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SUMMARY OF THE DRAFT WORLD-WIDE STUDY OF THE PETROCHEMICAL INDUSTRY *

by the UNIDO Secretariat

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INTRODUCTION

The Lima Declaration and Plan of Action of Industrial Development and Cooperation was adopted at the Second General Conference of UNIDO in March 1975 and was subsequently endorsed by the General Assembly at its seventh special session. In the Lima Declaration, the role of industry was reasserted as a dynamic instrument of growth, essential to the rapid economic and social development of the developing countries; the declaration called for an increase of the share of the developing countries in total world industrial production, and set a target whereby this share should be increased to the maximum possible extent and, as far as possible, to at least 25 % of total world industrial production by the year 2000. It declared that develpping countries should devote particular attention to the development of basic industries (such as petrochemicals) thereby consolidating their economic independence while at the same time assuring an effective form of import substitution and a greater share of world trade.

This study represents a concerted attempt to provide an overview of the opportunities for and constraints upon the development of the petrochemical industry. Through this study, the International Centre for Industrial Studies in UNIDO is contributing to an understanding of the issues involved in this sector, and is identifying the opportunities open to developing countries in their endeavour to increase their share in world industrial production, as the problems they have to solve to hit this target.

This study is intended as a tool for decision makers involved in the petrochemical industry; special attention has been devoted to developing countries. It has been prepared in the light of experience in this sector.

Due to the changes occuring not only from the petrochemical industry itself but also in external sectors having a very great impact on the petrochemical industry, such as the energy sector, financial sector, general development rate of growth, the study and its projections as well as the methodology used will have to be periodically revised in the light of changing circumstances.

The scope of the study is limited to the four main, large tonnage end-product families: plastics, synthetic fibers, synthetic rubbers and detergents, along with their correspoding intermediate and basic products.

1. MAIN FEATURES OF THE PETROCHEMICAL INDUSTRY

1. The petrochemical industry is growing constantly. World production from a few hundred tons in 1920 rose to 3.5 million tons in 1950 and is now in excess of 65 million tons. This rate of growth is one of the swiftest in industry.

2. The petrochemical industry is capital intensive and requires very high investments.

3. The markets for this industry covers several industrial sectors since it provides basic material for them.

4. Its dynamism is given primarily by its highly competitive position against other artificial and natural products.

5. The petrochemical industry has to compete with other sectors in obtaining its supply of raw materials.

6. The design, implementation and operation of petrochemical plants require a small, highly skilled and qualified work force to whom a great deal of responsibility is given.

7. The petrochemical industry is subject to restrictions of economy of scale, hence of outlets, though to a much lesser degree than pre-1973.

8. The production of petrochemicals necessarily involves the application of technologies which may be highly complex and which are generally owned by companies involved in manufacturing or else in research and development, who, however, are prepared in most cases to make them available under license.

9. The petrochemical industry is a complex, diversified industry, with a multiple choice of alternative products techniques and raw materials.

2. PAST AND PRESENT SITUATION

2.1. PRODUCTION OF PETROCHEMICALS

2.1.1. Factors affecting the production of petrochemical products

a. 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.

b. 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. It must be emphasized at this point that 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 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 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 that 1% in 1950 and is now somewhere between 4.5 and 5%.

The availability of raw materials can be linked with the existence of a refining industry discussed here below. It affects the basic petrochemical production.

c. 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. 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 ton of LPG and 0.65 ton of gasoline. 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 a refining plant is of great benefit to a petrochemical industry which is just starting up. The impact of the existence of a refining industry is mainly relative to basic petrochemical production.

d. 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 specialized 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.

e. Means of financing investment

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

Access to means of financing these very high investments (ploughing back of profits, shareholders' contribution has been and will increasingly be a major element governing the development and setting up of the petrochemical industry. In the past, the satisfaction of the financial requirements of the petrochemical industry, especially in the industrialized countries, was greatly facilitated by the existence of funds resulting mainly from the availability of raw materials at very favourable prices. On account of these raw material price levels, it was possible for the petrochemical industry to market competitively priced products which could compete with natural products, and also very easily supplant the products of other industries (for instance, acetylene manufactured from calcium carbide, or benzene derived from coal). Not only did these highly advantageous conditions favour a rapid increase in the penetration of petrochemical products, with spectacular consequences with regard to the market for these products and the volume of production, but they also released a large amount of accumulated capital, thus facilitating the financing of a new plant. This accumulated capital also enabled a great deal of money to be devoted to research, and this outlay, stimulated by competition between firms, proved to be very worthwhile, as it extended the accumulated capital without having any harmful effects on the development of the market.

f. <u>Developing a technology - the importance of research</u>

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 1950 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/[illegible] 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 specializing 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. 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 great receptivity of synthetic fibres to die stuffs; 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 realized 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 licenses have been acquired.

It must be pointed out that the research undertaken, stimulated by inter-company competition, sometimes on a world-wide scale, has been very profitable. Each major change in the choice of production techniques, which of course carried a considerable initial risk, has resulted in a marked reduction in cost-price or a significant improvement in the quality of the products. Research has also been indispensable to the design and implementation of larger and larger plants, which is mot important to the profitability of the petrochemical industry.

c. 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, i.e., the plastics processing industry, the textile industry, the tire industry, and the detergent industry. If these industries are not already present in a given country or area, there is no effective outlet 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, and tires. 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 tire industries in particular. Processing industries are very different in nature from the petrochemical industry; they do not require nearly such high investments, they employ a very large work force, 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 industrialized countries, in the form of after-sales service, promotion of end products and constant improvements in the quality of petrochemical products.

2.1.2. Localization of the petrochemical industry

The main factors governing the existence and development of a petrochemical industry, which have been analyzed in the preceding paragraph, have generally been present together in the industrialized 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 94% 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. Where favourable circumstances are occurring, in some of the developing countries, petrochemical production will develop. Moreover, these 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 1980, the share of the developing countries in the petrochemicals production will grow. The ethylene capacity in Latin America, Africa (1) and Asia (2) will increase by about 2.5 times from now to 1980; during the same period the increase of the capacities in Europe, United States and Japan will be lower than 40%.

2.1.3. World production situation by main products and regions

2.1.3.1. World production of plastics

- World plastics production was doubling every five years during the 1960's, but between 1970 and 1974 plastics production increase was little more than 50%.
- This production seems to be showing a widening geographical spread, as reflected in the following table.

Regional Share of World Plastics Production (%)

	1960	1965	1970	1974
The United States	50	39	30	32
Western Europe	32	39	41	43
Eastern Europe	9	10	10	10
Japan	9	11	14	14
Others	–	1	[illegible]	1

Source: Calculated on the basis of ECE-Chem/SE.[illegible]/R.3/Add.3, 5 April 1977.

1 Excluding South Africa
2 Excluding Japan

- The three largest individual producers, the United States, Japan and the Federal Republic of Germany, account for over half of the total world plastics production.

- From the total world plastics production, thermoplastics accounts for over two-thirds. In 1975, the percentage of thermoplastics to total plastics production in the three largest producing countries were as follows: the United States 74%, Japan 79% and the Federal Republic of Germany 66%.

2.1.3.2 World production of synthetic fibers

- During the 1960's world production of synthetic fibers grew faster than that of plastics and rubber because early in the 1960's this field was practically in its infancy.

- The production of man-made fibers in the total fiber output accounted for 22% in 1960, 40% in 1970, and 44% in 1975.

- Within the man-made fibers, synthetic fibers have been gaining impressively over cellulosic fibers. In 1970 synthetic fibers accounted for 58% of total man-made fibers output, and in 1975 the figure was 70%. At the same time, the cellulosic fibers physical output was diminishing.

- This production increase has shown a widening geographical apread with the emergence of developing countries as an important world producer, as given in the following table.

Regional Share of Synthetic Fibers World Production (%)

	1960	1965	1970	1975
United States	46	40	33	33
Western Europe	31	30	31	26
Eastern Europe	5	7	7	11
Japan	18	19	21	14
Others	-	4	8	16

Source: Calculated on the basis of ECE-CHEM/GE.1/R.3/Add.6, 16 May 1977.

- The largest world producers of synthetic fibers are the United States, Japan and the Federal Republic of Germany that together account for over 50% of world production.

- In 1975 the percentage of synthetic fibers to total man-made production in the three largest producing countries were as follows: The United States 84%, Japan 73% and the Federal Republic of Germany 82%.

2.1.3.3. World production of synthetic rubber

- During the 1960's, synthetic rubber production grew at 6.75% annually. This growth diminished to 2% annually during 1971-1975. During the same period, the share of synthetic rubber's share went up to 78% of total rubber consumption, but since 1972, natural rubber is making a strong comeback and has recaptured a few percentage points.

- The world production has shown a widening geographic spread as given in the following table:

Regional Share of Synthetic Rubber World Production (%)

	1960	1965	1970	1973	1975
United States	63	49	37	34	31
Western Europe	12	19	23	24	23
Eastern Europe	17	20	21	23	27
Japan	1	4	12	12	11
Other developed	7	7	4	4	4
Other developing	-	1	3	3	4

Source: Calculated on the basis of ECE-CHEM/GE.1/R.3/Add.15, 3 June 1977

- The figures for 1973 give the peak point after which a substantial drop followed mainly in the United States, Western Europe and Japan. World production is estimated to have recovered the 1973 level by 1977.

- The largest world producers of synthetic rubbers are the United States, the U.S.S.R. and Japan that together account for around [illegible]0% of world production.

- As a difference to plastics and synthetic fibers, the main producers of synthetic rubbers are oil multinationals and tire manufacturers in market economy countries.

- Concerning developing countries, Brazil, Mexico, Argentina and India account for about 90% of total developing countries' synthetic rubber production.

2.1.3.4. World production of intermediates and basic petrochemicals

- These products have a rather rigid stoichiometric relation to the main large tonnage end-product families shown above, and their production evolution has followed, in general, the growth pattern of plastics and synthetic fibers that together account for about 2/3 of world petrochemical production.

- The regional share in world basics production is as follows:

Regional share of basic petrochemicals (%)

	Ethylene			Benzene		
	1965	1970	1976	1965	1970	1976
United States	58	42	38	56	44	34
Western Europe	25	32	37	30	31	31
Japan	11	16	15	8	18	14
Others	6	10	10	6	7	21

- There are very few developing countries that have a sizeable basic petrochemical industry in operation. Among them are Brazil, Mexico, Venezuela, the Republic of Korea and Taiwan.

2.1.3.5. World production of the main petrochemicals

- World petrochemical production of the main end-products families is as follows:

10^6 Tons

	1950	1960	1970	1974	1975
Plastics	1.5	7.0	30.2	44.6	38.5
Synthetic Fibers	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

- World petrochemical production of the main basics is as follows:

10^6 Tons

	1965	1970	1976
Ethylene	8.0	18.5	26.0
Propylene	4.4	9.5	13.7
Butadiene	1.9	3.0	4.9
Benzene	4.8	8.8	13.3

- The present production capacities of the main petrochemicals by regions are given in Annex 1.

2.2 DEMAND FOR PETROCHEMICALS

2.2.1. Factors affecting the demand

The principal factors responsible for variations in demand in the world's main consumer areas are the following:

a. Existence of a market

In the early stages, the quality of the petrochemical products which came on the market was far from being perfect; in some cases, inadequacy of the properties still limit the development of the demand for these products. However, most of the problems have now been resolved, and the rapid growth in the demand for petrochemical products since the end of the Second World War is 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, and
- are sold at competitive prices.

