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

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INTRODUCTION

The Lima Declaration and Plan of Action on Industrial Development and Cooperation, adopted in March 1975, gave UNIDO the mandate to explore ways for increasing the share of the developing countries to at least 25% of total world industrial production by the year 2000. This mandate poses two practical problems: one, to explore the participation of each industrial sector in achieving the 25% of total world industrial production, and, two, to appraise the magnitude of the resources needed for its attainment.

This report relates to the study of both problems in the petrochemical sector. The report addresses itself to the first problem by analysing the world situation of the petrochemical industry, its structure and its evolution from the past up to the year 2000. Concerning the possible share of the developing countries in the total world petrochemical production by the year 2000, three alternatives are analysed, ranging from the continuation of the present conflicting situation up to the degree of cooperation required to achieve the Lima target and self-sufficiency.

Concerning the second problem, a world petrochemical model was developed that is able to simulate long-range situations. The three alternatives mentioned above were processed and duly quantified in order to measure the resources needed by each of them. The consequences and cooperative effort required in each case are also presented so that both developed and developing countries may become aware of the implications and serious commitments that might be made in implementing any of these alternatives.

Nevertheless, the three alternatives presented are only some among many others possible and the petrochemical model was constructed to simulate the techno-economic relationships of the petrochemical industry to be used in the first consultation meeting on petrochemicals in order to get a feedback from the participants. We are often aware that a model is an abstraction that only partially simulates reality although it gives useful techno-economic predictions. Current on-going work would give a closer approach to reality by using futures research techniques based on scenarios. These scenarios are built on the physical structure of the industry; on the specific aims, programmes and intentions of the actors (organizations active in the world petrochemical industry); and on the opportunities and constraints existing or becoming existent through the actions of the actors.

The appraisal of the three alternatives shown and the formulation of other hypotheses would be the themes for scenarios. Once the appropriate

feedback from the participants is received, ICIS would be in a position to prepare the corresponding scenarios for the following consultation meeting on petrochemicals. The study presented in this report is of the policy type and is addressed to policy-makers and decision-makers whose decisions and actions will shape the future development of this industry. Its scope is limited to the four main large-tonnage end-product petrochemical families: plastics, fibers, elastomers and detergents, along with their corresponding intermediate and basic products. The figures given are based on the internal information sources of our technical consultants **Bureau d'etudes industrielles et de coopération de l'institut français du pétrole** (BEICIP) unless otherwise referenced.

LIST OF ABBREVIATIONS

LNG = liquid natural gas

LPG = liquid propane gas

HDPE = high density polyethylene

LDPE = low density polyethylene

PVC = polyvinyl chloride

SBR = styrene butadiene rubber

PP = polypropylene

Syndets = synthetic detergents

PS = polystyrene

EEC = European Economic Community

EFTA = European Free Trade Association

CMEA = Council for Mutual Economic Assistance

TOE = tons of oil equivalent

ABS = acrylonitrile butadiene styrene resins

DDB = dodecil benzene

GDP = gross domestic product

MVA = manufacturing value added

DMT = dimethyl therephtalate

TPA = therephtalic acid

O-xylene = orthoxylene

P-xylene = paraxylene

VCM = vynil chloride monomer

I. MAIN FEATURES OF THE PETROCHEMICAL INDUSTRY

1. The petrochemical industry is growing constantly. World production rose from a few hundred tons in 1920 to 3.5 million tons in 1950 and now exceeds 70 million tons; this rate of growth is one of the swiftest in industry (14 per cent a year).

2. Its dynamism stems primarily from its highly competitive position in relation to other artificial and natural products.

3. This industry finds its markets in several industrial sectors, in that it provides them with basic material.

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

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

6. 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 are, however, in most cases prepared to make them available under licence.

7. Obligatory derivation of all high-tonnage petrochemicals from the basic petrochemicals, i.e., C_2 and C_3 olefins, C_6, C_7 and C_8 aromatics, methanol and ammonia.

8. Leading role played by petroleum products as a raw material for olefins and aromatics manufacture.

9. Leading role played by natural gas in methanol and ammonia manufacture.

10. The design, implementation and operation of petrochemical plants require a small, highly skilled and qualified work force who have to accept a great deal of responsibility.

11. The petrochemical industry is capital-intensive and requires very high investment, particularly at basic petrochemical production level.

12. The petrochemical industry is subject to restrictions of economy of scale, though to a much lesser degree since 1973.

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 of a refining industry which can supply gas oil or naphtha is much more important. The proportion of raw materials used in petrochemistry, out of the total crude oil and gas produced, although constantly growing, is still small. It was less that 1% in 1950 and is now somewhere between 4.5 and 5%.

The availability of raw materials should 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 the 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' contributions) 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. Developing a technology - the importance of research

The spectacular development of the petrochemical industry, due to the increasingly competitive nature of the products marketed, was made possible only through the continuous perfecting and improvement of a technology, thanks to particularly large sums being set aside for research. Between 1960 and 1970, the budget devoted by the leading chemical companies to the perfecting of existing techniques and the development of new processes was equivalent to 2/4% of their turnover in the United States and Europe. Companies engaged in production were not the only ones to undertake such research. Engineering companies and companies 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 most important to the profitability of the petrochemical industry.

g. 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 98% of world butadiene capacity. The importance of these regions in terms of production capacity also extends to intermediates and end products. In these regions more than 90% of the facilities for intermediates, plastics and synthetic rubber productions are located.

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 2.8 times from now to 1980, from 2.6 million to 7.3 million tons; during the same period the increase of the capacities in Europe, the U.S. and Japan will be lower than 40%, from 36 million to 49.9 million tons.

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 increase has also shown 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	16	14
* Others	-	1	3	1

Source: Calculated on the basis of ECE-CHEM/GE.1/R.3/Add.3, 5 April 1977.
*At this stage it is difficult to further disaggregate for lack of statistics.

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 41% 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 spread 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 6.7% annually. This growth diminished to 2% annually during 1971-1975. During the same period, 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 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 60% 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 Annexes 1(a), 1(b) and 1(c).

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 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 substitute natural 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 (customs barriers set up to protect a new industry)
- 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.

f. 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 quite large.

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 the 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.

