multi-stage oscillating sieve, where the desired product, consisting of very fine particles, is collected and sent to storage. Oversized particles are milled by a grinder. Smaller particles collected from the mils constitute a second-grade PVC.



PVC Bulk Polymerisation Process

d) *Advantages and drawbacks of the different processes*

Presently the emulsion polymerisation is used only to produce resins with very definite applications - coatings and plastisols-.

The Vietnamese market present and future, does not seem to justify the setting-up of such a unit.

The two other types of polymerisation have their advantages and their drawbacks.

The suspension type processes include four sections : polymerization, vinyl chloride recovery, drying, finishing and storage. The bulk process has only 3 sections : the drying section being unnecessary which will have the effect of making less equipment necessary in the polymerisation plant since the reaction occurs without water or suspension agents and also of eliminating the need for waste water treatment since water is not used. Note, however, that regulation of the bulk process is more difficult.

As regards product qualities, the two processes can generally cover the whole range of properties required by the Vietnamese market.

From a general point of view, the suspension type and bulk type processes lead to some differences in the quality of the products :

- Bulk resins present a slight advantage in the field of packaging
- Suspension resins present an advantage in the field of wire and cable coating
- Bulk resins present an advantage in the field of extrusion (rigid pipes, profiles) due to higher bulk density at the same porosity level.

Concerning investments, the equipment price is slightly lower in the case of a bulk process, but the difference between the two processes is greatly reduced if the amount of royalties for the bulk process is taken into account.

At this preliminary stage of the study, it is difficult to choose one process but taking into account the higher installed capacities in the world and the greater number of licensors for suspension processes, the technical definition of a suspension process will be given.

4. DEFINITION OF PVC UNIT AND PVC COMPOUND UNIT

1. Production of PVC
2. PVC compound production
3. Raw material and chemical specifications PVC unit
4. Economic data
5. Reception and shipping
6. Economic study

1. PRODUCTION OF PVC

1.1. CAPACITY

The polyvinyl chloride production unit is sized in order to be able to produce 60,000 tons of PVC from vinylchloride monomer on the bases of 8000 hours' production per year.

1.2. DESCRIPTION OF THE SECTIONS

VCM is polymerised with a catalyst in agitated reactors working discontinuously. Polymerisation takes place in suspension in a water solution - small spheres which form polymer pearls during the reaction.

At a certain temperature, the initiation reaction is shorted in the reactor, then once free radicals have been created, the chain reaction begins and becomes exothermic.

To avoid coalescence of the partially polymerized spheres, suspension stabilizers are added to the water. The tendancy to agglomerate can be reduced by the addition of products which increase the viscosity of the aqueous phase. By maintaining suitable reaction conditions and by using an appropriate combination of catalysts and additives, the molecular weight of the product can be controlled and so consequently can the physical properties of final product.

At the end of the reaction, the gazeous phase issuing under pressure form the reactors and containing not-reacted VCM is sent to the monomer recovery section.

The gazeous phase is condensed at a sufficiently high pressure with refrigerated water and the VCM is separated and recycled.

The slurry from the polymerisation reactors containing the PVC particles in suspension is sent to intermediate storage tanks, from where it is collected by pumps and sent to a centrifugal machine.

The polymer obtained is dried by hot air circulation in a drier. The dry PVC is transported to storage silos after screening.

2. PVC COMPOUND PRODUCTION

2.1. CAPACITY

The compounds unit can produce continuously either rigid PVC or flexible PVC. The unit is sized in order to be able to process 10,000 tons of resins on the basis of 14,000 tons of compounds per year.

2.2. DESCRIPTION

The unit is equipped and operated as follows :

The quantities of PVC and plasticizers to be blended are determined according to the formulation of the compound to be manufactured.

PVC is air-conveyed from the storage silos in a weighing hopper, then sent to a mixer.

The plasticizers are transferred to the mixer by volume pumps. Jacket heating allows hot product mixing and pregelification to take place.

After some time, the hot mixture is transferred by gravity into a buffer hopper.