In many cases, petrochemical products have been able to partially supplant the products already on the market, mostly natural products, the competition between these two kinds of products being the strongest at the level of the relative prices. However, there are very few instances of total substitution, since:

- a mixture between petrochemicals and natural products turns out to be the material best suited to the users for which it was developed. This is especially important for blends and composite materials.
- The stiff competition by petrochemicals has spurred the national products to improve their productivity and quality, thus becoming more able to hold their ground in their traditional markets. Additionally, it has helped to stabilize the price of the traditional products.

b. Degree of penetration of petrochemical products in the sectors of use

If the product marketed is well suited to the demand in its sector of application, the initial growth rate is rapid with a subsequent tendency to slow down as a relative saturation point is reached. Then the petrochemicals market growth resembles that of the sector of application as a whole.

The market penetration is generally partial and in industrialized countries, where the penetration is greatest, it is seen to reach a ceiling at about 80% of the total market. There are very few cases of total substitution like low density polyethylene bags for paper bags.

c. Potential market for petrochemical products

The potential market for plastics appears to be practically unlimited, considering the potential outlets in three end-uses sectors: packaging, transport and, over all, construction. By contrast, the potential market for synthetic rubber (mainly used in car manufacture) and for synthetic fibers (mainly used in clothing) is much smaller. As a result, the strong growth in the demand for these materials still recently registered in industrialized countries is expected to be limited in these countries on account of the present high degree of substitution already observed.

d. Prices

As in the case of all consumer goods, the demand tends to vary 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. The effect of the considerable and recent rise in the price of plastics was, to a large extent, limited as a result of the simultaneous rise in the price of rival products (most of them coming from natural sources).

In addition, the part played by variations in the prices of petrochemical end products themselves should be mentioned. This, for instance, recently favoured the demand of HD polyethylene and polypropylene against LD polyethylene in many applications except films.

e. Local production

Local petrochemical production usually leads to an acceleration of local demand. However, this effect is not always felt at once on account of:

- import restrictions
- at the beginning, the reluctance of processors to use a locally made product whose specifications are often initially considered inferior to those of products previously imported.

7. Local processing industry

The existence of such an industry has a definite influence on the development of local demand:

- It tends to make the product better known to the consumers than it would be if it were merely imported.

- local processing with a high added-value means that local production should be cheap compared with imported end products, particularly when labour costs are also low.

2.2.2. Development of the demand for petrochemical products over the last decade

During the sixties and up until 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. The year 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 1974 maximum.

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

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 toward 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 1974-1975 than it was in the industrialized countries. This can be explained as follows:

- economical growth was still generally sustained in developing countries

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

Here below are given significant figures summarizing the development of the demand for the major petrochemical end products over the last decade. For intermediate and basic petrochemicals, the volume and variations of the demand are simply and directly brought about by the demand for end products. A table summarizing the growth rate 1965-1975 for end products is given in Annex 2.

a. Plastics

Over the 1965-1975 period, demand for plastics in industrialized countries grew at average rates in the range of 7-11% p.a., this figure being badly affected by the results registered in 1974-1975. By contrast, 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 them.

b. Man-made fibers* - Synthetic fibers

Over the 1965-1975 period, average growth rate of the demand for man-made fibers in industrialized countries was in the range of 4.6% p.a. to 7.2% p.a. Corresponding figures for developing countries was as wide as 7 to 23% p.a. In these 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) has generally largely contributed to sustain the growth of the demand. An even higher growth of the demand has been registered for synthetic fibers, reflecting their gradual penetration in man-made fiber market whereas demand for cellulosic fibers has become stagnant at a world-wide scale. Synthetic fibers now account for around 70% of the man-made fibers world market (this percentage is not very different between industrialized and developing countries).

c. Rubber - Synthetic rubber

Over the 1965-1975 period, demand for rubber in industrialized countries rose at rates in the range of 3.4 to 8.8% p.a. with a fall at the end of the period. In developing countries as a whole, demand for rubber rose by 10% p.a. as an average with large variations at the scale of regions.

* Man-made fibers include cellulosic and synthetic (or non-cellulosic) fibers.

The penetration of the synthetic material into the rubber market amounts to 70% of the total. This percentage was only 5[illegible]% of the total in 1971. In these countries, the ratio synthetic rubber/total rubber tends to increase still whereas it goes toward stabilizing in the industrialized countries.

d. <u>Synthetic detergents</u>

From the beginning of the seventies on, only a modest growth of the demand for detergents was observed in industrialized countries, reflecting the deep penetration of syndets in the soap-detergent market. By contrast, in developing countries, demand for syndets has been growing at still high yearly rates, as a result of a strong development of the needs of soaps and detergents and of a moderate degree of penetration of syndets in the above market.

2.2.3. Size of the market - Geographical breakdown

Annex 3 shows the present* size and localization by regions of the markets for the main types of petrochemical products.

In 1974, world consumption of plastics reached nearly 45 million tons, a tonnage by far higher than that registered for synthetic fibers, 7.6 million tons and for synthetic rubber, 7.7 million tons.

Annex 4 shows the world consumption breakdown of major petrochemical end products (1974). The share of the developing countries (excluding China for which statistics are not available) in world market was 11% as an average. This percentage corresponds to only 9.35% of the total in the case of plastics but 19.3% for synthetic fibers, 12.8% for synthetic rubber and 20.3% for synthetic detergents.

Latin America ranks first among developing countries with regard to the volume of the demand for petrochemical products: 41% of the total in 1974. South Asia is the second market among developing countries, 21% of the total whereas the market of East Asia (excluding Japan and China), Africa (except South Africa) and the Middle East have about the same importance—respectively, 13%, 12% and 10% of the total.

2.2.4. Major trends in the evolution of demand for the main final products

a. <u>Plastics</u>

The major share of the plastics market is held by thermoplastics

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* 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 the 1974 level.

that account for 70% in industrialized countries and 85% in developing countries, of the total market. Concerning the situation and likely development of the main types of plastics, the following trends are observed:

- Polyolefins (LDPE, HDPE, PP) presently account for one-third world plastics market, and is expected to rise up to 40% by 1985. Taking into account the strong expansion of demand expected for high density polyethylene (HDPE) and polypropylene (PP), demand for low density polyethylene (LDPE) would likely grow at about the same pace as plastics on the whole. This situation should result in low density polyethylene concentrating in film applications whereas the other two polyolefins concentrate in more sophisticated applications like injection molding. Currently the prices for these three plastics are leveling off, thus favouring the cost-performance ratio of the more expensive HDPE and PP. Nevertheless, the penetration rate of HDPE and PP into polyolefin markets will likely remain lower in developing countries than in industrialized countries.

- PVC is the first individual plastic in the plastics world market with 22% of the total. Its future growth is expected to be lower than that of plastics as a whole, for it is besieged by high energy costs and health hazard problems. Nevertheless, PVC is expected to keep on holding its leading position supported by its forthcoming developments for rigid applications.

- Polystyrene (PS) accounts for 10.5% of the plastics world market and its share in this market is expected to remain constant as in the past. It is interesting to note that about the same percentage applies in most regions, therefore PS demand alone can be considered as characteristic of the plastic consumption level in any given area.

b. Synthetic fibers

Concerning man-made fibers, synthetic fibers alone will be responsible for its expansion, since cellulosic fibers, after years of stagnation, are gradually decreasing their market share. The major exception is Eastern Europe where cellulosic fibers has kept a very slight growth rate. The main reasons for the decline of cellulosic fibers are expensive raw materials and qualities below those of synthetics. Nevertheless, the high degree of substitution of cellulosics for synthetics (72% of the total in industrialised countries), coupled with the high degree of penetration of synthetics into the textile market, will become an important limiting factor in slowing market growth for synthetics. In developing countries synthetic fibers account for [illegible] of man-made market. In these countries, market growth would result from a deeper penetration of man-made fibers into the textile market (currently [illegible] of the total as against 50% in industrialized countries) and from the overall growth of the textile market. The demand pattern for the three main synthetic fibers is changing as follows:

- Polyester fibers, currently accounting for [illegible] of world synthetic markets, will keep on increasing in importance.
- Polyamid fibers presently accounting for 35% of world synthetic markets, will continue decreasing in importance.
- Acrylic fibers should keep almost a constant share of the world synthetic market of about 20% of the total.

c. Synthetic rubber

The ratio of synthetic rubber consumption to total rubber consumption has gone from 60.4% in 1965 to 68.2% in 1974. However, this percentage slightly decreased in 1975 as a result of a change in the rubbers competition: the production cost of synthetic rubber has been rising whereas the production cost of natural rubber is from now on in a downward trend. This new trend would lead to having about the same growth rate for natural and synthetic rubbers, at least industrialized countries which already have a high degree of substitution of natural for synthetic rubbers.

The single most important synthetic rubber is SBR that accounts for 60% of the total in industrialized countries and up to 80% in developing countries. It is envisaged that SBR will remain in its leading position for all its current applications. Most of the other synthetic rubbers with the exception of polybutadiene (that accounts for 10%-15% of the total) and butyl rubber (used in tubes) are generally used in specialty applications. Polyisoprene, still considered as a possible substitute of natural rubber a few years ago, seems to have no chance of development in the near future due to the newly gained competitiveness of natural rubbers.

d. Synthetic detergents

Alkybenzene sulfonates are by far the main active material used for preparing detergents. In 1975, its demand amounted to 1.2 million tons, of which 0.33 million tons were in developing countries.

The relatively high volume of alkylbenzene used in developing countries partly results from washing habits: handwashing with cold water, whereas machine washing with hot water requires substantially less of the active material. It is expected that alkyl sulfonates will continue to develop at a moderate growth rate and will keep its leading position in detergent markets, because no other surfactant can match this material on a cost-performance basis for spray-synthetic detergents.

Due to recent regulations on water pollution brought into industrialized countries, biodegradable detergents based on linear alkylate sulfonates have largely displaced "hard" detergents based on branched chain dodecylbenzene sulfonate. In industrialized countries there is a continuing trend toward liquid detergents that could alter the market structure and the linear alkylate sulfonate dominant position in it. These long-term threats come mainly from alpha olefin sulfonates and alcohol-based surfactants.

Detergent-range alcohols (non-ionic surfactants), second in importance as surface active material in industrialized countries, has very moderate prospects in developing countries.

2.3 International trade and distribution

2.3.1 - Current situation

Petrochemical products form a rather important share of international trade in 197[illegible], for instance, U.S. exports of synthetic fibers, thermoplastics and synthetic rubber amounted to 1,450 mn US$, i.e., more than 1% of the total U.S. exports. In 197[illegible], the internal and external exchanges of the EEC relating to the main petrochemical end products alone (thermoplastics, synthetic fibres, synthetic rubber) were about 5,000 mn US$. Such a value is equivalent to 9-10 % of the total imported crude oil (but represented 25 % in 197[illegible], before the skyrocketing of crude oil prices).

The impact of petrochemicals is even higher if we consider the case of Japan. For that country, exports of synthetic fibers alone amount to about 2.5 % of the total exports.

The only suitable traditional exporters are Japan, the EEC countries and the United States, though Canada, some EFTA countries and Eastern Europe have a significant weight for some products.

2.3.2 - Trade exchanges

Regarding exchanges, figures are taken for 1973, the last "normal" year before the world economic slowdown, and for 1975, the last year for which comprehensive statistics are available. The main conclusions that can be drawn from these data are the following:

- Except for a few products, the EEC countries are a net exporter.
- The United States imports mainly butenes, butadiene and benzene.
- As for Japan, the export-import balance is favourable for all the products considered except for xylenes and methanol.

Taking into account the trade evolution, the main trends are as follows:

(a) Olefins - About 80 % of the world ethylene market is accounted for by the U.S.A., Western Europe and Japan. Currently there is no significant trade in ethylene and propylene except between the EEC countries and within COMECON members. On the contrary, there is a relatively large amount of butenes/butadiene exported from Europe to the United States.