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* 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 50% 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. Synthetic detergents

From the beginning of the seventies and 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 9.3% 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: 4% 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. Plastics

The major share of the plastics market is held by thermoplastics,

* 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.

accounting 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 of the 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 industrialized 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 6% of the man-made market. In these countries, market growth would result from a deeper penetration of man-made fibers into the textile market (currently 2% 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 46% of world synthetic markets, will keep on increasing in importance.
- Polyamid fibers, presently accounting for 33% 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 in 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 50% 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

Alkylbenzene 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 instead of

machine washing with hot water requires substantially more of the active material. It is expected that alkylsulfonates 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, have 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 1976. For instance, U.S.A. exports of synthetic fibers, thermoplastics and synthetic rubber amounted to 1,450 mm US$, i.e., more than 1% of the total U.S. exports. In 1975, the internal and external exchanges of the EEC relative to the main petrochemical end products alone (thermoplastics, synthetic fibres, synthetic rubber) were about 5,000 mm US$. Such a value is equivalent to 9-10 % of the total imported crude oil (but represented 25 % in 1973, 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 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) Olefine - 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 CMEA 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 continues 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 such countries as the Rep.of Korea. Eastern Europe and EFTA countries constitute important markets for Western Europe in final petrochemicals, while Eastern Europe is emerging as an important synthetic rubber exporter.
Concerning plastics, EEC is largely the main exporter 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

To assess this share one should compare the international exchanges of petrochemicals with their consumption, and measure the importance of the total exports oompared to world production.

A. 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 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-xylene exports (about 35 % of their production) represent an exception.

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

- The most important trade is in end products, while for most basic and intermediate products trade can be considered as marginal (less than 10 % of production).

- 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 U.S.A.

- 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 the 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 until 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 competition.

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 relatively down to the level needed by the largest scale operators to have an attractive return on investment. But often prices have dipped lower to the point where medium-size producers are seldom able to make a profit.

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 is derived from eight major basic products: ethylene, propylene, butadiene, benzene, toluene, 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 U.S.A. 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 catalytic cracking).

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 U.S.A.

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) Japan

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) Eastern Europe

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

- methanol (and ammonia) are produced mainly from natural gas.
- There are few steam crackers in Eastern Europe based on naphtha, while 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 the Republic of Korea. 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 $\frac{1}{4}$ 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.O.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 at 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 under West European conditions. Besides, the production cost in new olefin plants will be about 12 % higher than in the case of a similar plant built before 1973.

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 new situation 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 flexible multiple feedstock crackers, 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:

- a 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) forecasts of the demand for these products have been set up. Annexes 9(a), 9(b) and 9(c) show 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 competitiveness 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 (=synthetic) fibers. The latter figures in annex 9(a) have been obtained by difference taking into account the stagnation of demand for cellulosics. The three most important types of synthetics are polyester, polyamid, and acrylics.
- rubber: natural and synthetic rubber. The latter figures in annex 9(a) have been obtained by difference 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.

The forecasted capacities to 1985, by regions, are given in Annexes 10(a), 10(b) and 10(c).

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 substantially their plant capacities. Nevertheless, the share of the developing countries will still remain low.

On the other hand, if the assumptions 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 reach 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, etc.) becomes 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 in self-sufficiency at regional level
- a less prevailing position of the industrialized countries

- despite the trend toward regional self-sufficiency, the trade volume would keep at least its present order of magnitude because of consumption increases and the appearance of new trade streams.
- the appearance of new trade streams such as sophisticated products exported from industrialized to developing countries (currently of little importance), commodities and high consumption products exported from developing countries (mainly hydrocarbon-producing countries) to industrialized countries.

These trends will demand greater efforts and resources in the areas of marketing and distribution by the emerging exporters 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 an industry which requires very high investments. Construction costs for petrochemical plants 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.

Investments for petrochemical plants vary according to the technical options and the localization of production. The estimated investment range, battery limits for 1977 European conditions, varies between 150 to 600 $/ton for basics, and from 200 to 2,300 $/ton for intermediate and finals. Local conditions greatly affect the main constituent elements of the construction cost. In particular construction costs are generally higher in the developing countries, chiefly due to the fact that contractors 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 *

Estimated manpower requirements are given in Annex 14, which shows that by 1985 the petrochemical industry will require a labour force of about 1.3 million, of which 285,000 would be in the regions of Latin America, Africa and Asia. It is foreseen that the composition of the required personnel would be as follows:

Technical personnel including:	
- engineers and managerial staff	3%
- foremen and technicians	16%
- skilled workmen	45%
Administrative personnel including:	
- managerial staff	2%
- clerks	7%
Sales and marketing personnel including:	
- managerial staff	2%
- clerks	2%
Unskilled workmen:	29%

The data from manpower-need estimates for 1985 facilitates the calculation of the manpower for different regions until 2000 under the three different scenarios (UNIDO, Cavendish and Leontief). The estimates of the three hypotheses give preliminary indications about the intensity of manpower training and development problems which could appear in different regions in this period.

The main problem in providing the skilled manpower according to the expansion of the petrochemical industry in developing countries is the structure disproportions between graduates supply and demand, which is due to the lack of sufficient specialization of chemical and mechanical engineers and all kinds of skilled manpower, as well as

*The information in this section was provided by an ILO study on manpower training needs in the petrochemical industry in developing countries, specifically conducted for this UNIDO paper.

graduates of secondary schools and vocational educational institutes. Aside from the shortage of qualified personnel in the developing countries, there is a lack of qualified trainers and adequate training programmes, insufficient finances, and a climate which favours "academic" study rather than vocational and technical training.

To achieve the target of providing required personnel for the petrochemical industry, the policymakers should be aware of not only the above problems, but also the positive and negative implications in the field of job-generation and induced employment. The positive implication is the backward and forward linkage of the petrochemical industry with other sectors of the economy; the negative implication is the influence of the industry on labour-intensive industries, i.e., development of synthetic fibre production competes with labour-intensive jute production in some developing countries whose exports revenue is heavily dependent on jute and the same could be said about substitution of the natural resin by synthetic ones. However, taking into consideration positive and negative effects in job-generation in developing countries as a whole, it must be stressed that the net employment-creation effect of the petrochemical development is a positive one. Most of the specialists, both in developing and developed countries, believe that for the conditions in the developing countries, on the average one new job in petrochemicals could create five to seven jobs in other industries.

Thus, the main policies which could be helpful to meet the growing requirements of the rapid petrochemical expansion in developing countries on the manpower development side are in the following areas of activity:

a) manpower planning;

b) co-operation and co-ordination of activities between the petrochemical industry and the educational system;

c) training policy and development of the institutional training;

d) co-operation among developing countries in the manpower training field; and

e) assistance of the developed countries in the manpower development field.