At the hopper outlet, the product is transferred, either by gravity flow, if hot, into the feed hopper of an extruder, or in the powder form, if cold, directly to the bagging machine.

After extrusion for which various possible ways exist, the compound is granulated, then transferred to storage silos.

3. RAW MATERIAL AND CHEMICAL SPECIFICATIONS

PVC UNIT

- ***Raw materials***

Vinyl chloride monomer

Purity	min 99.98 % weight
Butadiene	max 6ppm weight
Light-ends other than butadiene	max 10 pp wt
Heavy ends	max 10 ppm wt
Aldehyde	nil
HCl	max 1 ppm wt
Water	max 80 ppm wt
Iron	max 0.5 ppm wt
Peroxyde (H_2O_2)	max 0.2 ppm wt
Methyl chloride	max 60 ppm wt.

- ***Auxiliary materials***

Catalyst

Chain modifier

Polymerisation breaker

Other reagents

4. ECONOMIC DATA

- ***PVC UNIT***

The production unit will produce 60 000 tons of PVC per year on the basis of 8000 hours' operation.

PRODUCTION UNIT CONSUMPTION

- Raw materials

V C M	7.98 ton/hour

- Utilities

Steam	21.3 tons/hour
Cooling water	2400 m^3/hour
Demineralized water	68 m^3/hour
Electricity	2640 kWh/hour
Instrument air	1200 Nm^3/hour
Nitrogen	25 Nm^3/hour

NOTE : These are average consumption figures which can vary slightly according the type of process.

- ***COMPOUNDS UNIT***

- Auxiliary products

The consumption of auxiliary products, such as plasticizers, depends on the type of compound to be produced. For highly plasticized compounds consumption can reach up to 500/550kg per ton of PVC.

In the study, the average quantity of plasticizers is 400 kg/ton of PVC.

- Utilities

Cooling water	90 m^3/hour
Electricity	2400 kWh/hour
Instrument air	120 m^3/hour
Service air	40 m^3/hour

5. RECEPTION AND SHIPPING

VCM will be shipped to VIETNAM in ships of 3000 m^3 i.e. a boat every two weeks.

At the harbour, VCM will be unloaded by a loading arm, then transferred by pipeline to storage spheres located in the PVC unit.

Bagged PVC, resins and compounds will be distributed within the country by rail, road and sea.

6. ECONOMIC STUDY

6.1. INTRODUCTION

The bases of the economic calculation are generally the same than those used for the refining (see Volume III, Chapter 3).

For the working capital, we will take only one month of final products.

The utilities costs are as follows :

- 3 ¢/kWh for electricity
- 5 ¢/m³ for industrial water
- 8.7 US$/10⁶kcal for fuel.

At this stage of the project, a simple economic evaluation will be carried out.

The price of PVC will be calculated by taking a reimbursement period before taxes of 6 years.

I : investment cost
D : depreciation
O : operating cost
R : raw material cost
S : sales revenue.

PRODUCTION COST : $P = O + R$

GROSS CASH FLOW : $GCF = S - P$
Tax base : $GCF - D$
Tax : $T = (GCF - D) \times 0.4$

$$GCG = \frac{I}{6} = S - P$$

SALES REVENUE : $S = \frac{I}{6} - P$

6.2. RAW MATERIAL COST

The major part of VCM produced in the world is captive on site for the PVC production. Meanwhile export streams exist.

But export prices vary according to the origin : for instance, the American export prices are lower than those of JAPAN and EUROPE.

In the study, we will take a CIF price of 365 US$/ton.

6.3. INVESTMENTS

The costs are given in mid 1978 US dollars.