(b) Aromatics - Despite current overcapacities in benzene in Western Europe and the U.S., the latter still continue exporting benzene to Europe. The same observation applies to toluene and xylenes.

European imports are partly due to growing aromatics needs in low-lead content gasolines.
Finally, in recent years there has been a significant movement of aromatics from Eastern to Western Europe.

(c) Intermediate products - The U.S. still exports methanol, styrene and cyclohexane to EEC countries, whereas raw materials for synthetic fibers and plastics are exported by the U.S., EEC and Japan to developing coutries that have recently built polymerization facilities.

(d) End products - About 1.4 million tons of synthetic fibers in 1973 and 1.1 million tons in 1975 have been exported by the three main industrial regions. Japan and EEC continue to be the biggest exporters. For Japan, South East Asia remains its largest market due to the huge filament processing facilities in the Republic of Korea and Taiwan. Eastern Europe and EFTA countries contitute important markets for Western Europe in final petrochemicals, while Eastern Europe is emerging as an important synthetic rubber exporter.
Concerning plastics, EEC is by far the main export with Japan a strong second exporter, while Eastern Europe still remains a large net importer.

2.3.3. - Share of the international trade in the consumption

It is interesting to compare the international exchanges of petrochemicals with their consumption, and to measure the importance of the total exports compared to world production.

Data relative to the weight of inter-regional trade in world consumption is given in Annex 5. Figures are given for 1973, the last "normal" year. In fact, it is very difficult to draw general conclusions from the exchange and consumption data, each product and each area being a particular case. Nevertheless, the following facts can be pointed out:

- The ratio of exchanges (imports + exports) to consumption are of the same order of magnitude for Japan and the EEC countries, as far as end products are concerned (EEC internal trade not taken into account). The same ratio is far lower as concerns the U.S.

- The total exchanges relative to the EEC are very important when compared to the consumption. In 1973, the exchanges amounted to 89 % of the consumption for synthetic fibres, 58 % for plastics, 76 % for synthetic elastomers. In 1975 figures were 93 % for synthetic fibres, 67 % for plastics and 84 % for synthetic rubbers, the higher figures for 1975 mainly reflecting a depressed consumption situation. Figures relative to intermediate products are often lower, though sometimes important.

- Japan and EEC export a very large quantity of petrochemicals compared to their consumption, about 25-30 % for synthetic fibres and high density polyethylene, 22 % for low density polyethylene, 18 % for plastics and as concerns Japan 45 % for polybutadiene and 31 % for SBR.

- The position of the United States is quite different. In fact the U.S. exports a rather minor quantity compared to their consumption: 6 % for synthetic fibres, 7 % for plastics, o-xyline exports, about 35 % of their production, represent an exception.

The world exports/production ratio data does not take into account the internal trade of the EEC. The following conclusions can be drawn:

- Trade can be considered as marginal (less than 10 % of production) for most basic and intermediate products.

- Tonnages exchanged are relatively important for toluene and o-xylene (but not for benzene) and for end products, including synthetic rubbers (about 15 %), non-cellulosic man-made fibres (about 15%) thermoplastics (up to 21 % for high density polyethylene).

- The same ratios for 1975 could be slightly higher due to a poor production of most products in 1975 and to the fact that the decrease of exchanges has been more moderate.

2.3.4 - Major trends in the international trade

- The EEC internal trade should continue to be very active

- Propylene exports from EEC should develop due to a glut being formed by the faster-growing ethylene needs.

- Butadiene export from EEC to the U.S.A. should continue as long as significant feedstock shift for basic petrochemicals is not implemented in the USA.

- Aromatics, styrene and cyclohexane could continue to be exported from the U.S.A. to Europe in the same magnitude as now.

- As for Japan, export tonnages are likely to remain almost constant, with a slight decrease in the exports/consumption ratio due to the stronger international competition and the planned implementation of new petrochemical plants after 1980 in the Middle East and South East Asia.

- The prospects of huge capacity export-oriented plants emerging after 1980 in Eastern Europe and some oil producing countries with numerous buy-back deals between Eastern European countries and chemical companies or contractors, might substantially alter the current trade situation by toughening the competition, increasing very substantially the trade in basic and intermediate products, and geographically broadening the whole petrochemical trade.

2.3.5 - Price evolution of petrochemical products

Before 1973, the price of petrochemicals varied along the time with a general trend for decreasing. This was mainly due to the following factors by chronological order of apparition and influence:

- Technological improvements
- Larger diffusion of products
- Economy of scale with the implementation of larger units.
- A strong competition between manufacturers for same products.

Due to these main factors plus sometimes due to some overcapacity, the prices really decreased towards a position very close to the production costs, till the end of the 1960's.

However, up to around 1967 large advantages were gained by producers able to use large single-stream units while the market was then still predominantly made up of small units. Thus, in the early phase of the plant scale-up process, the operators of large units were content to allow the smaller producers to provide a "price umbrella" under which they themselves collected large profits without having to disrupt the business of their competitors.

Since around 1967, the impact of large plants on prices has made itself felt more and more to the point where today, abstracting from such transitory phases as the 1974 boom, prices are more in line with the level needed to allow the largest operators a normal return on investment and often below.

Between 1972 and 1974 prices have tripled or doubled, a slump in 1975 and a relative stabilization in 1976 have been recorded. Evolution of international prices is given in Annex 6.

2.4 Feedstock supply

2.4.1 - Current situation

The petrochemical industry, by virtue of its structure, is derived from 8 major basic products: ethylene, propylene, butadiene, benzene, talvene, xylenes, methanol and ammonia. Currently all these basics are produced almost exclusively from natural and associate gas, and oil refinery cuts mainly naphtha, the only important exception is benzene that is also produced as a by-product of metallurgical coke.

This situation of the petrochemical industry has remained without any structural change despite the very steep rise in feedstock costs due to the quadrupling of oil prices. The world petrochemical industry consumption of raw materials and fuel, by regions, is as follows in percentages:

	1973	1976
North America	35	33
Western Europe	34	32
Japan	17	16
Eastern Europe	11	15
Others	3	4
	100 %	100 %

(a) North America

The lowest cost of gas in the USA favoured its penetration in all fields but transport. In the petrochemical industry:

- methanol is always produced from natural gas feedstocks
- ethylene production developed as follows:

	From gas (ethane or LPG)	From naphtha or gas oil
1971	84 %	16 %
1976	77 %	23 %

In 1971 ethane was still largely predominant, accounting for 51 % of all ethylene produced, followed by propane (33 %) and naphtha gas oil. As a result the propylene produced (by steam cracking) was not sufficient to satisfy the demand the deficit being made up by propylene obtained as a by-product from FCC (fluid cracking catalytic).

The amount of butadiene produced was also insufficient, and the additional demand had to be met by means of imports and butane dehydrogenation.

The quantity of benzene produced by steam cracking was equivalent to only 10 % of the demand. Catalytic reforming of naphtha feedstocks was therefore used to provide a further 80 % in conjunction with toluene hydrodealkylation, and the remaining 10 % was obtained as a coke by-product. Catalytic reforming produced xylenes in far greater quantities than required by the petrochemical industry. The surplus was used as a solvent or in gasoline mixtures.

The decline in the part played by ethane and propane as raw materials for ethylene production is due to the rapid exhaustion of American gas reserves resulting from excessive use of this fuel.

In 1976 the North American petrochemical industry used roughly 6 % of the total hydrocarbon consumption (oil and gas) in the form of raw materials and fuels.

(b) Western Europe

The situation of Western Europe is the converse of that of the United States. The latter being motor fuel consumers have for some time now been obliged to upgrade heavy fractions to light fractions in order to make up the naphtha deficit. Western Europe, on the other hand, has for a long time had a surplus of naphtha since gasoline consumption is relatively lower compared to fuel oil requirements for industry and gas oil requirements for heating, transport and industry.

The surplus naphtha fraction, together with a limited supply of natural gas in some regions has let to naphtha being used for the production of methanol (17 % for 1973 production) and ammonia (33 % of 1973 production).

In 1973, 93 % of ethylene was produced from naphtha, and the rest from gas oil and LPG equally.

As a result the amount of propylene produced was more than adequate, and there was a surplus of butadiene, some of which was therefore exported to the USA.

As for benzene, in 1973, it was produced 14 % from coal, 32 % from steam cracking gasoline, 25 % from catalytic reforming and 29 % from toluene hydrodealkylation, the toluene being obtained half from steam cracking and half from catalytic reforming.

The catalytic reforming used for benzene production was more than adequate for xylene requirements.

In 1976 the petrochemical industry (including ammonia) used approximately 12 % of total hydrocarbon consumption (gas and oil) as raw materials and fuels.

(c) <u>Japan</u>

Japan is in a similar position to Western Europe, but has always been, and still is, lacking in both gas and oil.

Methanol is, however, mainly produced from natural gas feedstocks. Ethylene on the other hand was produced in 1976 exclusively from naphtha. This resulted in a more than adequate supply of propylene and butadiene.

However, as was the case in Western Europe, catalytic reforming of naphtha had to be used to a great extent in order to meet xylenes requirements and to make up the benzene deficit.

In 1976 the petrochemical industry (including ammonia) used about 15 % of the total hydrocarbon consumption (oil and gas) as raw materials and fuel.

(d) <u>Eastern Europe</u>

Full information is not always available on these countries, but it can be said that:

- methanol (and ammonia) are produced chiefly from natural gas.

Thus, in 1975 the feedstocks to produce ammonia in the USSR were as follows:

- natural gas	82.7 %
- coke oven	10.6 %
- coke and coal	4.5 %
- naphtha	0 %
- others	2.2 %

- steam crackers, of which there are as yet only a few in Eastern Europe, generally operate on naphtha, of which there tends to be a surplus whereas these countries have a deficit for gas oil.

Benzene, which in 1973 was produced in greater quantities than ethylene, is rarely obtained from steam cracking but more usually as a coke by-product, the complement being made up by catalytic reforming.

Although propylene produced by steam cracking should easily be sufficient to meet the demand, there seems to have been a large butadiene deficit. This was not likely made up through butane dehydrogenation.

In 1976, the petrochemical industry (including ammonia) used roughly 6 % of total hydrocarbon consumption (oil and gas) in the form of raw materials and fuels.

Others

In 1976, the petrochemical industry was still in its infancy in almost all the rest of the world. Seventy-five percent of hydrocarbon consumption was devoted to the production of ammonia for use in agriculture.

Options in the choice of raw materials are sometimes contrastive: for example, ethylene is produced from naphtha in Brazil, and also in South Korea and Taiwan. In Mexico, on the other hand, where there are large reserves of gas, ethane is used as a raw material. Other basic petrochemicals are as yet produced in very limited quantities only.

In 1976, the petrochemical industry (including ammonia) accounted for little more than 2 % of total hydrocarbon consumption (oil and gas).

2.4.2 - Availability of hydrocarbons

Known reserves of gas, oil and coal economically recoverable in 1976 by regions are given in Annex 7.

The present preponderance of oil over coal may be more balanced by the end of this century when coal might have regained some of its former status as a source for petrochemicals. In fact at the end of the 50's, coal, as petrochemical raw material for chemicals, peaked off in Western Europe and Japan from about 70 % in 1960 to about 5 % in 1973.

This situation points out that the proportions of known fossil reserves do not correspond to consumption since coal which accounts for 3/4 of all reserves supplies only 1/3 of total consumption.

From the total consumption of fossil fuels in 1976, the petrochemical industry only consumed 6.2 % of it, that amounted to 250 million T.Q.E. Out of this amount 200 million were used as raw materials and 50 million as fuel.

If known petroleum reserves could be earmarked only for petrochemicals, they could last more than 600 years at the 1976 consumption rate.