The above policy measurements mainly underline that the policymakers should formulate manpower planning at the same stage that they formulate petrochemical expansion, and closely integrate it into the overall plans for economic and production development of the petrochemical sectors. Moreover, they should coordinate the activities of the existing educational and training systems with industry in order to avoid duplication and overlapping between them, and to avoid the waste of human and financial resources nationwide. The next step would be to identify the right training system and to institutionalize this training, including the right mix between on-job and off-job training. The developing countries in their effort to provide required manpower for the petrochemical expansion could save a considerable amount of scarce resources by pooling them to create common support-services for the petrochemical industry, such as training institutions, research centres, marketing organizations, etc. In addition, the assistance of the educational institutions of industrialized countries is vital in encouraging the transfer of know-how needed for training the required personnel.

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 consistant and coherent pictures of the year 2000 compatible with the main hypothesis explored.

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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 simulation 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 hypotheses 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 orld etrochemical odel 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.

I+ 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 implememtation 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

In studying the dynamics of a sectoral structure, the most important element concerns the power relationships between the actors that participate directly or indirectly in the industry under consideration.

These actors usually are organizations, governments, groups and individuals whose relative power positions, expectations and intentions determine the duration and intensity of the power relationships between them. These relationships usually evolve within a framework of conflict-cooperation according to the degree of concurrence or disagreement reached by the actors.

As result of the above, actors usually determine their actions in terms of strategic postures that could be enounced by them and/or perceived by the other actors. The strategic posture indicates the ways (decisions, major action programmes) in which actors intend to use their means (the resources available to the actor) to achieve their aims and objectives and overcome their constraints. In the petrochemical industry the main actors have been the large chemical multinationals who until recently were in position to shape the world-wide development of this industry. These companies are originally from developed countries and can be of private, public or mixed ownership.

Currently emerging actors, new evolving power relationships between actors, increasing role of governments in this industry and a growing body of constraints (economic, technological, environmental, etc.) are changing substantially this situation.

Presently work is being carried out to analyse these changes and their likely outcome in terms of the strategy of the actors.

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. 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 dicisions. In the light of these circumstances it appears that industrial development planning on a national acale 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 they co-operate with the industrialized countries, where, in fact, some vital factors are almost exclusively concentrated: large

petrochemical companies, construction firms, sources of finance, technology, plant design, and operating and marketing experience. Moreover, these countries continue to account for a major share of the petrochemicals markets.

.2. Recommendations

1. The petrochemical industry is a heavy industry requiring substantial 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. Those developing countries that still do not have petrochemical industries may 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 the 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

In choosing a technology careful attention should be given to the following, overlooked factors:

- Adaptability to market requirements, for it will determine the operating rate of the plant which is an essential condition for

profitability. The choice of products and their specifications should be in line with the requirements and habits of the petrochemicals consumers, i.e., the processing industries.

- Ease of operation. The processes should be adapted to local conditions since in developing countries there is not enough experienced personnel able to correct operating deficiencies. The processes should be industry-tested, with sound, reliable equipment. State-of-the-art technical innovations which have not yet adequate industrial references can only be used by very experienced and highly qualified personnel.

  Before choosing a technology (there are several competing processes per product, but usually one or two of those become the commercially dominant technologies), intending operators should visit the users of the prospective technologies in order to see the equipment working and benefit from the user's experience, and to assess whether the necessary conditions for trouble-free operating conditions of the prospective technology are present or not in their local conditions.

- Profitability of the process. It should be ensured that the process adopted must give production costs able to face stiff competition from domestic and external producers.

b) Personnel recruitment and training

The manpower resources should be developed and trained at all levels for various functions existing in the petrochemical industry. For this purpose, the general education system should be reoriented to put greater emphasis on the natural sciences, technology and vocational skills. Technician training should be expanded and on-the-job training be given direct assistance by the local industry and by facilitating the transfer of know-how from foreign sources, in particular from multinational petrochemical companies, including temporary use of expatriate personnel where required. The national vocational training schools and university departments dealing with petrochemical training need to be expanded in quantitative and qualitative terms and co-ordination between industry and educational systems improved. The regional co-operation among the developing countries should be established and strengthened by the educational institutions of the industrialized countries and the cooperation of engineering and construction enterprises, as well as process owners.

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 materials
- 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 : climate, altitude, 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 petrochemcial 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 identical 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 petrochemcial industry is also that it involves importing from industrialized countries most if not all of the equipment, and means 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 among 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	5 802	1 220	848	3 920
EASTERN EUROPE	2 955	1 553	340	3 460	327	285	2 513
NORTH AMERICA	14 450	7 100	2 270	6 400	1 908	603	4 624
LATIN AMERICA	1 455	418	205	349	100	75	264
NORTH AFRICA	120	-	-	-	-	-	110
EAST AND WEST AFRICA	-	-	-	-	-	-	-
SOUTH AFRICA	200	-	20	-	-	-	17
MIDDLE EAST COUNTRIES	190	40	33	-	-	-	54
SOUTH ASIA	192	100	36	69	17	-	33
EAST ASIA (1)	480	215	77	134	42	-	585
JAPAN	4 510	2 800	872	2 550	636	315	1 164
PACIFIC AREA	290	80	34	-	-	-	33
WORLD TOTAL	39 007	20 306	6 040	18 764	4 250	2 126	13 317

(1) excluding JAPAN

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

(1) excluding JAPAN

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	3 397
EASTERN EUROPE	3 170	1 407	⩾ 52	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	⩾ 867
JAPAN	5 623	739	330	⩾1 145
PACIFIC AREA	300	70	7	32
WORLD TOTAL	39 141	6 833	2 917	11 616

(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

ANNEX I

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

REGIONS \ PERIODS	PLASTICS		MAN-MADE FIBRES		RUBBER		SYNTHETICS	
	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	8.5(2)	5.3	0.9(3)		0.7
EASTERN EUROPE	-	-	7.8	8.8(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	5.85	6.3	-	-
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	9.0	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	4.0	14.9	-	-
SOUTH AFRICA	-	-	3.6	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	10.5	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	25.5	17.1
PACIFIC AREA	-	-	5.1	8.2 (2)	3.85	0.5(3)	13.6	8.8

(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 : 5.7
1970/76 : Western Europe : 2.0 ; Eastern Europe : 9.4 ; North America : 2.85 ; Japan 3.55

(4) Production - 1970/74 : Western Europe : 4.5 ; North America : 4.8

Annex 3

WORLD DEMAND FOR PETROCHEMICAL END PRODUCTS

1974

(1,000 Ton)

REGIONS OF THE WORLD	PLASTICS	SYNTHETIC FIBRES	SYNTHETIC RUBBER	SYNDETS (1975)
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	2 495	2 700
LATIN AMERICA	1 923	497.0	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	1 498.8	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	44 603	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	16.89
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	5.3
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 ¢/LB (CURRENT)