Table of investments — in 10^3 US$

Process units	21 000
Offsites utilities	12 950
Erected cost in EUROPE	33 950
Total cost in EUROPE	39 040
Total cost in VIETNAM	56 600
Spare parts	1 970
Catalysts and chemical products	600
Royalties	2 300
Pre-operating and start-up expenses	3 960
Total investment	65 430
Working capital	3 400

TABLE 4.1

OPERATING COST - 10^3US$

VARIABLE CHARGES	
. Raw materials	23 300
. Fuel	987
. Industrial water	88
. Catalysts and chemical	600
. Electricity	768
Sub Total	25 743
FIXED CHARGES	
. Manpower	200
. Technical assistance	40
. Maintenance	385
. Insurance	654
. General overhead	87
. Land rent	70
. Interest on working capital	340
Sub-total	2 375
TOTAL	28 118

TABLE 4.2

CALCULATION OF THE PVC SALES PRICE

Total investment	85 430
Pay-out time	8
Gross cash flow	10 305
Total operating cost	28 118
Total sales	39 023
P V C sales price	850 US$/ton

6.4. RESULTS

Raw material cost constitutes 60 % of the total price. The PVC production profitability will mainly depend on the import VCM prices.

Meanwhile, in spi e of an uncertainty concerning future VCM prices, it seems more advisable in a first step to set up only the PVC production. The investment of the total PVC chain, i.e. chlorine production, VCM production, will be between 150 and 200 milliards US dollars, versus 65 million for PVC alone.

5. STEAM CRACKING

1. Introduction
2. Yields
3. Description of a unit of naphtha steam cracking
4. Description of ethane steam cracker

1. INTRODUCTION

The steam cracking is the operation of pyrolysis which transforms a petroleum fraction constituted by one or several hydrocarbons in some more reactive hydrocarbons, bases of the petrochemical industry which are olefins, diolefins and aromatics.

The raw materials which exist as feedstocks of the steam cracker are the following :

- light hydrocarbons : ethane and propane existing in natural gas and in the gas associated with crude oil
- liquefied gas coming from the refining : propane and butanes
- distillation gasoline (naphtha) and particularly light gasoline of low value as motor fuel
- heavier fractions of distillation such as kerosene and gas oil.

2. YIELDS

The feedstocks for an ethylene plant can be divided as follows :

GASEOUS FEEDSTOCKS

Of these components, ethane is the most favourable for the ethylene production. The ultimate yield on ethylene is about 78 % at a conversion of 66 % per pass.

Propane is the next best feedstocks, producing 36.6 % of ethylene at a conversion of 91 %. However, additionally some ethane is produced and the ultimate yield of ethylene can be increased to some 44 % including propane recycling and cracking to extinction.

For butane, a strong restriction has to be applied as n-butane is an excellent feedstock for ethylene production, while isobutane will produce predominantly propylene. Therefore the feedstock should consist substantially of n-butane with some isobutane. The once through ethylene yield is 31 %, the ultimate yield is around 36 %.

LIQUID CHARGES

A big difference between the gaseous feedstocks and the liquid feedstocks is that the former are well-defined : components while the liquid feestock contains normally so many components that other means of characterisation have to be applied.

For their suitability as feedstock, it is important to know the content of :

- Normal paraffins which can give a high yield on ethylene and a comparatively low yield of propylene
- Iso-paraffins which give a rather low yield of ethylene but a relatively high yield of propylene
- Naphthenes which give not much ethylene but are favourable for the butadiene yield and the amount of BTX in the pyrolysis gasoline
- Aromatics which hardly contribute to the ethylene yield but substantially increase the pyrolysis fuel oil quantity.

Average furnace yields are given in the following table.

The given yields are average yields at high severity. These yields can vary according to the severity, the feedstock analysis and the type of furnaces.

TABLE 5.1.

TYPICAL YIELD FOR A STEAM CRACKER WITH VARIOUS FEED

Wt. %	Ethane	Propane	Isobutane	n-Butane	Light Naphtha	Medium Naphtha	Kerosine	Gas Oil
Hydrogen	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cyclo-C_5 =	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C_5 = =	0.12	0.48	0.00	0.00	1.30	1.08	0.00	1.02
Cyclo C_5	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.05
C_6 =	0.00	0.00	0.00	0.40	0.00	0.40	1.00	1.30
Cyclo C_6 C_6 – C_6 — 200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05 0.19 13.17
[illegible] H_2S + C from CS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.00 0.44
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3. DESCRIPTION OF A UNIT OF NAPHTHA STEAM CRACKING

The description covers the following units or sections :

- Pyrolysis and primary separation of cracked gas in light products and heavy products
- Compression of cracked gas and treating (H_2S extraction by caustic washing and drying)
- Hydrogen recovery, methane separation, methanation of carbon monoxide
- Fractionation and products recovery : ethylene, propylene, C_4 cut, gasoline
- Refrigeration (ethylene and propylene cycled)
- Pyrolyses gasoline hydrogenation
- Butadiene extraction

a) PYROLYSIS AND PRIMARY SEPARATION

The cracking section is composed of a certain number of furnaces, which are of different design, according to the feedstock processed and the severity selected.