However, the part taken by the energy sector is such that substantial supply problems might be expected late in the 80's. In fact, the replacement of petroleum by other forms of energy will be a very slow process, all the more so since, despite the steep rise in oil prices alternative sources of energy are rarely in a position to compete the moment.

Although the current energy price acts as a brake on its growth, petroleum reserves are being fairly rapidly exhausted. Therefore, as far as natural gas and oil are concerned, the problem from now onwards will be the optimum management of its reserves.

The problem is more worrying in the case of petroleum since over the last six years new oil finds have done little more than balance consumption (finds = 1.25 times consumption) while gas finds have remained more or less at the same level.

2.5. Recent Developments and Future Trends in the Petrochemical Industry.

Over the past few years some important developments have taken place in the environment of the petrochemical industry that are markedly affecting this industry. They include a general economic slowdown in industrialized countries, the steep rise of energy costs, a major increase in plant construction costs, a growing awareness of pollution problems and the introduction of environmental regulations. Their impacts on this industry are given here below:

a) Increased production costs

The rise in the cost of energy, particularly oil, led to a considerable rise in feedstock costs and utilities that were translated in higher production costs of petrochemicals, that decreasingly affected the products as they move down stream. To illustrate this case see Annex 8.

Moreover, rising construction costs and stringent antipollution regulations have resulted in substantial investment cost increases.

The effect of these factors, particularly the increase in the price of raw materials, has been to increase olefin production costs by 350% between 1972 and 1977. Besides, the production cost in new olefin plants will be about 12 % higher than in the case of a similar plant built before 1977.

b) Slower market growth

The general decline in industrial activity and the steep rise in production costs have brought about a slowing down of market growth. Nevertheless the set back of petrochemicals demand has been limited due to the simultaneous and in many cases higher cost increases of the competitive natural products.

c) Changes in the production cost structure.

The steep increase in the cost of energy has brought about a major change in the production cost structure. Whereas in 1972 feedstock represented 42 % of the production cost of ethylene, it now accounts for 78 %. On the other hand, the proportion represented by amortization and return of investment has dropped from 40 % in 1972 to the current 12 % of the ethylene production cost. Therefore variable costs now are much more important than fixed costs.

This conjunctural change will affect the petrochemical industry in two ways:

- Those countries having feedstocks cheaply available due to large petroleum reserves or a favourable market structure of petroleum products, or government aid to this industry, will be in the strongest position concerning basic petrochemical production.
- Economies of scale will become less important since variable cost is the dominant factor in production, thus somewhat diminishing the effect of the limited-market constraint to the development of the petrochemical industry.

d) Difficulty in obtaining raw materials: trend toward flexibility.

The dramatically increased importance of feedstocks in the production cost has spurred a concern among petrochemical producers about securing their raw materials supply. Furthermore, the dwindling gas reserves in the U.S.A., the need to import naphtha in Japan, and the trend among West European petroleum refiners to release decreasing amounts of naphtha to the petrochemical industry are aggravating the medium- and long-term feedstock supply problem. Therefore, a renewed technological effort is being made toward a multiple feedstocks flexibility, even at the price of higher investment costs.

e) Excess capacity problems

As a result of the marked slowdown in petrochemical markets growth, the world industry is in an excess capacity situation. Therefore, one can expect delays in new capacity additions and/or the establishment of new petrochemical facilities. The most pressing problems at the moment are those of market outlets and competition. In the meantime, no major new investment commitments are likely to be approved until the supply/demand situation becomes more balanced and clear.

f) Trends toward international cooperation

The above described situation tends to produce a polarization towards cooperation due to the following effects on the factors affecting petrochemical production:

- a decrease of the market size constraint that nevertheless will still remain important.
- the very high impact of feedstock availability at attractive prices.

- the increasingly higher needs of financial means that entails either plentiful domestic financial resources, or external cooperation from other sources, or project implementation with foreign participation. This last alternative might help solve the market outlets problem through the opening by the foreign participant of a share in its own traditional markets.
- participation of companies from industrialized countries in projects in developing countries would be accelerated due to raw material availability and environmental problems.

3. MEDIUM TERM PROSPECTS: THE SITUATION IN 1985

3.1. DEMAND

3.1.1. Methodology and assumptions

A combination of three methods have been used for estimating the future demand for plastics, man-made fibres and rubber:

- macroeconomic approach based on trends observed over the 1965-1975 period with a particular emphasis on recent recession period beginning at the end of 1973,
- supply problems (producing capacities) at least for the next coming years, and
- analysis of structural changes and consumption analyses for the major petrochemical products.

Macroeconomic approach has been mainly based on an accurate analysis of the variations and trends of per capita elasticity coefficients - observed in world regions over the 1965-1975 period. The compatibility of the forecast results with those suggested by a sectoral analysis has been checked.

The main methodological factors for estimating the future development of the demand for plastics, man-made fibre and rubber are:

- Total consumption average growth rates over 10 and 5 years period

  As a result of the progressive saturation of the markets, these rates are expected to never exceed the rates p.a. previously observed.

- The levels of consumption (expressed in kg per capita)

  To different levels of consumption generally corresponds a certain pace of growth and certain end-uses breakdown of the demand. In addition, graphic reference to the "master curve" (corresponding to the per capita average demand in different regions for the same individual income) has been a helpful indication of the future development of demand.

- Per capita elasticity of demand versus income.

  They have been slightly decreasing, reflecting the gradual saturation of the markets.

a. Plastics

In industrialized countries, the coefficients of elasticity will keep higher than 3.0 up to 1980. Thereon, they would decrease to a limited extent corresponding to a still moderate degree of market saturation. Japan is the only exception among industrialized countries with a coefficient of elasticity of about 2.0. This situation reflects the relatively high

GDP growth rate expected for the next 10 years.

In developing countries, the coefficients of elasticity will in general keep higher than in industrialized countries, reflecting the large potential demand existing in these countries. However, there are two regions where the coefficient of elasticity will be close to 2.0: the Middle East, owing to the strong rise in income per capita, and East Asia, where the current consumption level is higher than those observed in other countries with about the same income level.

b. Man-made fibres

In industrialized countries, current coefficients of elasticity of about 2.0 will significantly decrease over the next 5 years reflecting the saturation of textile markets. Likewise, Japan will have lower coefficients of elasticity for the same reason given above. Concerning the developing countries, the remarks given above for plastics also apply to man-made fibers. However, the coefficients of elasticity of Middle East and East Asia will likely be even lower (close to 1.0) than in industrialized countries.

c. Rubber

With the exception of Eastern Europe, current coefficient of elasticity in industrialized countries is close to 1.0, thus reflecting the higher degree of market penetration and saturation. A coefficient of below 1.0 has been estimated for the next 5 years (between 0.85 and 0.9). In developing countries, the coefficient of elasticity will generally remain below 2.0. The remarks concerning Middle East and East Asia also apply here.

Taking into account the main factors of the growth of the demand for the main final petrochemical products (especially coefficients of elasticity and their variations) forecast of the demand for these products have been set up. Annex 9 shows the figures corresponding to the year 1985. As it appears from this table, the share of world market held by developing countries will be then 18.5% of the total (as against 11% in 1974).

3.1.2. Forecast of the demand for the main individual products

- Main final products

Structure of the demand for the main families of final products has generally been changing very gradully over the 10-15 last years, according to well established trends. This has been the basis of a preliminary forecast of the demand for final products when applying the extrapolated structure to the forecast figures of plastics, rubber, etc., previously estimated. Of course, the preliminary forecast has to be checked carefully and in some cases, corrected taking into account different elements (e.g., saturation of the market, better competitivity of one polymer versus others) able to modify the long-term trend.

By this way, starting from the forecast structure of demand and from the forecast volume of the demand for the main classes of petrochemicals, the following demand forecast has been done:

- plastics, namely low density polyethylene, high density polyethylene, polypropylene, PVC, polystyrene, ABS resins,
- man-made fibers: cellulosic and non-cellulosic (synthetics) fibers. The latter figures have been obtained by taking into account the stagnation of demand for cellulosics. The three most important types of synthetics are polyester, polyamid, acrylics.
- rubber: natural and synthetic rubber. The latter figures have been obtained by taking into account the moderate growth of natural rubber and, on the other hand, the saturation of some markets. The main types of synthetic rubber are SBR and polybutadiene.
- synthetic detergents: the most representative detergents are: DDB sulfonates and non-ionic detergents.

- Main intermediates and basic products

Starting from the forecast figures of the demand for final products and applying appropriate technical factors, forecast of the demand for intermediates can be easily obtained by up-stream integration. Consequently intermediate figures indicated in following tables correspond to final demand as if all intermediates needed were locally produced, since production of the four major classes of final products absorbs by far the largest part of main intermediates under consideration. The remainder part corresponding to miscellaneous uses has been estimated by referring to the sturcture of the demand in selected consuming areas.

3.2. PRODUCTION

3.2.1. Methodology and assumptions

As the overall time required to implement a petrochemical complex might take between 5 and 7 years under normal conditions, the methodology used is as follows:

- to compile the announced projects and facilities under design, construction and firm commitments.
- to estimate further production capacities taking into consideration specific hypotheses, product by product, and the following general assumptions:

a. An overall trend towards self-sufficiency in the developing countries reaching markets high enough to justify economic production.

b. Preferential locations in areas profiting by raw material availability and financial means.

c. Solution to the problems that could rise in some countries by constraints, like manpower formation or financial means available through international cooperation.

d. Location of the most sophisticated products preferentially in the industrialized countries.

e. Imports of the non-producing developing countries from both their traditional suppliers and the new producers in the region.

f. Production capacities and consumptions in 1985 balanced at world level with an average production factor of 0.85.

The petrochemical products have been separated in three groups for analytical purposes:

- First group: final and intermediate products that can be manufactured from imported raw materials. Their productions can be contemplated individually.
- Second group: ethylene and its derivatives. Their production is usually concentrated in complexes based on ethylene production, because of its high transportation cost.
- Third group: other basic products the production of which is rather linked to, or influenced by, the ethylene facilities.

In Annex 10 are given the forecasted capacities to 1985 by regions.

3.2.2. Forecast of production for the main petrochemicals

Few developing countries will enter the petrochemical industry between 1977 and 1980. As far as basic and intermediates are concerned, the new producing countries would be Egypt, Libya, Iraq, Qatar and Iran.

The other developing countries that have already a petrochemical industry would increase a great deal their plant capacities. Nevertheless, the share of the developing countries will still remain low.

On the other hand, if the hypothesis leading to the 1985 estimates would be confirmed, the share of developing countries in the world petrochemical production would be as follows:

Share of World Production Capacities by Developing Countries (%)

	1977	1985
- Ethylene	6	17
- Benzene	3	15.5
- Xylenes	6.4	16
- Monomers for synthetic fibers	4	14
- Synthetic fibers	16	23
- Synthetic rubbers	8	13
- Plastics	6	20

3.3. FUTURE PRICES EVOLUTIONS

During the previous past years the prices of petrochemicals have been upset by both sudden changes in some manufacturing cost elements (raw material, investment) and a situation of general overcapacity. It is expected that in the future, the overall situation will tend to equilibrium, and that the prices evolution will be more linked with changes in the production cost elements. From a general point of view the production cost evolution can be practically tied to two main factors: crude oil price evolution, and overall inflation (general price index related charges: investment related, manpower, maintainance, etc.). The impact of the crude oil price evolution (via naphtha, LPG, fuel ...) become less important when moving from the basic to the intermediate and final products. Annex 11 presents the respective shares of the present prices of some petrochemicals that will move accordingly with the crude oil price and the general inflation.

3.4. IMPACT ON THE INTERNATIONAL TRADE

According to the estimates done for 1985, the international trade of petrochemicals would be highly altered.