PRODUCT \ YEAR	1970	1971	1972	1973	1974	1975	1976
Ethylene						11.8	12.9
Butadiene			8	9.6	18.2	15.6	18.6
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	16.7
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	30.7
Nylon yarn not texturized	151	138	104	104	139 + 14	114	149
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 RESOURCES

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*

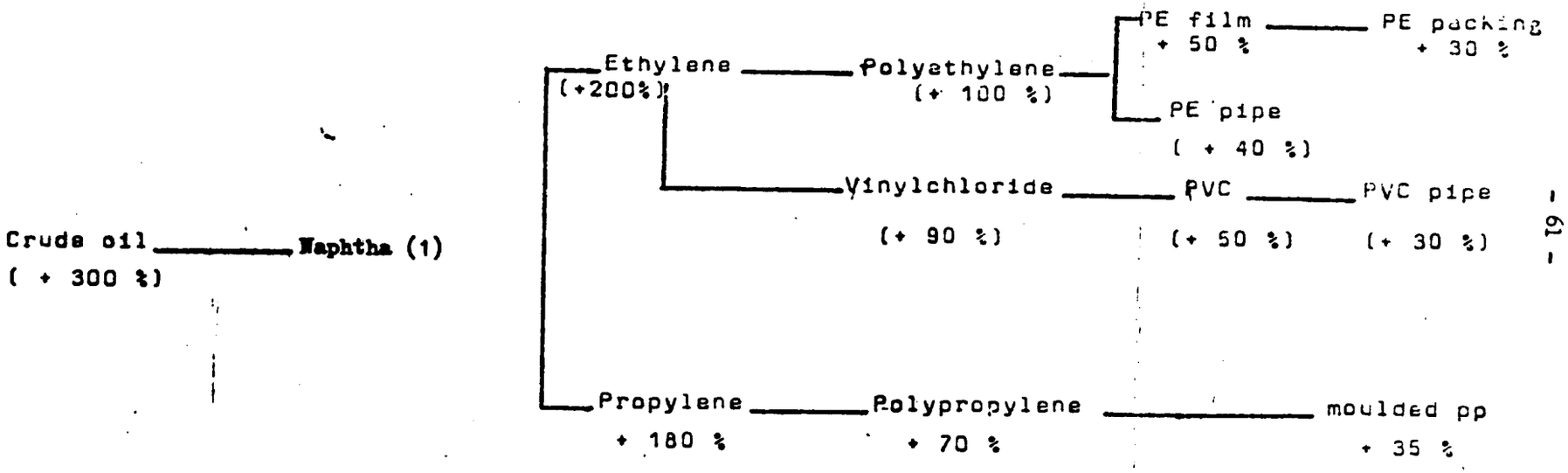
(2) *Known, probable and undiscovered*

(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 8

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) Naphtha price is dependent on offer and demand situation; it can vary up to some extent, independently from the crude price. During the considered period, the naphtha 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	36 330	3 200	2 553	4 800
EASTERN EUROPE	13 975	2 645	3 394	2 700
NORTH AMERICA	33 575	4 545	3 681	3 600
LATIN AMERICA	7 886	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	1 665	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	17 180
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 T

REGIONS OF THE WORLD	Vinyl chloride monomer	Styrene monomer	Acrylonitrile	DMT	TPA	Caprolactam	Ethylene oxide	Methanol
WESTERN EUROPE	7 935	5 123	1 464	978	560	546	1 800	6 100
EASTERN EUROPE	2 260	1 985	832	1 090	165	932	950	4 700
NORTH AMERICA	6 110	5 935	1 086	1 680	1 185	625	2 600	7 500
LATIN AMERICA	1 600	1 089	380	561	350	300	500	800
AFRICA	845	465	149	244	212	181	160	180
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	184	116	56	62	53	29		
ASIA excl. CHINA	3 424	3 243	1 460	1 744	1 547	1 304	1 215	3 660
CHINA	-	-	205	392	226	256	-	-
MIDDLE EAST	598	309	63.3	97	123	112	75	120
EAST ASIA	577	312	133	215	195	169	150	380
JAPAN	3 357	2 041	701	280	565	394	730	3 000
SOUTH ASIA	892	581	358	760	438	453	260	260
PACIFIC AREA	451	268	89	105	60	59	135	150
TOTAL WORLD	24 625	18 118	5 460	6 402	4 079	4 027	7 560	23 090
of which developing countries	4 328	2 640	1 232	2 207	1 401	1 442		

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	8 669	1 060	1 526
EASTERN EUROPE	6 150	3 050	2 156	4 098	873	699
NORTH AMERICA	23 300	11 056	2 569	10 640	1 970	1 175
LATIN AMERICA	4 990	2 149	604	1 848	627	308
AFRICA	1 930	772	322.2	947	79	162
NORTH AFRICA	661	245	97	290	-	57
WEST AFRICA	356	121	75	173	-	30
EAST AFRICA	300	87	70	121	-	25
CENTRAL AFRICA	181	51	23.6	56	-	15
SOUTH AFRICA	440	268	56.6	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	7 800	5 400	888	3 394	574	646
SOUTH ASIA	2 580	1 440	615	1 015	828	172
PACIFIC AREA	1 218	557	93	520	113	87
TOTAL WORLD	72 936	36 638	9 563.2	32 854	6 980	5 001
of which developing countries	12 108	5 243	2 034.6	5 206	2 311	833

Annex 10 (a)

PRODUCTION CAPACITIES - BASIC PRODUCTS - 1985

10^3T/year

REGIONS OF THE WORLD	Ethylene	Benzene	Ortho and para xylene	Methanol
WESTERN EUROPE	24 500	10 900	3 200	4 800
EASTERN EUROPE	8 100	5 000	2 000	7 000
NORTH AMERICA	28 000	12 500	4 200	7 700
LATIN AMERICA	5 200	2 200	950	1 200
AFRICA	2 200	1 100		1 500
ASIA				
MIDDLE EAST	3 000	650	230	1 700
EAST ASIA	2 200	750	640	430
JAPAN	8 200	4 000	2 180	1 200
SOUTH ASIA	3 100	1 200	400	1 000
PACIFIC AREA	1 300	600	100	650
TOTAL WORLD	85 800	38 900	13 900	27 180

Annex 10 (b)

PRODUCTION CAPACITIES - INTERMEDIATES - 1985 10^3 t/year

PRODUCTS / REGIONS OF THE WORLD	Vinyl chloride	Styrene	Caprolactam	DMT	TPA	Acrylonitrile
WESTERN EUROPE	8 600	6 300	1 200	1 595	650	2 150
EASTERN EUROPE	2 700	2 350	900	918	200	900
NORTH AMERICA	7 300	7 200	750	2 663	1 400	1 400
LATIN AMERICA	1 800	950	350	500	400	300
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	1 100
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	6 200