The number of furnaces is chosen with the objectives of minimum downtime and allowing decoking of one furnace without unduly upsetting the operations of the downstream equipment.

Furances consist in a convection section, and a radiant section zone for the preheat and the cracking of the feed.

The dilution steam is mixed with hydrocarbon feed before entering the convection zone. In this section of the furnace, the mixture hydrocarbon-steam is heated to about 580°C-600°C before entering the radiation zone. The convection zone furthermore preheats the water feed for the quench boilers.

In the radiation zone, vertical cracking tubes are hanged and disposed in one row which is heated on each side by two radiant walls with burners which can be fed either by fuel oil or fuel gas.

At furnace output, the cracked effluents are subject to a severe quench, in view of stopping the evolution of cracking reactions. The effluent from each furnace passes through special exchangers acting as HP steam generators, and the temperature is reduced to approximately 400°C. The tube wall temperature in the steam generation must be ma-ntained above the incipient condensation point of the heavy components in the cracked gas in order to avoid fouling and loss of heat transfer. For this reason, the steam must be generated at high pressure.

Before flowing to the priamry tower, the cracked gas at the outlet of the quench boilers is cooled further up to approximately 185°C, by injection of quench oil in the transfer line. This quench oil is a part of the fuel oil recovered and cooled at the bottom of the primary tower.

In the primary tower, the fuel oil components are spearated from the cracked gas. At the bottom of this tower, the heavy products are separated and provide quench oil and fuel oil streams.

The quality of separation in the primary tower is improved by gasoline and water recycle streams at the top of the column.

The cracked gas, after elimination of heavy ends in the primary tower, flows to the quench tower where they are cooled by direct contact with water. The dilution steam is thus condensed and water and hydrocarbons are collected in a drum and decanted.

The hydrocarbons are partly recycled to the primary tower, the excess being a part of the gasoline cut. The water phase is recycled to the quench tower after cooling. The excess of this water phase is sent to the dilution steam production system.

b) COMPRESSORS AND GAS TREATING

In this section, the cracked gas are compressed to the operating pressure of a demethaniser.

The overhead gases of the Primary fractionator are compressed in a 5 stage centrifugal compressor with a steam turbine drive up to 35-37 bars eff.

The condensates of the first stage drum are sent back to the primary tower, and the condensates of second stage drum feed a stripper.

Gas from the third stage of compression is treated in a caustic scrubber for removal of acidic components by absorption in 2 stages with circulating caustic solutions.

The gas compressed in the 5th stage is cooled with water and with propylene. Cooled vapors from the 5th stage cracked gas separator flow to a set of solid adsorbent type dehydrators, where they are dried to a dew point sufficient to prevent the formation of ice and hydrates in the subsequent low temperature separation sect-on. An activated alumina dessicant is used.

c) DEMETHANISER, METHANATION AND HYDROGEN RECOVERY

In this section, methane is separated from the C_2+ hydrocarbons and rich streams of hydrogen can be obtained.

The refrigeration required for the separation is supplied by a cascade system employing ethylene and propylene products as coolants.

Hydrogen at 95 % volume has to be purified before being used in the different hydrogenation processes. It contains carbon monoxide which if present in large quantities would rapidly poison the catalyst.

Thus, after heat exchange, hydrogen gas flows to a methanation reactor where carbon monoxide is hydrogenated to methane and water.

d) DEETHANISER, C_2 SPLITTER AND C_2 CUT HYDROGENATION

The C_2 cut from the bottom of the demethaniser is sent to the deethaniser.