The main new trends would be:

- a global increase of self-sufficiency at regional level
- a less prevailing position of the industrialized countries

- despite the increase of self-sufficiency, at least a holding of the total movements order of magnitude because of the increase of consumption, and the appearance of new streams,
- the appearance of new streams: sophisticated products exported from industrialized countries to developing countries (presently of few importance), commodity and high consumption products exported from developing countries (mainly hydrocarbon-producing countries, to some industrialized countries).

These trends imply a notable effort to be done by the new exporters in the areas of marketing and distribution in order to benefit from their attractive production costs.

3.5. FEEDSTOCK SUPPLY

The supply of raw materials for the petrochemical industry accounts for only a small part of total hydrocarbon consumption. Problems in connection with the availability of raw materials for the petrochemical industry will continue to be very much a function of the economic situation. Annex 12 presents an estimation of the hydrocarbons required by the manufacture of petrochemicals in 1985.

With regard to gas, the main raw material used for the production of methanol and also ammonia, only Japan, being entirely dependent on imports, can be expected to have a significant problem with regard to supplies. North America and Europe will, in certain areas, have to face price problems, since these regions make up their deficit of gas by relatively costly imports of LNG.

Everywhere but in Eastern Europe, there will tend to be a deficit of naphtha. Some regions, particularly Western Europe and Japan, will have to set aside a large amount of their straight run naphtha for use in the petrochemical industry (about 48% and 38% respectively in 1985). More costly refining schemes and strong tension on naphtha prices can be expected in these areas.

In the developing countries the low consumption of fuel oil and the high demand for naphtha will involve big problems. If ethane or LPG are available they will have a privileged place as steam cracking feedstocks; the use of gas oil may lead unavoidably to the production of poor quality fuel oil, which will be very difficult to sell on account of the lack of huge industrial development and the very low requirements of the domestic heating sector. The extensive use of naphtha without required upgrading facilities will have the same adverse effect because for 1 ton of naphtha produced in refinery, an amount of 3 tons of fuel oil is also obtained. It appears this will be the major problem for developing countries as far as petrochemical feedstocks are concerned.

3.6. ESTIMATION OF INVESTMENT AND MANPOWER NEEDS

3.6.1. Investments

The petrochemical industry is a heavy industry which requires very high investments. Construction costs for petrochemical plant have risen steeply in the last few years (50% increase from 1973 to 1976). This rise will have the following consequences:

- major projects will be undertaken by joint venture constituted either by several companies or by governments and companies.
- there will be less ploughing back of profits, but more contribution from shareholders and more external financing through long-term loans,
- the oil producing countries who have considerably increased their financial resources, will be better placed to resolve these problems,
- because of the very considerable rise in fixed costs, production costs will be higher for new plants than for those built before 1974

Newcomers on a given market will, therefore, have a handicap to overcome.

Investmnets for petrochemical plants vary according to the technical options and the localization of production. Local conditions greatly affect the main constitutent elements of the construction cost. In particular construction costs are generally higher in the developing countries, chiefly due to the fact that contrators and manufacturers of equipment are such a distance away, and also because of infrastructure problems.

The investment requirement estimates for the petrochemical industry are presented in Annex 13.

3.6.2. Manpower

The petrochemical industry is a capital-intensive industry which employs a relatively small number of highly qualified personnel. Estimated manpower requirements are given in Annex 14. By 1985 petrochemical industry worldwide will require a labour force of about 1.3 million made up as follows:

Technical personnel including:		87%
- engineers and managerial staff	3%	
- foremen and technicians	10%	
- skilled workmen	45%	
- unskilled workmen	29%	
Administrative personnel including:		9%
- managerial staff	2%	
- clerks	7%	
Sales and marketing personnel including:		4%
- managerial staff	2%	
- clerks	2%	

4. ASPECTS OF THE FORECAST UP TO THE YEAR 2000

4.1. METHODOLOGY

The aim is to examine several ways in which the development of the petrochemical industry could attain the growth objectives stated in the Lima Declaration.

The characteristics of this sector are given by its physical internal structure, that in the main include its stoichiometric relationships.

The dynamics of this sector are given by its social structure that includes the sectoral environment and the strategy of the actors.

For the purposes of this study, a World Petrochemical Industry Simulation Model has been used to explore various development alternatives to the year 2000 based on a combination of macroeconomic and specific regional and product hypotheses.

Further on-going studies will develop exploratory and normative scenarios using futures research techniques.

4.1.1. Brief description of the World Petrochemical Model

The futures explored are based on a small number of hypotheses and the relationships of the sector to its environment. Based on them, the world demand and world production can be estimated, and the constraints on inputs such as feedstocks, investment and manpower can be brought to light for subsequent calculation.

Considering that the variables of the model are mutually influencial, a computerized iterative process has been used at every stage and for the whole model to express such relationships between variables in order to arrive at consistent and coherent pictures of the year 2000 compatible with the main hypothesis explored.

4.2. MAIN HYPOTHESES

The attainment of the Lima objective of 25% share of world production by developing countries in the year 2000 can be expressed by a growth relationship between GDP, population and MVA (manufacturing value added) by regions. Therefore, the main hypotheses for the model concern GDP growth rates that are then translated into demand figures using macroeconomic relationships.

In order to properly explore the future, at least three GDP growth rate hypothesis should be considered:

a. the attainment of the Lima objective as the minimum.

b. a reference trend if things continue as they are.

c. the probable share of world production that developing countries may achieve as viewed by the business community.

Here it should be noted that each hypothesis involves two factors: one, a world GDP growth rate, the other, the relative share of developing countries in petrochemical world production by the year 2000.

Hypothesis A

It is based on a simplified model developed by UNIDO to assess the implications of the Lima target. It shows the different spreads with which industrialized and developing countries should grow to attain at least the 25% world production target. From the wide range of growth-rate relationships, the one giving the following values was chosen: world GDP growth = 4.0%, industrialized countries = 2.9% and developing countries = 6.8%.

These figures were chosen because they were the nearer to the historical growth rate achieved by developing countries during the high economic growth period 1960 - 1973, while industrialized countries still retained an attractive GDP growth rate.

Hypothesis B

It is based on Leontief's "The Future of the World Economy" and corresponds to the passive scenario X. It was chosen because it has a world GDP growth rate of 4.8%, the nearer to ensure comparability with hypothesis A, while providing a different world production target.

Hypothesis C

Seven different GDP growth rate hypothses given by different business organizations were analysed. The one given by the Cavendish Laboratory (U.K.) that corresponds to its high estimate was chosen. Its world GDP growth rate of 4.0% ensures a proper comparability with the other two hypotheses.

4.3. PICTURES OF THE PETROCHEMICAL INDUSTRY IN THE YEAR 2000

The results of the World Petrochemical Model for the three main hypotheses are given in Annex 15.

The more important conclusions to be derived for each hypothesis are as follows:

Hypothesis A

It is the only one that attains in excess the Lima objective. entails a major shift from the present international order and the nature of the relationship between industrialized and developing countries.

It requires over 20 years of sustained international cooperation as the major means to allow developing countries to achieve the required economic growth.

It also requires massive technical training programmes to ensure efficient plant operation rates, and the smooth and steady supply of world markets from new producers.

Investment financing is the equivalent of 0.32% of GDP over more than 20 years, which is a fairly high ratio. As a comparison, short-term estimates put petrochemical investment for developing countries projects in hand or scheduled for implementation between 1977 and 1980 at 0.25% of GDP.

Hypothesis B

This alternative involves the highest oil consumption. Without cooperation, the least solvent countries may find themselves deprived of this vital raw material for their petrochemical industry in the event of shortages.

The financial outlay is almost as large as in hypothesis A, but it is difficult to envisage how it can be solved since this hypothesis entails very little international cooperation. In fact, it projects a rather gloomy picture for developing countries.

Hypothesis C

It involves a minor political and economic effort, yet at the same time this is taken into account in the objectives as translated from the GDP growth rates.

Investments equivalent to 0.19% of GDP are intended only to satisfy the immediate domestic demand through production capacities, taking advantage of the economies of scale.

The need for qualified manpower is reduced, and fairly moderate world oil demand would mean few raw materials supply problems.

5. STRATEGY OF THE ACTORS

Actors are those elements who foremost dynamize the sector's structure. The actors' actions are presented in terms of their perceived strategic posture, which comprises the ways (decisions, major action programmes) in which actors intend to use their means (the resources available to the actor) to achieve their objectives and mission.

Herebelow is given an overview of some of the main actors active in the petrochemical industry, and the perceived international re-deployment strategy that is currently emerging.

5.1. Actor 1

5.1.1. U.S. oil multi-national corporations (and affiliates)

By their nature, the multinational corporations have as basic "raison d'etre" to defend, maintain and maximize profits. Among various multinational firms already constituted, the oil corporations are characterized by an advanced degree of internationalization and world-scale spreading. These corporations already dispose of:

a. a large financial autonomy with, as a consequence, a policy basically of self-financed investment;

b. a multi-national network of extracting and refining plants recently reinforced, under the impact of downstream integration, by a growing category of chemical fertilizers, petrochemicals and, in certain cases, of synthetic protein manufacturing plants;

c. a mobile multi-national network of skillful labour, technological equipment and services;

d. a multi-national network of closed marketing channels first reduced to crude oil, but increasingly extending to gas, fertilizers and several categories of petrochemicals and other derivatives of hydrocarbons.

e. strong research and development capabilities.

The perceived strategy of oil multi-national corporations covers various but supplementary aspects, which are as follows:

a. a financial strategy of self-financement of investment, but with a growing orientation toward international financial markets and governmental assistance.

b. a global production strategy implying a systematic policy of energy diversification and of further involvement in the fertilizer and petrochemical sectors. Another factor is the turning of petrochemical companies to heavier oil-cuts or oil itself because of the steady climbing of lighter feedstock prices and the acceptance of a larger dependence on oil corporations for ethylene supplies.

c. a technological strategy aiming at the control of technological processes, patents and services.

d. a commercial strategy which will aim to extend the present trade-closed channels of the OMC, essentially limited at present to crude oil and refined products, in order to cover petrochemical sectors.

e. a political strategy with a contradictory tendency simultaneously to seek and resist governmental intervention. The OMC are struggling against increasing state intervention while feeling its strategic necessity. The examples of government intervention are: subsidized oil refining companies through price control to protect their profit margins; state-pricing subsidies of the domestic crude oil which they have refined.

5.1.2. The states-oil European companies

The new strategy of the Western European oil companies for oil control and refining consists basically of the following three complementary elements:

a. To obtain from the EEC assistance for their refining ventures, and further reestablish their profits by both controlling Western European refining in the forecoming years and obtaining a release of their refined products' selling prices.

b. To obtain that the EEC assists those companies in developing their own system operations and vertical integration on a Western European community basis by helping them to accrue raw material and new resources.

c. Adopt a strategy of introducing partnership in new oil resources for Western Europe, acquired by Western European countries on a community basis.

5.2. Actor 2.

5.2.1. The Petrochemical Companies

a. Financial Strategy

A major difficulty facing most of the petrochemical companies, big or small, North American or Western European, is to finance their heavy investment plans both in the short and long term. The three following different cases have distinct corresponding implications:

1. some small and vulnerable companies can seek and get financial assistance from stronger groups on a joint-venture basis;
2. some small and vulnerable companies can seek and levy funds through banking and financial sectors;
3. some small and vulnerable companies can seek and obtain assistance from their own or other states.

b. Production Strategy

1. Changing production technology

If gas is to assume its proper pricing position in relation to oil, then the increasing trend to develop multi-feedstock crackers, either based on naphtha and heavier cuts or directly on crude oil, would accelerate. Especially in the United States, gas may lose more and more of its role as major feedstock in the world petrochemical industry.