Annex 10 (c)

PRODUCTION CAPACITIES - END PRODUCTS - 1985 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	6 690	1 700	680
AFRICA	3 320	300	200
ASIA			
MIDDLE EAST	3 430	350	220
EAST ASIA	3 120	1 150	200
JAPAN	9 160	2 140	1 600
SOUTH ASIA	4 250	1 250	400
PACIFIC AREA	1 710	300	120
TOTAL WORLD	99 980	20 000	11 820

Annex 11

ESTIMATED PETROCHEMICAL PRICE TRENDS

(based on current prices)

	Share of present price expected to vary with crude oil price %	Share of present price expected to vary with overall inflation %
Ethylene	50	50
Propylene	50	50
Butadiene	50	50
Benzene	50	50
Oxylene	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 product)	Total requirements	Of which Hydrocarbons for non petrochemical ammonia
WESTERN EUROPE	112.4	29.1	141.5	(15.4)
EASTERN EUROPE	68.9	12.7	81.6	(27.3)
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	(98.0

Annex 13

INVESTMENT REQUIREMENT ESTIMATES

10^9 US$ (1977)

AREA	UP TO 1980*	1980 - 1985
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 14

MANPOWER NEEDS ESTIMATES (MEN)

1985

Area	Technical personnel	Administrative personnel	Marketing and sales personnel
Western Europe	283 300	28 300	14 200
Eastern Europe	160 500	16 000	8 000
North America	326 400	31 600	16 300
Latin America	85 300	8 500	4 300
Africa	23 800	2 400	1 200
Asia			
Middle East	26 900	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	1 800	900
TOTAL WORLD	1 159 600	114 900	58 000