The deethaniser overhead is sent to the acetylene hydrogenation unit.

In order to face eventual high acetylene contents, two hydrogenation reactors are used in series with intercoolers in order to limit the temperature rise due to the acethylene hydrogenation reaction.

70 % of the acethylene conversion takes place in the first reactor. The hydrogen make up is made with hydrogen 95 % volume.

The deethaniser overhead vapor is sent to splitter which separates ethylene from ethane and heavier hydrocarbons.

Ethylene produced is drawn off as a sidestream in order to get a product free from methane (introduced by C_2 hydrogenation).

e) DEPROPANISER, C_3 CUT HYDROGENATION

The C_3+ deethaniser bottom and condensate stripper bottoms are sent to the depropaniser. The C_3 cut is the overhead of the depropaniser.

The depropaniser liquid overhead is sent to the hydrogenation reactors through a coalescer.

Before entering the reactors, the feed is mixed with 95 % hydrogen. Two reactors are used with fixed bet catalysts.

The reactor effluent is sent to a demethaniser column where the light gases are taken overhead.

The demethaniser bottom is the chemical grade propylene product.

f) DEBUTANISER

The depropaniser bottoms are sent to the debutaniser column. The C_4 cut is separated at the overhead.

The bottom product is the gasoline cut, which together with gasoline ex compression, is sent to the hydrogenation unit.

g) *Pyrolysis gasoline hydrogenation*

This section is composed of 4 parts : reactor, stabilizer, rerun column, depentaniser.

A fixed bed reactor is used, containing a nickel catalyst supported on alumina.

The gasoline feedstock is mixed with hydrogen and sent to the reactor.

In the stabilizer, the lights products are separated from the heavy products.

The aim of the rerun column is to eliminate the gums and part of the heaviest components.

h) *Refrigeration cycles*

This section provides cooling for liquefying the cracked gas before fractionation, and for various reflux streams in the low temperature fractionation section.

The process scheme needed for the separation of the cracked products requires cooling at different temperature levels in the interval between 20°C and - 100°C.

The principle of cascade refrigeration is generally selected for simplicity of operation and for optimum investments versus operating costs.

The choice of cooling fluids, ethylene and propylene, allow a great flexibility of supply since they are products of the steam cracking unit. Furthermore, their physical properties are well adapted to the duties required.

The temperature levels of refrigeration are :

- For the propylene refrigerant : + 7°C, -21°C, -33°C
- For the ethylene refrigerant : -68°C, -100.5°C

i) *Butadiene extraction*

The yield in butadiene is increasing with the severity of cracking and may be around 4 % of the cracked feedstock, or 40/50 % of the C_4 cut. The steam crackers of naphtha are generally the main sources of butadiene.

The specifications of polymerisation butadiene are very tight, so that only an extractive distillation is able to overcome the difficulties of acetylenic components removal.

In this type of unit, butadiene is separated from the C_4 fraction by extractive distillation with a solvent such as acetonitrile (SHELL) or n-methyl-pyrrolidone (BASF-LURGI). All these processes include extractive distillation in one or two columns, whereby all butadiene and substituted acetylenes are separated in a solvent phase. The solvent is recovered by stripping and the impurities are removed from butadiene by distillation. The solvent is removed from the raffinate by washing with water and subsequent distillation.

4. DESCRIPTION OF A UNIT OF STEAM CRACKER OF ETHANE

The basic process is the same than the naphtha process but there are some differences in the description.

In the case of ethane, only one type of furnace is used.

The primary tower is not necessary because of the very low amount of fuel oil components to be separated.

No in-line quenching with oil is inlcuded, nor low pressure steam boiler on the quench oil. The quench bo-ler effluent enters directly the quench tower.

The compression capacity is larger than in the case of liquid feedstocks, due to the large amount of ethane recycle, and there is no condensate stripper.

The deethaniser, C_2 splitter and hydrogenation set up are larger than for liquid feedstocks.

The depropaniser, gasoline hydrotreater and butadiene extraction are not included.

The refrigeration cycles are the same, but refrigeration horse power is less than in the case of liquid feedstocks.

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