2. Setting up multi-nationalization

The tendency toward establishing new manufacturing plants and marketing platforms by Western European companies in other countries is stimulated by simultaneously motivating the companies' need to escape "high" domestic labour and financing costs and that of consolidating their export markets.

3. Geographical orientations

Geographical orientations of the multi-nationalization is realized as follows: Southern European petrochemical companies are pushing into two main directions: the U.S.A. and Northern Europe. It should be noted that the multi-national expansion of European petrochemical companies through their joint-venture with the U.S. and other strong groups is associated with a striking development of propylene plants in particular. Furthermore, multi-nationalisation and new differential specialization are developing demands to the oil-producing countries that are already moving strongly into processing domestically their hydrocarbons and basic petrochemicals. However, further specialisation and achievement of geographical multi-national expansion require a greater development of research and technology that Southern European petrochemical companies are not able to do it alone, and these companies will depend on international banks and financial institutions and/or on multi-national and specialized chemical corporations, through joint-ventures in developed countries. Moreover, the oil-price increase caused the loss of low-priced feedstock, and, therefore, stimulated the specifically and run-integrated petrochemical companies to seek again new advantageous positions by going into joint ventures or direct bilateral agreements with the oil-exporting countries (The United States in Saudi Arabia, Japan in Iran and France in Qatar), whereby those companies can simultaneously :

- reduce the financial burden of their raw materials, purchases, and accede to local under-priced associated gas and crude oil;
- consolidate their exports by shifting some of their new projects to the oil-producing countries, thus multinationalizing their production and extending further their export markets.

5.3. Manufacturing Re-deployment strategy

The rise in the price of feedstocks and energy costs reduced the rate of profit of the companies dealing with petrochemical industries and at the same time the acute competition and relative stagnation within their existing sales' markets brought up differential strategies as follows:

The vertical integration, upstream in the case of petrochemical companies seeking fuel stock and energy, downstream in the case of oil multi-national corporations or major companies moving further to end products. This strategy implies a continuation of three strategic goals:

a. secure, stabilize and maximize profits from a direct or partial control of the feedstock and the energy sources which allow seizing the oil or gas rents at maximum;

b. go into variant downstream manufacturing operations, the most profitable for the most value-adding of the petrochemical industries.

c. develop new processes to reduce and, whenever possible, to eliminate intermediate stages and their outputs as well as by-products.

6. RECOMMENDATIONS FOR THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY IN THE DEVELOPING COUNTRIES

The conditions which most favour petrochemical projects have tended to be present together in the industrialized countries, hence the concentration of the petrochemical industry today in Europe, the United States, and Japan.

Although a number of major projects are at present in the planning or construction stage in several of the developing countries, the situation of this industry in 1980 will still be far from the objectives contained in the Lima Declaration.

When setting up a petrochemical industry in a developing country, a number of obstacles have to be faced. The most important among them being small market size, difficulty in penetrating markets abroad, amount of capital required, the need for skilled, qualified manpower, raw material and infrastructure requirements.

Taking into account expected trends and constraints, some attempt can be made to formulate overall strategies aimed at overcoming or minimizing these constraints, and recommendations which will help promote petrochemical development in the developing countries, with emphasis on the setting up of sound projects which will benefit the country.

6.1. SUGGESTED OVERALL STRATEGIES

National industrial development planning

Setting up or developing petrochemical production in developing countries involves a great deal of outlay, particularly in financial terms. The new industry, once set up, affects many other sectors ranging from refining to textiles, plastics and rubber processing, construction, agriculture, transport, etc.. In addition it creates manpower and infrastructure problems which can be resolved only in the medium or long term; and it involves a number of major decisions. In the light of these circumstances it appears that industrial development planning on a national scale offers the best means of creating a favourable environment for petrochemical development in the developing countries.

Co-operation with industrialized countries

It is difficult to imagine how developing countries might acquire at present certain means indispensable to the development of petrochemical production unless through co-operation with the industrialized countries, where in fact some vital factors are almost exclusively concentrated: large petrochemical companies, construction firms, sources of finance, technology, a fund of plant design and operating as well as marketing experience; moreover, these countries continue to account for a major share of the petrochemicals market.

6.2. RECOMMENDATIONS

1. The petrochemical industry is a heavy industry requiring susbtantial resources in terms of investment, raw materials, skilled personnel and infrastructure. If implementation conditions are not optimum, benefit to the country will be slight. Unless justified by specific, particularly favourable circumstances, it is preferable that a certain level of industrial development be reached before a basic petrochemical industry is set up. Those developing countries which have not yet reached such a level could start by manufacturing petrochemical end products, in particular synthetic fibers, best suited to prevailing conditions and the needs of most of these countries.

2. Before the decision to set up the petrochemical industry is taken, a very detailed assessment has to be made, on one hand of possible advantages for the country (raising the gross domestic product, foreign currency saving, securing raw materials, etc..) and on the other hand, the resources required (estimation of requirements and determination of available resources).

3. Industrial planning and choice of product must be the result of well-considered decisions, bearing in mind the country's needs and the possibilities it offers. The following aspects in particular must be covered:

a) An in-depth market survey, the market being one of the determining factors in the success of a petrochemical undertaking:
 the domestic market and probable future development must be studied in the greatest possible detail. The study should identify local constraints likely to limit petrochemical consumption, such as product quality and price problems, distribution networks, process industries. Petrochemical process industries should receive particular attention : these include textiles, plastic processing, tire and other rubber processing industries. They will constitute the petrochemical industry's direct clients, and if they do not develop sufficiently, petrochemical outlets will be seriously affected. Thus means must be found, wherever necessary, to encourage such development, e.g., economic incentives,

personnel training, setting up of petrochemical application demonstration units.

The domestic market survey as a whole should lead to formulation of a marketing strategy for the future products.

The export market survey should cover in particular international competition, customs protection, transport costs and existing distribution networks. Also included should be an assessment of the investments required, usually considerable, in order to reach these markets. One possible solution would be to use the services of an international company, who would become a participant in the project.

b) Inventory of the country's raw material resources and their valorization. This should give consideration to uses other than in the petrochemical industry, and particularly, in the case of oil and gas producing countries, to export opportunities. Possible consequences for local refining industry of the arrival of a new petrochemical industry likely to seriously affect markets, will also have to be considered.

c) Techno-economic studies, based on the results of the above studies: these should include in particular an accurate and realistic investment estimate, allowance for the effects of inflation, and a detailed foreign currency balance, so as to allow the best possible assessment of each project's positive effects on the country.

d) Accurate assessment of infrastructure requirements in respect of different schemes, and comparison with existing facilities. If the petrochemical industry is set up in a country lacking an adequate infrastructure, it will not operate satisfactorily, or, alternatively, considerable additional investment will be required to set it up.

4. The following problems have to be resolved in the course of project implementation.

a) Technical choice

The judicious choice of technologies to be used in petrochemical plants is vital to the success of any undertaking in this field. The wrong choice may seriously compromise the future of a project which has involved considerable outlay, chiefly on investment and manpower.

The main criteria to be considered are :

- Adaptability to market requirements
- Ease of operation, adaptation to local conditions
- Profitability of the process.

b) Personnel recruitment and training

Petrochemical industry personnel are few in number but are, above all, highly skilled and qualified, and have to accept considerable responsibility. The greatest of care must be given to personnel recruitment and training. Firstly, personnel must have a certain level of general education and skill, and secondly specialized training may be quite lengthy and must not be rushed. It is recommended that wherever possible the services of process licensors and the selected contractors be used, as well as those of specialized industrial training companies and, in the case of joint ventures, those of the international companies involved. Moreover, co-operation between countries, especially between developing countries, should be encouraged with a view to making personnel training easier and more efficient by using units established in producing countries.

c) Plant localization

In deciding on the localization of a petrochemical plant, many very different considerations have to be borne in mind, and the final choice may in some cases be a compromise between conflicting factors.

The region where the production unit is to be set up is determined first of all, and, this once settled, a more specific choice of site can be made.

When determining the region, the following considerations have to be taken into account :

- a reliable supply of raw material:
- minimization of the cost of obtaining raw materials and of dispatching products to the consumer
- availability of an existing or potential work force
- existence or cost of setting up the infrastructure necessary for the implementation and operation of the petrochemical industry
- interest for each of the regions under consideration of establishing this type of industry
- geographical features : clămate, altitute, incidence of earthquakes, and consequences of these on investment and operating costs.

Once the region has been decided, the choice of the site itself can be made, according to criteria relative to the available land and infrastructure. The first essential is of course that an area of land suitable for a petrochemical plant should be available. The chosen site should comprise the infrastructure indispensable for the setting up and proper functioning of the petrochemical plant. The infrastructure needed includes the following main items :

- facilities for the delivery of the constituent equipment
- a supply of water and electricity
- effluent disposal facilities
- transport facilities
- housing.

d) Pollution regulations

Specific regulations to deal with problems presented by the petrochemical industry must be drawn up by the relevant authorities. Such regulations are indispensable to contractors for the design of pollution control systems, and must therefore be in existence when the tender documents are sent out. It is recommended that the different ministries concerned, e.g., industry, health, development, should draw up relevant regulations, referring if necessary to other countries' experience.

e) Marketing policy implementation

On the basis of the market survey results, marketing policy and organization should be planned prior to plant start-up : it may prove helpful to facilitate market penetration by preceding product launching with imports of iddetical products from plants using the same techniques.

f) Financing sources and schemes

The petrochemical industry requires very high investments. In the particular case of developing countries, a specific aspect of the petrochemical industry is also that it involves importing from industrialized countries most if not all of the equipment, and meane high investment in foreign currency. Therefore the possibility of raising the funds required for financing the required investment amounts will probably be decisive for petrochemical industry development in developing countries.

5. Government support

In order to set up and develop on a sound basis in the developing countries the petrochemical industry must receive Government support.

Aspects where support is essential include :

- import duty concessions on machinery and equipment
- tariffs and other types of protection
- tax incentives
- export promotion
- private sector investment promotion
- development of industrial estates making land and infrastructure available
- assistance with manpower training.

6. Promotion of co-operation

Co-operation between countries, particularly developing countries, offers a means of reducing or overcoming several barriers, in particular as regards :

- domestic market limitations
- financing problems (resources can be combined)
- raw material and infrastructure requirements (plants can be sited in the most favourable areas).

Moreover, co-operation makes for more efficient personnel training and exchange of information thus enabling many countries to benefit from the experience of others in setting up petrochemical plants.