Annex 15

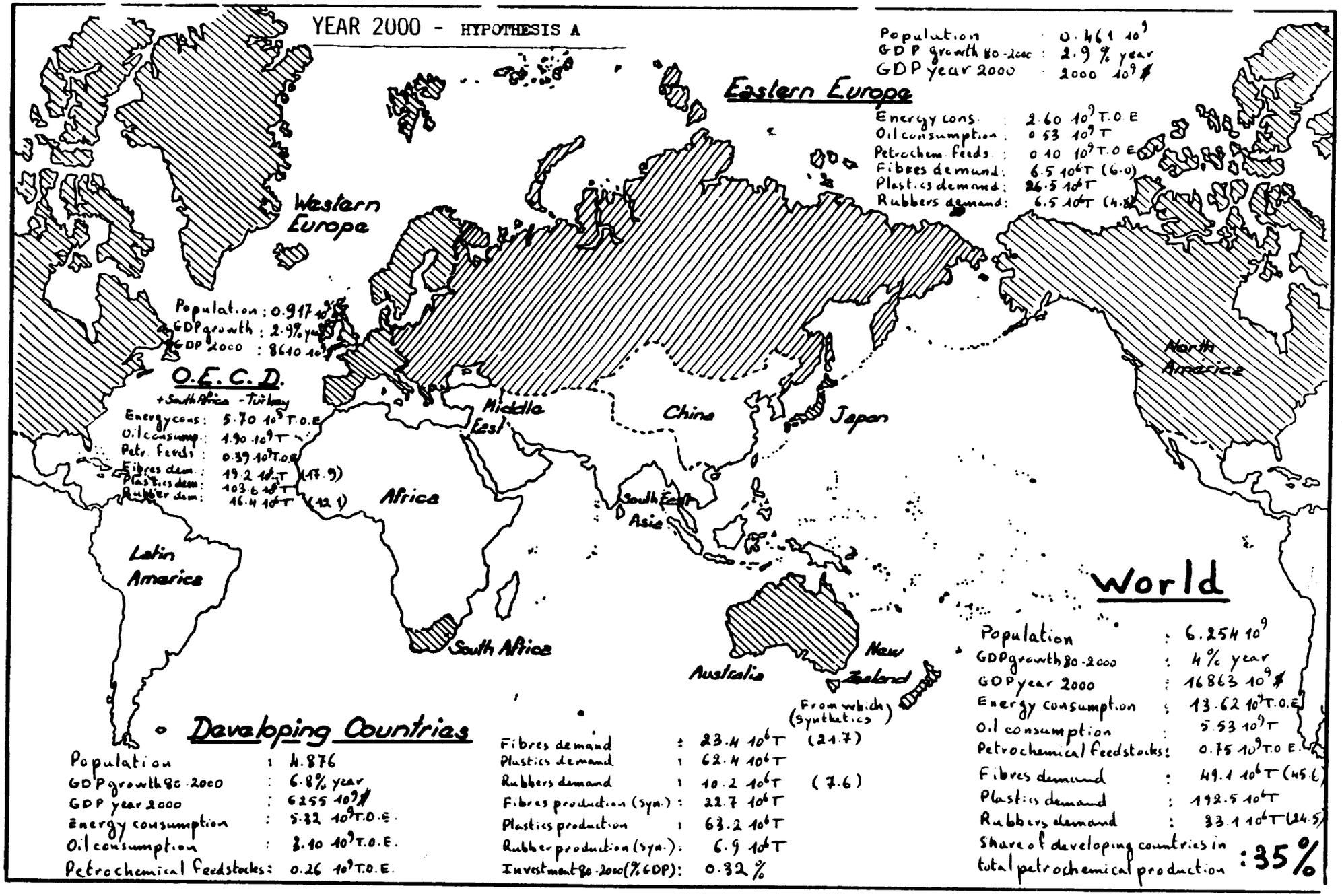
PICTURES OF 2000 COMPARED

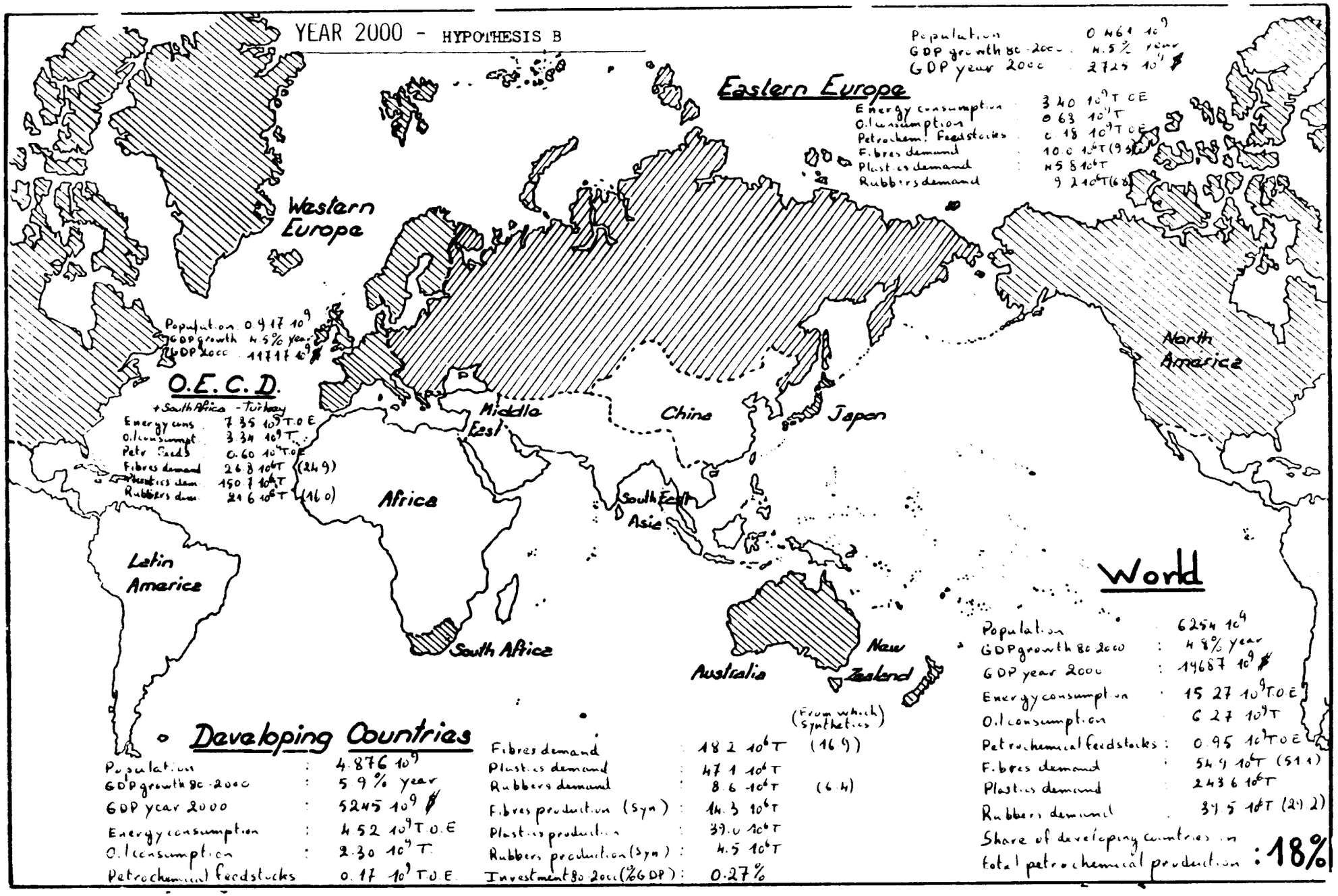
FACTORS	INDUSTRIALIZED COUNTRIES			DEVELOPING COUNTRIES			WORLD		
	Hypothesis A	Hypothesis B	Hypothesis C	Hypothesis A	Hypothesis B	Hypothesis C	Hypothesis A	Hypothesis B	Hypothesis C
Population 10^9 inhabitants	1379	1379	1379	4876	4876	4876	6254	6254	6254
GDP growth % year	2.9	4.5	3.5	6.8	5.9	5.2	4.0	4.8	4.0
GDP 2000 $10^9$$ (1977 $)	10608	14443	12055	6255	5245	4660	16863	19687	16715
Energy consumption 10^9TOE	8.3	10.75	9.42	5.32	4.52	3.84	13.62	15.27	13.26
Oil consumption 10^9T	2.43	3.97	2.67	3.10	2.30	1.64	5.53	6.27	4.51
Petrochemical feedstocks**10^9TOE	0.49	0.78	0.64	0.26	0.17	0.14	0.75	0.95	0.78
Fibres*demand 10^6T	23.9	34.2	28.4	21.7	16.9	14.0	45.6	51.1	42.4
Plastics demand 10^6T	130.1	196.5	158.7	62.4	47.1	38.9	192.5	243.6	197.6
Rubber*demand 10^6T	16.9	22.8	19.7	7.6	6.4	5.7	24.5	29.2	25.4
Fibres*production 10^6T	22.9	36.8	30.6	22.7	14.3	11.8	45.6	51.1	42.4
Plastics production 10^6T	129.3	204.6	166.6	63.2	39.0	31.0	192.5	243.6	197.6
Rubber*production 10^6T	17.6	24.7	21.2	6.9	4.5	4.1	24.5	29.2	25.3
Ethylene production 10^6T	68.8	111.5	91.4	38.6	25.2	20.0	107.4	136.7	111.4
Share of rpoduction of petrochemical products %	65	82	82	35	18	18	100	100	100
Investment for petrochemical industry $10^9$$	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 10^6workers	1.86	2.98	2.48	1.44	0.98	0.71	3.30	3.94	3.19