Annex 1 (a)

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	5 302	1 2[illegible]	[illegible]	3 32[illegible]
EASTERN EUROPE	2 955	1 553	340	3 490	327	[illegible]	2 513
NORTH AMERICA	14 450	7 100	2 270	6 400	1 906	[illegible]	4 [illegible]
LATIN AMERICA	1 455	418	205	349	100	75	2[illegible]4
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	2 553	636	315	1 184
PACIFIC AREA	290	80	34	-	-	-	33
WORLD TOTAL	39 007	20 306	6 040	18 764	4 250	2 126	1[illegible] 317

(1) excluding JAPAN

Annex 1 (b)

EXISTING CAPACITIES

INTERMEDIATE PRODUCTS

10^3 tons/year

PRODUCTS / COUNTRIES	Ethylene oxide	Vinyl chloride	Styrene	MONOMER FOR SYNTHETIC FIBRES: Caprolactame	Acrylonitrile	DMT	TPA	ADIPIC ACID	[illegible]
WESTERN EUROPE	1 730	4 860	2 945	800	1 110	1 220	515	840	[illegible]
EASTERN EUROPE	302	1 195	164	419	275	667	45	3	n.a.
NORTH AMERICA	2 450	3 100	3 580	430	745	1 923	950	[illegible]	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	2 203	2 931	4 800	[illegible]	1 706	[illegible]

(1) excluding JAPAN

Annex 1 (c)

EXISTING PRODUCTION CAPACITIES (MID 1977)

10^3 TONS/YEAR

REGIONS \ PRODUCTS	Main plastics (2)	Synthetic rubber (3)	Detergents (4)	Synthetic fibres
WESTERN EUROPE	15 416	1 884	1 114	3 337
EASTERN EUROPE	3 170	1 407	≥ 62	1 058
NORTH AMERICA	12 265	2 195	755	3 970
LATIN AMERICA	1 061	285	605	687
NORTH AFRICA	-	-	-	3
EAST AND WEST AFRICA	-	-	-	5
SOUTH AFRICA	189	30	-	51
MIDDLE EAST COUNTRIES	163	45	10	131
SOUTH ASIA (1)	403	30	≥ 31	270
EAST ASIA (1)	551	148	13	≥ 657
JAPAN	5 623	739	300	[illegible]
PACIFIC AREA	380	70	7	32
WORLD TOTAL	39 141	6 833	2 917	11 618

(1) *Excluding JAPAN*
(2) *Includes : LD polyethylene, HD polyethylene, PVC, Polypropylene, Polystyrene*
(3) *Includes : styrene butadiene rubber and polybutadiene*
(4) *Includes : alkyl-benzene and detergent range alcohols*

TABLE 2

AVERAGE ANNUAL GRO[illegible] RATE OF THE DEMAND FOR PLA[illegible]CS, 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 - [illegible] ; [illegible] Europe : 4 [illegible] ; North America : [illegible]*

Annex 3

WORLD DEMAND FOR PETROCHEMICAL END PRODUCTS

1974

REGIONS OF THE WORLD	PLASTICS	SYNTHETIC FIBRES	SYNTHETIC RUBBER	SYNDETS (197[illegible])
WESTERN EUROPE	15 430	1 770	1 720	3 300
EASTERN EUROPE	4 500	830	1 800	1 500
NORTH AMERICA	13 872	2 591	2 435	2 700
LATIN AMERICA	1 923	437.0	398	900
AFRICA	724	196.9	162	250
NORTH AFRICA	220	50.6	51	110
WEST AFRICA	102	29.3	45	50
EAST AFRICA	108	21.3	39	40
CENTRAL AFRICA	64	9.4	11	25
SOUTH AFRICA	230	86.3	16	25
ASIA (excl. CHINA)	7 554	1 498.6	1 056 *	1 950
CHINA	-	-	65	-
MIDDLE EAST	405	116.7	83	150
EAST ASIA excl. JAPAN	576	185.6	73	400
JAPAN	5 800	655.1	615	850
SOUTH ASIA	773	362.7	220	550
PACIFIC AREA	600	155.4	78	250
TOTAL WORLD	44 003	7 538.1	7 709	10 850
of which developing countries	4 171	1 451.3	985	2 225

* including CHINA

** of which about 20 % active materials

Note: In most cases 1976 figures were again at 1974 level, recovering from the heavy drop in demand recorded for 1975.

Annex 4

WORLD CONSUMPTION BREAKDOWN OF MAJOR PETROCHEMICAL END PRODUCTS - PERCENTAGE

REGIONS OF THE WORLD	1974
WESTERN EUROPE	31.61
EASTERN EUROPE	11.91
NORTH AMERICA	31.68
LATIN AMERICA	4.71
AFRICA	1.81
NORTH AFRICA	0.54
WEST AFRICA	0.29
EAST AFRICA	0.28
CENTRAL AFRICA	0.14
SOUTH AFRICA	0.55
ASIA excl. CHINA	16.69
MIDDLE EAST	1.01
EAST ASIA excl. JAPAN	1.40
JAPAN	11.81
SOUTH ASIA	2.27
PACIFIC	1.39
TOTAL WORLD	100.0

Annex 5

WEIGHT OF INTER-REGIONAL TRADE COMPARED TO PRODUCTION

(MAIN EXPORTS/WORLD PRODUCTION)

1973

PRODUCT	%
Ethylene	0.7
Propylene	0.6
Butadiene, butenes	3 - 4
Benzene	5.4
Toluene	12.7
O.xylene	14.1
Mixed xylenes	5.6
Styrene	8.3
Methanol	8.6
Phtalic anhydride	6.9
Ethylene glycol	11.0
Formaldehyde	1.5
Acetone	5.7
Cyclohexane	9.0
Caprolactame	9.5
Acrylonitrile	8.4
Dimethylterephtalate	5.9
Synthetic detergents	4.5
Styrene-butadiene rubber	11 -. 15
Polybutadiene rubber	12.7
Synthetic rubber	15.0
Acrylic fibres	> 14
Polyamide fibres	> 11
Polyester fibres	> 6
Synthetic fibres	15.2
L.D. polyethylene	14.4
H.D. polyethylene	20.7
Polypropylene	20.1
Polyvinylchloride	9.8
Polystyrene	6.8

Footnote: At the world level, world production is considered as equal to world consumption.

Annex 6

PETROCHEMICAL PRODUCTS PRICES

FOB U.S.A.

US C/LB (CURRENT)

PRODUCT / YEAR	1970	1971	1972	1973	1974	1975	197[illegible]
Ethylene						11.8	12.9
Butadiene			8	9.6	18.2	15.0	16.5
Benzene	21.2	19.8	21.4	35.8	113	29.3	80.6
O.xylene	3.5	3.1	3.1	5.0	10.4	7.4	10.9
P.xylene	5.9	5.9	5.6	6.9	11.5	14.4	10.7
Styrene	6.3	5.5	5.8	13.6	24.0	17.8	19.3
Caprolactam	18.8	19	20	21.7	53.0	39.7	40.4
DMT	15.2	14.1	14.1	14.3	25.4	22.8	23.4
VCM	5.2	5.0	5.0	5.8	11.3	10.5	13.8
Ld polyethylene	13.5	13.7	12.1	16.8	33.8	26.4	27.3
Hd polyethylene	13.4	12.8	12.2	16.0	34.6	24.6	26.3
PVC	19.2	19.7	20.1	24.7	34.3	28.5	27.4
Polybutadiene	18.7	20.1	19.7	19.4	32.7	30.1	32.0
SBR	17.7	17.6	17.4	19.1	27.4	29.8	[illegible]
Nylon yarn not text	151	138	104	104	139 + 14	114	143
Polyester staple	49.5	40.2	36.2	48.5	66.5	47.2	51.2
Acrylic staple	65.6	61.2	55.5	51.0	63.2	58.1	59.0

Annex 7

RESERVES AND FOSSIL FUEL RESSOURCES

10^6 TOE

Reserves	Natural gas	Crude oil	Coal	Total
NORTH AMERICA	7 904	5 116	124 880	137 900
E.E.C.	3 228	2 440	30 674	36 342
Others WESTERN EUROPE	808	913	1 340	3 061
JAPAN	60	4	687	751
EASTERN EUROPE	26 985	11 109	202 840	240 934
AFRICA	5 989	8 263	8 426	22 678
LATIN AMERICA	2 587	4 039 (4)	1 713	8 339
MIDDLE EAST	16 982	50 160	200	67 342
CHINA	716	2 729	67 533	70 978
AUSTRALIA-NEW ZEALAND	1 102	214	16 347	17 663
SOUTH EAST ASIA	2 270	2 619	8 846	13 735
WORLD (1)	68 631	87 606	463 486	619 723
World resources (2) Range of estimates	(171 to 344) x 10^3	(184 to 1840) x 10^3	(720 to 3600) x 10^3	(1075 to 5784) x 10^3
Expected value	300 000	300 000 (3)	2 200 000	2 800 000

(1) *Proved and recoverable reserves at 1976 economic conditions*

(2) *Known, probable and undiscovered*

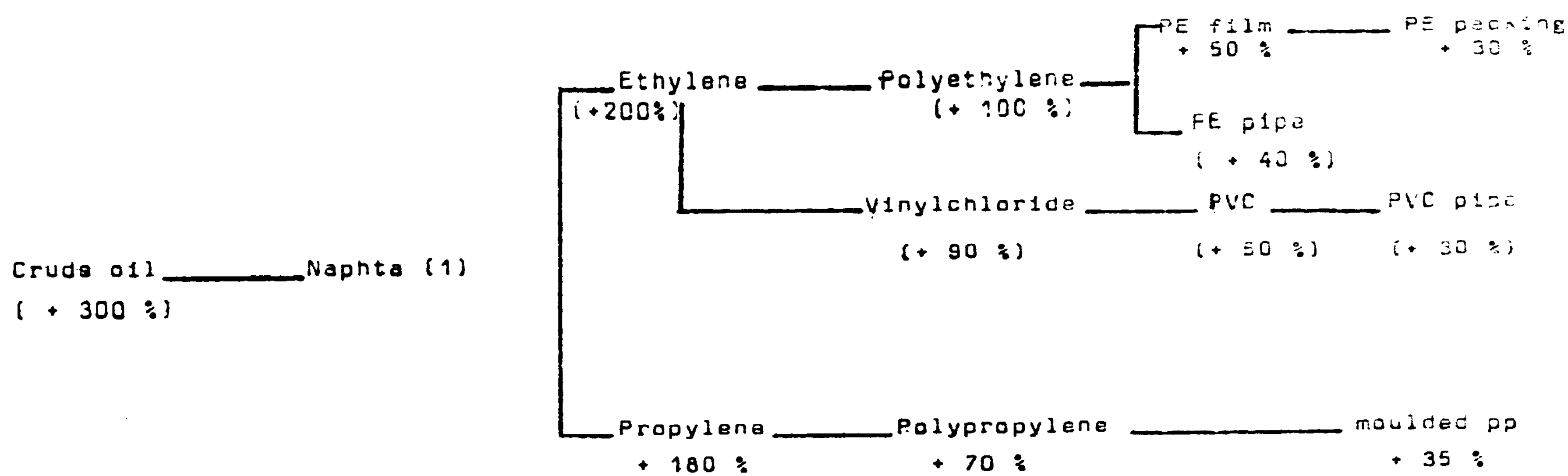
(3) *Oil recovered from tar sands and shale oil could double this value.*

(4) *Venezuela oil belt and large extension of Mexico oil reserves (claimed by Pemex) are not included in this figure.*

Annex 6

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 %.