* Synthetic

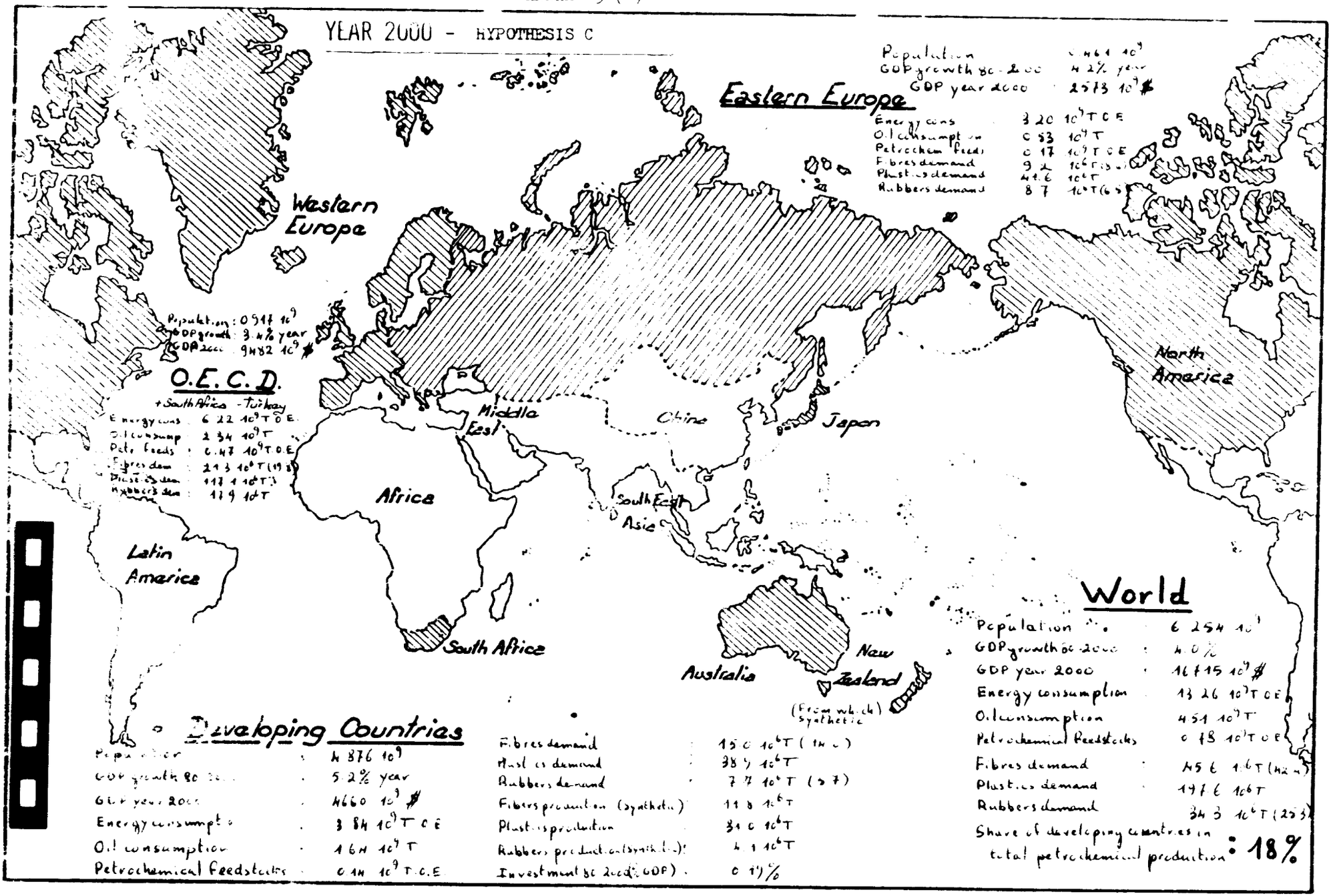
** Including fuel requirements

ANNEX 15 (a)