Annex 9 (a)

WORLD DEMAND FOR PETROCHEMICAL END PRODUCTS

1985

1,000 tons

REGIONS OF THE WORLD	PLASTICS	SYNTHETIC FIBRES	SYNTHETIC RUBBER	SYNDETS (1975)
WESTERN EUROPE	38 030	3 200	2 553	4 800
EASTERN EUROPE	13 975	2 645	3 394	2 700
NORTH AMERICA	33 575	4 545	3 661	3 60[illegible]
LATIN AMERICA	7 865	1 490	909	1 850
AFRICA	3 255	749	431	580
NORTH AFRICA	1 909	270	129	290
WEST AFRICA	575	168	100	110
EAST AFRICA	490	75	95	90
CENTRAL AFRICA	295	29	31	50
SOUTH AFRICA	805	207	76	40
ASIA (excl. CHINA)	23 310	5 650	2 710	3 240
CHINA	-	1 080	213	-
MIDDLE EAST	2 210	380	245	310
EAST ASIA excl. JAPAN	2 525	670	174	750
JAPAN	14 675	1 865	1 252	1 150
SOUTH ASIA	3 900	1 855	826	1 030
PACIFIC AREA	1 975	293	123	410
TOTAL WORLD	120 306	18 572	12 801	17 130
of which developing countries	18 971	6 017	2 722	4 480

Annex 9 (b)

WORLD DEMAND FOR MAIN PETROCHEMICAL INTERMEDIATES

FORECAST 1985

1 000 [illegible]

REGIONS OF THE WORLD	Vinyl chloride monomer	Styrene monomer	Acrylonitrile	DMT	TPA	Caprolactam	Ethylene oxide	[illegible]
WESTERN EUROPE	7 935	5 123	1 484	[illegible]	[illegible]	546	[illegible]	[illegible]
EASTERN EUROPE	2 250	1 985	832	1 090	[illegible]	930	[illegible]	[illegible]
NORTH AMERICA	6 110	5 935	1 068	[illegible]	1 165	[illegible]	[illegible]	7 [illegible]
LATIN AMERICA	1 600	1 089	380	564	350	300	[illegible]	[illegible]
AFRICA	845	465	149	244	212	181	[illegible]	[illegible]
NORTH AFRICA	294	148	53.5			75		
WEST AFRICA	155	86	23.5			48		
EAST AFRICA	132	75	11.3			21		
CENTRAL AFRICA	80	40	5.0			8		
SOUTH AFRICA	104	118	56	62	53	28		
ASIA excl. CHINA	3 424	3 243	1 460	1 74[illegible]	1 547	1 381	1 [illegible]	[illegible]
CHINA	-	-	205	39[illegible]	[illegible]	256	-	-
MIDDLE EAST	598	309	63.3	[illegible]	[illegible]	112	75	[illegible]
EAST ASIA	577	312	133	[illegible]	195	158	150	[illegible]
JAPAN	3 357	2 [illegible]	701	[illegible]	565	[illegible]	740	[illegible]
SOUTH ASIA	892	581	358	[illegible]	435	453	[illegible]	[illegible]
PACIFIC AREA	451	268	69	[illegible]	60	59	[illegible]	[illegible]
TOTAL WORLD	21 625	18 118	5 460	6 [illegible]	4 [illegible]	4 027	[illegible]	[illegible]
of which developing countries	4 328	[illegible]	1 [illegible]	2 [illegible]	1 [illegible]91	1 [illegible]		

Annex 9 (c)

WORLD DEMAND FOR MAIN BASIC PRODUCTS

FORECAST 1985

1000 T

REGIONS OF THE WORLD	ETHYLENE	PROPYLENE	BUTADIENE	BENZENE	P.XYLENE	O.XYLENE
WESTERN EUROPE	21 400	11 064	1 766	8 663	1 060	1 526
EASTERN EUROPE	6 150	3 050	2 156	4 096	873	539
NORTH AMERICA	23 380	11 056	2 569	10 640	1 970	1 175
LATIN AMERICA	4 990	2 149	684	1 813	627	309
AFRICA	1 938	772	322.2	947	79	[illegible]
NORTH AFRICA	661	245	97	290	-	57
WEST AFRICA	356	121	75	173	-	30
EAST AFRICA	300	67	70	121		25
CENTRAL AFRICA	181	51	23.6	56	-	15
SOUTH AFRICA	440	268	56.5	307	79	35
ASIA excl. CHINA	13 480	7 990	1 973	6 112	2 258	1 044
CHINA	-	-	158	505	425	-
MIDDLE EAST	1 424	567	183	563	150	115
EAST ASIA	1 616	583	129	635	281	111
JAPAN	7 860	5 400	886	3 394	574	546
SOUTH ASIA	2 580	1 440	615	1 015	828	[illegible]
PACIFIC AREA	1 218	557	93	520	113	67
TOTAL WORLD	72 [illegible]	36 636	[illegible]	[illegible]	6 903	[illegible]
of which developing countries	12 108	5 243	2 034.6	5 266	2 311	633

Annex 10 (a)

CAPACITIES OF PRODUCTION BASIC PRODUCTS IN 1985

[illegible]

REGIONS OF THE WORLD	Ethylene	Benzene	Ortho and para xylene	Methanol
WESTERN EUROPE	24 500	10 000	3 200	4 700
EASTERN EUROPE	8 150	5 000	2 300	7 000
NORTH AMERICA	29 000	12 [illegible]	4 100	7 200
LATIN AMERICA	5 200	2 200	950	1 230
AFRICA	2 200	1 100		1 500
ASIA				
MIDDLE EAST	3 000	650	230	1 7[illegible]
EAST ASIA	2 200	750	640	430
JAPAN	8 200	4 000	2 160	1 200
SOUTH ASIA	3 100	1 250	400	1 000
PACIFIC AREA	1 300	600	100	600
TOTAL WORLD	85 [illegible]00	38 [illegible]	13 900	27 180

Annex 10 (b)

CAPACITIES OF PRODUCTION IN 1985

INTERMEDIATE PRODUCTS

10^3 t/year

PRODUCTS / REGIONS OF THE WORLD	Vinyl chloride	Styrene	Caprolactam	DMT	TPA	Acrylonitrile
WESTERN EUROPE	8 600	6 300	1 200	1 535	650	2 [illegible]
EASTERN EUROPE	2 700	2 350	900	918	270	[illegible]
NORTH AMERICA	7 300	7 200	750	2 663	1 400	1 [illegible]
LATIN AMERICA	1 800	950	350	500	400	[illegible]
AFRICA	1 400	200		25		
ASIA						
MIDDLE EAST	1 500	350		60	80	
EAST ASIA	1 100	350	250	485	250	200
JAPAN	2 900	2 750	700	740	1 220	1 [illegible]
SOUTH ASIA	1 400	650	250	114	300	150
PACIFIC AREA	500	300				
TOTAL WORLD	29 200	21 400	4 400	7 100	4 500	6 [illegible]

Annex 10 (c)

CAPACITIES OF PRODUCTION IN 1985

END PRODUCTS

$10^3 t/y$

REGIONS OF THE WORLD / PRODUCTS	Main plastics	Synthetic fibres	Synthetic rubber
WESTERN EUROPE	29 400	4 400	2 500
EASTERN EUROPE	9 500	3 050	2 700
NORTH AMERICA	29 400	5 350	3 200
LATIN AMERICA	6 600	1 700	600
AFRICA	3 320	300	200
ASIA			
MIDDLE EAST	3 400	350	220
EAST ASIA	3 150	1 150	200
JAPAN	9 100	2 140	1 600
SOUTH ASIA	4 250	1 250	400
PACIFIC AREA	1 710	300	120
TOTAL WORLD	99 9[illegible]	20 000	11 620

Annex 11

ESTIMATION OF PETROCHEMICALS PRICES EVOLUTION

	Share estimated to move according to crude oil price evolution %	Share estimated to move according to the overall inflation %
Ethylene	50	50
Propylene	50	50
Butadiene	50	50
Benzene	50	50
O. Xylene	50	50
P. Xylene	50	50
Styrene	40	60
D M T	30	70
Acrylonitrile	33	67
Ld Polyethylene	29	71
Polystyrene	28	72
Polyester fibres	17	83
Acrylic fibres	16	84

Annex 12

HYDROCARBONS REQUIRED BY THE MANUFACTURE OF PETROCHEMICAL PRODUCTS

1985

10^6 T.O.E.

REGIONS OF THE WORLD	Feedstock requirements	Net utilities requirements (excluding fuel recovered as by products)	Total requirements	From which Hydrocarbons for non petrochemical ammonia
WESTERN EUROPE	112.4	29.1	141.5	(15.4)
EASTERN EUROPE	68.9	12.7	81.6	(27.9)
NORTH AMERICA	129.4	29.4	158.8	(19.7)
LATIN AMERICA	21.9	6.9	28.8	(4.8)
AFRICA	9.5	2.5	12.0	(2.8)
CHINA	16.7	4.4	21.1	(10.5)
MIDDLE EAST	8.5	2.6	11.1	(1.4)
EAST ASIA	11.3	3.8	15.1	(1.7)
JAPAN	39.3	11.4	50.7	(1.9)
SOUTH ASIA	22.5	4.3	26.8	(11.3)
PACIFIC AREA	4.3	1.4	5.7	(0.6)
TOTAL WORLD	444.7	108.5	553.2	(93.0)

Annex 13

MANPOWER NEEDS ESTIMATES (MIN)

198[illegible]

Area	Technical personnel	Administrative personnel	Marketing and sales personnel
Western Europe	28[illegible] 3[illegible]0	28 300	14 [illegible]
Eastern Europe	180 [illegible]	19 000	8 000
North America	3[illegible]6 400	31 600	16 3[illegible]
Latin America	55 [illegible]	8 500	4 300
Africa	23 [illegible]	2 [illegible]	[illegible] 200
Asia			
Middle East	26 500	2 700	1 300
East Asia	52 100	5 200	2 600
Japan	124 200	12 400	6 200
South Asia	59 600	6 000	3 000
Pacific area	17 500	1 600	900
TOTAL WORLD	1 159 [illegible]	114 300	58 000

Annex 14

INVESTMENT REQUIREMENT ESTIMATES

10^9 US$ (1977)

AREA	UP TO 1980*	1980 - 1995
WESTERN EUROPE	14.5	14.9
EASTERN EUROPE	6.7	13.2
NORTH AMERICA	12.8	27.2
LATIN AMERICA	5.9	15.3
AFRICA	1.2	5.6
ASIA		
MIDDLE EAST	2.2	5.7
EAST ASIA	3.5	5.3
JAPAN	4.9	8.1
SOUTH ASIA	2.4	10.2
PACIFIC AREA	9	2.9
TOTAL	55.0	108.4

* Corresponding to the plants that will start up before 1981

Annex 15

PICTURES OF 2000 COMPARED

FACTORS		INDUSTRIALIZED COUNTRIES			DEVELOPING COUNTRIES			WORLD		
		Hypothesis A	Hypothesis B	Hypothesis C	Hypothesis A	Hypothesis B	Hypothesis C	Hypothesis A	Hypothesis B	Hypothesis C
Population	10^9 inhabitants	1379	1379	1379	4876	4876	4876	6254	6254	6254
GDP growth	% year	2.9	4.5	3.5	6.8	5.9	5.2	4.0	4.8	4.0
GDP 2000	10^9 $ (1977 $)	10608	14443	12055	6255	5245	4660	16863	19687	16715
Energy consumption	10^9 TOE	8.3	10.75	9.42	5.32	4.52	3.64	13.62	15.27	13.26
Oil consumption	10^9 T	2.43	3.97	2.87	3.10	2.30	1.64	5.53	6.27	4.51
Petrochemical feedstocks**	10^9 TOE	0.49	0.78	0.64	0.26	0.17	0.14	0.75	0.95	0.78
Fibres* demand	10^6 T	23.9	34.2	28.4	21.7	16.9	14.0	45.6	51.1	42.4
Plastics demand	10^6 T	130.1	196.5	158.7	62.4	47.1	38.9	192.5	243.6	197.6
Rubber* demand	10^6 T	16.9	22.8	19.7	7.6	6.4	5.7	24.5	29.2	25.4
Fibres* production	10^6 T	22.9	36.8	30.6	22.7	14.3	11.8	45.6	51.1	42.4
Plastics production	10^6 T	129.3	204.6	166.6	63.2	39.0	31.0	192.5	243.6	197.6
Rubber* production	10^6 T	17.6	24.7	21.2	6.9	4.5	4.1	24.5	29.2	25.3
Ethylene production	10^6 T	68.8	111.5	91.4	38.6	25.2	20.0	107.4	136.7	111.4
Share of rpoduction of petrochemical products	%	65	82	82	35	18	18	100	100	100
Investment for petrochemical industry	10^9 $	310.9	499.4	411.8	248.6	189.1	122.6	559.5	688.5	534.4
Share of GDP for investment in petrochemical industry	%	0.18	0.24	0.22	0.32	0.27	0.19	0.22	0.25	0.21
Labor	10^5 workers	1.86	2.98	2.48	1.44	0.96	0.71	3.30	3.94	3.19

* Synthetic
** Including fuel requirements

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