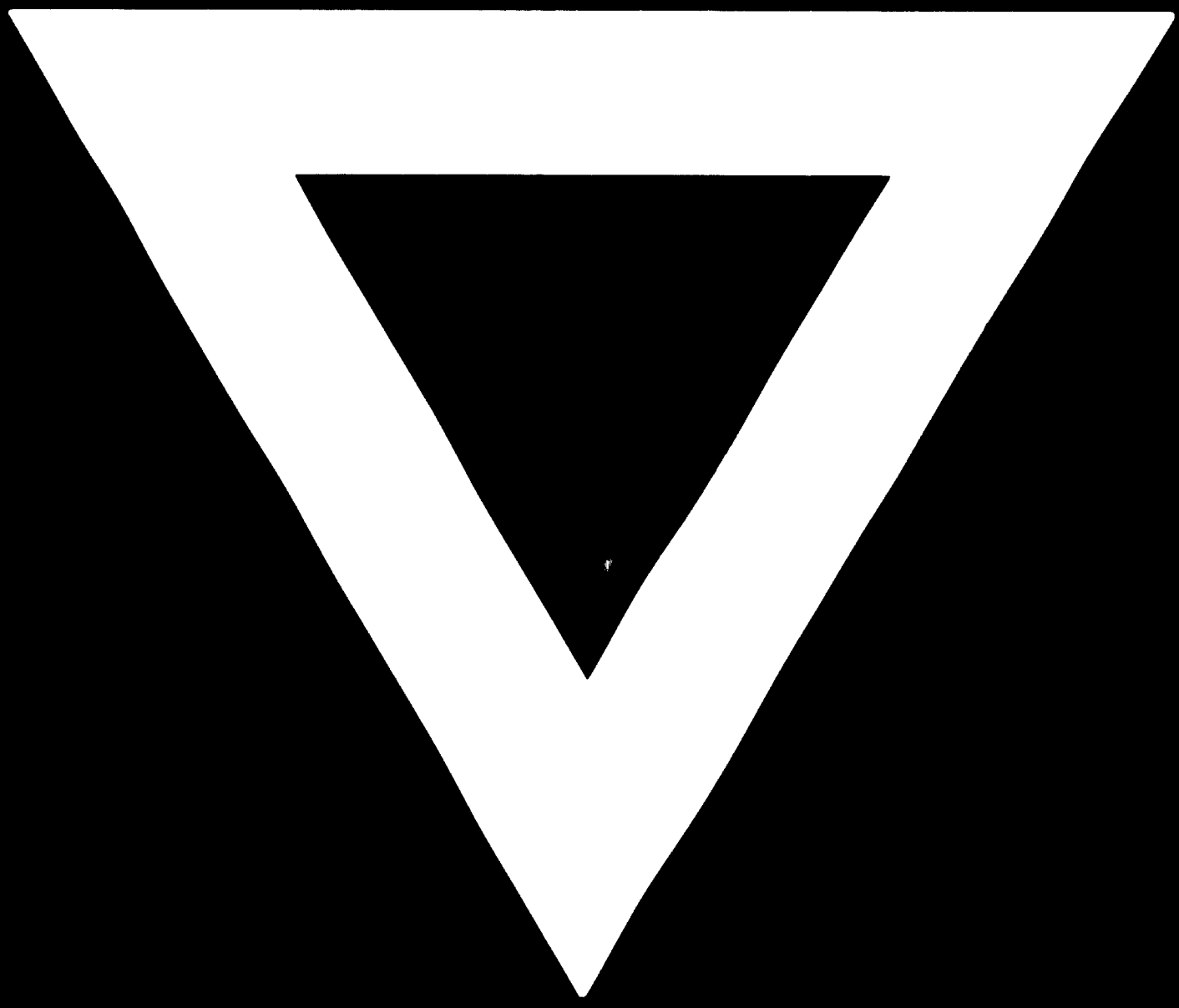

YEAR 2000 - HYPOTHESIS A
Eastern Europe
Population 0.461 10^9
GDP growth 80-2000 : 2.9 % year
GDP year 2000 2000 10^9 $
Energy cons. : 2.60 10^9 T.O.E
Oil consumption : 0.53 10^9 T
Petrochem. feeds : 0.10 10^9 T.O.E
Fibres demand : 6.5 10^6 T (6.0)
Plastics demand : 26.5 10^6 T
Rubbers demand : 6.5 10^6 T (4.8)
Western Europe
Population : 0.917 10^9
GDP growth : 2.9% year
GDP 2000 : 8610 10^9 $
O.E.C.D.
+South Africa -Turkey
Energy cons. : 5.70 10^9 T.O.E
Oil consumption : 1.90 10^9 T
Petr. feeds : 0.39 10^9 T.O.E
Fibres dem. : 19.2 10^6 T (17.9)
Plastics dem. : 103.6 10^6 T
Rubber dem. : 16.4 10^6 T (12.1)
Middle East
China
Japan
North America
Africa
South East Asie
Latin America
South Africa
Australia
New Zealand
World
Population : 6.254 10^9
GDP growth 80-2000 : 4 % year
GDP year 2000 : 16863 10^9 $
Energy consumption : 13.62 10^9 T.O.E
Oil consumption : 5.53 10^9 T
Petrochemical feedstocks : 0.75 10^9 T.O.E.
Fibres demand : 49.1 10^6 T (45.6)
Plastics demand : 192.5 10^6 T
Rubbers demand : 33.1 10^6 T (24.5)
Share of developing countries in total petrochemical production : 35%
Developing Countries
Population : 4.876
GDP growth 80-2000 : 6.8% year
GDP year 2000 : 6255 10^9 $
Energy consumption : 5.32 10^9 T.O.E.
Oil consumption : 3.10 10^9 T.O.E.
Petrochemical feedstocks : 0.26 10^9 T.O.E.
Fibres demand : 23.4 10^6 T (21.7)
Plastics demand : 62.4 10^6 T
Rubbers demand : 10.2 10^6 T (7.6)
Fibres production (syn.) : 22.7 10^6 T
Plastics production : 63.2 10^6 T
Rubber production (syn.) : 6.9 10^6 T
Investment 80-2000 (% GDP) : 0.32 %
From which (synthetics)


YEAR 2000 - HYPOTHESIS B
Eastern Europe
Population 0 416 10^9
GDP growth 80-2000 : 4.5% year
GDP year 2000 : 2725 10^9 $
Energy consumption : 3 40 10^9 T OE
Oil consumption : 0 63 10^9 T
Petrochem. Feedstocks : 0 18 10^9 T OE
Fibres demand : 10 0 10^6 T (9 3)
Plastics demand : 11 5 8 10^6 T
Rubbers demand : 9 2 10^6 T (6 8)
Western Europe
Population 0 417 10^9
GDP growth 4 5% year
GDP 2000 11711 10^9 $
O.E.C.D.
+ South Africa - Turkey
Energy cons : 7 35 10^9 T O E
Oil consumpt : 3 34 10^9 T
Petr Feeds : 0.60 10^9 T O E
Fibres demand : 26 8 10^6 T (24 9)
Plastics dem : 150 7 10^6 T
Rubbers dem : 21 6 10^6 T (16 0)
North America
Middle East
China
Japan
Africa
South East Asie
Latin America
South Africa
Australia
New Zealand
World
Population : 6254 10^9
GDP growth 80-2000 : 4 8% year
GDP year 2000 : 14687 10^9 $
Energy consumption : 15 27 10^9 T O E
Oil consumption : 6 27 10^9 T
Petrochemical feedstocks : 0 95 10^9 T O E
Fibres demand : 54 9 10^6 T (51 1)
Plastics demand : 243 6 10^6 T
Rubbers demand : 34 5 10^6 T (29 2)
Share of developing countries in total petrochemical production : 18%
Developing Countries
Population : 4 876 10^9
GDP growth 80-2000 : 5 9% year
GDP year 2000 : 5245 10^9 $
Energy consumption : 4 52 10^9 T O E
Oil consumption : 2 30 10^9 T
Petrochemical feedstocks : 0 17 10^9 T O E
Fibres demand : 18 2 10^6 T (16 9)
Plastics demand : 47 1 10^6 T
Rubbers demand : 8 6 10^6 T (6 4)
Fibres production (syn) : 14 3 10^6 T
Plastics production : 39 0 10^6 T
Rubbers production (syn) : 4 5 10^6 T
Investment 80-2000 (% GDP) : 0 27%
(From which synthetics)

ANNEX 15 (c)


YEAR 2000 - HYPOTHESIS C
Eastern Europe
Population : 0 461 10⁹
GDP growth 80-2000 : 4 2% year
GDP year 2000 : 2513 10⁹ $
Energy cons : 3 20 10⁹ T C E
Oil cons : 0 53 10⁹ T
Petrochem Feed : 0 17 10⁹ T O E
Fibres demand : 9 2 10⁶ T (5 %)
Plastics demand : 41 6 10⁶ T
Rubbers demand : 8 7 10⁶ T (6 %)
Western Europe
Population : 0 391 10⁹
GDP growth : 3 4% year
GDP 2000 : 9482 10⁹ $
O.E.C.D.
+South Africa -Turkey
Energy cons : 6 22 10⁹ T O E
Oil consump : 2 34 10⁹ T
Petr feeds : 0 47 10⁹ T O E
Fibres dem : 21 3 10⁶ T (19 %)
Plastics dem : 117 1 10⁶ T
Rubbers dem : 12 9 10⁶ T
North America
Middle East
China
Japan
Africa
South East Asie
Latin America
South Africa
Australia
New Zealand
(From which) synthetic
Developing Countries
Population : 4 876 10⁹
GDP growth 80 : 5 2% year
GDP year 2000 : 4660 10⁹ $
Energy consumption : 3 84 10⁹ T C E
Oil consumption : 1 64 10⁹ T
Petrochemical feedstocks : 0 14 10⁹ T O E
Fibres demand : 15 0 10⁶ T (14 %)
Plastics demand : 38 5 10⁶ T
Rubbers demand : 7 7 10⁶ T (37)
Fibres production (synthetic) : 11 8 10⁶ T
Plastics production : 31 0 10⁶ T
Rubbers production (synthetic) : 4 1 10⁶ T
Investment 80 2000 (% GDP) : 0 17 %
World
Population : 6 254 10⁹
GDP growth 80-2000 : 4 0 %
GDP year 2000 : 16 715 10⁹ $
Energy consumption : 13 26 10⁹ T O E
Oil consumption : 4 51 10⁹ T
Petrochemical Feedstocks : 0 48 10⁹ T O E
Fibres demand : 45 6 10⁶ T (42 %)
Plastics demand : 149 6 10⁶ T
Rubbers demand : 34 3 10⁶ T (25 %)
Share of developing countries in total petrochemical production : 18%

C-665



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